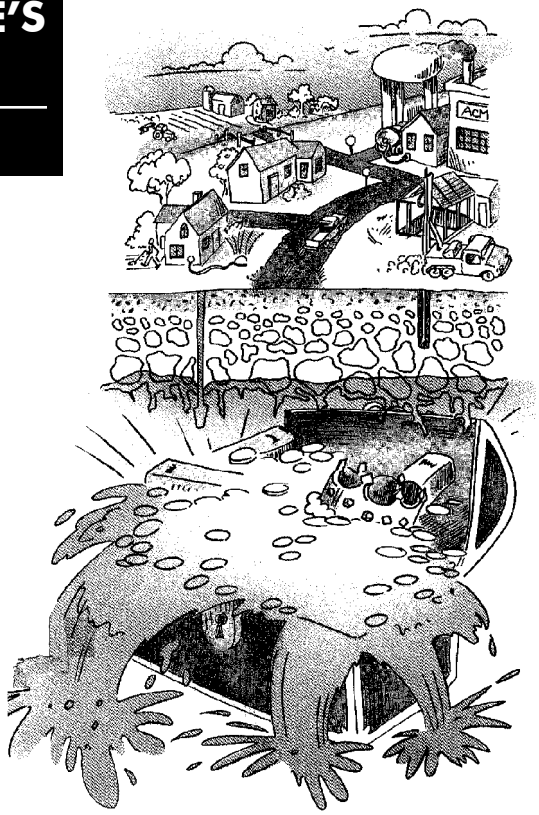
TOPIC 5. GROUNDWATER — NATURE'S HIDDEN TREASURE

Chapter 5(A): Groundwater — I Dig It!



Purpose

To help students see the extent and importance of groundwater in Canada.

Subject areas

History, Environmental Studies, Math, Language Arts, Science

Procedure

Review: Remind the students that groundwater is a large part of the hydrologic cycle and the world's water supply. Because we can't see groundwater, we tend to forget about it.

- Groundwater is an essential and vital resource for about a third of all Canadians, yet few of us understand or appreciate its value. Our knowledge about groundwater seems to depend on where we live in Canada.
- Ask the students if they have ever drunk water from a well. Try to find out how much they know about groundwater before distributing the information sheets.

Vocabulary

aquifer *confined* *crevice*	*impermeable* *unconfined* *unsaturated*

References

- Freshwater Series A-5: "Groundwater — Nature's Hidden Treasure"
- *A Primer on Fresh Water*: "Water — Underground"

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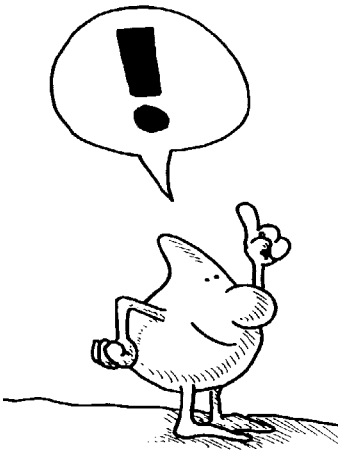
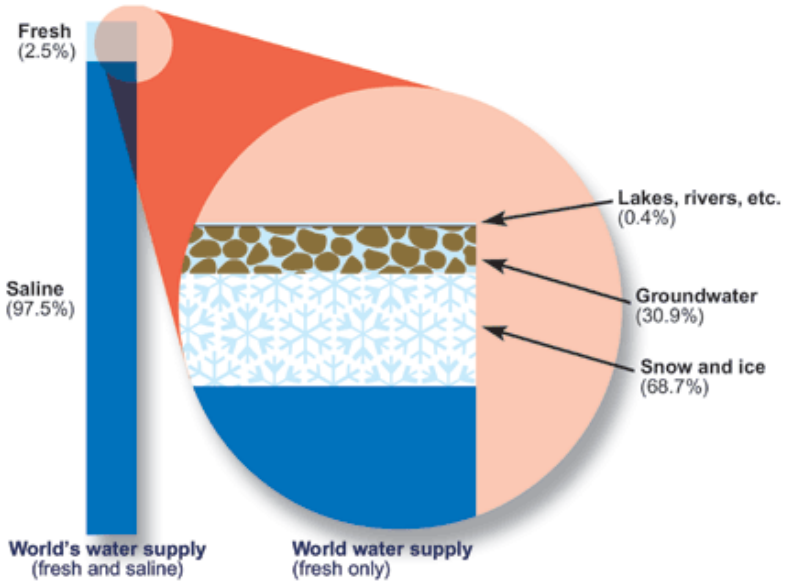


Picture the postcard view of Canada. What do you see? Sparkling blue lakes, long meandering rivers, and glistening white glaciers. Groundwater, which exists everywhere under the surface of the land, is not part of this picture. And because it is "hidden" from view, we tend not to think of it too much, instead we concentrate on the quality of our beautiful lakes and rivers. The question is, should we be concerned about groundwater quality since there is so much of it and since it is protected by ground cover? What do you think?

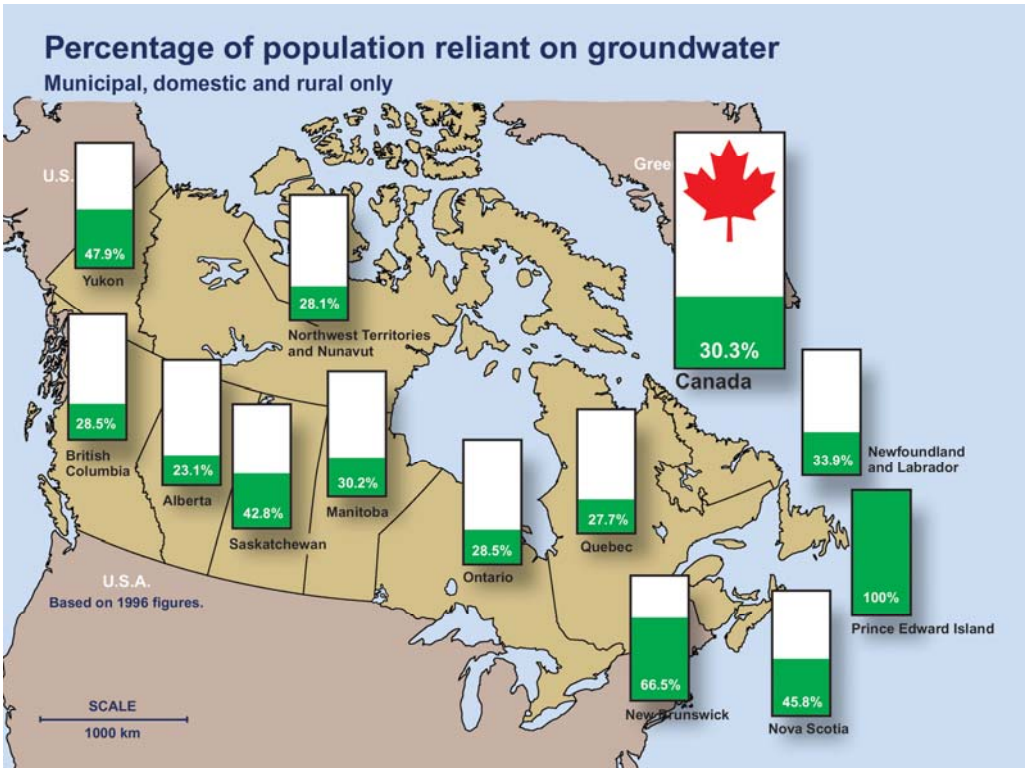
What's going on down there?

About one third of all the fresh water in the world is found underground! Just think, that's twice as much as we can see on the surface. Look at the diagram "Groundwater and the world's freshwater supply" to get an idea of the amounts.

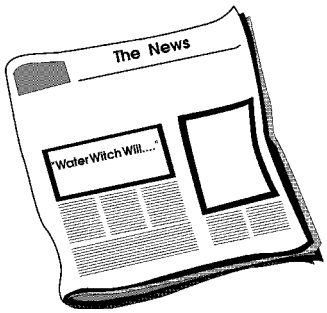
Groundwater and the world's freshwater supply



Over one quarter (30.3%) of Canadians rely on groundwater for all their daily needs. If you look at the diagram of Canada below you can see which areas depend entirely on groundwater and which regions hardly use it.



Water witches??



Your Current Events class this afternoon has set off a special spark of interest in you. As you thumb through the newspaper looking for headlines of noteworthy events in the world, your eyes light on the following:

> **Water Witch Will Find Water For You**
>
> Using the latest "divining rod," this water witch will point out the best place to dig a well on your property!

Come on now, water witch? Divining rod? Pointing to water in the ground? Sounds like one of these headlines you read at the grocery checkout.

Believe it or not, many people will not start to dig a well until they have called in a water witch, or diviner, to locate the spot where they are likely to find water. A water witch will use a steel divining rod or a forked stick (or even a clothes hanger!) and walk back and forth over the property. When the rod twitches or vibrates over a certain spot, this means there is groundwater below. Fact or fiction? Check it out with older people in your area. You may be surprised by some of the stories you hear.

Whether water witches can locate the best spot to dig for groundwater or not, the fact is that there is lots of groundwater beneath us. Even under deserts!

Did You Know?

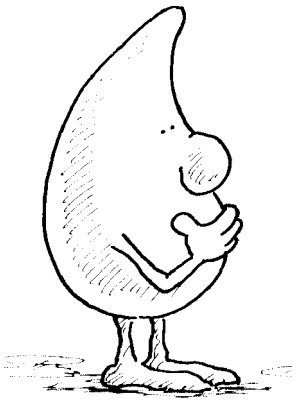
Groundwater provides nearly all the water used to raise livestock in Canada.

Groundwater flow

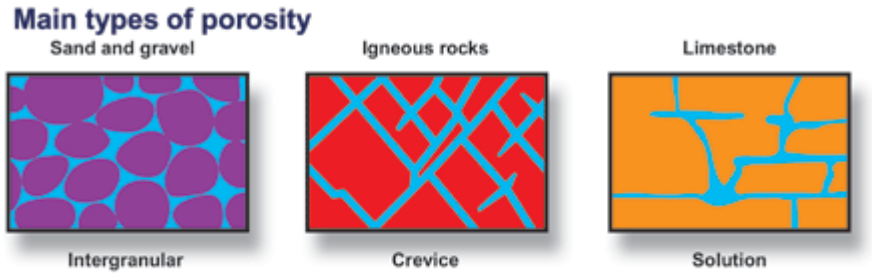
We know that groundwater moves underneath the soil because it is part of the hydrologic cycle, but just how fast does it flow?

Groundwater flows through the soil at different rates: it may move quickly, depending on the kind of soil it is in, but fast flow is unlikely; it can move as slowly as 10 centimetres a day and travel only 1 to 2 kilometres a year; or, one water molecule can be in the ground thousands of years before being discharged.

When you think of groundwater flowing you should know that it does not flow as our rivers above ground do, nor does it collect in underground lakes.

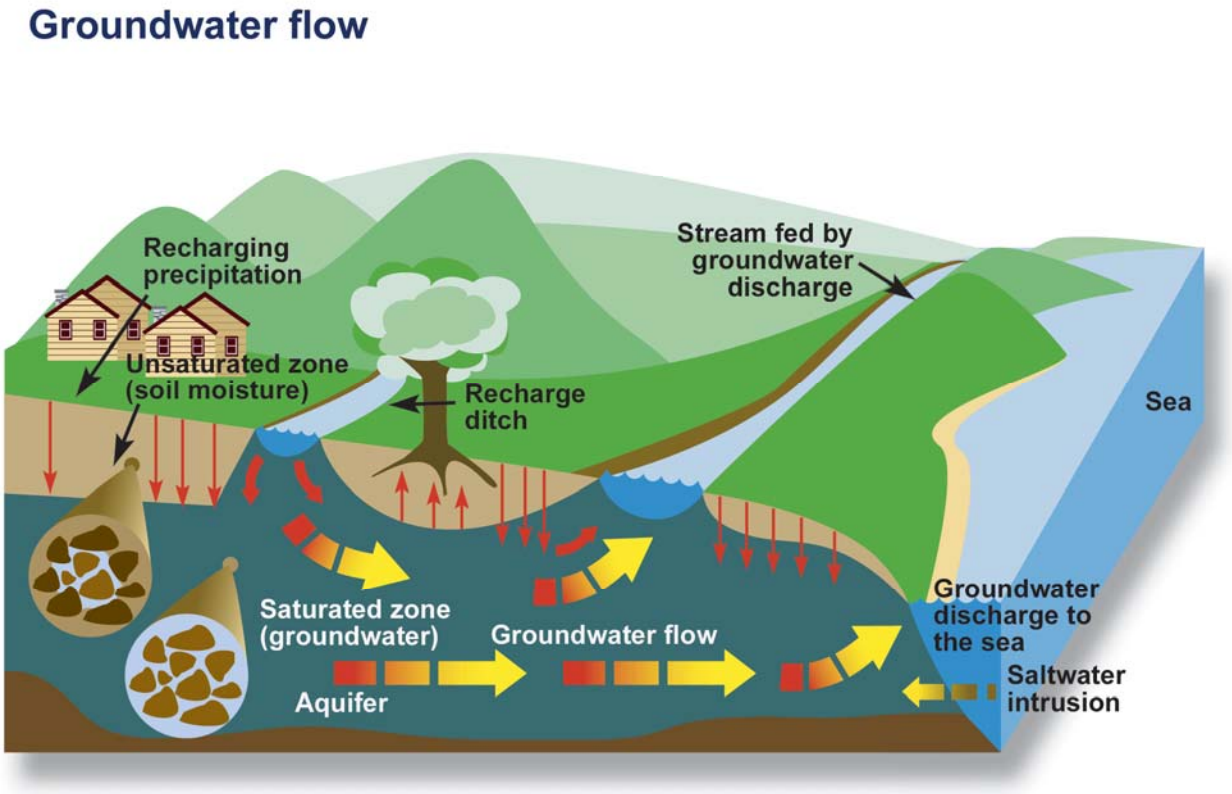


Rather, it is found almost everywhere underground — in the spaces between particles of rock and soil, or in **crevices** and cracks in rock — as you can see in the following diagram.



Where groundwater can be found. It fills the spaces between sand grains, in rock crevices, and in limestone openings.

Look at the diagram "Groundwater flow." In it you can see the **unsaturated** zone, where the spaces in the rock and soil contain air as well as water; and the saturated zone, where the water is called groundwater and it is always on the move.

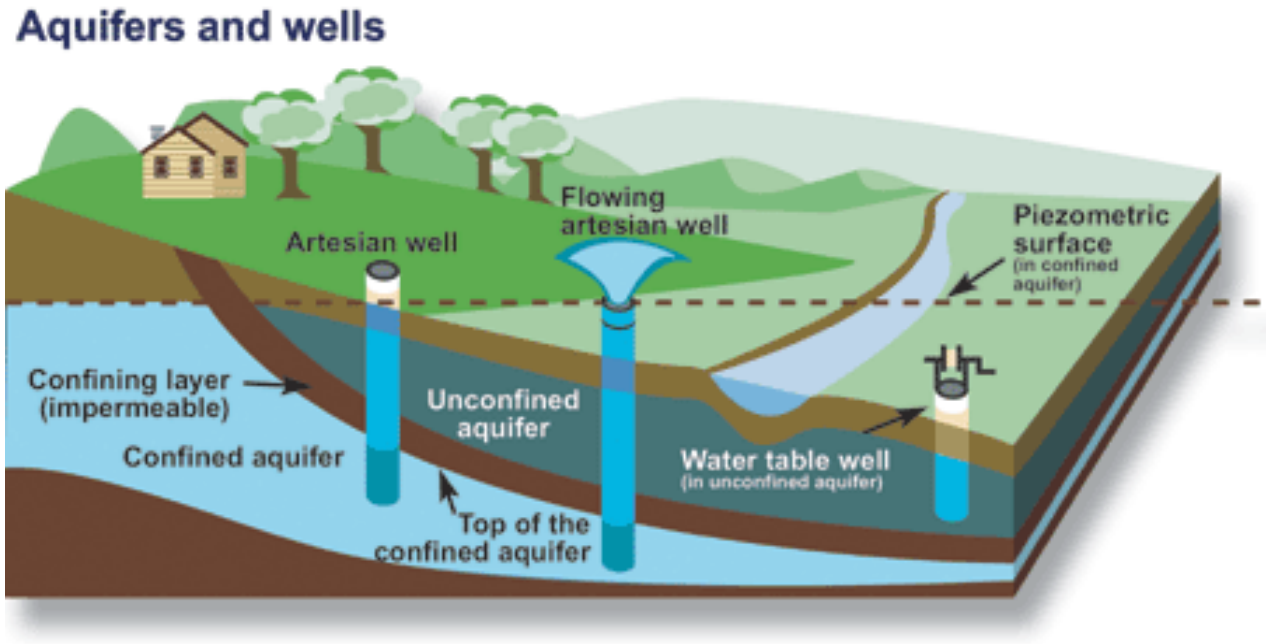


Remember: Although groundwater may move very slowly through the system, it is a very important part of the hydrologic cycle. Eventually it finds its way back to the lakes, rivers, and oceans.

Aquifers

The underground areas of soil or rock where quantities of water are found are called **aquifers**. These aquifers are the sources of wells and springs.

Look at the diagram "Aquifers and wells" and see if you can tell the difference between **confined** and **unconfined** aquifers.



Did You Know?

Water can be hard or soft. Groundwater tends to be harder than surface water because it has been filtered through soil and rock, picking up some minerals from the process. Which do you think would make it easier to work up a good lather in the shower or bath — hard or soft water?

What is a water table?

That's what we call the top or surface of the groundwater supply. Water progresses slowly down through the sand and gravel until it comes to **impermeable** rock where it can't go any further down because the rock is watertight. Above this rock is the groundwater supply or the saturated zone, and the top part of that supply is the water table.

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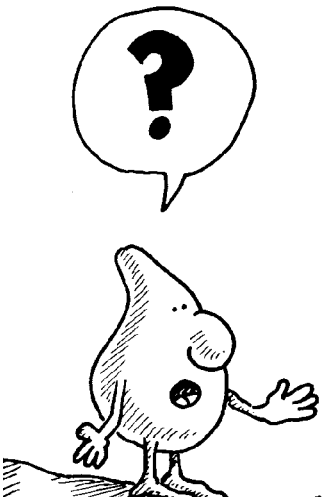


Activity 1 — Math and Research

Check back to the diagram "Percentage of population reliant on groundwater."

- Show these percentages on a graph.
- Research: Find out how many people live in Canada. How people live in each and territory? Based on the percentages of groundwater users provided, calculate how many people from each province rely on bar groundwater supplies.
- If there is an average of four persons per household, how many many households rely on province groundwater?
- Make up five math problems based on your research.

Research: Why do so few people in the Northwest Territories use groundwater? Why is this so different from the Yukon? Why does everyone in Prince Edward Island use groundwater?

Explain the use of groundwater in your own province or territory. Do you have lots of other sources of supply?

Activity 2 — Local Research

Which witch is the water witch?

As mentioned earlier, it might be interesting to find out if people in your area have ever used "witches," or "diviners," to locate good places to dig wells — especially if you live in a rural area, or if your parents and grandparents have come from a rural area.

You may find out other beliefs or superstitions which have some truth in them.

Interview people from the community. Ask them about water witches, or diviners, and find out if they have heard about them. Come back and report to the class what you have learned.

If you can find someone to give you instructions, try your own hand at being a water witch.

Activity 3 — Science

Groundwater occurs in the tiny spaces between soil particles (silt, sand, and gravel) or in cracks in bedrock, much like a sponge holds water. The underground areas of soil or rock where abundant quantities of water are found are called "aquifers," and this is where we find the sources of wells and springs which provide water for 30% of Canadians.

1. Demonstrate how much water can be held between grains of sand:

    - Fill a container with sand and gradually pour in water. You will be surprised at the amount of water a "full" container can hold.

2. Test to find out which soil is the most absorbent: sand, gravel, potting soil, or clay. This will also show you which soil is easier for water to travel through quickly. (Just for review, *absorbent* means that something will hold water.)

What you will need:

- 4 beakers the same size (or you can use funnels with cloth covering the hole)
- 1 beaker to hold 500 mL of water
- four kinds of soil: sand, gravel, clay, potting soil
- water

What to do:

- Fill each of your beakers three quarters full with sand.
- Put 500 mL water in the water-beaker.
- Pour water into the sand until the soil is saturated. Record the exact amount of water the sand absorbed.
- Top up the water beaker to 500 mL three more times and repeat the same step with the clay, the gravel, and the potting soil.
- Show the results on a bar graph.

Which type of soil is the most absorbent?

- Do you think the results will be the same each time you do the experiment?
- Report your findings. Write a sentence for each of the different kinds of soil. Find out what kinds of soil can be found in the area where you live.

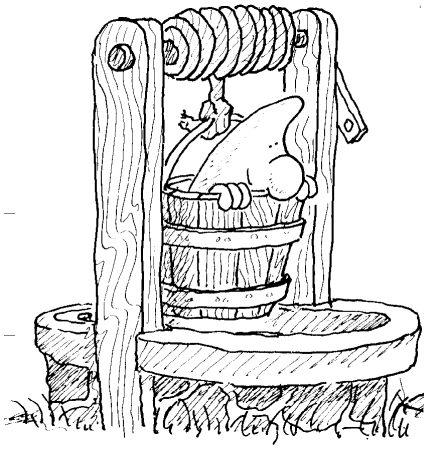
Activity 4 — General

Look at the diagram "Aquifers and wells." Explain the difference between confined and unconfined aquifers. What is an artesian well?

Activity 5 — Historical Review

You have just met a very befuddled water molecule who has recently been discharged from an underground source. The water molecule is having trouble understanding all the changes that have occurred in Canada during the past 300 years.

- Your assignment is to review what the water molecule has missed. Explain the changes and events clearly so that they can be easily understood.



- Brainstorm together. What areas need to be covered in your review? For example:
  - Who lives in Canada? Where people come from?
  - What historical events have happened in 300 years. Make a time line.
  - What has happened in science? Technology?
  - What are recreational uses of water?
  - What about living accommodations? Cities? Transportation? Boats? Water did ways? Roads? Water contraptions like taps, showers, pipes, toilets, dishwashers?
  - Explain new sources of water pollution and the need for water treatment plants
  - Identify other areas that need to be explained.

Activity 6 — Environmental Studies

Contact your local Department of Health to find out the regulations controlling the drilling of water wells in your area. Write a report, create a chart, or make a presentation to the class.

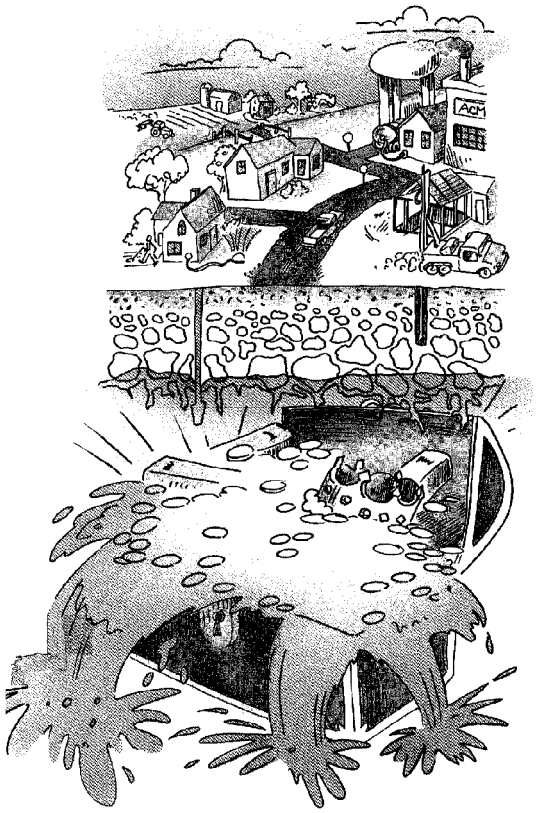
Activity 7 — Research

Do you know what a "sink hole" is? If you lived in parts of the United States like Texas or Florida, you might be familiar with one. Sink holes occur where there is not enough water on the surface to support the people who live there, so they keep pumping up the underground supply. Unfortunately, the underground supply only contains so much water; the groundwater supply is depleted (or mined) and the ground sinks.

Find out more about sink holes. Have there been any around where you live? Explain. What can be done to prevent sink holes?

TOPIC 5. GROUNDWATER — NATURE'S HIDDEN TREASURE

Chapter 5(B): Groundwater — Why We Should Be Concerned



Purpose

To help students grow aware of how we threaten our supply of groundwater and to consider ways we can lessen the stress on this resource.

Subject areas

Science, Environmental Studies, Art

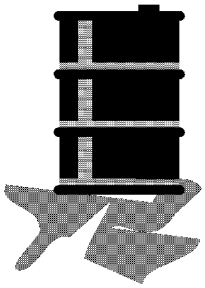
Procedure

1. Review groundwater with the students. Point out that it's easy to believe our groundwater supply is safe from the pollution which affects surface water, but this is not the case. Just because we can't see groundwater, doesn't mean we aren't affecting its quality.

- We need to take precautions to protect groundwater because there are many threats to its purity — some of these threats are from people and some from natural causes.

2. Brainstorm with the students for possible threats to the groundwater supply. Ask how their own households contribute. Depending on where they live, some of the following topics may be discussed:

- leaky sewer lines
- septic systems
- leaky oil tanks or pipelines
- spills/leaks from industrial chemicals



- landfills
- mill tailings in mining areas
- chemicals for preserving wood

Understanding the quality of groundwater and how it becomes polluted is important because:

- it is difficult to identify the sources of groundwater pollution and when we do find pollution, it is difficult to clean up. Why? It is not easily accessible and it travels slowly
- it is easier to prevent pollution than to clean it up
- we need to understand that what we do now will help ensure that our children and grandchildren will not have a problem.

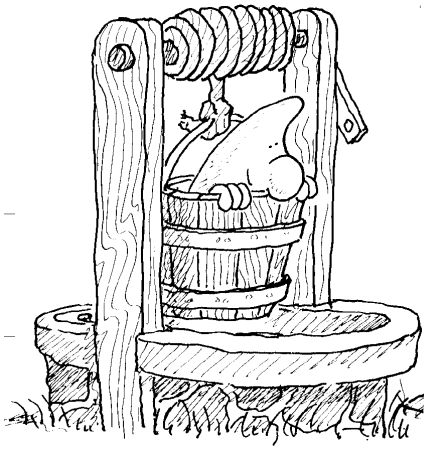
3. Discuss "orphan" wells. There are thousands of these across Canada where the wells have run dry and they have been left open — to become a source of contamination.

Vocabulary

Anthropogenic	***Potable***
corroded	***saltwater intrusion***

References

- Freshwater Series A-5: "Groundwater — Nature's Hidden Treasure"
- *A Primer on Fresh Water*: "Water — Underground"



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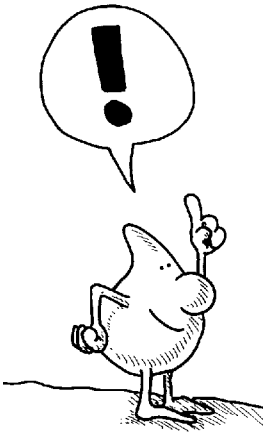


There's so much groundwater, why worry?

Suppose you are researching groundwater pollution and you come across this sentence: "Groundwater becomes contaminated when anthropogenic substances find their way to the groundwater zone." Huh? What in the world does that mean? It helps when you know that "anthropogenic" means "people-created." The question is, what are the people-created substances that contaminate groundwater?

Read the following story about a small town in Ontario, which could just as easily be a community anywhere.

> Residents of Manotick, a town near Ottawa, can tell you about a groundwater supply that has been polluted by toxic chemicals from an anthropogenic source. The polluted water in some of their households is so bad that they have been told not to shower with the water, let alone drink it. What is the source? Some people are speculating that the chemicals are coming from an old dry-cleaning plant.

Did You Know?

Leaks of petroleum products have been increasing over the past two decades because underground steel tanks installed in the 1950s and 1960s have become **corroded**. This causes about half of them to leak by the time they are 15 years old. Often you will see your local garage closed for repairs as old tanks are dug up and replaced with newer fibreglass ones.

How we contaminate groundwater

Other sources of groundwater contamination include leaky septic systems, landfills, industrial wastes, livestock wastes, mill tailings in mining areas, sludge disposal, graveyards, runoff of salt and other chemicals on roadways, coal tar, pesticides/fertilizers, and atmospheric fallout found in rain and snow.

Groundwater pollution from natural causes

Don't think that people are the only causes of groundwater contamination. Nature adds contaminants too. Some of these are too much iron, manganese, and arsenic; uraninium in bedrock; and **saltwater intrusion**, which occurs when seawater seeps into groundwater near coastal areas.

The good news and the not-so-good news

The good news is that groundwater is generally safer than surface water for drinking because soil and rocks provide natural processes that filter and purify the water. The bad news is that these processes don't work when anthropogenic substances reach the water supply. Other bad news is that since groundwater moves so slowly, once it becomes contaminated, the pollutants take a very long time to leave the system.

The news media often come up with stories about underground pollution which may have started years ago — it's very hard to trace the cause of some pollution (ask the people from Manotick, Ontario). And even if the polluter is identified, the business may have closed long ago, so we can't get the guilty party to pay. Guess who ends up paying?

Cause for concern

So, the message is — we should be concerned about our groundwater supply. Consider the following:

- The health of a million or more Canadians may be affected by drinking contaminated well water.
- It is often impossible to restore polluted groundwater to **potable** quality because it is difficult to reach and it moves so slowly through the soil.
- Since 1979, over 500 wells in New Brunswick have been contaminated by leaking petroleum tanks.
- Organic herbicides sprayed along transmission corridors for power lines have contaminated bedrock wells in Quebec.

Groundwater and deep wells can be contaminated by waste disposal sites as the following diagram shows.

And don't forget "orphan wells"

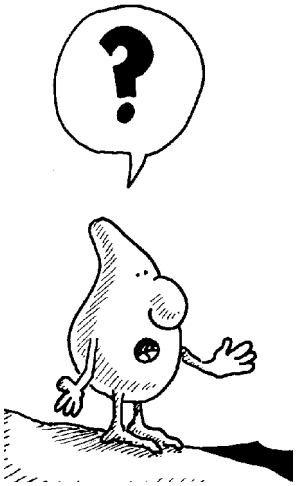
In some parts of the country, people overuse the groundwater supply (or there may be a drought) and this causes the water table to drop. Wells run dry because they cannot reach the water. Some of these wells which run dry permanently are abandoned and are known as "orphan wells." Sometimes, instead of being boarded over, these wells are left open and, unfortunately, some people use them to dump wastes in so they become contaminated. Many of the contaminants find their way back into the groundwater supply.

Are we doing anything about cleaning up the groundwater we have polluted?

All levels of government in Canada are starting to take some actions to protect our water supply, but there is still a long way to go. Although groundwater is hidden, it is just as important as the sparkling lakes and rivers in our postcard image of Canada. Instead of concentrating on cleaning up, we must prevent contamination in the first place. For example:

- leaking underground storage tanks should be replaced by tanks that will not corrode
- landfills should be located where they will not contaminate underlying groundwater

- hazardous materials should not be stored where they can spill into recharge areas
- orphan wells should be boarded up so they do not become handy disposal sites
- what do you think?



TOPIC 5. GROUNDWATER — NATURE'S HIDDEN TREASURE

Chapter 5(B): Groundwater — Why We Should Be Concerned

Activity 1 — Environmental Studies

Your information sheets talk about ways we can prevent pollution of our groundwater. The suggestions are aimed mostly at industries. What can we do in our households? (Some municipalities have already begun helping householders take care of waste materials.)

- Draw up a list of things we can do, such as taking hazardous household substances to the waste disposal area.
- Prepare a report or a speech.

Activity 2 — Science

Take another look at natural causes of groundwater pollution:

- arsenic
- iron
- manganese
- uranium
- saltwater intrusion

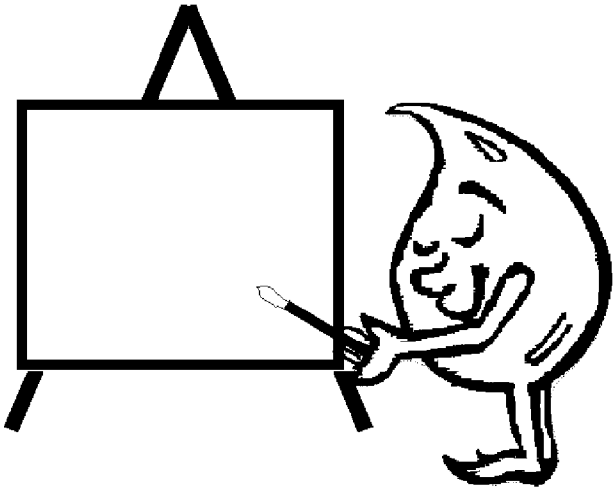
Take one natural cause and research to find out about it. For example, what is arsenic? What effects does arsenic have on people? Or, how can saltwater intrude on groundwater? What's the problem, it's all water, isn't it?

Activity 3 — Art

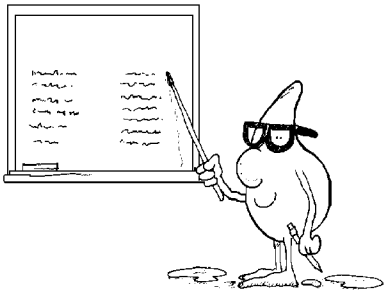
Create your own comic strip character to give tips for protecting our groundwater supply. Use your character in a poster.

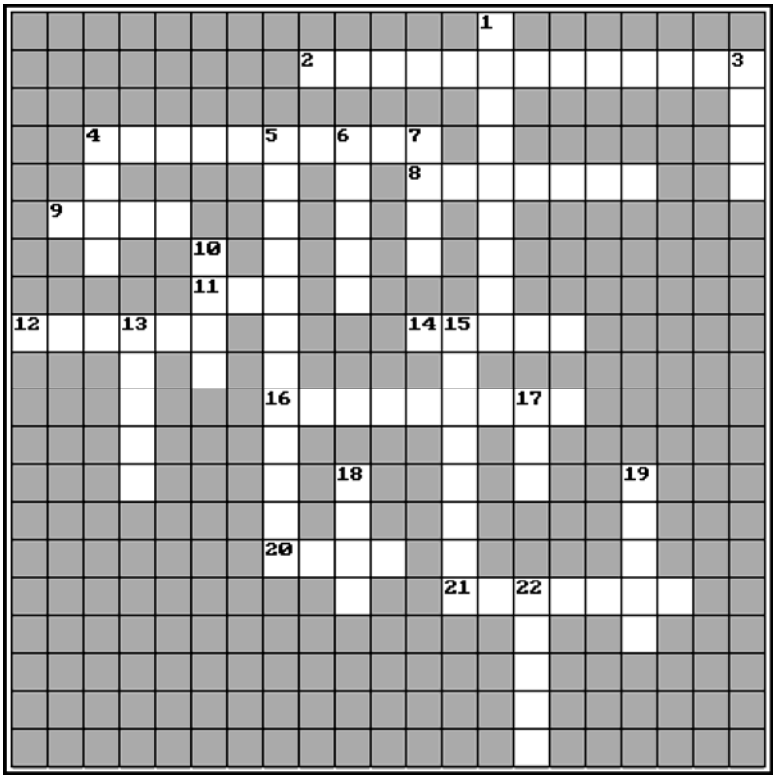
Activity 4 — Environmental Studies, Art

- Look back at the different ways that groundwater becomes polluted and how this affects people.
- Get poster board and markers from your teacher and design posters to inform people about the dangers of pollution to groundwater.
- On your poster show ways that this pollution can be avoided.



TEST 3
Crossword Puzzle





Across

2. Pollution caused by people is called _____ pollution.
4. When water is taken from a stream, lake, etc., and used on land, it is called _____ use.
8. Where water collects underground.
9. The rate at which water moves.
11. Everyone must _____ water wisely.
12. Filtration occurs in a _____ tank.
14. When you use water to get rid of soap, you _____.
16. Saltwater _____ is one source of natural pollution.
20. Pollution can get into groundwater from a _____ in an underground tank.
21. If you pay for the amount of water you use, you are paying a _____ rate.

Down

1. Another word for contamination.
3. The amount we pay for water should cover the of supply.
4. What you dig to find water.
5. When water is used for swimming and sailing, we this use _____.
6. Leftover matter that we consider useless and try dispose of.
7. Sludge is sometimes taken to a _____ fill site for
10. Free from pollution.
13. We _____ water and wastewater to get rid of
15. When water is used in its natural setting, it is this kind of use.
17. The mining industry uses water to separate rocks _____.
18. Charging a _____ rate for water used does not water conservation.
19. Most of our electricity comes from hydroelectric _____.
22. Another word for poisonous.

Fill in the blanks

1. A "water witch" is said to locate water underground with the use of a _____.

2. Groundwater is found in wells and springs which have their sources in _____.

3. The water rate structures which encourage people to conserve water are the _____rate and the _____ rate.

4. Water seeps into the ground through the process of _____.

5. The two basic ways we use water are in its natural setting or _____; and taking it from the stream and using it on land — _____use.

True or False

T F 1. Approximately 75% of Canadians rely on groundwater for their water supply.

T F 2. Groundwater spends about one year underground.

T F 3. If pollution is "anthropogenic," this means it was caused by people.

T F 4. During the summer months about half of all treated water is sprayed onto lawns.

T F 5. Most Canadians who pay for their water, pay a flat rate.

T F 6. Both instream water users and withdrawal users can contaminate the water supply.

T F 7. On average, Canadians pay $500 per 1000 litres of tap water.

T F 8. People who live on the prairies pay the highest costs in Canada for their water.

T F 9. Two-thirds of all the fresh water in the world is found underground.

T F 10. Impermeable rock is rock which lets water filter through.

Question Time

List five causes of groundwater pollution:

1. _____
2. _____
3. _____
4. _____
5. _____

What are two examples of withdrawal use?

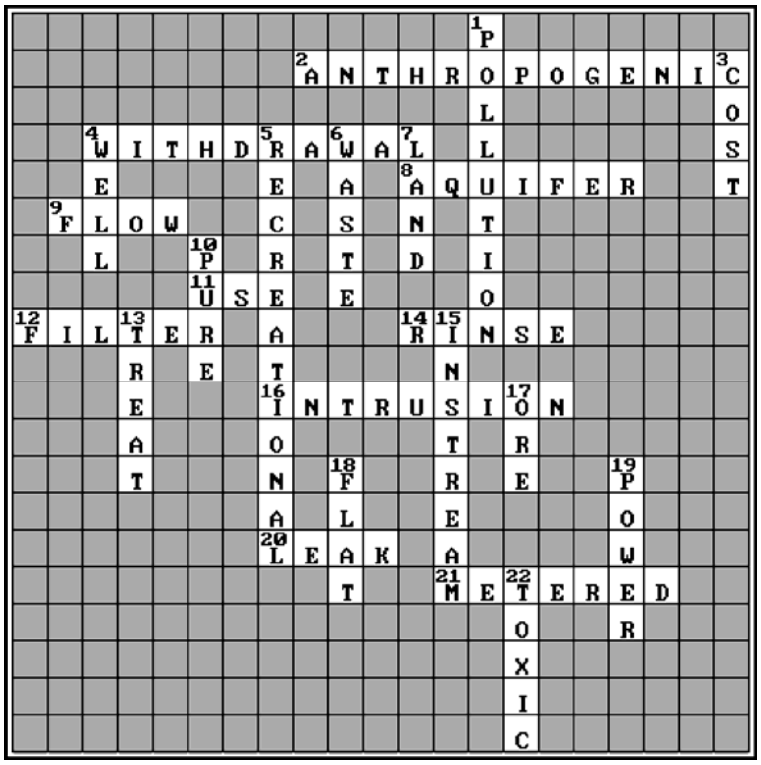
1. _____
2. _____

What are two examples of instream use?

1. _____
2. _____

Describe one simple way to prevent groundwater pollution.

TEST 3
Crossword Puzzle



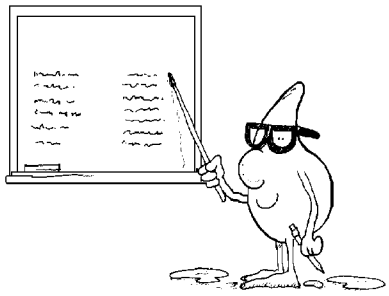


Figure 1

Fill in the blanks

1. A "water witch" is said to locate water underground with the use of a **divining rod**.
2. Groundwater is found in wells and springs which have their sources in **aquifers**.
3. The water rate structures which encourage people to conserve water are the **constant** or the **metered** rate and the **increasing block** rate.
4. Water seeps into the ground through the process of **percolation**.
5. The two basic ways we use water are in its natural setting or **instream**; and taking it from the stream and using it on land — **withdrawal** use.

True or False

1. **False**. Approximately 26% of Canadians rely on groundwater for their water supply.
2. **False**. Groundwater can spend days, months or hundreds of years in the ground.
3. **True**. If pollution is "anthropogenic," this means it was caused by people.
4. **True**. During the summer months about half of all treated water is sprayed onto lawns.
5. **True**. Most Canadians who pay for their water, pay a flat rate.
6. **True**. Both instream water users and withdrawal users can contaminate the water supply.
7. **False**. On average, Canadians pay $1.14 per 1000 litres of tap water.
8. **True**. People who live on the Prairies pay the highest costs in Canada for their water.
9. **True**. Two-thirds of all the fresh water in the world is found underground.
10. **False**. Impermeable rock is rock which keeps water from filtering through.

Question Time

Possible responses:

List five causes of groundwater pollution:

- leaky sewer lines
- septic systems
- leaky oil tanks or pipelines
- spills/leaks from industrial chemicals
- landfills
- mill tailings in mining areas
- chemicals for preserving wood
- pesticides/herbicide use

What are two examples of withdrawal use?

- thermal power generation
- agriculture
- manufacturing
- mining

What are two examples of instream use?

- hydroelectric power generation
- transportation
- freshwater fisheries
- wildlife
- recreation
- waste disposal

Describe one simple way to prevent groundwater pollution.

You be the judge!