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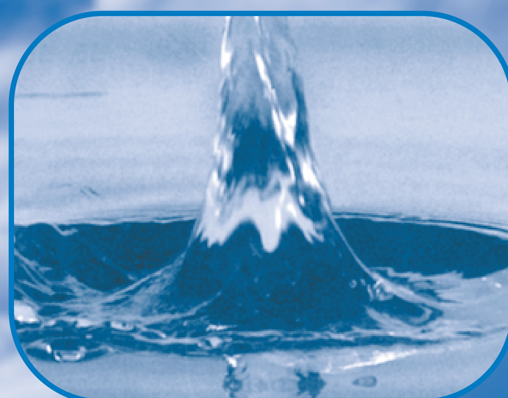
A Primer on FreshWater



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Questions & Answers

Canada

A Primer on Fresh Water

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Preface

Water is the lifeblood of the environment. Some very simple organisms can survive without air, but none can grow without water. Although Canada has more water than most nations, changes in water availability in terms of quantity and quality greatly affect Canadian life. The impacts of droughts have been most severe in the Prairies, while those of flooding have been experienced more profoundly in British Columbia, Quebec, and the Atlantic provinces. In recent years, Great Lakes levels have fluctuated to such a degree that daily surveillance has been necessary. Apart from natural phenomena, drinking water has become a major Canadian concern. For domestic use, 30% of all Canadians rely on groundwater, which, if contaminated, poses difficult cleanup problems. In the North, the emergence of toxics is a major issue. And all of Canada could be affected by climate change and its effects on water.

A Primer on Fresh Water was put together to answer a wide range of questions. They are grouped to focus on different aspects of water: its physical characteristics; its availability both above and below ground; the uses we make of it; and how we share and manage it. The Primer also contains some practical advice on what we, as individuals, can do to help conserve this precious resource for our use and for that of future generations.

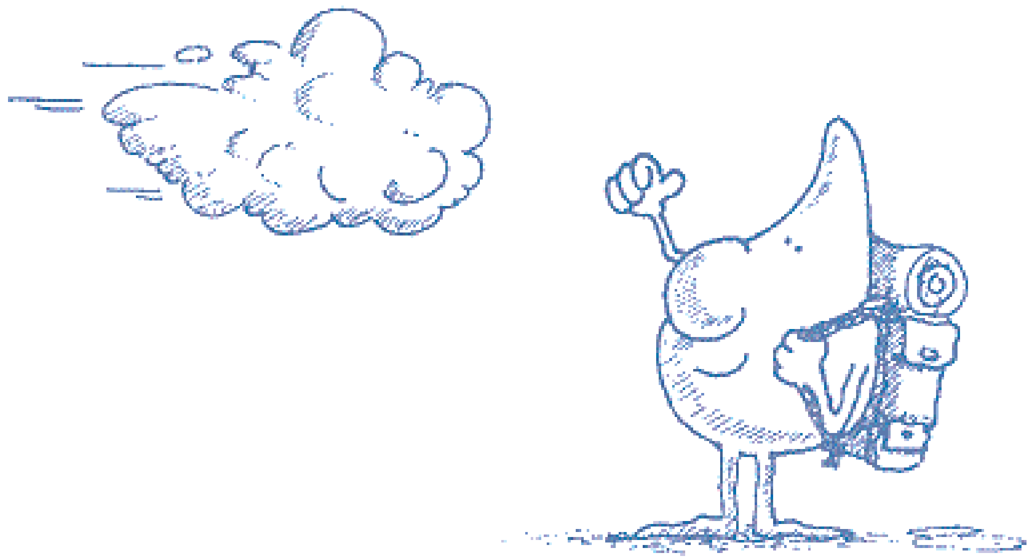
Introduction

In 1986, the World Commission on Environment and Development called on the nations of the world to practice sustainable development: to meet the needs of present generations without compromising the ability of future generations to meet their own needs. In 1992, the United Nations Conference on Environment and Development turned the idea of sustainable development into a global action plan. The concept of sustainable development is similar to the traditional philosophy of many Aboriginal peoples of Canada, who consider the impact on the seventh generation of any decision.

Canadian citizens enjoy both rights and responsibilities. One of these responsibilities is to care for Canada's environment. An “environmental citizen” is someone who has accepted this responsibility and is committed to acting on it.

Learning is the key to environmental action. In addition to awareness and concern, effective environmental action requires knowledge. This publication will help Canadians learn more about an important environmental issue — fresh water. It is intended for use by individuals, educators, communities, and organizations who want to improve their understanding of the environment.

The contents of the Primer will be subject to constant revision and improvement, not only by government specialists, but also by many other stakeholders, including educators, provincial and local agencies, business groups, and environmental organizations. Your feedback is welcomed.



WATER — Forever on the move

1. What is water?

Water means different things to different people. It has unique physical and chemical properties; you can freeze it, melt it, evaporate it, heat it, and combine it.

Normally, water is a liquid substance made of molecules containing one atom of oxygen and two atoms of hydrogen (H_2O). Pure water has no colour, no taste, no smell; it turns to a solid at 0°C and a vapour at 100°C at standard mean sea level pressure. Its density is 1 gram per cubic centimetre (1 g/cm^3), and it is an extremely good solvent.

All life depends on water. It makes up over one half of the human body. A person can live without food for more than a month, but can live for only a few days without water. All living things, from the tiniest insect to the tallest tree, need water to survive.

2. Where did all the water in the oceans, lakes, rivers, and under the ground come from?

There are a number of theories that try to answer this question. Some scientists believe that water was here from the start; some think it came later, from comets. Many scientists believe that 4.5 billion years ago, when the earth was being formed, its primitive atmosphere contained many poisonous substances. Among the chemicals present at the time were the basic constituents needed to form water.

Over time, the earth cooled and a mass of molten lava became the soils and bedrock we know today. This process began when water was formed in the atmosphere and fell to the ground as rain. The rain continued for many, many years. While the earth cooled from the falling rain, forces from within created vast land masses and oceans. Many scientists believe that life itself began in these oceans and, over the years, evolved and adapted to dry land.

3. What is the hydrologic cycle?

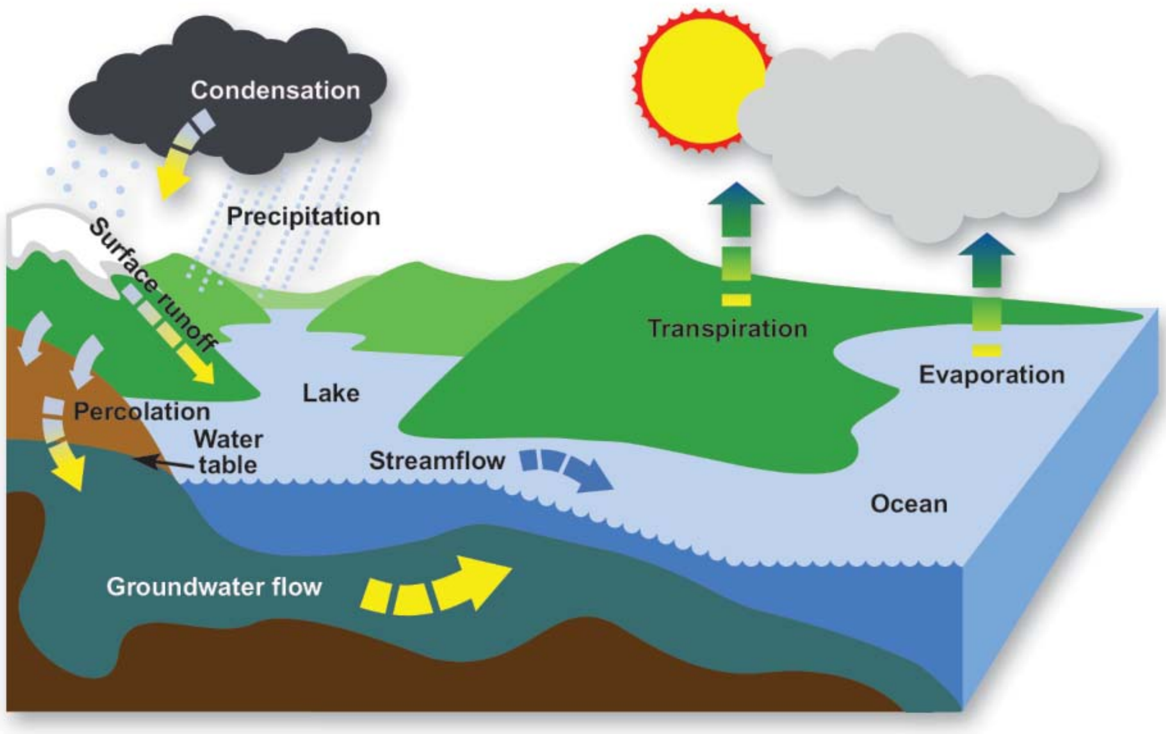
From the beginning of time when water first appeared, it has been constant in quantity and continuously in motion. Little has been added or lost over the years. The same water molecules have been transferred time and time again from the

Once evaporated, a water molecule spends about 10 days in the air.

oceans and the land surface into the atmosphere by evaporation, dropped on the land as precipitation, and transferred back to the sea by rivers and groundwater. This endless circulation is known as the "hydrologic cycle". At any instant, about 5 litres out of every 100 000 litres is in motion.

Over time, major cyclic changes in climatic processes have produced deserts and ice cover across entire continents. Today, regional short-term fluctuations in the order of days, months, or a few years in the hydrologic cycle result in droughts and floods.

The hydrologic cycle



4. Is water related to climate?

Water and climate are intimately related. It is obvious, from a water resource perspective, how the climate of a region to a large extent determines the water supply in that region based on the precipitation available and on the evaporation loss. Perhaps less obvious is the role of water in climate. Large water bodies, such as the oceans and the Great Lakes, have a moderating effect on the local climate because they act as a large source and sink for heat. Regions near these water bodies generally have milder winters and cooler summers than would be the case if the nearby water body did not exist.

Water has a basic role in the climate system through the hydrologic cycle. The evaporation of water into the atmosphere requires an enormous amount of energy, which ultimately comes from the sun. The sun's heat is trapped in the earth's atmosphere by greenhouse gases, the most plentiful of which by far is water vapour. When water vapour in the atmosphere condenses to precipitation,

Water is the only substance found on earth naturally in three forms – solid, liquid and gas.

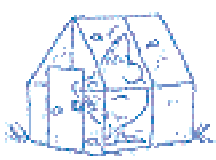
this energy is released into the atmosphere. Fresh water can mediate climate change to some degree because it is stored on the landscape as lakes, snow covers, glaciers, wetlands, and rivers, and is a store of latent energy. Thus water acts as an energy transfer and storage medium for the climate system.

The water cycle is also a key process upon which other cycles operate. For example one needs to properly understand the water cycle in order to address many of the chemical cycles in the atmosphere.

5. Most scientists are predicting extensive climate change. How would this affect water resources?

We have all experienced the natural variability in climate from time to time in the form of cool summers, warm winters, and droughts. It is now believed that changes to the atmospheric composition may result in unprecedented changes in the global climate within the next 100 years. The increasing concentrations of "greenhouse" gases, such as carbon dioxide (from the burning of coal, oil, and gas for industry and energy production, and from large-scale deforestation) and methane (from rice paddies, wetlands, and livestock), trap heat near the earth's surface. As a result, the global mean temperature is expected to increase, with resulting changes in climate being more pronounced in the northern latitudes, which include much of Canada.

Because of the intimate relationship between climate and the hydrologic cycle, changes in the climatic regimes would directly affect the average annual water flow, its annual variability, and its seasonal distribution. For example, greater climatic variability would mean changing the frequency of extreme weather events and increasing the incidences of dry and wet year sequences. Water supplies would become more uncertain as a result of this combined with increased summer evapotranspiration, reduced snowpacks, and unknown water use responses to climate change. Current design criteria for hydrologically related infrastructures such as dams, culverts, urban sewage capacities, wharves, channels, docks, and dykes, as well as for zoning, flow allocation, dam management, and flood damage reduction efforts, may prove to be inadequate under future climatic conditions.



The effects of climate change on the quality of water would modify the stress on aquatic life and cause new cleanup problems. For example, unusually low water levels — which can impair navigation, stimulate the growth of noxious nearshore weeds, and increase the probability of summer fish kills due to anoxia (lack of oxygen) — would require increased dredging activities, thus harming bottom-dwelling organisms and contaminating surrounding waters. Further, low flows will decrease the dilution of effluents resulting in increased contamination levels in receiving waters.

6. How would climate change affect water resources in the North?

Most scenarios of climate change based on a doubling of atmospheric carbon dioxide predict significant warming in the Far North. For example, the Canadian Climate Centre model estimates an increase of from 4°C to 10°C in winter and from 2°C to 4°C in summer, with the smaller increases in the Yukon. Higher temperatures would, by the year 2100, probably lead to longer periods of open water, extending inland and marine navigation seasons. However, later summer/fall river levels would likely decline as runoff is expected to remain relatively constant, although spread over a larger period. Higher temperatures would also cause some areas of permafrost (permanently frozen ground) to melt, resulting in erosion or "slumping" and the degradation of critical wetland and fish spawning habitats due to the increased transport and deposition of suspended

Water helps to regulate the earth's temperature.

sediment in rivers. The melting of permafrost would also affect the stability of docks, highways, tailings ponds, pipelines, and buildings. It would also drastically alter surface-water and groundwater hydrology as well as related wildlife habitats.

Changes in precipitation due to climate change, have not been so well defined by models, but experience from recent mild winters in some parts of the North suggests that snowfall may increase, while summer precipitation may not change. While greater winter precipitation may increase spring breakup flows, higher summer evaporation is likely to decrease mean annual flows for many northern rivers and to cause drier summers, making forests more vulnerable to fire.

It is anticipated that climate induced stresses on forests and taiga will all but eliminate the southern arctic ecozone from the mainland. This area is presently the major summer range and calving grounds for Canada's largest caribou herds as well as habitat for bear, wolf, moose, arctic ground squirrels, and lemmings. It is a major breeding and nesting ground for a variety of migratory birds including yellow-billed, arctic, and red-throated loons, tundra swans, snow geese, oldsquaws, gyrfalcons, ptarmigans, and snowy owls. It is home to Canada's Inuit and includes the Queen Maud Gulf lowlands, an internationally recognized waterfowl area. Reduced duration and extent of nearshore sea ice threatens the survival of Canada's polar bears, particularly in Hudson Bay, where bears are having difficulty surviving longer periods of summer open water without access to their prime source of food (seals on sea ice). Studies of possible impacts of increasing ocean temperatures for a scenario of doubling the atmospheric carbon dioxide indicate that all salmon species may be eliminated from the north Pacific due to their inability to withstand warmer sea temperatures.

Water also occurs as forms of precipitation such as freezing rain and wet snow. These generally occur within specific storms but they can have long-lasting impacts. This includes the devastation of trees and structures. It can also include, for example, the covering of the surface by ice so that wintering animals, like deer or caribou, are unable to reach their food supply. Whether these forms of precipitation may or may not change in occurrence, severity, or location are also quite important from a climate point of view.

Both the continued relevance of traditional knowledge and the persistence of Aboriginal cultures are also at risk. Aboriginal peoples' culture is much more sensitive to environmental degradation because many live, at least in part, in closer connection to the land than non-Aboriginal people. Where environmental damage or change restricts access to traditional foods, traditional hunting, fishing, or gathering areas, or to traditional spiritual places, the impact can be loss of Aboriginal culture.

The potential impacts of climate change scenarios on the Mackenzie River basin were assessed and reported in the Mackenzie Basin Impact Study. The Mackenzie basin is one of five basins worldwide that is being assessed under the Global Energy and Water Cycle Experiment (GEWEX). Information on the Mackenzie Basin GEWEX Study (MAGS) can be found at: www.usask.ca/geography/MAGS.

7. Why is snow important in water resources?

Snow is precipitation in the form of ice crystals. When it falls to the ground and accumulates, it may be considered as water in storage. In Canada, about 36% of the total annual precipitation is in the form of snow. When the winter snowpack melts in the spring, it becomes a significant portion of the water available for streamflow. Because snow accumulates during periods when the evaporation loss

About 70% of the earth is covered in water.

is low, the relative contribution of its meltwaters to streamflow in some regions may be greater than the flow contributed by rainfall. Snow supplies at least one third of the water used for irrigation in the world and is an important contributor to hydropower reservoirs. The fact that snow acts as water storage over the winter and provides soil moisture recharge in the spring is of particular importance to agricultural productivity in some regions.

8. How do climate, snow, and ice affect the water resources in the North?

The cold northern climate slows down many processes in the hydrologic cycle. For example, in the Northwest Territories and Nunavut, where water bodies remain ice-covered for six to ten months of the year, there is little evaporation or precipitation occurring in winter due to the low moisture capacity of air at low temperatures. Runoff from winter snowfall is concentrated in the brief period of spring snowmelt, breakup, and flooding. Most of the highest streamflows in the Northwest Territories and Nunavut occur during spring runoff, except in the Mackenzie Mountains part of western Northwest Territories, where significant summer rainfall floods occur. Melting snow can also contribute to runoff for substantial parts of the summer — for example it takes about two months for snowmelt to make its way through the Mackenzie River system.

The Yukon has an appreciably different climate. There the ice cover lasts from five to eight months, most of the precipitation is in winter, and evaporation is high. The runoff in the Yukon comes from both snowmelt and glacial melt. Glacial melt causes the characteristic August high water levels in the western Yukon rivers that drain off high mountains. This high water period is critical to the local ecosystems.

9. What is a drought?

A drought is a sustained and regionally extensive occurrence of appreciably below-average natural water availability in the form of precipitation, streamflow, or groundwater. Droughts are natural events of varying duration that have occurred throughout history and they are part of the cyclical fluctuations of our planet's climate system.

10. Where do droughts occur?

Droughts can occur anywhere. However, regions with a semi-arid or arid climate, and only marginal annual precipitation to meet their water demands, are more vulnerable to droughts. In Canada, southern Saskatchewan and the interior valleys of British Columbia experience frequent droughts.

11. What causes floods?

Flooding is almost always a natural occurrence; an exception would be flooding due to the collapse of a dam. There are many conditions and variables that determine whether a lake or river overtops its banks or an ocean rises along its shores. The most common causes of flooding in Canada are water backing up behind ice jams and the rapid melting of heavy winter snow cover, particularly when accompanied by rainfall. Heavy rainfall by itself can also cause floods. On large lakes, severe storms can result in strong surges when sustained high winds from one direction push the water level up at one end of the lake. Flooding is worse if high tides occur at the same time.

Certain conditions affect only specific regions in Canada. For example, under-sea disturbances such as volcanic eruptions or earthquakes may result in catastrophic waves called "tsunamis" in the ocean coastal regions. In the glaciated areas of Canada, lakes dammed by glaciers (extensive bodies of land ice) may drain suddenly, resulting in glacier-outburst floods. These floods are

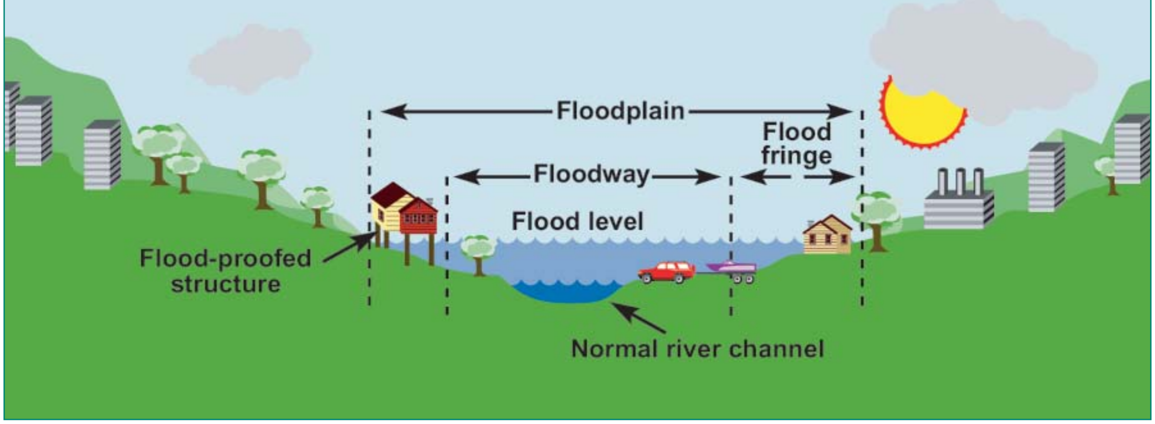
Almost two billion people were affected by natural disasters in the last decade of the 20th century, 86% of them by floods and droughts.

called "jökulhlaups" and can be devastating to the local ecosystem as they can cause flood levels of up to 100 times greater than those of normal rain or snowmelt floods.

12. Is it true that you should not build close to a river because you might get flooded?

Generally, *yes*. It depends, however, on the characteristics of the river and the floodplain. In Canada, the floodplain is usually divided into two zones: the floodway and the flood fringe. Damage and risk to life are greatest in the floodway, where the water depths and velocities are the greatest. It is within these areas that you should not build, since you could expect to suffer considerable damage, not just once in a lifetime but time and time again. Within the flood fringe you may be able to build, providing that you undertake some protection measures such as adequate flood-proofing.

The floodplain



13. How do you find out whether or not you are on a floodplain?

If you are considering buying property, be sure to consult with your municipal or regional office, provincial authorities, or Environment Canada offices in your region to determine whether flood risk maps have been produced for your area.

If maps are unavailable, talk to neighbours or local historians or check at local libraries or archives for records of past flooding.

Among the worst floods in Canada's recent history was Manitoba's Red River flood of May 1997.

WATER — Underground

14. What is groundwater?

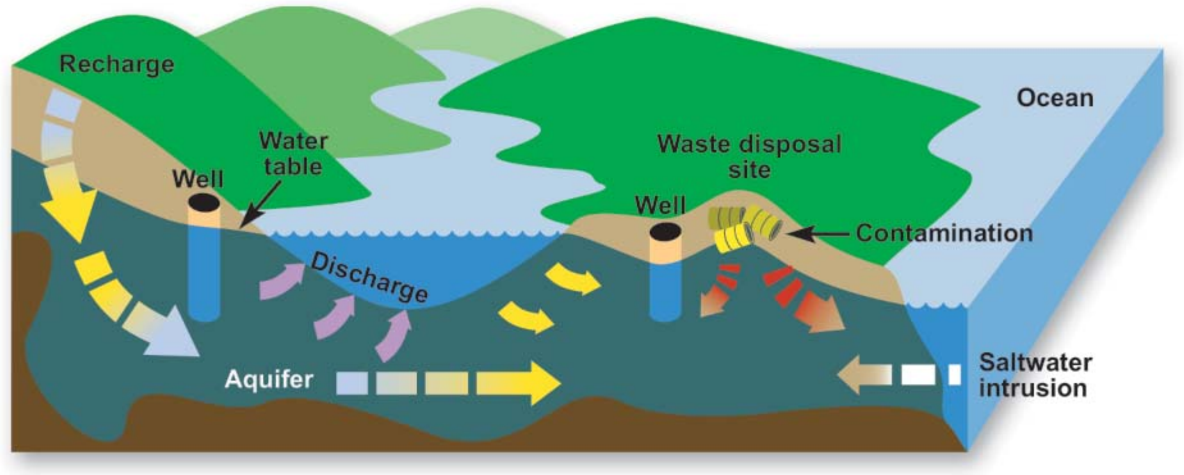
A third of the world's fresh water is found underground. Even in Canada, there is more water underground than on the surface. This water is found in aquifers and appears at the surface as springs. Very often groundwater is interconnected with the lakes and rivers.

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 substantial quantities of water are found are called "aquifers". These aquifers are the source of wells and springs. It is the top of the water in these aquifers that forms the "water table".

The origin and composition of aquifers is varied. Many important Canadian aquifers are composed of thick deposits of sands and gravel previously laid down by glacial rivers. These types of aquifers provide most of the water supply for the Kitchener–Waterloo region in Ontario and the Fredericton area in New Brunswick. The Carberry aquifer in Manitoba is an old delta lying on what was formerly Glacial Lake Agassiz. It is well developed as a source of irrigation water. Prince Edward Island depends on sandstone aquifers for its entire water supply. A major glacial outwash sand and gravel aquifer occurs in the Fraser Valley in British Columbia. It is extensively used for municipal, domestic, and industrial water supplies. The Winnipeg and Montreal aquifers that are used for industrial water supply, are composed of fractured rocks.

Of the total world's freshwater supply, 30.8% is groundwater, including soil moisture, swamp water and permafrost.

Groundwater system



To concentrate only on major (i.e., large) aquifers, however, is misleading. Many individual farms and rural homes depend on relatively small aquifers such as thin sand and gravel deposits of glacial or other origin. Although these aquifers are individually not very significant, in total they make up a very important groundwater resource.

15. Can an aquifer dry up completely?

Groundwater resources are depleted or "mined" when pumping from an aquifer is not matched by recharge. This can happen in two ways: by overpumping or by decreasing recharge, for example, caused by drought. The drying up of an aquifer should not be confused with the failure of individual wells in that aquifer, which happens much more frequently. Well failures can have many causes:

- A well may be too shallow, so that a temporary decline in water levels lowers the water table below the bottom of the well.
- Mineral and/or bacterial deposits can plug the screen at the opening of the pipe at the bottom of the well (very common).

Aquifer depletion is a more serious problem in the United States than in Canada. However, increased demand could potentially lead to serious problems in this country. The depletion of deeper aquifers may be permanent where the weight of overlying sediments causes the aquifer to compress as the water is pumped out. The aquifer would therefore never again be fully recharged even if pumping ceased, because its capacity to store water has been reduced.

In Canada, there is more water underground than on the surface.

16. Are there any areas in Canada where aquifers are depleted?

In Canada, there have been no major problems with aquifer depletion because most major population centres use surface water. Where groundwater is used (for example, Prince Edward Island and Kitchener–Waterloo, Ontario), the safe yields of the aquifer have been determined and are managed accordingly. Some places, where groundwater was used for municipal supply in the early 1900s, have had to switch to surface water or augment their groundwater supplies with surface water because the increasing demand for water exceeded the safe yield of their aquifers (for example, Lloydminster, on the Alberta/Saskatchewan border, and Regina, Saskatchewan).

17. What is groundwater recharge?

Groundwater recharge refers to the replenishment of water in an aquifer. Much of the *natural* recharge of groundwater occurs in the spring and comes from the melting snowpack or from streams in mountainous regions. It can also occur during local heavy rainstorms. Often groundwater discharges into a river or lake, maintaining its flow in dry seasons.

18. What causes springs? Do they come from groundwater?

Springs are created when groundwater naturally flows to the surface. Groundwater discharged from a spring may have traveled underground many kilometres before reaching the surface. Usually, spring water discharges occur or increase when rain or snowmelt has recharged the groundwater system.

19. Is groundwater important to Canada's water supply?

Groundwater is extremely important in supplying fresh water to meet the needs of Canadians. The interdependency of surface water, groundwater, and atmospheric water is of great importance in the hydrologic cycle. The role of groundwater is critical. Perhaps the most significant function of groundwater is its gradual discharge to rivers to maintain streamflow during dry weather periods throughout the year.

Over four million Canadians residing in urban areas rely on groundwater for their domestic water supply. Another four million rural Canadians also use groundwater. Prince Edward Island (with no major rivers) depends almost entirely on groundwater, while the Northwest Territories uses mostly surface water. On the other hand, in the Yukon, groundwater use is seasonal. For example, the city of Whitehorse uses groundwater for 50% of its water supply during the winter months and for very little during the remainder of the year.

In addition, bottled groundwater, known as "spring water" or "mineral water", is being bought by many Canadians to replace drinking water that flows through their taps, particularly in the areas bordered by Lake Ontario and the St. Lawrence River.

As well as supplying human needs, groundwater is used for livestock watering, irrigation, aquaculture, and mineral and hydrocarbon extraction.

20. What is the relationship between groundwater and permafrost?

Most of the terrain in the Northwest Territories and Nunavut consists either of rugged glaciated Canadian Shield rock or of ground which is underlain by permafrost (permanently frozen ground). Both of these inhibit the flow of groundwater. The major exceptions include the Mackenzie Mountains in western Northwest Territories and the Yukon and the limestone terrain southwest of Great Slave Lake, where soils, fractured rock, and glacial debris provide material that can store and release groundwater.

On a local scale, the seasonal development of a thawed "active layer" above the permafrost can provide permeable pathways for the subsurface movement of water and contaminants.

Although everybody on Prince Edward Island uses groundwater to meet their daily water needs, over half of Islanders (57%, the highest proportion in Canada) depend on private wells for their water supply.

21. How does groundwater become contaminated?

Groundwater becomes contaminated when anthropogenic, or people-created, substances are dissolved or mixed in waters recharging the aquifer. Examples of this are road salt, petroleum products leaking from underground storage tanks, nitrates from the overuse of chemical fertilizers or manure on farmland, excessive applications of chemical pesticides, leaching of fluids from landfills and dumpsites, and accidental spills.

Contamination also results from an overabundance of naturally occurring iron, sulphides, manganese, and substances such as arsenic. Excess iron and manganese are the most common natural contaminants. Another form of contamination results from the radioactive decay of uranium in bedrock, which creates the radioactive gas radon. Methane and other gases sometimes cause problems. Seawater can also seep into groundwater and is a common problem in coastal areas. It is referred to as “saltwater intrusion”.

22. Compared with surface water, is groundwater safe for human consumption?

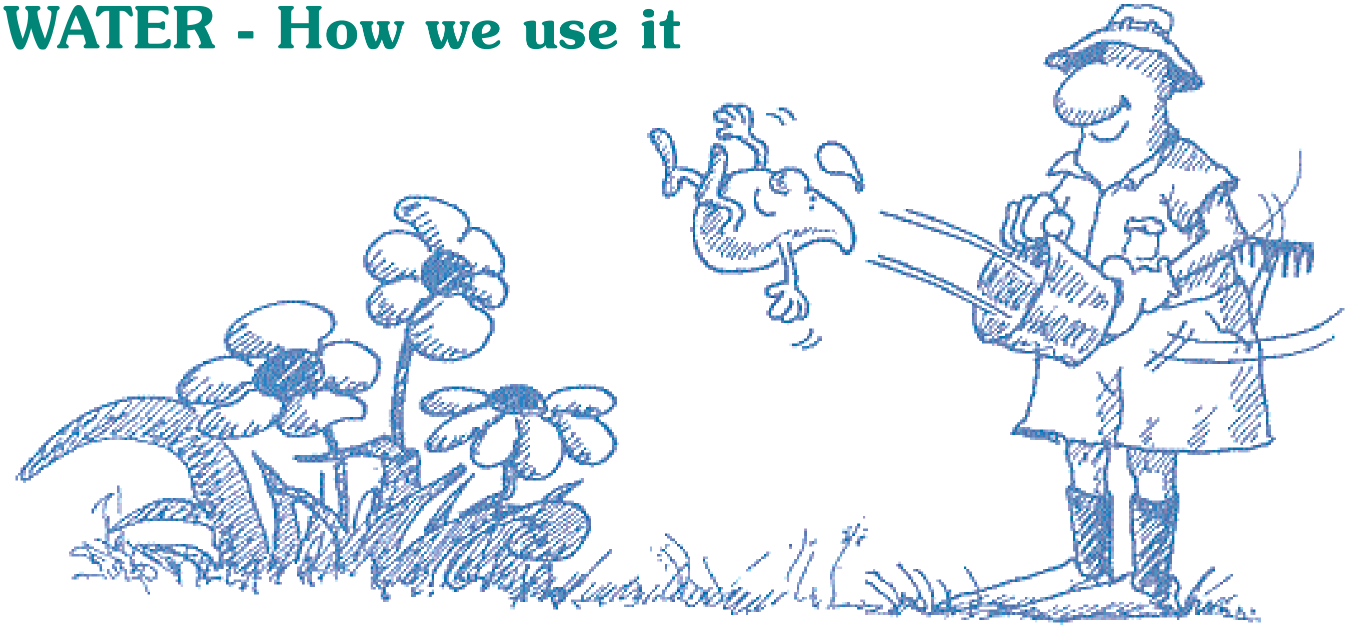
Groundwater is generally safer than surface water for drinking because of the filtration and natural purification processes that take place in the ground. These processes become ineffective, however, when sewage, fertilizers, toxic chemicals, and road salt, seep into the ground.

Household, commercial, and industrial wastes that end up in dumps, waste lagoons, or septic systems can pollute groundwater. Acid rain also threatens to recharge aquifers with contaminated water.

Generally, groundwater is not as easily contaminated as surface water, but once it is contaminated, it is much more difficult to clean up because of its relative inaccessibility.

One drop of oil can render up to 25 litres of water unfit for drinking.

WATER - How we use it



23. Canadians are among the biggest water users in the world. Nearly all of our economic and social activities depend on water. How do we use it?

There are two basic ways in which we use water:
1) *Instream* uses, such as hydroelectric power generation, transportation, fisheries, wildlife, recreation, and waste disposal, take place with the water remaining in its natural setting, "in the stream".
2) *Withdrawal* uses, such as thermal power generation, mineral extraction, irrigation, manufacturing, and municipal use, remove water from its natural setting for a period of time and for a particular use, and eventually return all or part of it to the source. The difference between the amount of water withdrawn and the amount of water returned to the source is water "consumed" (for example, by evaporating and not returning to the local source).

In 1996, thermal power generation accounted for about 64% of total withdrawals; manufacturing came next, with nearly 14% of the total. Municipal, agricultural, and mining activities withdrew 12%, 9%, and 1% of the total, respectively.

24. How much of Canada's farmland is irrigated?

Much of the land producing fruits and vegetables, as well as a significant amount of the land used to grow tobacco, is irrigated. In western Canada, irrigated forage crops help stabilize the livestock industry.

According to the 2001 Census of Agriculture, there were 17 204 farms in Canada reporting that they used irrigation on a total of 784 469 hectares of farmland. The provincial breakdown is as follows:
- Alberta, 499 240 hectares
- British Columbia, 111 181 hectares
- Saskatchewan, 68 490 hectares
- Ontario, 49 271 hectares
- Manitoba, 28 145 hectares
- Quebec, 22 578 hectares
- Atlantic provinces, 5 562 hectares

In all regions except Europe and North America, agriculture is by far the biggest user of water, accounting worldwide for about 69% of all withdrawals.

25. How much water is used for irrigation?

Approximately 70% of the water used in irrigation is consumed (water withdrawn but not returned to the water course). British Columbia, Alberta, and Saskatchewan use 3500 million cubic metres. Due to incomplete data, only information on the irrigated areas of Western Canada is available; water use for irrigation in Atlantic Canada is estimated to be very small.

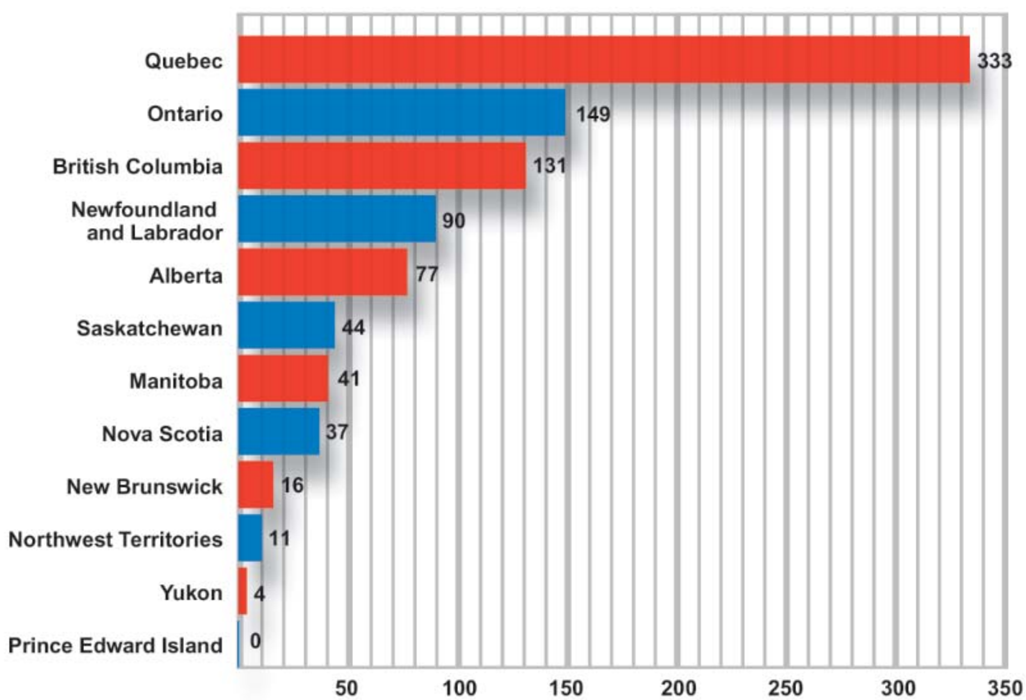
26. How many dams are there in Canada?

Canada now ranks as one of the world's top 10 dam builders. Although the Canadian Dam Association's register of dams (2003) reports 933 large dams, there are many thousands of small dams. A large dam is defined as being higher than 15 metres or, under certain conditions, higher than 10 meters.

In Canada, large dams are used primarily for hydroelectric power generation (596 dams), but are also used for the following purposes:

- multi-purposes (86 dams)
- tailings (82 dams)
- water supply (57 dams)
- irrigation (51 dams)
- flood control (19 dams)
- recreation (7 dams)
- other purposes (35 dams)

Number of large dams in Canada



Source:
Canadian Dam Association's register of dams (2003)

Canada is the largest producer of hydroelectricity, followed by the United States and Brazil.

27. What proportion of Canada's electrical generation has hydropower as its source?

The United Nations ranks Canada as the world's largest hydroelectric producer, with more than 13% of the global output.

In 1999, 62% of the total power generated in Canada came from hydro sources. Every province in Canada, with the exception of Prince Edward Island, has some hydropower capacity; but Quebec, Ontario, Newfoundland and Labrador, Manitoba, and British Columbia account for most of the hydropower produced in Canada, with their combined output representing more than 90% of total hydroelectricity production.

The largest hydroelectric development in Canada is the James Bay project in Quebec; its eight dams and 198 dikes contain five reservoirs that cover 11 900 square kilometres. The combined output of its generating stations is 15 237 megawatts. Canada's other principal hydroelectric generating stations are the Churchill Falls plant in Labrador with an installed capacity of 5225 megawatts, and Gordon M. Shrum powerhouse on the Peace River, British Columbia, with an installed capacity of 2416 megawatts.

28. How important is water in the production of electrical energy from coal or nuclear fuel?

After the fuel itself, water is the most important raw material used in large-scale thermal power production. Production of 1 kilowatt-hour of electricity requires 140 litres of water for fossil fuel plants and 205 litres for nuclear power plants for cooling purposes. Most plants have a closed-loop system, with only a small proportion of the water actually "consumed" (lost through evaporation); most of the water is used over and over again. Seawater is sometimes used for cooling purposes in the Atlantic provinces.

29. Which form of energy production — solar, hydro, nuclear, gas, or oil — is least harmful to the environment?

No form of energy production is 100% environmentally friendly. However, some methods of energy production are less damaging to the environment by being renewable, by causing less damage to the ecosystem, and by producing less-damaging waste. Solar and wind generation are both relatively clean and are renewable, but are not yet practical for large-scale production. Hydroelectricity is also renewable and relatively clean, but if a large dam is built, wildlife habitat, farmland, forests, and town sites can be lost; social alienation can occur; and heavy metals such as mercury can be released into the water. Hydroelectricity forms the most important source of renewable energy for Canadians. Of the combustible fuels, hydrogen is the cleanest burning, followed by natural gas and light fuel oil. The combustion of all fossil fuels, however, produces carbon dioxide — a greenhouse gas. Even though nuclear energy (fission) is a form of energy production that is not based on combustion, the disposal of the resulting radioactive waste and the possiblity of major accidents remain serious problems.

30. How does the water that we use in our home get there?

Across Canada, 11% of the water used in Canadian municipalities comes from groundwater (2001); the rest is from lakes and rivers. In cities, water is distributed through a series of pipes connected to a municipal water supply system. In rural areas, it is usually obtained from wells. Water supply systems typically have intake, treatment, storage, and distribution components. There are many different treatment types, depending on the characteristics of the source water. Likewise, the storage and distribution systems vary greatly between municipalities, depending on the unique characteristics of each city or town.

Rural residents usually have individual groundwater supplies. Wells must be carefully prepared and maintained to prevent pollution.

Water is delivered by trucks to several regions of Canada. In the Far North, water may have to be trucked to homes that do not have conventional water

Water power meets about 62% of Canada's electrical needs.

supplies because the ground is frozen. Water is also delivered by truck in some rural areas of the east and in the Prairies where shallow wells go dry.

Where there are piped systems in the North, the pipes are often buried very deep, up to 3 or 4 metres, to get below the worst of the frost, and are insulated to prevent the water from freezing.

In permafrost areas, the heat lost from even insulated underground pipes would melt the permafrost and cause the ground to cave in. Therefore, above-ground utilidors (insulated boxes) are used to carry water, sewer, and sometimes hot water (for heating) pipes to individual residences. These are heated, insulated, metal or wood-clad enclosures that are generally installed on piles or blocking.

31. Why do we have to pay to use water?

First, there are numerous administrative costs incurred in order to manage our water resources effectively and efficiently. Second, water supplies usually have to be pumped, stored, moved, and treated to make water available and safe for use — and then have to be taken away after discharge. Third, existing water systems, also called water "infrastructure", have to be maintained and upgraded or replaced as required. All of these services cost money.

32. What is the cost of water? How much do we use?

Water prices across Canada are generally low compared to other countries. The average household pays $33.18 per month, and uses about 26 500 litres per month, for water delivered to the residence. Monthly bills range between $19 and $52, the lowest being in Quebec, Newfoundland and Labrador, and British Columbia, and the highest in the Prairie provinces and northern Canada (2001).

Although the operating costs for trucked service are very high, the lower capital costs make it more economic than piped service for most northern communities. Consumption is much lower for areas with trucked service, about 200 litres per capita per day in the Northwest Territories and Nunavut.

33. What costs do water revenues cover?

Several studies show that water revenues are not sufficient to cover operational, repair, upgrading, or expansion costs. They cover only a small part of the costs of supplying water. For example, irrigation water charges recover only about 10% of the development cost of the resource.

The cost of maintaining (repairing and upgrading) municipal water supply and sewage systems is estimated at $23 billion over the next 10 years. The fact that this money is not currently available is further evidence that water revenues do not cover costs.

34. Who sets water prices in Canada, and how are they determined?

Provincial and municipal officials set water prices in Canada. Most provinces levy licence fees to major water users for access to the resource. The provincial licence fees for water are not set in accordance with any pricing principles, but rather are related to the cost of administering the licensing program.

Municipalities also levy charges to water users. In many areas, users are charged a flat monthly, quarterly, or annual rate in exchange for access to unlimited amounts of treated water. In other places, the charges are based on the volume of water used, as measured by a water meter. Irrigation water fees are paid according to land area irrigated, not water volume used.

35. Are householders going to have to pay more for using water in the future?

It is expected that the price of water will increase in the future to bridge the gap between the cost of providing water to the user and the revenue received from those using it. As with most resources, the amount of water used decreases as

It is estimated that in 1999, 26.5 million Canadians received central water services.

prices rise. Canadians use larger amounts of water per capita than users in other countries who face higher prices. Canadians pay, on the average, about one quarter of European and about three quarters of American domestic and industrial water prices. This supports the conclusion that water in Canada is generally underpriced.

36. How does the cost of tap water compare with the cost of other drinks?

Tap water is very inexpensive compared with some other liquids. For example, 1 litre of water costs about 0.001 dollar, while the same amount of bottled water would cost $1.50; cola, $0.85; milk, $1.10; and table wine, $9.00.

37. Do all houses in Canada have running water and sewerage services?

Over 92% of urban households are serviced by municipal water and sewer systems (2001). The remainder, as well as most of the rural population, is serviced by private individual systems (usually groundwater), septic tanks and/or tile fields, or trucked services.

In the Northwest Territories and Nunavut, for example, 16% of the communities have centralized water distribution systems either above or below ground, while 74% have trucked water supply and waste disposal systems. The remaining 10% use private systems, water buckets, privies, or trucked services. Specifically, in the Northwest Territories, seven communities have piped systems: Fort Smith, Hay River, Yellowknife, and Edzo have inground pipes while Norman Wells, Inuvik, and Rae have above-ground pipes, or utilidors (insulated boxes). In Nunavut, only Iqaluit, Rankin Inlet, and Nanisivic have piped above-ground systems.

38. What is water conservation?

Water conservation activities are essentially designed to do two things: (1) reduce the *absolute* amounts of water we use (less water per person or given product or service) and/or (2) reduce the *rate* (using water only when we need it) at which we use water in our daily lives — either at home, at work, in business, or in industry. The reduction in water use will not only reduce the volume of polluted water, but will also allow municipal sewage treatment plants to function better because they work best with more concentrated inflow. In all cases, the goal of water conservation is to use our water resources more efficiently. Water conservation allows us to do the same task or job, but with much less water.

39. Why is water conservation important in Canada?

Water conservation is important for three reasons. First, some regions of Canada are water-short due to semi-arid conditions. Dry summers place these areas of the country under additional stress. Second, other parts of the country, particularly the rural areas, often rely on groundwater as their sole source of supply. Excessive water use or withdrawals can lower water tables in these rural areas. And, third, in many urban areas in Canada, municipal water utilities are experiencing limits on supply because of infrastructure problems — either due to summer peak demands exceeding system capacities or due to older sewer and water systems that are in need of upgrading or repair.

In all three contexts listed above, water conservation helps by putting less pressure on the existing water supply (and wastewater treatment systems). Recognizing the importance of water resources to all life and reducing the *rate* at which we use water and/or the *absolute* amounts we use is the essence of what conservation is all about. It can help us "stretch" our existing reserves without having to invest in more expensive sources of new supply. This "frees up" supply, either to serve the needs of future growth (in population or industry) or to serve an existing population for a longer period of time.

Residential indoor water use in Canada: toilet – 30%; bathing and showering – 35%; laundry – 20%; kitchen and drinking – 10%; cleaning – 5%.

40. How can water conservation be implemented?

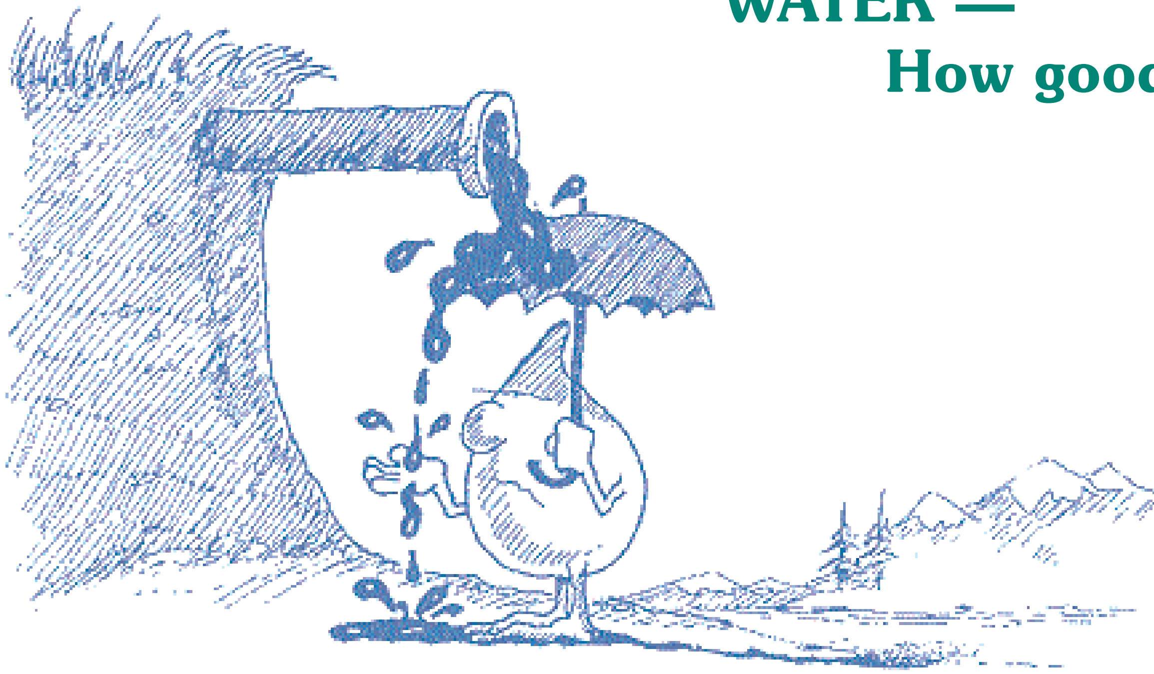
There are many water-saving opportunities available to consumers, industry, and governments. Generally, three groups of actions are important — physical measures, economic measures, and social measures. *Physical measures* refer to alterations that can be made to water using equipment or processes. Domestic examples include the use of low-flow shower heads and water-conserving toilets, laundry facilities that recycle previously used water, and the implementation of universal water metering in communities. Industrial examples include the installation of water-recycling equipment, such as cooling towers, and process changes that lower water use. *Economic measures* refer to means of altering the ways in which users pay for the right to use water. Examples include revisions to municipal water rates to assure full cost recovery, water charges based on quantities used, and implementation of volume-based charges for self-supplied industries. *Social measures* refer to broad social policies and actions designed to lower water usage. Examples include revisions to plumbing codes, legal restrictions on water use during drought periods, and campaigns to inform the public about the importance of water.

The last section of the Primer, Water: Dos and Don'ts, provides many examples of actions that individual water users can take to implement conservation and efficiency.

41. What are the benefits of conservation?

In addition to "stretching" available water supplies to meet increasing demands, water conservation has distinct economic advantages. For example, use of water-saving shower heads can not only save the homeowner the cost of the water itself but also save over $100 annually in water-heating costs. Furthermore, conservation retrofitting of an existing building could generate benefits ranging between 15 and 20 times the costs incurred. Finally, water conservation lessens the demands made on a vital natural resource, thereby contributing to the sustainability of the Canadian environment.

On average, 13% of municipal piped water is lost in pipeline leaks – up to 30% in some communities.



WATER —
How good is it?

42. What do we mean by water quality?

Water quality is defined in terms of the chemical, physical, and biological content of water. The water quality of rivers and lakes changes with the seasons and geographic areas, even when there is no pollution present. There is no single measure that constitutes good water quality. For instance, water suitable for drinking can be used for irrigation, but water used for irrigation may not meet drinking water guidelines. Canadian water quality guidelines provide basic scientific information about water quality parameters and ecologically relevant toxicological threshold values to protect specific water uses.

For information on drinking water guidelines, visit Health Canada's Web site at www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/index_e.html

For information on recreational water quality, visit Health Canada's Web site at www.hc-sc.gc.ca/ewh-semt/water-eau/recreat/index_e.html

For information on the Canadian water quality guidelines for the protection of aquatic life and for agricultural water uses (irrigation and livestock water), contact:

National Guidelines and Standards Office
Environment Canada
Ottawa, ON K1A 0H3
Tel.: 819-953-1550
Fax: 819-953-0461
E-mail: ceqg-rcqe@ec.gc.ca
Web site: www.ec.gc.ca/ceqg-rcqe/

Every year, 1.8 million people die from diarrhoeal diseases (including cholera); 90% are children under five, mostly in developing countries.

43. What are the key factors that influence water quality?

Many factors affect water quality. Substances present in the air affect rainfall. Dust, volcanic gases, and natural gases in the air, such as carbon dioxide, oxygen, and nitrogen, are all dissolved or entrapped in rain. When other substances such as sulphur dioxide, toxic chemicals, or lead are in the air, they are also collected in the rain as it falls to the ground.

Rain reaches the earth's surface and, as runoff, flows over and through the soil and rocks, dissolving and picking up other substances. For instance, if the soils contain high amounts of soluble substances, such as limestone, the runoff will have high concentrations of calcium carbonate. Where the water flows over rocks high in metals, such as ore bodies, it will dissolve those metals. In the Canadian Shield, there are large areas with little soil and few soluble minerals. Consequently, the rivers and lakes in these areas have very low concentrations of dissolved substances.

Another factor influencing water quality is the runoff from urban areas. It will collect debris littering the streets and take it to the receiving stream or water body. Urban runoff worsens the water quality in rivers and lakes by increasing the concentrations of such substances as nutrients (phosphorus and nitrogen), sediments, animal wastes (fecal coliform and pathogens), petroleum products, and road salts.

Industrial, farming, mining, and forestry activities also significantly affect the quality of Canadian rivers, lakes, and groundwater. For example, farming can increase the concentration of nutrients, pesticides, and suspended sediments. Industrial activities can increase concentrations of metals and toxic chemicals, add suspended sediment, increase temperature, and lower dissolved oxygen in the water. Each of these effects can have a negative impact on the aquatic ecosystem and/or make water unsuitable for established or potential uses.

44. How do we measure water quality?

The quality of water is determined by making measurements in the field or by taking samples of water, suspended materials, bottom sediment, or biota and sending them to a laboratory for physical, chemical, and microbiological analyses. For example, acidity (pH), colour, and turbidity (a measure of the suspended particles in the water) are measured in the field. The concentrations of metals, nutrients, pesticides, and other substances are measured in the laboratory.

Another way to obtain an indication of the quality of water is biological testing. This test determines, for example, whether the water or the sediment is toxic to life forms or if there has been a fluctuation in the numbers and kinds of plants and animals. Some of these biological tests are done in a laboratory, while others are carried out at the stream or lake.

45. How does water quality in the Yukon compare with that in the Northwest Territories?

The Yukon has much more variable water quality and generally higher levels of sediment than the Northwest Territories, except for the mountainous western part of the Mackenzie River basin. This is due in part to the more rugged terrain in the Yukon, which has several large mountain ranges (such as the St. Elias on the west and the Mackenzie Mountains on the east). Much of the rest of the Northwest Territories is dominated by Canadian Shield terrain, which is much older, has less relief, and is largely scraped bare of readily erodible material by continental glaciation. The extreme seasons in the Yukon, combined with its complex geology, glaciation, and sources of erodible material, are also a contributing factor.

Worldwide, one billion people lack access to safe drinking water, 2.4 billion to adequate sanitation.

46. What is good quality drinking water?

Good quality drinking water is free from disease-causing organisms, harmful chemical substances, and radioactive matter. It tastes good, is aesthetically appealing, and is free from objectionable colour or odour. The guidelines for Canadian drinking water quality specify limits for substances and describe conditions that affect drinking water quality.

For a copy of *Guidelines for Canadian Drinking Water Quality*, visit Health Canada's Web site at www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/guidelines_sixth-rec_e.html

47. How can we be sure that water is safe to drink?

Municipalities have the responsibility to provide their citizens with safe drinking water and to provide sufficient warning about pollution risks related to recreational uses. Samples are regularly collected and analyzed to check drinking water quality. The results of these analyses are compared with the Canadian drinking water quality guidelines to decide whether or not the water is safe to drink.

It should be noted that there is a difference between "pure water" and "safe drinking water".

Pure water, often defined as water containing no minerals or chemicals, does not exist naturally in the environment. Under ideal conditions, water may be distilled to produce "pure" water.

Safe drinking water, on the other hand, may retain naturally occurring minerals and chemicals, such as calcium, potassium, sodium, or fluoride, which are actually beneficial to human health and may also improve the taste of the water. Where the minerals or chemicals occur naturally in concentrations that may be harmful or displeasing, then certain water treatment processes are used to reduce or remove the substances. In fact, some chemicals are actually added to produce good drinking water; the best examples of chemical addition are chlorine, used as a disinfectant to destroy microbial contaminants, and fluoride, used to reduce dental cavities.

48. Some of my friends buy bottled water for drinking and cooking. What is my assurance that bottled water is good quality drinking water?

Sales of bottled water continue to increase each year. The Canadian Bottled Water Association reports that 1998 consumption was estimated at 703 million litres. Recently, the bottled water industry provided Canadians with potable drinking water during times of crises — the floods in Quebec and Manitoba and the ice storm in Ontario and Quebec.

Bottled water is regulated as a food product under the Food and Drugs Act. Federal food inspectors regularly audit the operations of bottled water companies to ensure compliance. Members of the Canadian Bottled Water Association (CBWA) produce about 85% of the bottled water in Canada. Since 1990, these members are subject, not only to federal and provincial regulations, but also to third-party inspections, water testing and analysis, and adherence to the CBWA Model Code. For additional information on the standards required of CBWA members, contact:

Canadian Bottled Water Association
70 East Beaver Creek Road, Suite 203-18
Richmond Hill, ON L4B 3B2
Tel.: 905-886-6928
Fax: 905-886-9531
E-mail: info@cbwa-bottledwater.org
Web site: www.cbwa-bottledwater.org

Improved water supply reduces diarrhoea morbidity by between 6% to 25%; improved sanitation reduces it by 32%.

49. Are drinking water supplies in urban areas better or worse than those in rural areas?

The answer to this is not a simple "yes" or "no". In general, one can say that the quality of water in rural areas is better because these areas are removed from industrial activities, which may result in the degradation of the quality of river water, lake water, or groundwater. There are, however, many exceptions. In areas with intensive agricultural activity, mining, and logging, the impacts on water quality can be severe.

50. If we could boil all the water we consume, could we eliminate pollution?

No. Boiling water kills germs but will not remove heavy metals and chemicals.

51. Is chlorine in the water supply necessary, and could it become a health hazard?

Chlorine was introduced as a disinfectant in water treatment around 1900. It has since become the predominant method for water disinfection. Apart from its effectiveness as a germicide, it offers other benefits such as colour removal, taste and odour control, suppression of algal growths, and precipitation of iron and manganese. In addition, chlorine is easy to apply, measure, and control. It is quite effective and relatively inexpensive.

Chlorine as a disinfectant in water treatment can be a health hazard if its concentration or the concentrations of certain by-products (e.g., trihalomethanes, a chlorinated organic compound) are greater than the Canadian drinking water quality guidelines allow. If the maximum acceptable concentrations are exceeded, the authorities responsible for public health should be consulted for the appropriate corrective action.

52. Some people say that you shouldn't pour solvents and other household chemicals down the drain because they pollute the rivers and lakes. Is that true? How else can I get rid of them?

While household chemical products are generally safe for the uses they are designed for, some may become harmful to the environment as they accumulate in it. For this reason you should not put these products down a drain. Most sewage treatment facilities are not capable of removing such toxic substances. You should also be aware, in most instances, that anything put into the storm sewer system goes directly to the receiving lake or river completely untreated. So, before you dump anything down a drain or into a storm sewer, remember that you or others may be drinking it some day.

For those substances that you have at home now and want to get rid of, such as old paint, find out whether there is a hazardous waste disposal site in your community and take them there. You may also contact your local environmental health officer for assistance. Make sure the containers are labeled to indicate the contents.

53. As a responsible consumer how can I tell if the products I buy are potentially harmful to the environment?

Most household chemical products and pesticides sold in Canada have warning labels. These labels tell us whether the product is flammable, poisonous, corrosive, or explosive. The labels usually also give first aid instructions.

Keep in mind that some products that are hazardous do not require warning labels. Canadian laws for hazardous household chemicals are regulated by Health Canada. The laws for pesticides (such as mothballs, house and garden pesticides, or insect repellents) are controlled by Agriculture and Agri-Food Canada. The symbols used on hazardous household chemical products are shown on the next page.

The addition of chlorine to our drinking water has greatly reduced the risk of waterborne diseases.

The warning symbols are based on shape: the more corners a symbol has, the greater the risk. When shopping for household chemical products, always look for these symbols. Read the label to find out how to use the product safely and what precautions to take for its disposal.

For more information on product safety, visit Health Canada's Web site at: www.hc-sc.gc.ca/cps-spc/index_e.html

54. What happens to water that drains out of our home?

Sewers collect the liquid waste and discharge it into lakes, streams, or the ocean. Most, but not all, municipalities treat their sewage using mechanical and/or biological processes before discharging it. Regardless of the process, sewage treatment plants concentrate the sewage into a solid called "sludge", which is then used on agricultural land, disposed of in a landfill site, or incinerated. Residents of rural areas, the North, and cottage country may have individual septic systems or have sewage collected by truck. Waste from outdoor privies slowly percolates through the ground along with other groundwater. It can end up infecting lakes, streams, or wells if located too close to these sources of water.

55. How effective are wastewater treatment plants in eliminating water pollution?

Conventional wastewater treatment plants remove suspended solids and some of the organic matter. More advanced plants also remove phosphorus and nitrogen, which are nutrients for aquatic plants. Both of these nutrients are present in human sewage as well as in runoff from agricultural areas. Laundry detergents were once a major source of phosphorus, but regulations controlling its use in detergent manufacturing have minimized its impact on receiving waters in Canada.

56. Who determines whether or not a beach should be closed?

Regional health officers determine whether or not a beach should be closed using the guidelines for Canadian recreational water quality developed jointly by federal and provincial experts. These guidelines deal mainly with health hazards in instances where people have direct recreational contact with water. This includes infections transmitted by pathogenic microorganisms, such as microbes and viruses, and injuries due to impaired visibility in muddy waters. When a public beach is unsafe for swimming, warning posters are displayed in visible locations.

For a copy of *Guidelines for Canadian Recreational Water Quality*, visit Health Canada's Web site at www.hc-sc.gc.ca/ewh-semt/water-eau/recreat/index_e.html

More than 23 000 different chemicals and substances are available for use in consumer goods and industrial processes in Canada.

57. Eutrophication is a form of pollution. What is a eutrophic lake?

Eutrophication is the natural aging process of lakes as they become better nourished, either naturally or artificially. Eutrophication occurs naturally with the gradual input of nutrients and sediment through erosion and precipitation, resulting in a gradual aging of the lake. Humans speed up this natural process by releasing nutrients, particularly phosphorus, into rivers and lakes through municipal and industrial effluent and through increased soil erosion resulting from poor land use practices. Eventually, a lake will develop high nutrient concentrations and dense growths of aquatic weeds and algae. These plants die and decompose, causing depletion of dissolved oxygen in the water. This process often results in fish kills and changes in a lake's fish species. Ultimately, eutrophication will fill the lake with sediment and plant material.

58. How does irrigation affect water quality?

Irrigation affects water quality in different ways, depending on the original water quality, the type of soil, the underlying geology, the type of irrigation, the crop grown, and the farming methods used.

Although a large portion of irrigation water is used by plants (evapotranspiration) or evaporates from the soil, part of it is returned to the source. As is often the case with water use, when the water returns to the stream or water body, the quality has been lowered. The water that runs off the fields carries with it sediments, fertilizers, herbicides, pesticides (if these chemicals are used on the fields), and natural salts leached from the soil, and eventually these substances enter our rivers, lakes, and groundwater supplies.

59. Is the discharge of cooling water from electrical power plants a form of pollution?

Yes; it is called "thermal pollution". In 1996 — the last year for which national estimates are available — thermal and nuclear power plants in Canada discharged 28 billion cubic metres of water. Almost all of this had been used for condenser cooling. However, most of these facilities have controls on the maximum temperature of their discharge waters, and many of them use cooling ponds or towers.

Thermal pollution, when not regulated, can be a problem. Artificially heated water can promote algae blooms, threatening certain species of fish and otherwise disturbing the chemistry of the receiving water body. When this water is not reused by industries or for heating in nearby communities, large amounts of energy and potential dollar savings are lost. When it is reused, it can also have an improved effect on climate change by displacing the use of some fossil fuels.

60. What effect can a dam have on the water quality of a river system?

Generally, rivers are dammed to create reservoirs for power production, downstream flood control, recreation, or irrigation. When a dam is constructed, the land behind it is flooded. This may mean the loss of valuable wildlife habitat, farmland, forests, or town sites. Accumulation of sediments in the reservoir can have a detrimental effect on water quality by creating increased concentrations of harmful metal and organic compounds in the reservoir. If vegetation is not removed behind the dam before flooding, other problems can occur. For example, the eutrophication process may occur at a faster rate and adversely affect the water quality.

61. What is dredging?

Dredging is the removal of sediments or earth from the bottom of water bodies using either a type of scoop or a suction apparatus. This material, often called "spoils", is then deposited along the shore, formed into islands, or transported elsewhere away from the site. Dredging is usually done to increase the depth or width of water channels for navigation or to allow increased flow rates to accommodate larger volumes of water.

Health problems related to water pollution in general are estimated to cost Canadians $300 million per year.

62. Can dredging do any harm?

Dredging can disturb the natural ecological balance through the direct removal of aquatic life. For example, in estuaries (part of the river mouth where fresh water and seawater are mixed), oyster beds can be destroyed; in the freshwater environment, those bottom-dwelling organisms on which fish depend for food may be eliminated from the food chain. In addition, when spoils are deposited directly in a water system, they may smother the remaining organisms, and silt or sediments released from dredging activities can cover and destroy fish feeding and breeding habitats.

Furthermore, contaminants accumulate over long periods of time in the sediments. Some toxic substances which may reside in the sediment (e.g., mercury) can re-enter the water system when the sediments are dredged. Such contaminants then endanger the health of water users, particularly the organisms that live in the body of water. Nutrients are also released by dredging. These can cause eutrophication of the system, resulting in oxygen depletion and possibly the death of fish and other aquatic organisms.

63. Can dredging be beneficial to an aquatic ecosystem?

Yes, in some instances, dredging is beneficial to the environment. Dredging can be used to enlarge or create wetlands and provide more habitat opportunities and greater biological diversity within targeted geographic area. In some cases, disturbed lake and river bottoms can be re-colonized once the actual dredging activities have stopped. Dredged spoils can be used to create islands and contoured shorelines which can provide nursery habitat for fish, nesting and staging habitat for waterfowl, and winter habitat for furbearing mammals. In many cases, however, the material removed by dredging (i.e., dredgeate) requires containment or treatment and would not be suitable for wildlife habitat creation.

Although dredging can disturb the normal balance and productivity of an aquatic ecosystem, proper attention to mitigation and construction procedures may result in the beneficial effects of dredging outweighing the negative effects.

64. What is acid rain?

Acid rain refers to rainwater that, having been contaminated with chemicals introduced into the atmosphere through industrial and automobile emissions, has had its acidity increased beyond that of clean rainwater. Acidity is measured on a pH scale. For example, vinegar, an acid, has a pH of 3, and lemon juice, another acid, has a pH of 2. It is generally accepted that rain with a pH less than 5.3 is acidic.

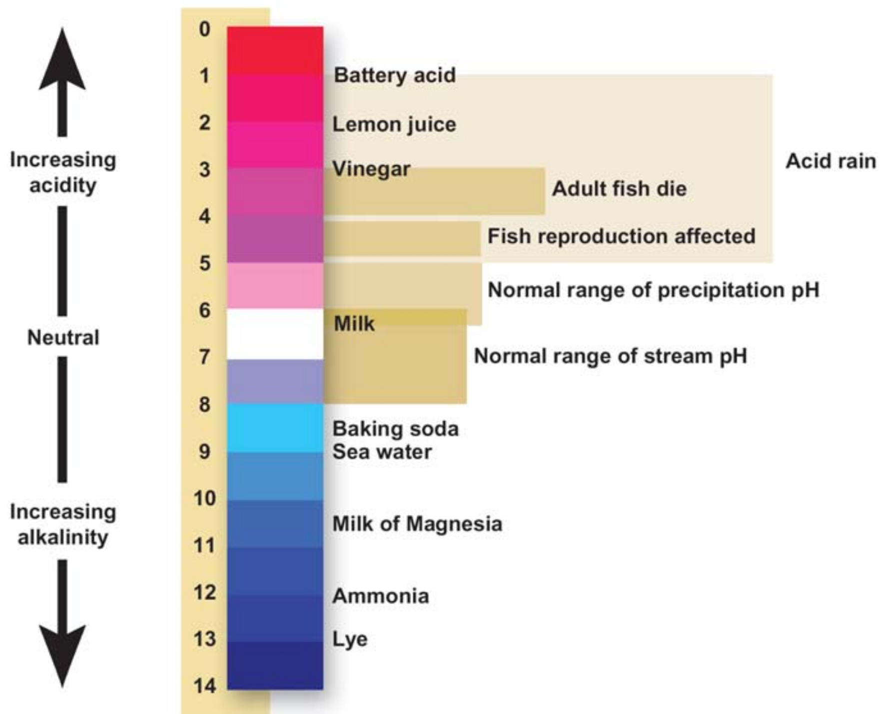
Emissions of sulphur and nitrogen oxides from a variety of sources enter the atmosphere everyday. While in the atmosphere, these compounds combine with atmospheric water to form acids. The most common acids formed in this manner are sulphuric acid and nitric acid. When mixed with rain, these acids fall as wet deposition (acid rain). In the absence of rain, the particulate matter slowly settles to the ground as dry deposition. Together, wet and dry deposition of acidic substances is known as acid precipitation.

65. How does acid deposition affect water quality?

The effects of acid deposition on water quality, although complicated and variable, have been well documented. Impacts from these acidic compounds in the atmosphere can occur directly, by deposition on the water surface, or indirectly, by contact with one or more components of the terrestrial ecosystem before reaching any aquatic system. The interactions of acid deposition with the terrestrial ecosystem, including vegetation, soil, and bedrock, result in chemical alterations of the waters draining these watersheds, eventually altering conditions in the lakes downstream.

Acid rain with a pH of 3.6 has 100 times the acidity of normal rain with a pH of 5.6.

The pH scale



The extent of chemical alteration resulting from acidic deposition depends largely on the type and quantity of the soils and the nature of the bedrock material in the watershed, as well as on the amount and duration of the precipitation. Watersheds with soils and bedrock containing substantial quantities of carbonate-containing materials, such as limestone and calcite, are less affected by acidic deposition because of the high acid-neutralizing capacity derived from the dissolution of this carbonate material. Thousands of lakes in Canada, however, lie on the Precambrian Shield. This vast expanse of bedrock possesses

On the Canadian Prairies, a common type of surface water source is the farm dugout, which is a small on-farm reservoir.

few limestone-type materials and, consequently, has only a limited ability to neutralize acidic deposition. Consequently, lakes and rivers in these areas generally show acidification effects, including decreasing pH levels and increasing concentrations of sulphate and certain metals such as aluminum and manganese.

66. What is acid mine drainage?

Acid mine drainage or, more generally, acid rock drainage, results when rock containing metallic sulphides, such as pyrite, become exposed to water and air. Examples of this are mine tailings and excavation of acid rock through highway construction. The rate of acid generation is greatly enhanced by the presence of sulphur-oxidizing bacteria.

The impact of this process is increased acidity and metal levels in receiving waters (surface water and groundwater) to the detriment of fish and other organisms, as well as to drinking water supplies.

67. Our northern rivers and lakes have long been considered to be of pristine quality. Is this still true?

The quality of Canada's northern rivers and lakes is generally good in comparison with the extensively utilized watercourses in the heavily populated regions of southern Canada.

Some pollution concerns do exist in the North, and these must be closely monitored to ensure that good water quality is conserved. The North contains significant reserves of gold, silver, uranium, other metals, and diamonds, which have led to the development of a number of mining operations throughout the North. By-products from the mines can include metals such as copper, lead, zinc, arsenic, and cyanide, which are discharged into receiving waters. A number of large uranium ore bodies have been discovered in the southern Keewatin part of Nunavut, but none have been developed yet, due to public concerns about the potential for negative environmental impacts.

The operation of oil and gas facilities in northern Alberta and in the Mackenzie valley, could lead to a degradation of water quality either through accidental spills in the refinery or along the transportation route. Monitoring of water, suspended sediments, and instream biota is required to ensure that water quality is not deteriorating.

Toxic organic compounds such as organochlorine pesticides and PCBs (polychlorinated biphenyls) have also been detected in snow and in fish in the Northwest Territories. The exact pathways for entry of these compounds into northern waters have not yet been identified, but they likely include long-range atmospheric transport from agricultural and industrial sources in the south or from other continents.

Long-term comprehensive monitoring for northern rivers and lakes is essential to keeping governments, the public, developers, and industrial users informed on the quality of northern rivers and lakes. This information is required by regulatory agencies to ensure that water quality concerns can be addressed before they become problems. The marine water system in the North, in contrast to the freshwater one, has had significant inputs of contaminants from various global sources, including long-range air and sea transport. The resultant contamination of water and especially of country (native) foods is of particular concern to the Inuit, many of whom live near the sea and depend on it for their food.

To learn more about research into contaminants in the North, visit the National Water Research Institute's Web site at www.nwri.ca/research/contaminants-e.html.

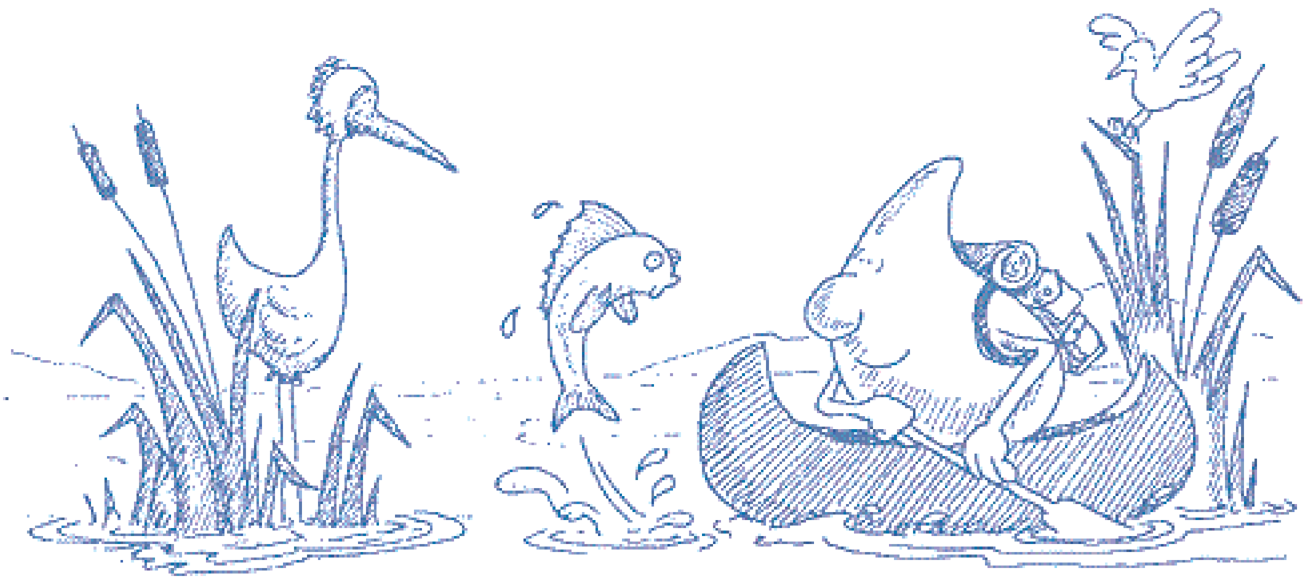
The Great Lakes provide drinking water to 8.5 million Canadians.

68. Has water quality in Canada improved or deteriorated in the last 10 years?

In some aspects it has improved, while in others it has deteriorated. Some problems identified 10 or 20 years ago have been partly solved. However, we have also identified new problems. For example, although the problem of accelerated eutrophication has not disappeared as a threat to our aquatic ecosystems, we can say that this problem is now largely under control in the Great Lakes basin where regulations have proven effective. Although we must continue to take great care in limiting the discharge of phosphorus into our lakes and rivers, attention is now being directed more toward addressing issues associated with toxic chemicals.

Today, in terms of water quality, toxic chemicals overshadow all other problems in the Great Lakes and in many other water bodies in Canada. Although we are striving to solve this threat to water quality, we still have a long way to go before it is under control.

You can survive about a month without food, but only 5 to 7 days without water.



WATER — An ecosystem perspective

69. What is an aquatic ecosystem?

An aquatic ecosystem is a group of interacting organisms dependent on one another and their water environment for nutrients (e.g., nitrogen and phosphorus) and shelter. Familiar examples are lakes and rivers, but aquatic ecosystems also include areas such as floodplains and wetlands, which are flooded with water for all or only parts of the year. Seemingly inhospitable aquatic ecosystems can sustain life. Thermal springs, for instance, support algae and some insect species at water temperatures near the boiling point; tiny worms live year-round on the Yukon ice fields; and some highly polluted waters can support large populations of bacteria.

Even a drop of water is an aquatic ecosystem, since it contains or can support living organisms. In fact, ecologists often study drops of water — taken from lakes and rivers — in the lab to understand how these larger aquatic ecosystems work.

70. What is the range of organisms found in aquatic ecosystems?

Aquatic ecosystems usually contain a wide variety of life forms including bacteria, fungi, and protozoans; bottom-dwelling organisms such as insect larvae, snails, and worms; free-floating microscopic plants and animals known as plankton; large plants such as cattails, bulrushes, grasses, and reeds; and also fish, amphibians, reptiles, and birds. Viruses are also a significant part of the microbial ecology in natural waters and have recently been shown to play an important role in the nutrient and energy cycles.

The assemblages of these organisms vary from one ecosystem to another because the habitat conditions unique to each type of ecosystem tend to affect

Freshwater lakes and rivers, ice and snow, and underground aquifers hold only 2.5% of the world's water. By comparison, saltwater oceans and seas contain 97.5% of the world's water supply.

species distributions. For example, many rivers are relatively oxygen-rich and fast-flowing compared to lakes. The species adapted to these particular river conditions are rare or absent in the still waters of lakes and ponds.

71. What types of freshwater aquatic ecosystems do we have in Canada?

Canada contains an abundance of freshwater ecosystems, including lakes, ponds, rivers, streams, prairie potholes, and wetlands.

A *lake* is a sizable water body surrounded by land and fed by rivers, springs, or local precipitation. The broad geographical distribution of lakes across Canada is primarily the result of extensive glaciation in the past.

Lakes can be classified on the basis of a variety of features, including their formation and their chemical or biological condition. One such classification identifies two types of lakes: *oligotrophic* and *eutrophic*. Oligotrophic lakes are characterized by relatively low productivity and are dominated by cold-water bottom fish such as lake trout. Eutrophic lakes, which are shallower, are more productive and are dominated by warm-water fish such as bass. Great Slave Lake (Northwest Territories) and most prairie lakes represent the two types, respectively.

Ponds are smaller bodies of still water located in natural hollows, such as limestone sinks, or that result from the building of dams, either by humans or beavers. Ponds are found in most regions and may exist either seasonally or persist from year to year.

Rivers and *streams* are bodies of fresh, flowing water. The water runs permanently or seasonally within a natural channel into another body of water such as a lake, sea, or ocean. Rivers and streams are generally more oxygenated than lakes or ponds, and they tend to contain organisms that are adapted to the swiftly moving waters (e.g., black fly larva and darter fish). Some of the larger rivers in Canada include the St. Lawrence, Mackenzie, Fraser, Athabasca, North and South Saskatchewan, and Saint John rivers.

Some rivers flow into *oceans*, the great saltwater bodies that cover 70% of the earth's surface. The tidal areas where saltwater and fresh water meet are called *estuaries*. These productive ecosystems, found on Canada's coasts, contain unique assemblages of organisms, including starfish and sea anemones.

72. How does an ecosystem work?

Energy from the sun is the driving force of an ecosystem. This light energy is captured by primary producers (mainly green plants and algae) and converted by a process called *photosynthesis* into chemical energy such as carbohydrates.

The chemical energy is then used by the plants to perform a variety of functions including the production of plant parts such as leaves, stems, and flowers. The raw materials used for this purpose are nutrients (e.g., nitrogen, phosphorus, oxygen, and calcium): substances necessary for the growth of all plants and animals.

Animals are incapable of photosynthesis. They therefore eat either plants, other animals, or dead tissue to obtain their energy and required nutrients. In ecosystems, the transfer of energy and nutrients from plants to animals occurs along pathways called *food chains*. The first link in a food chain consists of *primary producers*: green plants and other organisms capable of photosynthesis.

Plant-eating organisms, known as *primary consumers*, are the next link in the food chain. They, in turn, are eaten by *secondary consumers*: carnivores (flesh eaters) or omnivores (plant and animal eaters). *Decomposers* such as bacteria and fungi make up the final link in the food chain. They break down dead tissues and cells, providing nutrients for a new generation of producers.

Nearly 70% of the earth's fresh water exists in the form of glaciers and permanent snow cover.

Most organisms in an ecosystem have more than one food source (e.g., fish feed on both insects and plants) and therefore belong to more than one food chain. The consequent overlapping food chains make up *food webs*: complex phenomena with links that are constantly changing.

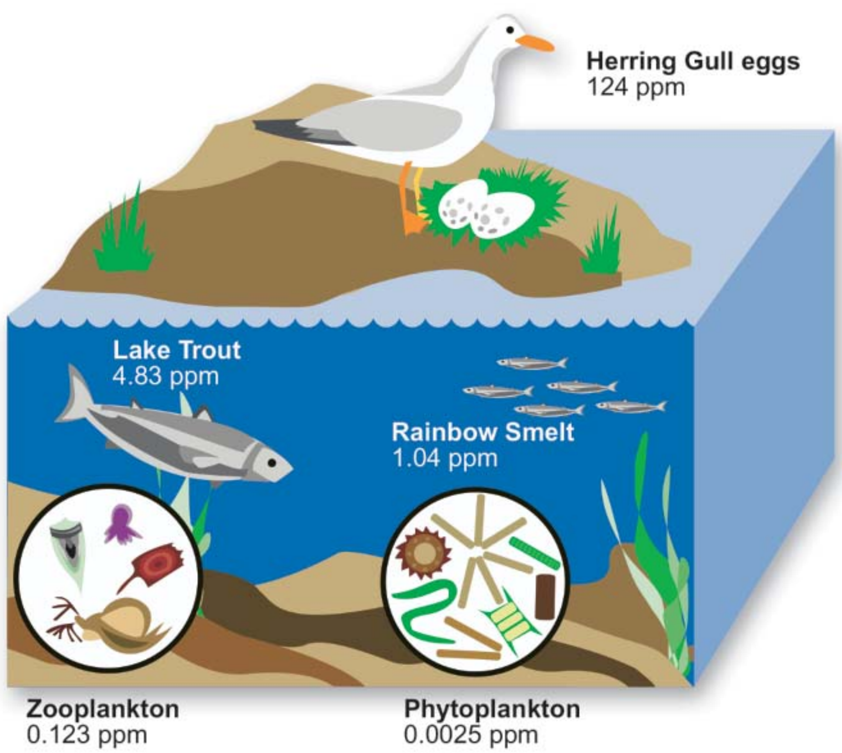
73. What is the significance of a toxic substance to the food web?

A toxic substance is one that can cause harm to the environment or human life. Most are synthetic and include PCBs, pesticides, dioxins, and furans.

Some toxic substances can enter a food web and be transferred through it. The uptake of any environmental substance by an organism is called *bioconcentration*. Although nutrients taken up through this process are usually converted into proteins or excreted as waste, many toxic compounds accumulate in the fat or certain organs (e.g., liver) of animals.

As contaminated organisms are eaten by others, the toxic substances are transferred up the levels in the food web and become more concentrated, sometimes to harmful levels. This process is called *biomagnification*. The species at the top level of the food web, including humans, are often subjected to higher concentrations of toxic substances than those at the bottom. Toxic substances reaching harmful levels is one sign that the aquatic ecosystem is unhealthy.

Bioaccumulation and biomagnification



ppm = parts per million

Source: *The Great Lakes – An Environmental Atlas and Resource Book*, 1987

74. What do we mean by an "unhealthy aquatic ecosystem"?

Healthy aquatic ecosystems are those where human disturbances have not impaired the natural functioning (e.g., nutrient cycling) nor appreciably altered the structure (e.g., species composition) of the system. An unhealthy aquatic ecosystem is one where the natural state is out of balance.

Only 0.3% of total global fresh water is stored in lakes and rivers.

These disturbances can be *physical* (e.g., injection of abnormally hot water into a stream), *chemical* (e.g., introduction of toxic wastes at concentrations harmful to the organisms), or *biological* (e.g., introduction and propagation of non-native animal or plant species). Symptoms of poor ecosystem health include the following:

- The loss of species.
- The accelerated proliferation of organisms. One example is algae blooms caused by an excess of phosphorous and nitrogen compounds in the water. This condition is called "eutrophication".
- Increased incidences of tumours or deformities in animals.
- A change in chemical properties. Perhaps one of the most significant has been a reduction of pH in water caused by acid rain.
- The presence of certain organisms that indicate unsanitary conditions. Coliform bacteria, for example, are a sign that the system may contain organisms that cause a variety of human diseases such as diarrhea, typhoid, and cholera.
- The loss of traditional Aboriginal culture associated with the ecosystem.

Many symptoms of poor ecosystem health occur simultaneously. For instance, increased lake acidity may kill certain species, thereby allowing the temporary proliferation of species more tolerant of acidity.

75. Why is aquatic ecosystem health important to humans?

Because everything is connected, where an ecosystem is out of balance eventually humans will begin to suffer as well. Our health and many of our activities are dependent on the health of aquatic ecosystems. Most of the water that we drink is taken from lakes or rivers. If the lake or river system is unhealthy, the water may be unsafe to drink or unsuitable for industry, agriculture, or recreation — even after treatment. Uses of aquatic ecosystems are impaired when these systems are unhealthy. Following are some examples.

- Inland and coastal commercial fisheries have been shut down due to fish or shellfish contamination or the loss of an important species from the system.
- The frequency of urban beach closures has escalated as a result of contamination by animal feces and medical waste.
- Navigation problems for pleasure craft, caused by the rapid expansion of bottom-rooted aquatic plants, have increased.
- The proliferation of non-native species has created problems. One recent example is the rapidly expanding zebra mussel population, introduced from the ballast waters of a European freighter into the Great Lakes. Zebra mussels have few natural predators, and because the female can produce 30 000 eggs yearly, they are expected to spread throughout most of the freshwater systems of North America. This mussel species is already clogging industrial and municipal water treatment intake pipes, coating boats and piers, and causing beach closures.

76. Can we restore the health of an aquatic ecosystem?

Perhaps, but it takes time and is dependent on the nature of the disturbance. The effects of dredging, for example, may last from one to several years, but many of the displaced organisms such as fish can re-establish themselves. In other cases, more severe disturbances (e.g., dam construction) may cause local extinction of already endangered species. These ecosystems are unlikely to recover naturally.

In many cases, mechanisms exist that allow us to help restore ecosystem health or minimize detrimental impacts caused by human use. Following are some of these mechanisms.

Almost 9%, or 891 163 square kilometres, of Canada's total area is covered by fresh water.

- Environmental legislation: Legislation such as the Canadian Environmental Protection Act (CEPA) is designed to ensure that Canadians and the aquatic environment are protected from exposure to toxic substances and from the risks associated with the use of chemicals.
- Integrated resource planning: This approach ensures that relationships among land use, development, water flows, water quality, and aquatic ecosystems are considered prior to an area's land use designation.
- Technology: Measures to improve the quality of waste discharges and to lower both water demands and effluent loading are being implemented in response to environmental and water use concerns.
- Environmental monitoring: Monitoring of chemicals in water, sediment, and organisms helps to identify potential ecosystem problems and to track existing problems.
- Compensatory measures: For example, a fish hatchery operation can produce young fish that a disturbed habitat can no longer supply.

77. What are wetlands?

Wetlands are defined as lands saturated by surface or near surface waters for periods long enough to promote the development of hydrophytic vegetation (e.g., weeds, bulrushes, and sedges) and gleyed (poorly drained) or peaty soils.

There are five basic classes of wetlands: bogs, fens, saltwater and freshwater marshes, swamps, and shallow water.

78. Where are wetlands found in Canada?

Wetlands cover about 14% of the land area of Canada. They were once abundantly distributed throughout the country. Recently, however, wetlands have become an increasingly scarce resource in settled areas of the country. Throughout Canada, wetlands have been adversely affected by land use practices that have resulted in vegetation destruction, nutrient and toxic loading, sedimentation, and altered flow regimes. For example, in southern Ontario, 68% of the original wetlands have been converted from their natural state to support alternative uses such as agriculture and housing. Similarly, only about 25% of the original wetlands of the "pothole" region of southwestern Manitoba remain in existence. In the North, however, most of the wetlands are intact.

79. What kinds of animals use wetlands?

Wetlands are important to species from many familiar classes of animals, as well as to less commonly known creatures.

Every drop of water contains microscopic zooplankton, which are a vital component of the food chain. The water's surface and the wetland bottom are covered with insect eggs, larvae, and nymphs. Members of the fish, amphibian, and reptile groups are all dependent on the habitat provided by wetlands. Numerous bird and mammal species make extensive use of the water and its adjacent shores. These species can be important to humans economically or as indicators of environmental health.

80. How do wildlife species use wetlands?

Food and shelter are the primary requirements of life. Wetlands provide these functions for many species of animals that either live permanently within the wetland or visit periodically. Almost every part of a wetland, from the bottom up, is important to wildlife in some way. Frogs bury themselves in the muddy substrate to survive the winter, and some insects use bottom debris to form a protective covering. Fish swim and feed in wetlands, often eating the eggs of insects that have been deposited in the water. Wetland vegetation provides

Canada has about 25% of the world's wetlands – the largest wetland area in the world.

nesting materials and support structures to several bird species and is a major source of food to mammals, even those as large as moose. Small mammals use the lush vegetation at the edge of wetlands for cover and as a source of food, and they themselves are a food source for birds of prey. Each species has adapted to using the wetland and its surrounding area in a particular way.

81. Why are wetlands important?

Wetlands provide a critical habitat for a wide range of plants and animals and support one third of the wildlife species identified as endangered, threatened, or vulnerable by the Committee on the Status of Endangered Wildlife in Canada. Wetlands provide "outdoor laboratories" for education and scientific research and contribute to landscape variety and open space.

Wetlands are among Canada's most valuable and productive ecosystems. They generate between 5 billion and 10 billion dollars annually in economic returns to Canadians. Wetlands support commercial fishing, sportfishing, waterfowl hunting, trapping, recreation, mining, peatland agriculture and forestry, water purification, groundwater discharge, and flood peak modification. Up to 80% of all North American waterfowl are born on prairie pothole wetlands. In Alberta, for example, 204 species of birds, 16 species of mammals, and 61 species of amphibians and reptiles depend on wetlands.

82. How can we protect our remaining wetlands?

Through conservation programs. Wetland conservation encompasses the protection, enhancement, and use of wetland resources according to principles that will assure their highest long-term social, economic, and ecological benefits. It is recognized that some wetlands should be protected and managed in their natural state; some actively managed to allow sustained, appropriate use of wetland renewable resources; and some developed for their non-renewable resource values.

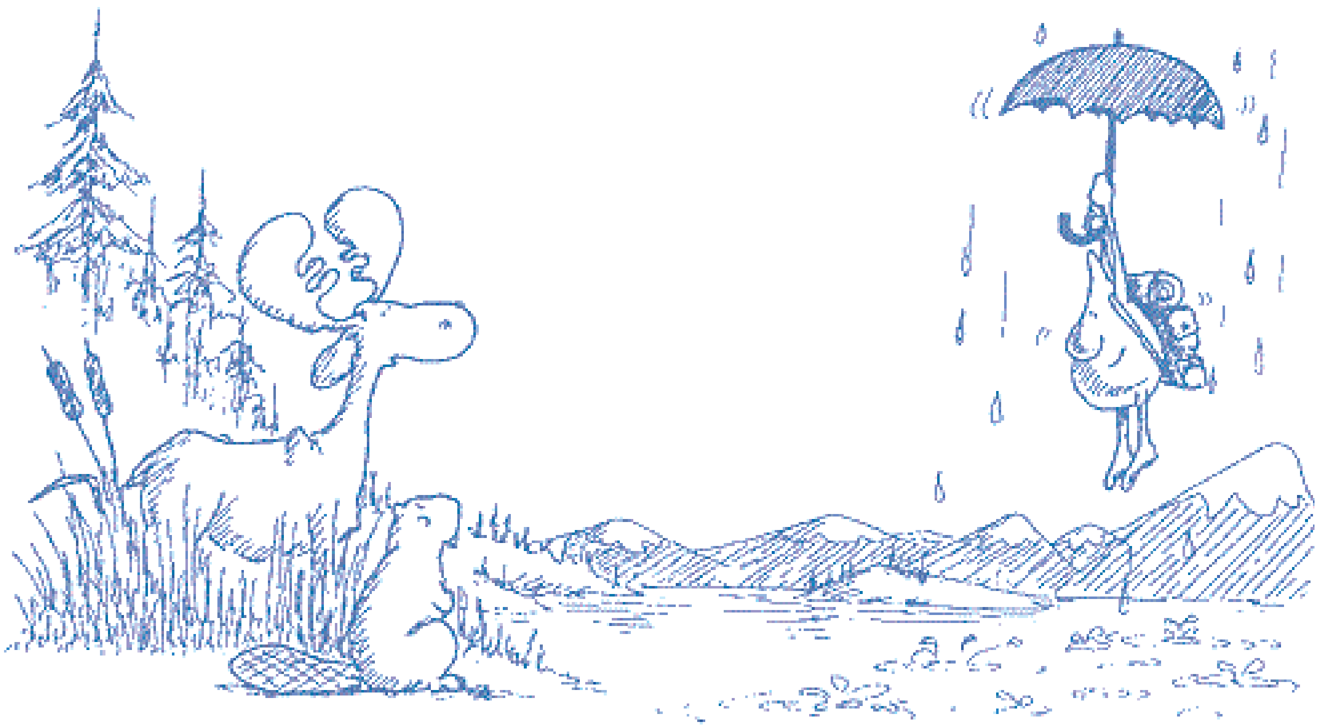
A significant program that aims at protecting our remaining wetlands is the North American Waterfowl Management Plan (NAWMP). In 1986, the governments of Canada and the United States signed the plan in reaction to the sharp decline in waterfowl populations associated with the destruction of their habitat. They were joined by Mexico in 1993.

The plan itself outlines the scope of the work to be done on a continental basis and provides broad guidelines for habitat protection and management actions. Many partners — from federal and provincial or state governments to nongovernmental organizations and landowners — representing various interests, work in partnership to achieve the NAWMP's goal to restore, protect, and enhance wetland habitat for the benefit of waterfowl, biodiversity, and humans.

To receive additional information on the NAWMP, contact:

North American Waterfowl Management Plan
c/o Canadian Wildlife Service
Environment Canada
Ottawa, ON K1A 0H3
Tel.: 819-934-6034
Fax: 819-934-6017
E-mail: nabci@ec.gc.ca
Web site: www.nawmp.ca

The wetlands of Lake Ontario have suffered severe loss over the last two centuries due to agricultural drainage and urban encroachment.



WATER — In Canada

83. Is Canada a "water-rich" country?

Assessing the "water-richness" of Canada is a complex process involving many geographic, physical, economic, and social issues. Canada's fresh water can be found in the form of rivers, lakes, groundwater, ice, and snow. Considering that on an average annual basis, Canadian rivers discharge close to 7% of the world's renewable water supply, Canada appears to have a generous water endowment. Aggregate measures, however, can be deceiving.

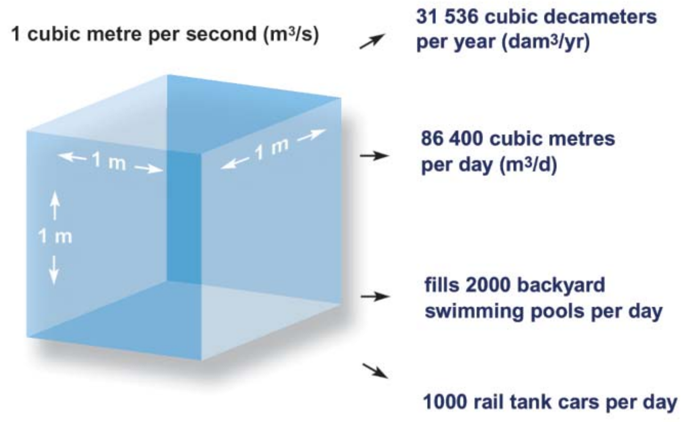
Some areas in the interior of British Columbia, the southern Prairies, and the high Arctic experience arid or semi-arid climates (less than 35 centimetres of annual precipitation). In these areas, the water supply is further limited because the groundwater tends to be salty and unsuitable for many uses.

Approximately 60% of Canada's fresh water drains north, while 85% of the population lives within 300 kilometres of the Canada–United States border. Many areas have restricted water supplies, and water availability constitutes a major concern for water management. Even in the Great Lakes basin, the world's largest freshwater lake system, some off-lake areas in southern Ontario experience periodic and even chronic water shortage, and groundwater "mining" takes place (i.e., more water is taken out of the aquifer than is being recharged). In this region, a significant increase in the consumptive use or a reduction in the supply of Great Lakes waters would result in a lowering of long-term mean levels of the lakes.

In many of the settled areas of the country, water is extremely polluted and is either unsuitable for human, animal, and industrial use or usable only at a relatively high cost of treatment.

Annually, Canada's rivers discharge 7% of the world's renewable water supply – 105 000 cubic metres per second.

Water flow comparison



84. How do you measure water in lakes and rivers?

Environment Canada's Water Survey of Canada, along with many contributing agencies, presently measures the rate of flow (discharge) in rivers and records the levels of lakes and rivers at more than 2900 locations in Canada.

- Water levels are read manually by gauge readers or continuously recorded either electronically or on graph paper or in digital form.
- Rate of flow (or discharge) requires multiple measurements of channel depth, width, and flow velocity to yield the average discharge in the stream crossing for a given water level. Measurements can be made electronically from a bridge, by wading into a stream, by boat, or from a cableway strung across the river. In winter, the measurements are made through the ice.

Typical river flows (from lowest to highest daily average, m^3/s)

Location	River	Annual average	Daily average	
			Highest	Lowest
Prince Edward Island	Dunk River at Wall Road	2.55	84.7	0.212
Saskatchewan	Qu'Appelle River near Lumsden	5.44	436	0
New Brunswick	Lepreau River at Lepreau	7.37	340	0.028
Manitoba	Manigotagan River near Manigotagan	8.93	103	0.065
Ontario	Rideau River at Ottawa	37.2	583	1.48
Newfoundland	Gander River at Big Chute	119	1 170	2.78
Alberta	Athabaska River at Hinton	175	1 200	10.8
Yukon	Yukon River at Whitehorse	243	646	32.6
Saskatchewan	South Saskatchewan River at Saskatoon	254	3 940	14.2
Quebec	Rivière aux Outardes à la Centrale de Chute-aux-Outardes	387	2 830	10.5
New Brunswick	Saint John River below Mactaquac	809	11 100	21.5
Ontario	Ottawa River at Britannia	1 180	5 060	245
Newfoundland	Churchill River above Upper Muskrat Falls	1 740	6 820	253
British Columbia	Fraser River at Hope	2 720	15 200	340
Ontario	Niagara River at Queenston	5 880	9 760	2 440
Ontario	St. Lawrence River at Cornwall	7 350	10 700	4 500
Northwest Territories	Mackenzie River at Norman Wells	8 480	33 300	1 680

Note: This table is based on historical data to 1999, extracted from the national HYDAT database.

With approximately 8% of its territory covered by lakes, Canada has more lake area than any other country in the world.

- With sufficient measurements of flow over a variety of water levels (including extreme lows and highs), a water level–discharge relationship is established at each location so that the discharge can be computed from measured water levels.
- Historical records from over 8000 active and discontinued sites permit the estimation of streamflow at ungauged locations.

85. Why do you need to know how much water Canada has?

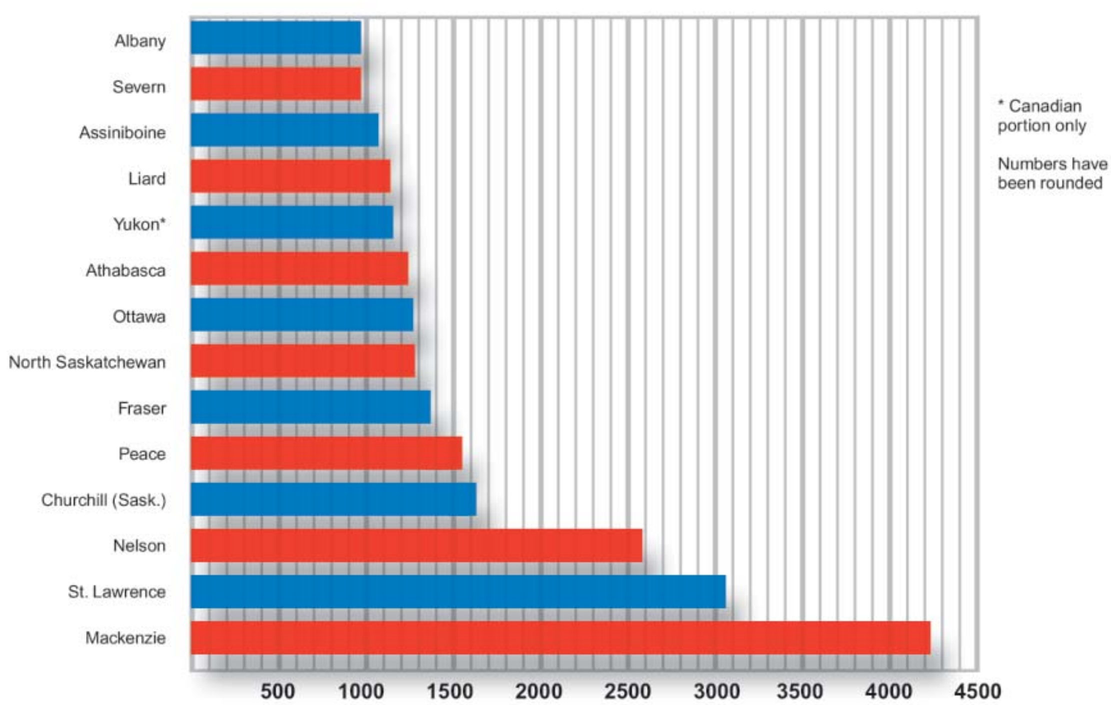
Water level and discharge information is essential for the wise management of Canada's water resources. For example,

- to allocate water between various users
- to manage water resources or minimize the impacts of extreme flows (e.g., flood protection, floodplain mapping, diversion canals, and irrigation)
- to design and construct bridges, canals, culverts, roadways, water supplies, irrigation facilities, and countless other structures
- to plan and conduct environmental programs and assessments related to water quality, fisheries, and wildlife habitat
- to ensure that the nation's water resources are developed in a manner that conserves and protects the environment.

86. Which are the largest bodies of water in Canada?

Our rivers and lakes situated north of 60 degrees latitude constitute some of Canada's largest water bodies. The Mackenzie River, for example, is over 4000 kilometres long and is the country's largest river. Great Bear Lake, Northwest Territories, is the world's ninth largest lake (by area). The St. Lawrence–Great Lakes drainage basin is the largest in southern Canada.

Longest rivers in Canada
(kilometres)



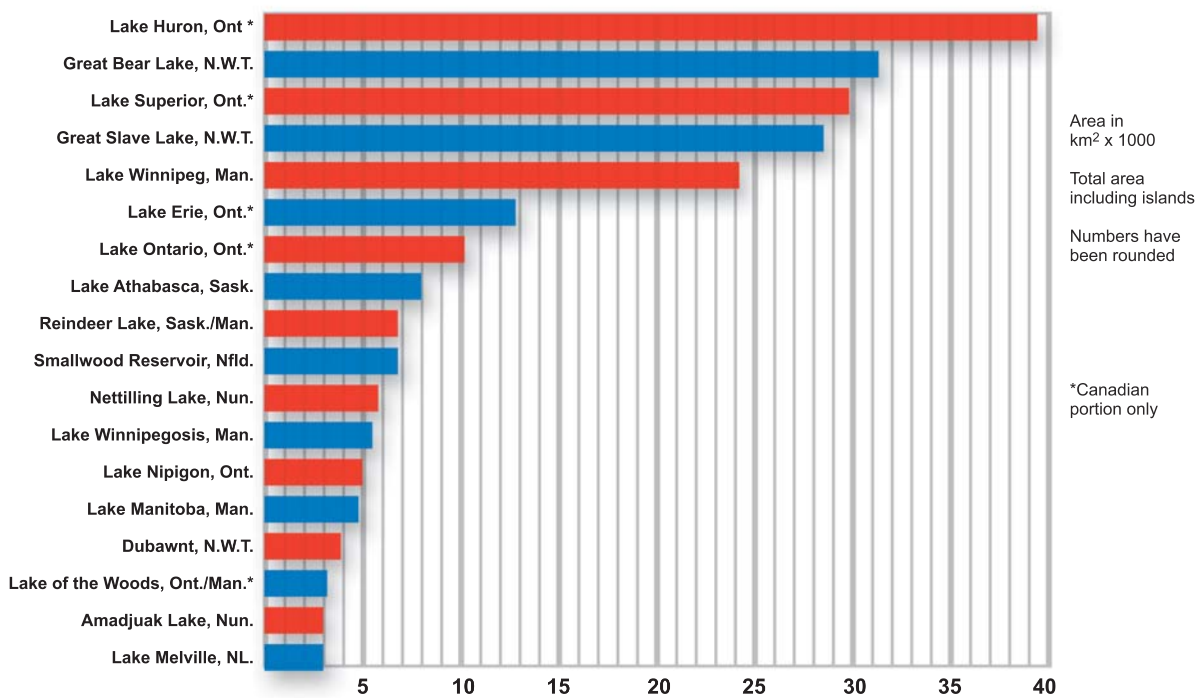
In Canada, an estimated area of 200 000 square kilometres, or about 2% of the country's area is covered by glaciers and icefields.

87. What percentage of Canada's fresh water is found in the Northwest Territories and Nunavut?

The Northwest Territories and Nunavut cover 34% of Canada's land mass, and have 18% of its lake area. Average annual runoff produced within the two territories is 18% of the total for Canada, and another 5% of that total flows into this area from the south.

The Northwest Territories' and Nunavut's portion of Canada's fresh water must be estimated on the basis of the total mean annual flow of rivers, as accurate data on water stored in its lakes, under the ground, and in glaciers are unavailable. However, northern runoff is less significant than commonly perceived because the North is a cold desert. Relatively little water is actually circulating in the hydrologic cycle, due to permafrost conditions, seasonal storage of water in snow, and long-term storage in glaciers.

Largest lakes in Canada



88. What is meant by sustainable development of water resources?

Many Aboriginal peoples of Canada believe that one must consider the impact of any decision on one's children, grandchildren, and great grandchildren seven generations hence to ensure that their needs can be accommodated in the future. Sustainable development has been defined by the Canadian Council of Ministers of the Environment as "development which ensures that the utilization of resources and the environment today does not damage prospects for their use by future generations".

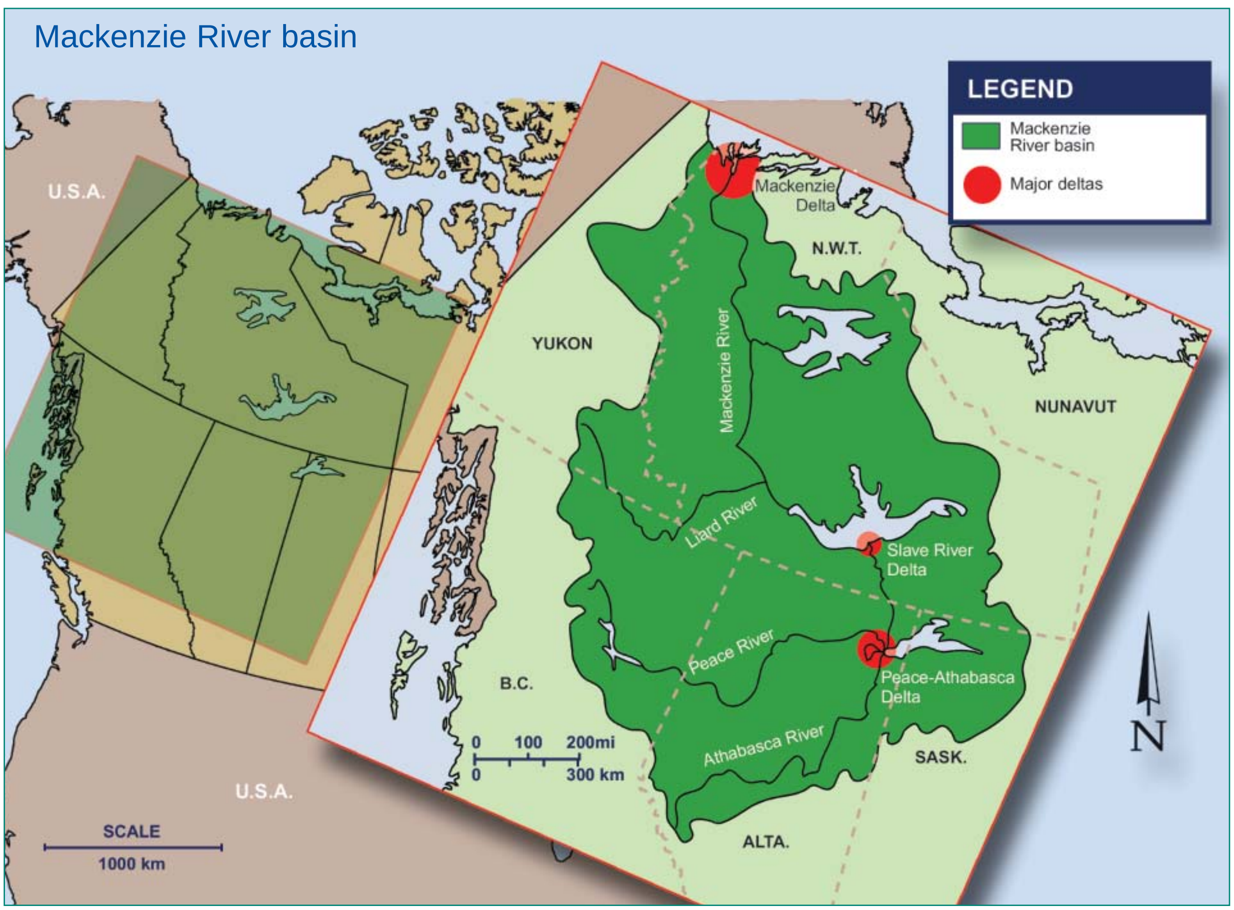
Industrial development on a river may involve activities that seriously damage our soil, water, and atmosphere. To make the development "sustainable",

Canada's longest inland waterway stretches 3 700 kilometres from the Gulf of St. Lawrence to Lake Superior.

environmental, social, and economic planning cannot proceed independently of each other. They must be integrated. Our water resources must be developed in harmony with the natural ecosystem so that neither the water resource nor the plant and animal life dependent on it are depleted or destroyed for short-term gain and at the expense of future generations. Long-term economic growth depends on a healthy environment.

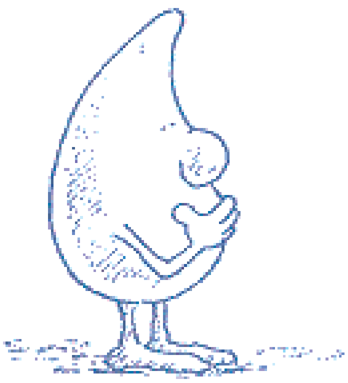
89. Is the water that flows into the oceans from lakes and rivers wasted?

Not at all. It is an essential part of the global hydrologic cycle. This water is vital to navigation, recreation, fish and wildlife support, and waste dilution, and so sustains the lifestyles of large and small communities across Canada. Even in the least populated northern reaches of this country, the seasonal fluctuation of high and low flows strengthens a stable relationship among natural forces such as climate, sediment transport, and freshwater discharge to the marine environment. For example, the Mackenzie River system has two inland deltas and one of the world's largest marine deltas, the Mackenzie Delta. (A delta is sediment deposited where a river discharges into a lake or ocean.) Most of the birds using the western flyway make their home in these deltas or use them to rest and feed on their long migrations. Northern rivers flowing into the Arctic Ocean are an essential component of the hydrologic cycle and contribute to this large aquatic ecosystem.



In Canada, the individual river system with the largest drainage area is the Mackenzie River, with 1 805 200 square kilometres.

WATER — How we share it



90. What do we mean when we talk about watersheds, river basins, catchment basins, and drainage basins?

Generally speaking, these four terms have similar meaning and are frequently used interchangeably. They refer simply to the total land area drained by a river and its tributaries. Originally, “watershed” denoted the imaginary line, or drainage divide, separating the waters flowing into different rivers or river basins, and is still often used in this context. Through common usage, it has also evolved to mean the area drained by a river system. “Drainage area” and “watershed” are more prevalent in North American practice, while “catchment” is customary in British and Australian water source communities. Canada’s landmass is composed of five major drainage basins: Atlantic (which includes the Great Lakes and the St. Lawrence River); Pacific; Hudson Bay; Arctic; and the Gulf of Mexico. Each of these can be further divided into a hierarchy of progressively smaller basins or watersheds down to areas that drain individual lakes and rivers.

91. Do most river basins fall within provincial, territorial, or national boundaries?

River basins are defined by topography. Smaller basins (subbasins of the larger basins) often fall within provincial or territorial boundaries. However, most larger basins cross one or more of these boundaries. For example, the Mackenzie River basin contains seven provincial and territorial boundaries, as well as federal lands, and involves three provinces, two territories, and the federal government in its management. Some basins, such as the Saint John River basin, extend beyond the Canadian border. These are often referred to as Canada–United States “boundary waters”. The Great Lakes are an example of a very large boundary basin.

92. Do we divert water between different watersheds and river basins in Canada, and if so why?

In Canada, major diversion projects have been developed by power utilities to increase flows for hydroelectric production, especially in northern projects such as the Churchill–Nelson region in Manitoba and in the James Bay region in Quebec. Projects have also been constructed for irrigation purposes and industrial development such as aluminum production.

The Prairie Provinces Water Board, a federal–provincial board, administers the Prairie Provinces Master Agreement on Apportionment (1969). The agreement requires Alberta to deliver 50% of annual natural flows to Saskatchewan. In the case of the South Saskatchewan River, an average of 80% has been passed on since 1970. Even during the severe drought of 1988, 58% of the river's natural flow entered Saskatchewan.

While, in the past, major diversions and transfers have been used to fulfill water resource and economic development objectives, it is widely recognized that we have moved away from the era of large scale diversions and transfers in Canada and the United States. Environmental and social considerations are making these transfers of water a less desirable option. Present approaches now favor reducing the demand on water uses.

93. What are the advantages and disadvantages of diverting streamflow from one drainage basin to another?

In the past, diverting flow from one basin to another has been primarily based on economic development through energy generation, irrigation, and industrial output.

Interbasin diversions can have undesirable social and environmental consequences. For example, the amount of water being removed in relation to the amount of water available, existing water demand and uses, quality of water being transferred, including the potential for the introduction of undesirable non-native species and pathogens, can all have significant impacts. The implication of introducing non-native species is particularly significant when major drainage basins are involved.

Social structures may also be affected. Sometimes communities are flooded out or people are forced to change their livelihood or otherwise modify their traditional way of life. For example, the Aboriginal community of Southern Indian Lake in Manitoba had to be partially relocated as water levels rose behind a control structure so that the reservoir could spill through a diversion channel into the Nelson River. The community was also forced to abandon its commercial fishing on the lake, as mercury from flooded soils accumulated to dangerous levels in the whitefish.

In order to protect the health and integrity of Canada's drainage basins the Government of Canada opposes bulk water removals, including interbasin diversions, from major Canadian watersheds. However, decisions on smaller scale diversions must be weighed carefully between the economic benefits to society and the environmental disruption of water-based ecosystems and the impact on communities within the watersheds.

94. How do problems arise over sharing water?

We all live downstream from somebody else! If water is removed, consumed, or transferred *upstream*, it will not be available *downstream*. If the river flow is reduced, even temporarily, by upstream storage such as a reservoir, then downstream activities such as shipping, recreational boating, and fish spawning may suffer. Similarly, pollution upstream can make the water unfit for use downstream and force downstream users to clean it up before it can be used again.

95. Is it complicated to work out a solution to user conflicts?

User conflicts arise because the same water is required for many purposes. A lake, for example, provides the water source for a community's drinking water while at the same time providing for the needs of farmers, boaters, swimmers, and local industry. The biggest challenge, when conflicts arise, is obtaining the support of all parties to study the problems and to work together to find a solution. Rarely is a single government or agency responsible for all of the actions required to prevent or resolve any given conflict among users. The issues are often complex and complicated and involve a number of different types of studies (technical, economic, environmental, sociological, and legal).

Forty percent of Canada's boundary with the United States is composed of water.

Public involvement at various stages during the process is vital. Above all, what is needed is a real commitment from all parties to maintain an open dialogue focused on maximizing social, economic, and environmental benefits.

96. Are there any rules governing how two or more provinces, territories, or Aboriginal governments share the use of water from the same river or lake?

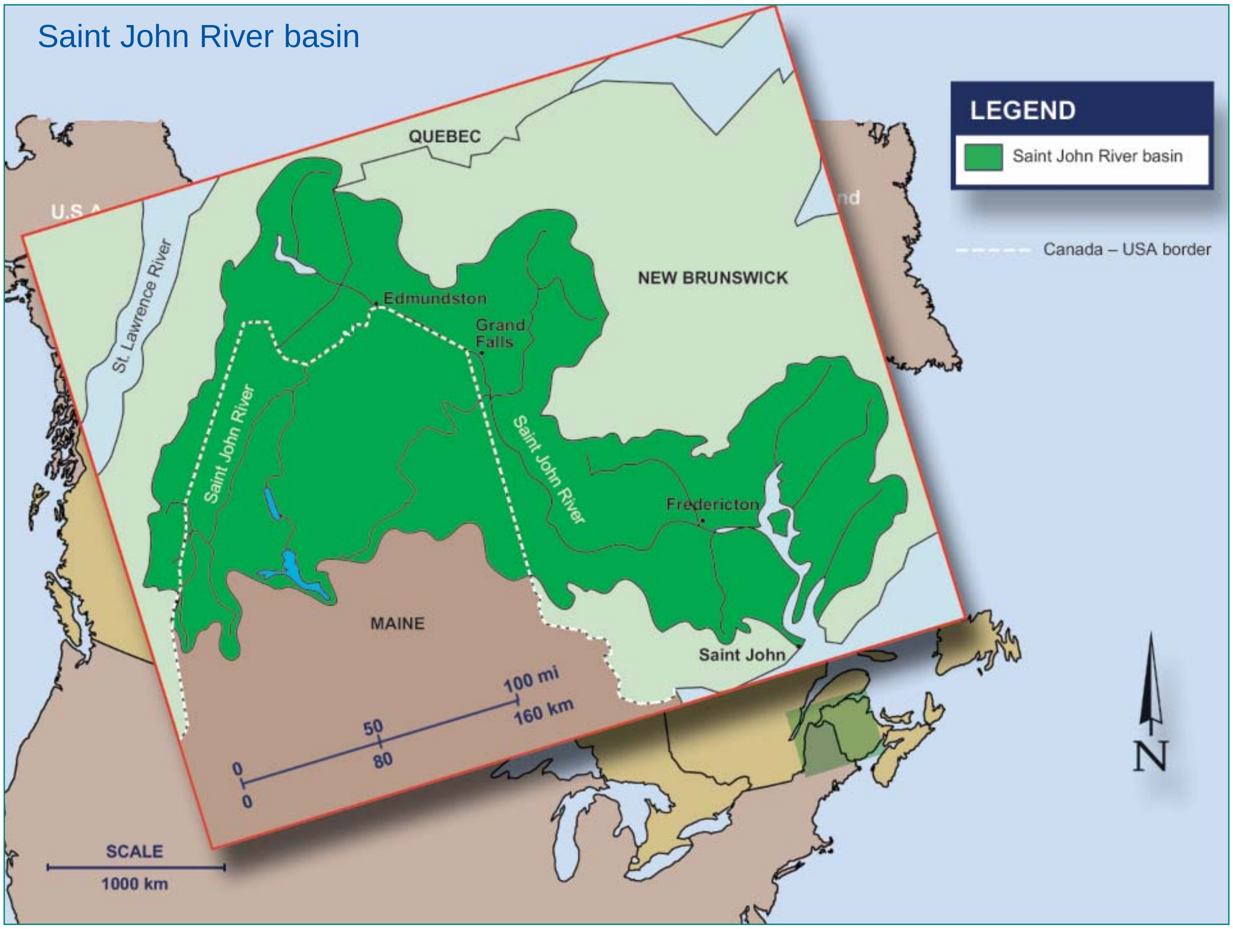
There really are not hard and fast rules unless the governments involved have negotiated such rules among themselves. For example, after many years of negotiation, the three Prairie provinces agreed in 1969 on a formula for sharing common water sources. The agreement ensures that one half of the natural (eastward) flow of waters originating in or flowing through Alberta is reserved for Saskatchewan, and that one half of the eastward flow originating in or flowing through Saskatchewan is reserved for Manitoba. In addition, a broad water resources cooperation agreement was concluded in 1997 by governments in the large Mackenzie River basin. The agreement endorsed the principle of managing water resources for future generations in a manner consistent with the maintenance of the integrity of the aquatic ecosystem and provided for early and effective consultation on potential developments in the basin.

97. What arrangements do Canada and the United States have for the sharing of boundary waters?

The longest-standing and arguably one of the most important bilateral environmental agreements between Canada and the United States is the Boundary Waters Treaty of 1909. The treaty established the principles and mechanisms to prevent and resolve disputes regarding the quantity and quality of these waters. These principles provide the basis for the protection of waters shared by our two countries. Pursuant to the treaty, governments established the International Joint Commission (IJC) in 1911 as an impartial binational commission to oversee the implementation of the treaty. The treaty stipulates that the IJC's approval must be obtained for situations involving the use, obstruction, or diversion of boundary and transboundary waters that affect the water's natural level or flow. The treaty also allows for the governments of Canada and the United States to use the IJC as an independent fact-finding mechanism to carry out studies on matters of concern along the boundary and to make recommendations to both governments. As a result of the IJC's work, additional institutional arrangements have been established for the management of specific boundary waters. For example, IJC studies and recommendations on Great Lakes pollution led to the establishment of the Great Lakes Water Quality Agreement in 1972 and its subsequent amendments in 1978 and 1987. In addition to a number of international agreements on shared boundary waters, more than 20 water boards have been established to oversee the management of various boundary and transboundary watersheds and report either to the IJC or to the Canadian and U.S. federal governments.

Some neighboring provinces and states have also entered into voluntary arrangements for managing and protecting boundary water resources. The best known example of this type of arrangement is the Great Lakes Charter of 1985, signed by the eight governors and two premiers of the Great Lakes–St. Lawrence River states and provinces. The charter commits the signatories to manage the water resources of the Great Lakes basin cooperatively and in accordance with a watershed strategy that reflects the unity of the Great Lakes system. In the Atlantic region, the province of New Brunswick and the state of Maine have set up the International St. Croix Waterway Commission to deal with the water management issues of this shared river basin.

Almost 60% of the world's fresh water falls within a transboundary basin; where at least one of the tributaries crosses a political boundary.



98. Why is the Chicago diversion from Lake Michigan of interest to Canada?

The Chicago diversion is the largest and best known out-of-basin diversion of the Great Lakes. The diversion was built in 1848 as a means of alleviating water quality concerns in Lake Michigan and to provide a navigation link between the Great Lakes and the Mississippi River. While the rate of the diversion has at times exceeded 280 cubic metres per second (cms), the United States Supreme Court decreed in 1967 (amended in 1980) that the rate of diversion of water from Lake Michigan into the Illinois–Mississippi system be limited to 91 cubic metres per second. Periodically, pressures develop within the United States to increase the rate of diversion, but these are opposed by Canada and by most of the Great Lakes states because of the negative impact on downstream hydropower generation, navigation and shipping, and other economic aspects throughout the Great Lakes–St. Lawrence drainage basin.

Canada, as well as most of the Great Lakes states, oppose any increase of the diversion. This binational opposition coupled with the existing United States Supreme Court Decree suggests that further proposals to increase the flow of the diversion are unlikely at this time.

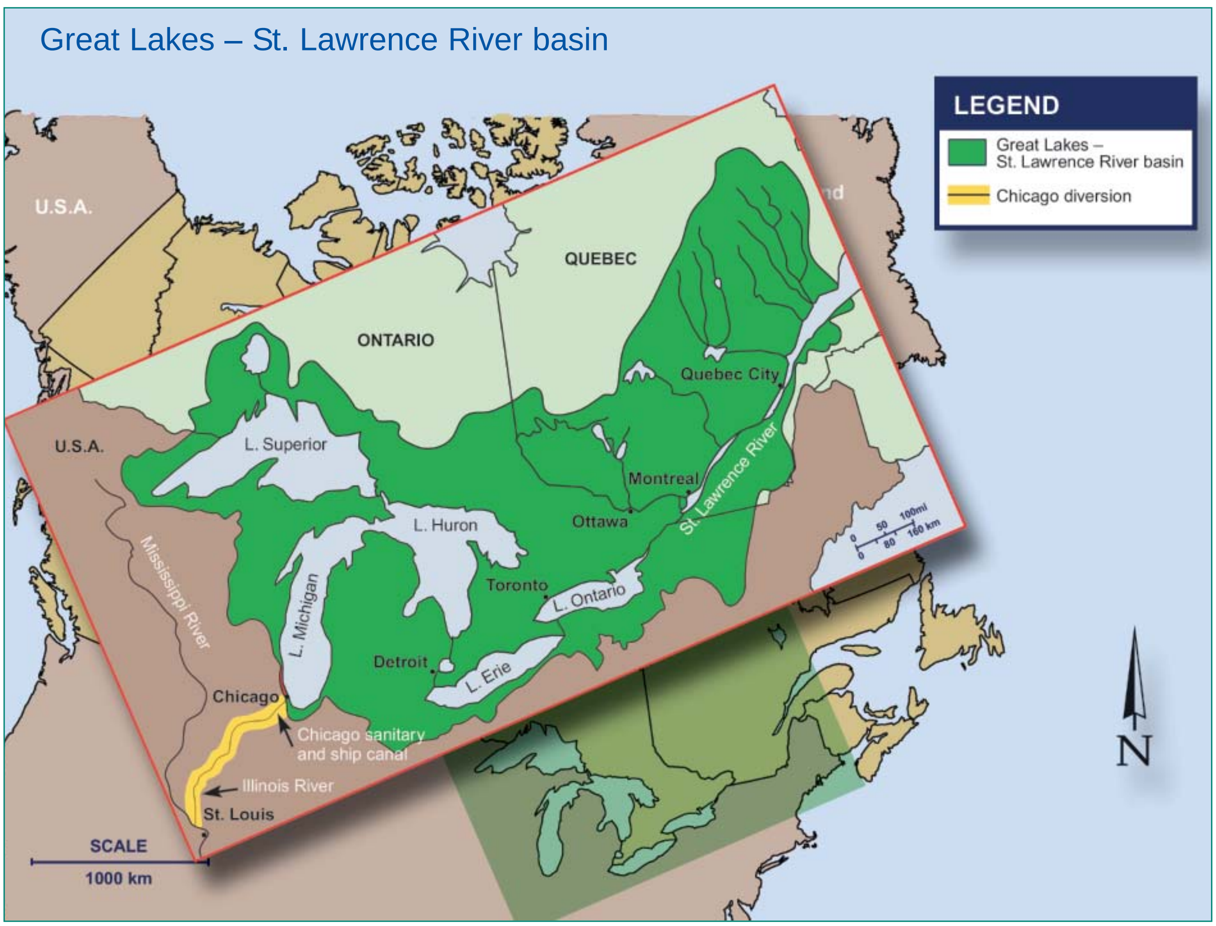
Although the Canadian Dam Association register of dams (2003) reports 933 large dams in the country, there are many thousands of smaller dams.

99. A lot has been written about bulk water removals, including water exports. Does Canada export any water now?

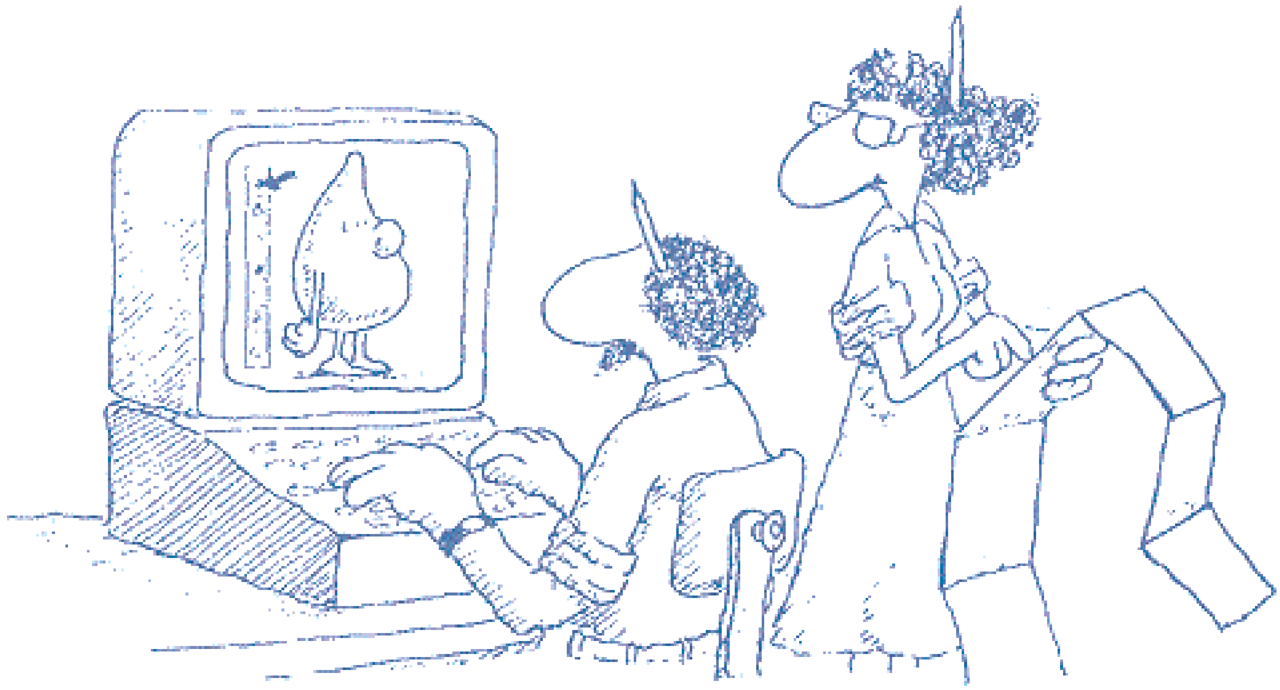
Canada does not export water in bulk via interbasin-transfers, pipelines, or by ocean tanker. Water is exported in small consumer containers and it is also shared between some border communities for domestic water supply purposes. Bulk water removals can individually and cumulatively cause undesirable environmental impacts.

Early in 1999, the Government of Canada launched a comprehensive strategy to prohibit the bulk removal of water from the Canadian portion of major drainage basins, including water removal for export purposes. The strategy is based on principles of ecosystem integrity and sound watershed management. Actions by both the federal and provincial/territorial governments are required to fulfill the strategy.

The strategy includes amendments to the International Boundary Waters Treaty Act to prohibit the bulk removal of water from boundary watersheds, principally the Great Lakes; a joint reference, with the United States, to the International Joint Commission to study the effects of water consumption, diversion, and removal, including removals for export from boundary waters; and a proposal to develop, in cooperation with provinces and territories, a Canada-wide accord for the prohibition of bulk water removals to protect all of Canada's watersheds.



The Great Lakes support 33 million people, including nine million Canadians and eight of Canada's 20 largest cities.



WATER — How we manage it

100. Why do we need to manage water?

The use of water is increasing as urban, industrial, and agricultural expansion has led to increasing competition for the same water supply. Water management involves the anticipation and/or resolution of user conflicts in a manner that protects the environment. Good water resource management maintains a balance between growing social and economic demands and the continued ability of our freshwater resources to support them.

101. Who is responsible for water management in Canada?

In Canada, the responsibility for water management is shared by the federal, provincial, and municipal governments, and in some instances, by Aboriginal governments under self-government agreements. For the most part, waters that lie solely within a province's boundaries fall within the constitutional authority of that province. The waters flowing in the national parks, First Nation reserves, and other federal lands come under federal jurisdiction. The federal government is also responsible for waters that form or flow across the international boundary between Canada and the United States, and for waters in the Northwest Territories and Nunavut, with the exception of certain limited authorities for Aboriginal governments as defined in self-government agreements. On April 1, 2003, responsibility for the management of water resources in the Yukon was transferred to the Government of the Yukon.

The shared responsibility for fresh water in Canada necessitates close cooperation and collaboration among all levels of government, Aboriginal peoples, and the public.

Today, around 3 800 cubic kilometres of fresh water is withdrawn annually from the world's lakes, rivers and aquifers. This is twice the volume extracted 50 years ago.

102. Who is responsible for water management in the Northwest Territories and Nunavut?

The federal government, specifically Indian and Northern Affairs Canada (INAC), has the overall responsibility for the management of water resources in the Northwest Territories and Nunavut. Through land claims agreements, First Nations and the Inuit, and the territorial governments share in this management through participation on joint resource management boards. As well, Aboriginal governments have certain limited authorities as defined in self-government agreements.

The Northwest Territories Water Act, the Mackenzie Valley Resource Management Act, and the Nunavut Waters and Nunavut Surface Rights Tribunal Act provide a unique framework for managing water resources. Among other things, they establish a water board in each territory that is responsible for conservation, development, and use of water resources. Indian and Northern Affairs Canada (INAC) is responsible for enforcing the legislation and for resource planning, collecting data, and supplying information to territorial water boards and the public. The department is also involved in water quality issues and the effect of contaminated water on the health of northerners. Furthermore, under its Northern Water Research Studies Program, INAC's Water Resources Division shares responsibility with Environment Canada's Water Survey of Canada for the hydrometric network that monitors flows on major water courses, and shares responsibility with Environment Canada for collecting water quality data.

103. What are the major water issues in the Yukon?

Because the Yukon is a subarctic desert and water is relatively scarce, water is of critical concern to its industries, communities, and ecosystems. However, flooding connected with ice formation and breakup is also a common concern, as most communities are built in valleys. In addition, water quality-related mining issues are of major concern. From a management point of view, boundary questions are also relevant, as water flows across the Yukon's borders with Alaska, British Columbia, and the Northwest Territories.

104. What are Historic Canals?

Initially built for transportation, trade, and, in some cases, defence, a number of Canada's canals no longer serve commercial purposes. These canals, now referred to as Historic Canals and managed by the Canadian Parks Service, have developed into places to appreciate and enjoy cultural and natural heritage through land- and water-based activities.

The Historic Canals vary from the single locks of the St. Peter's Canal in Nova Scotia, the Sainte-Anne, Carillon, and Saint-Ours canals in Quebec, and the Sault Ste. Marie Canal in Ontario, to the complex systems of interconnected locks, channels, and natural waterways of the Chambly Canal in Quebec and the Rideau Canal and its Tay Branch, and the Trent–Severn Canal and its Murray Canal Branch in Ontario.

The objective of the Historic Canals is to foster their appreciation, enjoyment, and understanding by providing for navigation, by managing cultural and natural resources for purposes of protection and presentation, and by encouraging appropriate uses.

The larger canals have an impact that goes far beyond the movement of boats from one lock to another. They form extensive heritage corridors that link cities and towns and whose drainage basins encompass large geographical areas. The canal corridors encompass rivers, lakes, wetlands, channels, and locks. To provide adequate water for the canals, a complex water control system is in place using dams and monitoring systems. Natural landscapes and habitats along the canals complement the cultural resources and contribute to the environmental

Canada has 563 lakes having an area greater than 100 square kilometres.

quality of the canals. The Historic Canals are managed to provide the optimum balance between the use of the natural resources, especially water, the safety of the public, and the protection of the historic resources.

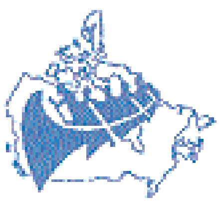
In some cases, the management of these heritage corridors is subject to federal–provincial agreements. Various levels of government, as well as groups and concerned individuals, have a role in fostering public appreciation, enjoyment, and understanding of the values represented by the Historic Canals.

Some other historic canal systems, such as the Shubenacadie Canal in Nova Scotia, have fallen into a state of disarray. Originally built for defence and commerce in the early 1800s, it provided a transprovincial route from Halifax to the Bay of Fundy and then on to the Gulf of St. Lawrence via a marine railway. Small portions of the system have been restored and are currently maintained by the Shubenacadie Canal Commission, a voluntary board of provincial and municipal representatives.

105. What are Canadian Heritage Rivers?

The Canadian Heritage Rivers System, established in 1984, is a cooperative program of the Government of Canada and all of the provincial and territorial governments. The program objectives are to give national recognition to the important rivers of Canada and to ensure long-term management that will conserve their natural, historical, and recreational values for the benefit and enjoyment of Canadians, now and in the future.

Since 1984, sections of 39 rivers, with a total length of more then 8000 kilometres, have been added to the system. For more information on the Canadian Heritage Rivers System, contact:



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106. What laws do we have in Canada to protect lakes and rivers?

Water resources in Canada are primarily the responsibility of the provinces. All provinces have laws to manage and protect lakes and rivers. Some examples of provincial legislation include Manitoba's Water Proctection Act, Ontario's Safe Drinking Water Act, and Newfoundland and Labrador’s Water Resources Act.

The federal legislation related to the protection of our lakes and rivers includes over 14 statutes, administered by several federal departments including its direct constitutional authority for navigation and fisheries. The most recent federal legislative initiatives to strengthen environmental protection, including water, are the renewal of the Canadian Environmental Protection Act and amendments to the International Boundary Waters Treaty Act.

The first Canadian Heritage River was the French River in Ontario, designated in 1986.

107. What is the 1987 Federal Water Policy?

The 1987 Federal Water Policy was formulated after several years of intensive consultation, both within and outside government.

The policy's overall objective is to encourage the use of fresh water in an efficient and equitable manner consistent with the social, economic, and environmental needs of present and future generations. The policy is premised on two main goals: to protect and enhance the quality of the water resource and to promote the wise and efficient management and use of water.

The policy stresses that government action is not enough. Canadians at large must become aware of the true value of water in their daily lives and use it wisely. We cannot afford to continue undervaluing and therefore wasting our water resources.

Currently, there are 2921 active water level and streamflow stations being operated in Canada.

The 1987 Federal Water Policy – strategies and policy statements

Policy statements to which the 5 strategies are being applied:

1. Management of Toxic Substances
2. Water Quality Management
3. Ground Water Contamination
4. Fish Habitat Management
5. Provision of Municipal Water and Sewer Infrastructure
6. Safe Drinking Water
7. Water Use Conflicts
8. Interbasin Transfers
9. Water Use in Irrigation
10. Wetlands Preservation
11. Hydroelectric Energy Development
12. Navigation
13. Heritage River Preservation
14. Management of Northern Water Resources
15. Native Water Rights
16. Canada-U.S. Boundary and Transboundary Water Management
17. Potential Interjurisdictional Water Conflicts within Canada
18. International Water Relations
19. Drought
20. Flooding
21. Shoreline Erosion
22. Climate Change
23. Water Data and Information Needs
24. Research Leadership
25. Technological Needs

The world's largest inland freshwater delta is formed where the Peace and Athabasca rivers flow into Lake Athabasca.

108. What is the Canadian Environmental Assessment Act?

The Canadian Environmental Assessment Act (CEAA) was proclaimed on January 19, 1995. A compulsory five year review of the Act was undertaken, with the renewed Act taking effect on October 30, 2003.

The act sets out, for the first time in legislation, responsibilities and procedures for the environmental assessment of projects involving the federal government. It establishes a clear and balanced process that brings a degree of certainty to the environmental assessment (EA) process and helps responsible authorities (RAs) determine the environmental effects of projects early in their planning stage.

The act applies to projects for which the federal government holds decision-making authority, whether as a proponent — when it makes or authorizes funding to enable a project to proceed, when it sells, leases, or disposes of federal lands, or when it issues a permit or license, or grants an approval — or takes any other action for the purpose of enabling the project to be carried out.

Objectives

The act has four stated objectives:

- to ensure that the environmental effects of projects receive careful consideration before RAs take action
- to encourage RAs to take actions that promote sustainable development, thereby achieving or maintaining a healthy environment and a healthy economy
- to ensure that projects to be carried out in Canada or on federal lands do not cause significant adverse environmental effects outside the jurisdictions in which the projects are carried out
- to ensure that there is an opportunity for public participation in the EA process

Guiding Principles

In general, the following principles should be used in the application of the act:

- Early application. The process should be applied as early in the project's planning stages as practicable and before irrevocable decisions are made so that environmental factors are incorporated into decisions in the same way that economic, social, and policy factors have traditionally been incorporated.
- Accountability. The self-assessment of projects for environmental effects by federal departments and bodies is a cornerstone of the process.
- Efficient and cost effective. Each project should undergo only one EA, and the level of effort required to undertake an EA for the project should match the scale of the project's likely environmental effects.
- Open and participatory. Public participation is an important element of an open and balanced EA process.

109. Does water resource development take into account environmental considerations?

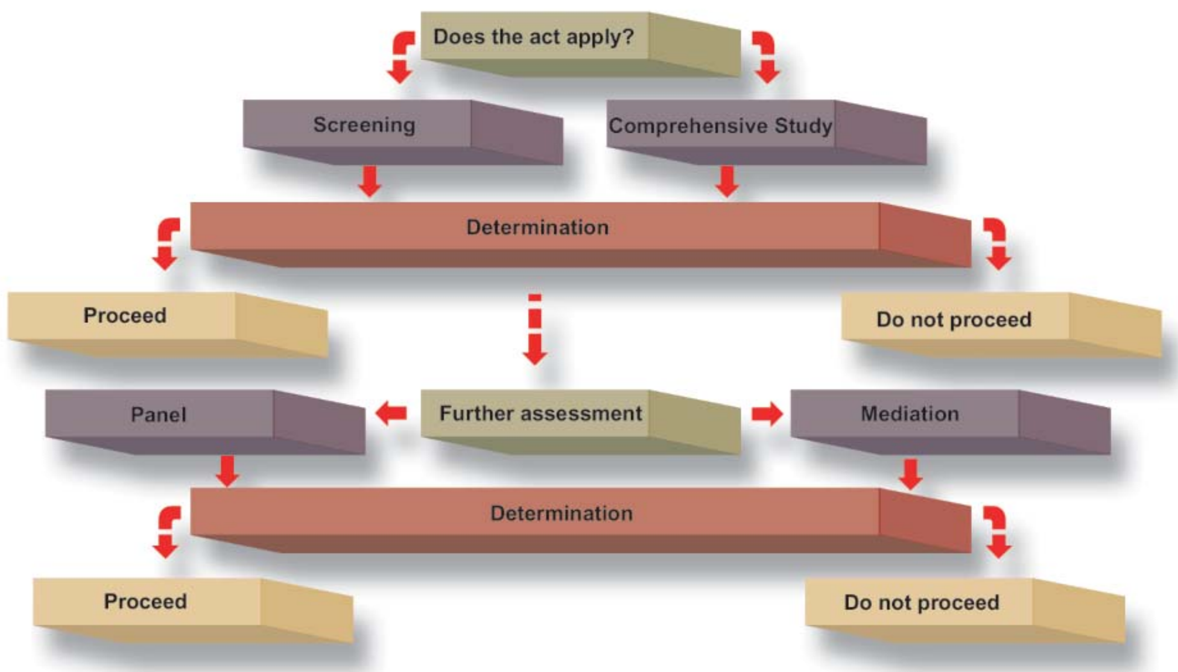
Under the self-assessment role, federal departments hold themselves accountable for following the assessment process described under the Canadian Environmental Assessment Act (CEAA). This process requires all departments to screen proposals for potentially adverse environmental effects and to ensure that public concerns have been considered.

All water development projects affect some part of the environment. Smaller projects, such as constructing a weir or operating a water intake pipe, will harm the environment to a lesser degree than, for instance, a large-scale hydroelectric project that diverts or stores large quantities of water.

The highest waterfall in Canada is Della Falls, B.C. at 440 metres.

The negative impacts of such a large project, however, can be reduced. After a site has been chosen, field studies, monitoring, and a literature review will provide an understanding of the existing environmental conditions. This permits prediction of the impacts that the project will have on the environment and is the essence of the Environmental Impact Statement, which is produced for a project under CEAA. Based on these predictions, design engineers working with other professionals such as biologists can mitigate impacts by adjusting the project design.

Overview of the Canadian Environmental Assessment Act (CEAA)



To learn more about the purpose and types of environmental assessment, see “Basics of Environmental Assessment” on the Canadian Environmental Assessment Agency’s Website at www.ceaa-acee.gc.ca/010/basics_e.htm.

110. What does environmental screening try to achieve?

Screening determines whether a water resource proposal, such as building dykes, filling a reservoir, or dredging a harbour, will have potentially adverse environmental effects and whether these can be corrected. If so, the project may go ahead without detailed environmental impact studies, but only after scientists and water managers have designed adequate measures to protect the environment or minimize negative environmental effects.

Henderson Lake, British Columbia, has the greatest average annual precipitation in Canada – 6 655 millimetres.

For water development projects, these measures might include the construction of fish ladders for migrating fish, the creation of wetland habitat for waterfowl nesting, and the establishment of industrial processes to reclaim pollutants and prevent their entry into the hydrologic cycle. These measures along with their costs are then considered part of the overall project.

111. What do we mean by an "ecosystem approach" to water management?

An ecosystem or holistic approach to water management requires an understanding of the interrelationships of the biological, chemical, and physical properties of an aquatic ecosystem. Once we understand the ecosystem, we can take certain measures to minimize large-scale and long-term impacts resulting from human uses.

In cases where these impacts cannot be avoided, alternative measures can be taken. For example, the loss of fish habitat caused by dam construction may require the operation of a fish hatchery to replace young fish that can no longer be supplied by the lost habitat.

112. Are there any rules on how to deal with sensitive water development?

Manuals and handbooks dealing with habitat protection are produced by environmental and regulatory agencies as well as nongovernmental organizations and universities. Guidelines to maintain water quality for stream crossings and fish passage and for waste disposal are developed and continually improved. Such guidelines recommend conditions that should not be exceeded in order to sustain a particular water use and the well-being of the aquatic environment.

Provincial and federal environmental legislation is also updated periodically to ensure comprehensive protection of our ecological resources from the impacts of development.

113. Why is it necessary to obtain a licence for surface water or groundwater use?

To share the resource equitably, a provincial or territorial licence is required to define the allowable quantity and timing for each use. Although seemingly abundant, the groundwater supplies in certain regions of North America are coming close to depletion and are being threatened with contamination.

114. Can floods be predicted?

To some extent, heavy rain forecasting and warning systems minimize flood damage effects, and help prevent the loss of life.

There are a number of forecasting centres across Canada that monitor conditions that influence flooding. When it is determined that there is a potential for flooding, the forecasters notify dam operators, municipal officials, emergency personnel, and the media. Warning systems and emergency procedures are put into effect to allow residents to protect their homes, move valuables to safe ground, and, if necessary, to evacuate. The warning system also allows officials time to prepare such protective actions as sandbagging along river banks.

115. Water management also deals with flood protection. What are some methods of protection?

The most recognizable methods of flood protection are engineering works such as dams, dykes, and diversion channels. These types of projects can be expensive to build and maintain and yet they do not necessarily provide a complete guarantee of safety. During extreme events, floodwaters may overtop dykes and exceed the capacity of reservoirs and diversion channels.

During the 1970s, an alternative to the structural approach was developed to reduce the amount of damage and suffering caused annually by floods. In 1975, the federal government initiated the National Flood Damage Reduction Program in cooperation with provincial and territorial governments. One of the main objectives of the program was to produce maps identifying flood-risk areas within selected floodplains and designating them as such. The active mapping phase of

Eureka, in Nunavut, has the least average annual precipitation – 64 millimetres.

the program was finished in the late 1990s. New development in designated areas was discouraged under the program. Cities were encouraged to adopt suitable land use policies and appropriate zoning to restrict development in designated floodplains. Although this approach stressed nonstructural methods for reducing flood damages, it was also recognized that a combination of structural and nonstructural methods would be necessary in certain conditions.

Existing buildings or new construction may be protected by various flood-proofing methods. For example, buildings may be elevated on posts, piers, or landfill. Flood walls or ring dykes can protect groups of buildings. Foundations and basements can be designed to allow some flooding. Consideration should also be given for the protection of electrical, sewage, and other services.

116. What is the importance of reservoirs to water management?

Without a water supply from reservoirs, many of our farming communities in western Canada (the British Columbia interior, southern Alberta, and Saskatchewan) would have drastically reduced populations and economic activity. During the past several years, Regina and Moose Jaw have greatly depended on the Diefenbaker Reservoir. The water supplying the Lac Seul Reservoir averted a major power outage in Manitoba and northwestern Ontario in 1988.

Like everything else, reservoirs are not a perfect solution, but they do substantially reduce the probability of failure of domestic water supply and power shortages. Management of reservoirs in many systems such as the Ottawa River is a compromise between low flow augmentation and flood protection. In water-short areas, there is no compromise, only conservation.

117. Is water research necessary for water management?

Definitely. Research is a valuable management tool. To manage water properly, we rely on a scientifically sound knowledge base. The 1987 Federal Water Policy states that "scientific and socio-economic research, technological development, and data collection are essential tools for dealing with the increasing scope and complexity of the emerging water problems". There is also growing recognition of the validity of Aboriginal traditional knowledge regarding the environment and the holistic interaction of various elements.

In addition to the St. Lawrence Centre in Montreal, Quebec, Environment Canada operates the National Water Research Institute (NWRI) with major facilities in Burlington, Ontario, and in Saskatoon, Saskatchewan. These sites conduct a Canada-wide program of research and development in water science in partnership with other Canadian research establishments and the international freshwater scientific community. A major goal is to advance our understanding of the physical, chemical, and biological processes controlling the quality and health of aquatic ecosystems.

The NWRI publication *Research into Action to Benefit Canadians* contains short summaries of how practical, applied science supports the development of regulations, guidelines, policies and international agreements; and the tangible economic and health benefits that stem from sound stewardship of our aquatic resources (*www.nwri.ca/researchintoaction/intro-e.html*).

118. Why do we need all this information on water?

Environmental monitoring, resource inventories, and field studies all provide a record of past or present water resource conditions. The data describe the state of the resource for different geographic locations and at different times; the physical, chemical, and biological characteristics of the water; and the economic, social, and institutional makeup of the system of which the water resource is a part. For

Many of the lakes on the Canadian Shield, including those of the Great Lakes, were created by glacial erosion.

example, the information includes data on water quantity and quality, runoff characteristics, water user needs, fish and waterfowl numbers, vegetation distributions, and habitat inventories.

Other information is obtained by studying changes in the resource over time. For this, an understanding of the cause and effect relationships between different environmental components, the water resource, and human activities is necessary. These relationships can be determined from experimental research in the laboratory or in the field and from physical or numerical models, including computer simulation. From models, scientists can forecast trends in water quantity and quality. Based on this and information obtained by monitoring the water resource, managers develop water management strategies, plan the development of river basins, and operate water facilities such as dams for the greatest benefit to all users.

119. Why is computer modeling used?

The use of mathematical models to simulate real situations represents an important step in both the understanding and appreciation of the governing factors in a typical water management problem. Models can also be used as a comparatively cheap, fast, and safe way in which to test the viability of various water resource management strategies before deciding which to implement.

120. What are these computer models supposed to achieve?

Mathematical models are used by water managers both for planning purposes and for simulation of operational conditions.

The *planning models* use water quantity, water quality, and various socio-economic data collected over 30 years or so to study the impact on the environment of proposed dams, changes in operating procedures, dykes, diversions, effluent treatment plants, and new water uses. Such studies usually assume that past meteorological conditions are representative of future ones. A planning model was used to design the weirs for the Peace–Athabasca delta, the world's largest freshwater delta, to mitigate the detrimental effects of the upstream Bennett Dam constructed in 1970.

Operational models are used to forecast flows, levels, and water quality over a relatively short period of several days or weeks. An operational model is used for the Ottawa River basin to determine flow releases from the 13 major reservoirs in the system.

121. Are the developments in computer and communication technology affecting the way Canadian agencies manage water resources?

Information and Communication Technologies (ICTs) have increased our abililities to store, analyze, and distribute information and data.

Currently, supercomputers can process several hundred million operations per second. This enables water managers to cope with increasingly complex problems in a limited time frame. Satellite telecommunications make data almost instantly available from remote locations for monitoring, forecasting, and operational decision-making purposes. However, even with these significant informatics advances, formidable problems remain in such areas as short- and long-term river flow and lake levels forecasting, and in prediction of the pathways and effects of toxic contaminants in aquatic systems. In day-to-day management, computer modeling programs are, for example, assisting in reservoir operation, flood forecasting, and municipal water demand.

The Internet, which encompasses the technologies of e-mail, listservers, the World Wide Web (WWW), file transfer protocol (ftp), e-commerce, video conferencing etc., is providing an unprecedented opportunity for decision makers, stakeholders, and the general public to have access to a wide array of information from all levels of government, industry, business, and community groups.

In nearly all the world's major religions, water is attributed important symbolic and ceremonial properties.

WATER — The Great Lakes

The issues and concerns faced by water resource managers in Canada are perceived not only in a national perspective (i.e., those problems common to all parts of the country), but also in a regional context (i.e., the interaction of a wide range of problems, many specific to a particular area, such as droughts on the Prairies, floods in the coastal provinces, and fluctuating water levels in the Great Lakes).

The example of the Great Lakes presented here provides insight into one of the regions making up the Canadian mosaic. The Great Lakes basin, which straddles the Canada–United States border, contains 18% of the world's fresh surface water and is home to almost a third of the Canadian population.

122. How important are the Great Lakes to Canada and the United States?

The Great Lakes basin (the lakes plus the area of land draining into the lakes) is home to 8.5 million Canadians and 30.7 million Americans.

As well as providing drinking water, the lakes have played a major role in the development of both countries. They allow goods to be shipped to and from the heart of the continent; they are a source of hydroelectricity; and they are the site of industrial, commercial, agricultural, and urban development. The Great Lakes also provide an array of recreational opportunities.

123. What are some of the problems and issues confronting the management of the Great Lakes system?

The Great Lakes basin is a huge ecosystem. The specific problems in the Great Lakes have changed over time, but the broader issues have remained — those of deteriorating water quality through industrial and municipal uses, fluctuating water levels, flooding, and shoreline erosion. Other concerns are acid rain, airborne toxics, depletion of wetland areas, increased demands on the shoreline land base, the impacts associated with the unintentional introduction of exotic species, and climate change.

The Great Lakes are the largest system of fresh, surface water on earth, containing roughly 18% of the world supply.

124. How important are wetlands as part of the Great Lakes ecosystem?

Great Lakes coastal wetlands are highly productive and diverse communities of plant and animal life. They are essential to the well-being of the Great Lakes ecosystem. Their unique vegetation provides cover and food for wildlife, helps protect shorelines from erosion, and helps improve water quality by filtering pollutants and trapping sediment.

These wetlands are home to a wide variety of wildlife species — some of which are classified as rare, endangered, or threatened. Many fish species depend on Great Lakes wetlands for spawning, resting, and feeding. Wetlands are also critical for waterfowl as both nesting and migration habitat. In fact, it is estimated that 68 bird species are either totally or partially dependent on Great Lakes basin wetlands. About 20 species of mammals, 28 species of amphibians, and 27 species of reptiles have been associated with the marshes of Lake Erie.

Wetlands are also important to humans. We use them for wildlife observation, water supplies, sportfishing, waterfowl hunting, trapping of furbearing animals, harvesting of trees, berries, and other vegetation, adult and public school education, and a variety of recreational pursuits.

Unfortunately, humans also alter and fill in wetlands in order to use them for other purposes. About two thirds of the original wetlands in the lower Great Lakes basin have already been lost or severely degraded, while the health of those that remain continues to be threatened. As the area of Great Lakes wetlands shrinks, the importance of remaining wetlands becomes even greater.

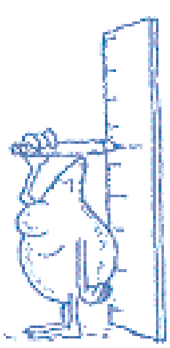
125. Is recreation an important use of the Great Lakes?

Recreation is an increasingly important social and economic activity in the Great Lakes basin. Millions of people, from both within and outside the Great Lakes basin, use the lakes and their shorelines for a variety of recreational purposes.

Among the major recreational activities around the Great Lakes are boating, sportfishing, hunting, bird-watching, camping, swimming, windsurfing, hiking, picnicking, and driving along the shoreline.

These recreational uses supported the establishment of provincial and federal parks and led to a major service industry involving marinas, hotels, motels, resorts, campgrounds, and other nearby land-based recreational establishments. In addition, many people who use the Great Lakes for recreation have cottages or homes along the shoreline.

126. What causes the levels of the Great Lakes to rise and fall?



The Great Lakes receive their supplies of water from inflows from upper lakes in the chain and from precipitation that falls not only on the lakes themselves but also on their drainage basins and eventually flows into the lakes. They lose water through evaporation, outflows, and consumptive uses. The difference between the amount of water coming into the lakes and the amount going out determines whether lake levels remain steady, whether they rise, or whether they fall.

Because the combined effects of precipitation, runoff, and evaporation vary from season to season and from year to year, the levels of the lakes also vary. Lake outflows also vary as a function of lake levels. For example, the lakes usually rise in the spring due to additional runoff and recede in late summer and early fall as runoff decreases.

Lake levels can change over periods of years for the same reasons. During periods of years in which precipitation and runoff in the Great Lakes basin are high and evaporation low, lake levels can gradually increase. In periods of low precipitation and high evaporation, lake levels can gradually lower. The resultant variation in lake outflows offsets a part of these water supply variations, but not

The combined shoreline of the Great Lakes is equal to about 45% of the earth's circumference.

all, hence the variations in lake levels. The length of time required for noticeable changes, and the degree of the changes, will depend on how wet or how dry the weather is and on ambient temperatures.

127. Why do water levels sometimes seem to change from day to day?

Water levels can change in a matter of hours. Sustained high winds from one direction can push the water level up at one end of the lake (this is known as "surge") and make the level go down by a corresponding amount at the opposite end. When the wind stops, the water will oscillate back and forth until it levels itself out, much as it would in a bathtub. This is known as "seiche".

128. How often do extremes in lake levels occur?

Since long-term lake level fluctuations are influenced by weather trends, we cannot predict when and how often extremes in levels will occur.

Levels of some of the Great Lakes fell to record lows in the late 1920s, the mid-1930s, and the mid-1960s. Extremely high levels occurred in the early 1950s, the early 1970s, and the mid-1980s. The most recent record high lake levels period occurred between 1985 and 1987 when all of the lakes, except Lake Ontario, reached their highest levels recorded in the twentieth century. Over the following two years, lake levels dropped rapidly to their long-term averages. The 1990s were characterized by persistently high water levels and outflow throughout the Great Lakes–St. Lawrence system.

129. How do water level fluctuations of the Great Lakes affect people living along their shores and industrial and commercial operations?

For people living on the shores of the Great Lakes, high water levels can increase the risks of shoreline flooding, erosion, and damage caused by waves during storms. Industries and commercial operations along the lake shores can face the same risks. While high water levels allow ships to carry heavier loads, extremely high levels and flows through the connecting channels can cause navigation problems. High levels can also be beneficial for hydroelectric plants, which can produce more electricity with the additional water. During extremely high water levels, however, the amount of water available to these plants can exceed their capacity and be spilled.

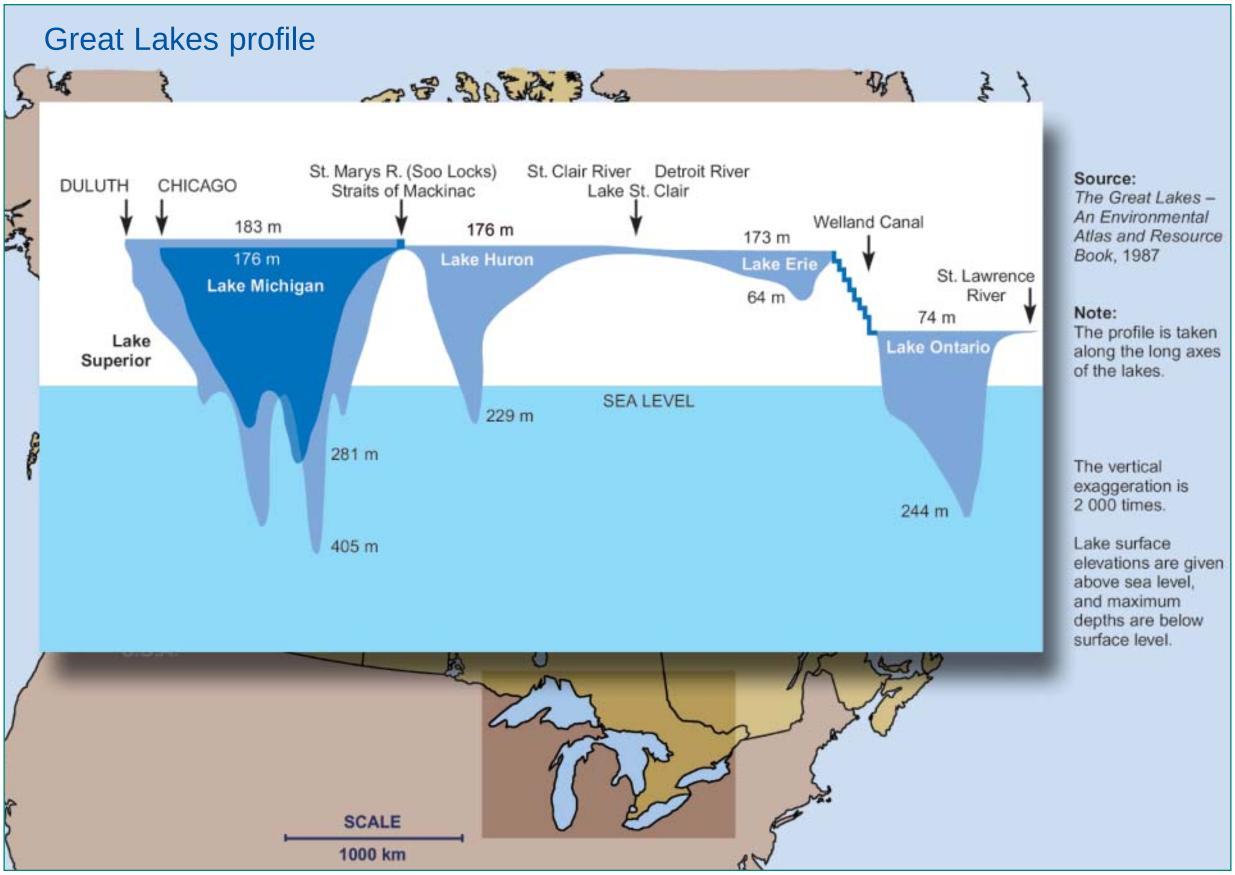
Erosion of the shoreline at one point will supply the sand that helps build a beach farther down shore. This contributes to the constantly changing shorelines of the Great Lakes. Low water levels increase the size of lakeshore beaches, but extremely low levels can expose unsightly and, sometimes, hazardous rocks, mudflats, and other objects that can pose problems to both swimmers and boaters. As well, very low water levels can make some recreational docking facilities unfit for use. For industries depending on ships to transport their products and supplies, extremely low levels can interfere with loading and unloading. These ships may also have to carry lighter loads. Very low levels may cause reduced flows through connecting channels and thereby result in reduced hydropower production.

Wetlands also depend on fluctuating water levels to maintain their ecological balance over the long term. This is true even though extremely high lake levels may flood marshes and lead to changes in their plant and animal populations, and very low levels may dry marshes out and cause other changes to plant and animal life.

The Great Lakes Basin covers an area of 750 000 square kilometres.

130. How have land use changes in the Great Lakes basin affected the lakes themselves?

Since early in the twentieth century, significant changes in land use in the Great Lakes basin have occurred, including deforestation, urbanization, and drainage of wetlands. These activities have changed the runoff characteristics of the drainage basin. Although the extent to which these changes affect lake levels is difficult to define, research suggests that land use changes have increased water flows into the Great Lakes from some tributary streams.



131. Do people also cause changes in lake levels?

Several human activities have affected levels and flows of the Great Lakes. For example, structures have been built to regulate the outflows of Lakes Superior and Ontario. Lake Superior has been regulated since 1921 as a result of hydroelectric and navigation developments in the St. Marys River. Lake Ontario has been regulated since 1960 after completion of the St. Lawrence Seaway and Power Project. Besides assisting navigation and allowing for dependable hydropower, these regulation structures have helped, to some extent, to stabilize the range of lake level fluctuations.

Diversions bring water into, and take water out of, the Great Lakes. The Long Lac and Ogoki diversions bring water into Lake Superior from sources that once flowed into James Bay. They were constructed for hydropower generation and logging. The Lake Michigan diversion at Chicago takes water out of Lake Michigan to the Mississippi River for domestic, navigation, hydroelectric, and sanitation purposes. The Welland Ship Canal, which was built to allow ships to

Passage of a major storm on Lake Erie can cause short-term lake level changes of as much as 4 metres.

bypass Niagara Falls and to provide water for power generation, routes additional water out of Lake Erie into Lake Ontario.

In addition, the St. Clair and Detroit rivers have been dredged and modified. This has caused some drop in the levels of Lakes Michigan and Huron. Channel and shoreline modifications in connecting channels of the Great Lakes have affected lake levels and flows as well. For example, in the Niagara River, construction of bridges and infilling of shoreline areas have slightly reduced the flow carrying capacity of the river.

Human effects on lake levels have been relatively small, however, compared to the changes caused by the natural factors described earlier.

132. Who is responsible for flooding and shoreline erosion on properties along the St. Lawrence River and the Great Lakes?

Planning for and managing the development of the Canadian shoreline is the responsibility of provincial and municipal governments. The protection of shore property is primarily the responsibility of the property owner.

133. How do both countries share the Great Lakes?

The Canada–United States border runs through four of the five Great Lakes and their interconnecting rivers, causing them to come under federal jurisdiction in both countries. Although the land on and under the shores of the lakes is provincial jurisdiction in Canada, the waters of the boundary lakes and rivers are under federal authority.

Canada and the United States are party to the 1909 Boundary Waters Treaty, which was designed to address and resolve disputes and issues regarding the Great Lakes and other boundary waters. This treaty established the International Joint Commission, a quasi-judicial body that may give or withhold approval for the use, obstruction, or diversion of boundary waters shared between Canada and the United States. When requested, it investigates matters of concern to one or both governments and, on mutual consent, it may decide matters of difference between both governments, although it has never been asked to do so.

The Great Lakes Water Quality Agreement (1972, 1978, 1987 Protocol) and the Niagara River Treaty (1950) are examples of arrangements between Canada and the United States that have followed the Boundary Waters Treaty. The federal governments of both countries provide considerable technical support to, and work closely with, the International Joint Commission, for example, on the management, wise use, and stewardship of the Great Lakes. For more information, contact:

Canadian Section Office of the International Joint Commission
234 Laurier Avenue West, 22nd Floor
Ottawa, ON K1P 6K6
Tel.: 613-995-0088
Fax: 613-993-5583
E-mail: commission@ottawa.ijc.org
Web site: www.ijc.org

134. What is being done to resolve concerns about fluctuating Great Lake water levels?

The Governments of Canada and the United States provide the mandate and technical support to the International Joint Commission (IJC) for their international operational boards that monitor and decide on flow conditions in the St. Marys, Niagara, and St. Lawrence rivers. The IJC also carries out major reference studies on Great Lakes levels. The most recent investigation was

Only 1% of the waters of the Great Lakes are renewed each year by snow melt and rain.

completed in 1993 in response to a request by the Canadian and United States governments in 1986, when Great Lakes water levels were at record highs for the twentieth century.

This IJC reference study examined all lake level interests in the basin, including owners of shoreline property, fishers, boaters, shippers, wildlife, and producers of hydroelectricity. Among the findings was the recommendation that federal governments should not undertake commitments to further regulate Great Lakes levels as a means of reducing shoreline flooding and erosion on the lakes. Instead, comprehensive shoreline land use and management programs should be undertaken to help adapt shoreline activities to fluctuations in water levels.

The Government of Canada, through Environment Canada, also established the Great Lakes–St. Lawrence Water Levels Information Office in Burlington, Ontario to act as a focal point for material and public contact regarding fluctuating Great Lakes water levels. In times of extreme high or low water levels, Environment Canada, in cooperation with provincial agencies, is instrumental in providing information and warnings of events to the many Great Lakes interests affected by lake levels. Environment Canada has also cooperated with and provided funds to the province of Ontario and local conservation authorities to identify, map, and plan for more effective use of shoreline lands that are prone to flooding and erosion hazards.

135. What is being done to resolve concerns about Great Lakes water quality?

The Canada–United States agreement provides the framework for resolving water quality concerns in the Great Lakes.

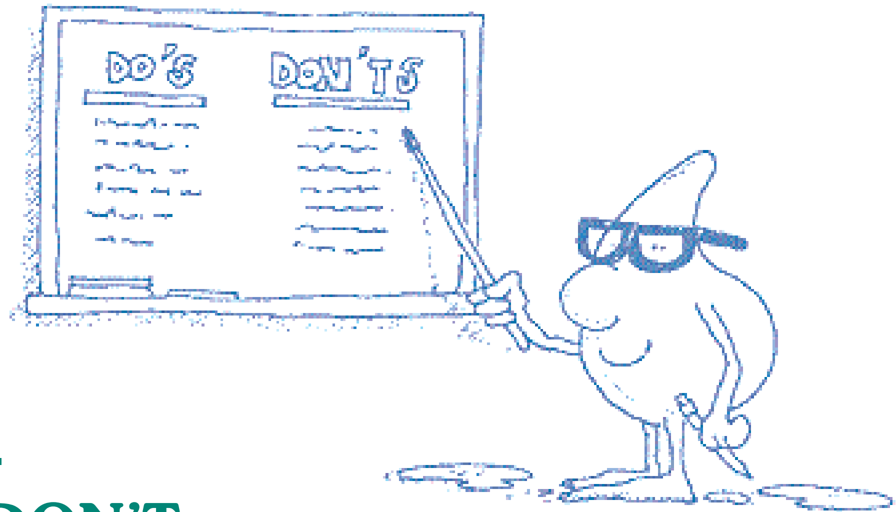
The Great Lakes Water Quality Agreement (GLWQA) was first signed in 1972; it was revised in 1978. The 1978 agreement was amended by protocol in 1987. The 1972 GLWQA prescribed, among other things, targets for phosphorus loading reductions to control nutrient enrichment problems in the lakes. The 1978 agreement placed more emphasis on industrial pollutants and toxic substances and set water quality objectives for specific chemicals.

The 1987 protocol advanced the cleanup of the Great Lakes by calling for the restoration of particularly degraded areas of concern and seeking the control of all sources of pollution, including airborne toxic substances. The protocol has also strengthened the public accountability of the governments of Canada and the United States, which must now report publicly to the International Joint Commission (IJC) on the progress of implementation of specific annexes to the agreement.

As well, every two years the Great Lakes Water Quality and Science Advisory Boards of the IJC present their independent reports on progress (or lack thereof) toward achieving the objectives of the GLWQA. These reports are available from

Great Lakes Regional Office of the International Joint Commission
100 Ouellette Avenue
Windsor, ON N9A 6T3
Tel.: 519-257-6714
Fax: 519-257-6740
E-mail: commission@windsor.ijc.org
Web site: www.ijc.org

Every year 1.5 million recreational boaters enjoy the Great Lakes.



WATER — DOs and DON'Ts

1. Individuals Can Do Something about Conserving and Using Water Wisely!

Surrounded by seemingly unlimited freshwater resources, Canadians are the world's most wasteful water users. In reality, our supplies of clean, usable water are limited, and we must learn to use them more wisely if we are to continue to enjoy the benefits they provide. Water conservation begins at home, and you can do your share by observing the following DOs and DON'Ts in and around the house.

What better place to start to use water wisely than in our own homes. It's where we spend most of our time and where we have the most control over how things are done.

In the Kitchen

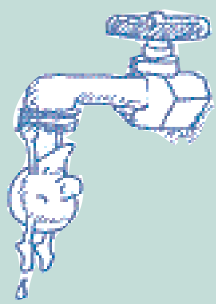
- Use an aerator and/or a water flow-reducer attachment on your tap to reduce your water usage.
- Always turn taps off tightly so they do not drip.
- Promptly repair any leaks in and around your taps. (One leak can waste several thousand litres of water per year.)
- When hand-washing dishes, never run water continuously. Wash dishes in a partially filled sink and then rinse them using the spray attachment on your tap.
- If you have an electric dishwasher, use it only to wash full loads, and use the shortest cycle possible. Many dishwashers have a conserver/water-miser cycle.
- When cleaning fruit and vegetables, never do so under a continuously running tap. Wash them in a partially filled sink and then rinse them quickly under the tap.
- When boiling vegetables, save water by using just enough to cover them and use a tightly fitting lid.

- Keep a bottle of drinking water in your fridge instead of running your tap until the water gets cool each time you want some water. Do not forget to rinse the container and renew the water every two to three days.

In the Bathroom

About 65% of indoor home water use occurs in our bathrooms, and toilets are the single greatest water users.

- When washing or shaving, partially fill the sink and use that water rather than running the tap continuously. (This saves about 60% of the water normally used.) Use short bursts of water to clean razors.
- When brushing your teeth, turn the water off while you are actually brushing instead of running it continuously. Then use the tap again for rinsing and use short bursts of water for cleaning your brush. (This saves about 80% of the water normally used.)
- Always turn taps off tightly so they do not drip.
- Promptly repair any leaks in and around taps.
- Use aerators and/or water flow-reducer devices on all your taps.
- Use either low-flow shower heads or adjustable flow-reducer devices on your shower heads. (They reduce flow by at least 25%.)
- Take short showers — turn off the water while you are soaping and shampooing and then rinse off quickly. Some shower heads have a shut-off lever that allows you to maintain the water pressure and temperature when you stop the flow.
- If you prefer bathing, avoid overfilling the tub.
- Reduce water usage by about 20% by placing a weighted plastic bottle filled with water in the water tank of your toilet. Low-cost "inserts" for the toilet tank are an alternative to plastic bottles. With a toilet insert, a family of four could save 45 000 litres of water per year. Toilet inserts are available at most hardware and plumbing supply stores.
- You can reduce water usage by 40% to 50% by installing low-flush toilets.
- Flush your toilet only when really necessary. Never use the toilet as a garbage can to dispose of cigarette butts, paper tissues, etc.
- Check regularly for toilet tank leaks into the toilet bowl by putting a small amount of food colouring into the tank and observing whether it spreads to the bowl without flushing. Repair leaks promptly. Ensure that the float ball is properly adjusted so that the tank water level does not exceed the height of the overflow tube. Also, periodically examine whether the plunge ball and flapper valve in the tank are properly "seated", and replace parts when necessary.
- Regularly check for leaks at the base of your toilet and have any promptly repaired.
- Never flush garbage of any kind down the toilet. Household cleaners, paints, solvents, pesticides, and other chemicals can be very harmful to the environment. And paper diapers, dental floss, plastic tampon holders, etc., can create problems at sewage treatment plants.
- Locate your water meter and periodically record the reading late in the evening and again early the next morning between any water use. Then compare the readings to see whether there was any water leakage during the night. If so, track it down and have it repaired.



In the Laundry Room

- Wash only full loads in your washing machine.
- Use the shortest cycle possible for washing clothes, and use the "suds-saver" feature if your machine has one.

- If your washer has an adjustable water-level indicator, set the dial to use only as much water as is really necessary.
- If you have a septic system, spread out your washing to avoid heavy-use days that could overload the system.
- Use only cleaning products that will not harm the environment when they are washed away after use. Look for "environmentally friendly" products when shopping.
- Promptly repair any leaks around the taps, hoses, or fittings of your washer, or the taps of your laundry sink.

In the Yard and Garden

- Lawns and gardens require only 5 millimetres of water per day during warm weather. Less is needed during spring, fall, or cool weather.
- Water lawns every three to five days, rather than for a short period every day. In warm weather, apply 5 millimetres of water for each day since the last watering.
- The amount of water applied can easily be measured by placing a can in the area being sprinkled. Measure the time required to apply the proper amount of water and use this information for future sprinkling.
- Grass that is green does not need water. Water is required when the grass starts to develop a black tinge along the top. Recovery is almost immediate when water is applied at this stage. Blackening does not hurt grass; browning does.
- Do not overwater in anticipation of a shortage. Soil cannot store extra water.
- Use shut-off timers or on–off timers, if possible. Do not turn on sprinklers and leave for the day.
- Water during the cool part of the day, in the morning or evening. Do not water on windy days.
- Keep your lawns healthy and maintain them at a height of 6.5 centimetres. Taller grass holds water better, and a healthy lawn will choke out weeds.
- Young or freshly transplanted garden plants need small quantities of water more frequently until they are well established.
- Most shrubs and young trees need water only once per week, even in warm weather.
- Wash your vehicle only when absolutely necessary.
- Clean sidewalks and driveways with a broom, not with a hose.

In the Bush

- Do not wash in the lake or river.
- Wash your dishes away from the water's edge, moving into the bush approximately 10 metres. Use sand instead of soap to scrub them clean.
- Do not dump waste food or garbage in the water.
- Clean fish well away from the water's edge.
- Build latrines well back from the water's edge.
- If a latrine is needed only for temporary use, dig a shallow pit approximately 15 centimetres deep, at least 10 metres away from the water's edge and cover over with earth when moving on.
- Dig shallow pits, approximately 15 centimetres deep, to bury compostable waste such as food waste or fish guts. Or burn waste to avoid attracting animals.
- Pack out all nondegradable waste, such as cans, bottles, tinfoil, and plastic.
- Fill outboard motors over land, not over water.
- Consider using an electric motor or a canoe instead of a gasoline motor.

For more information on the ways in which you can use water more efficiently in your home, consult our publication *Water: No Time to Waste — A Consumer's Guide to Water Conservation*, available on the Freshwater Website (*www.ec.gc.ca/water*).

2. Avoid Using Hazardous Household Products

Most proprietary household chemicals are safe to use and are environmentally friendly when used according to the directions on the package. However, some have a harmful cumulative effect on the environment when they are over-used or incorrectly disposed of.

- Buy only those environmentally hazardous products you really need, and buy them in quantities you will be able to completely use up so that you will not have to worry about disposing of the leftovers later.
- Additional information on nonhazardous household products and their uses can be obtained from the following and similar organizations:

Canadian Manufacturers of Chemical Specialties Association
56 Sparks Street - Suite 500
Ottawa, ON K1P 5A9
Tel.: 613-232-6616
Fax: 613-233-6350
E-mail: morinm@cmcs.org
Web site: www.cmcs.org

Consumers Association of Canada
436 Gilmore Street, 3rd Floor
Ottawa, ON K2P 0R8
Tel.: 613-238-2533
Fax: 613-238-2538
E-mail: info@consumer.ca
Web site: www.consumer.ca

The federal government endorses products that are environmentally responsible. Look for the Environmental Choice EcoLogo[M]. Products bearing this label have been tested and certified by the Environmental Choice Program. Each dove represents a sector of society — consumers, industry, and government — linked together to improve and protect the environment. The logo identifies the products that maximize energy efficiency and the use of recycled or recyclable materials and minimize the use of environmentally hazardous substances. Consumers can make informed choices. For more information, contact:

Environmental Choice Program
TerraChoice Environmental Marketing
1280 Old Innes, Suite 801
Ottawa, ON K1B 5M7
Toll free: 1-800-478-0399
Fax: 613-247-2228
E-mail: ecologo@terrachoice.ca
Web site: www.environmentalchoice.com/

3. Don't Misuse Your Household's Sewage System

If you do not want toxic chemicals in household products harming the environment and even coming back to you in your water or your food, dispose of them properly.

- Always try to use completely, or to recycle to other people, all of the contents of such products as oven cleaners, toilet bowl cleaners, sink drain cleaners, bleaches, rust removers, and most other acidic and alkali products. This also includes paints, solvents, carpet and furniture cleaners, polishes, and glues.
- Such items as disposable diapers, dental floss, plastic tampon holders, and hair can create many problems in the sewage treatment plant; they should all be tossed into the wastebasket, not the toilet.
- Contact your local fire department or municipal/city hall regarding the disposal of flammable liquids such as barbecue starter fluids, lighter fluids, gasoline, and furnace oils.
- Where possible, choose latex (water-based) paint instead of oil-based paint. Use it up instead of storing or dumping it.

4. Avoid the Use of Pesticides and Hazardous Materials In Your Garden and Yard

Some pesticides and hazardous materials accumulate in the groundwater and food chain and are toxic to various forms of life, particularly when they are not used according to the directions specified on the package or when the empty containers are disposed of without proper precautions.

- Reduce or avoid the use of pesticides to control household or garden pests by employing more environmentally responsible methods such as
    - pulling weeds by hand
    - pulling off and disposing of infested leaves
    - picking off larvae
    - using an insecticidal soap solution to dislodge or suffocate insects, or dislodging them using a stream of water from a garden hose
    - rotating garden crops each year to prevent depletion of soil nutrients and to control soil-borne diseases
    - cultivating your garden; regular hoeing will control weeds and keep plants healthy and more resistant to insects
- Use natural fertilizers such as bonemeal or compost.
- Spread sand rather than salt on your sidewalks and driveways to get traction on winter ice.

5. Don't Dump Hazardous Products Into Storm Drains

Storm drains empty into underground storm sewer systems, discharging directly into nearby lakes and streams, which are important habitats for fish and wildlife. Unlike domestic wastes collected by sanitary sewers, the contents of storm sewers are generally not treated at sewage treatment plants prior to their discharge into a stream or lake. Therefore dispose of oils, detergents, paints, solvents, and other products at local recycling or disposal facilities. Some communities organize special days for collecting these wastes or have their own hazardous-waste collection sites. Contact your health and environment officers or local waste disposal company for times and place. If your community doesn't have either, promote the idea.

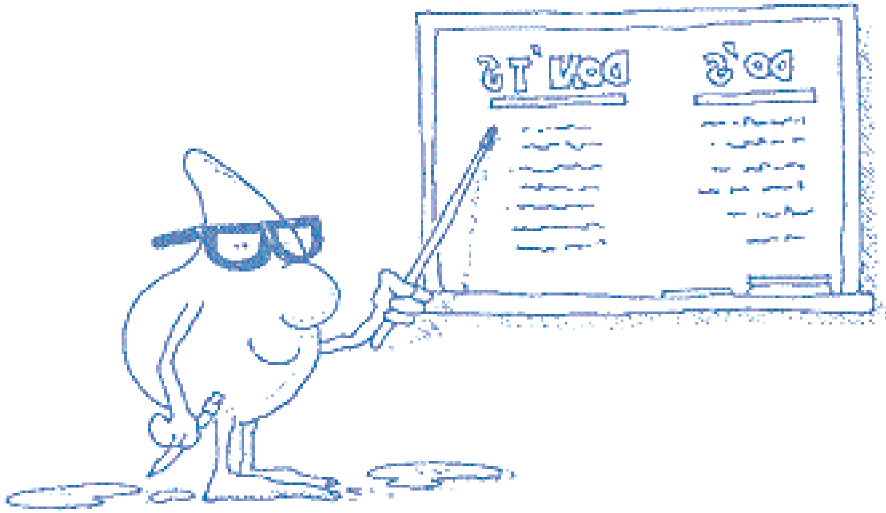
6. Don't Sit Back and Just Let Things Happen

An informed and committed public can become a powerful constituency in support of environmentally concerned political leaders, and even by themselves can provide a catalyst for environmental issues. You can make a difference!

- Become informed.
- Trust in the ability of the individual to take action on environmental issues, and work together with other individuals, experts, and politicians.
- Be willing to change your attitudes, behaviours, and expectations.
- Join and support local and national groups that work to solve environmental problems on institutional, national, and international levels. There are about 1800 such groups across Canada.
- Urge and support federal, provincial, and municipal action on environmental issues.
- Do not use products that are harmful to the environment. Urge stores to abandon wasteful packaging and to use biodegradable materials.
- Exercise your rights as a citizen: request information, participate in public hearings, serve on advisory committees, and address review boards. Under federal legislation, these options are available within the terms of both the Canada Water Act and the Canadian Environmental Protection Act.
- When voting in municipal, provincial, and federal elections, make your choices based on the environmental views, positions, and practices of the candidates.
- Educate your children and your friends. Environmental problems cannot be solved in a single generation; your children and their children will have to carry on the work.

We welcome readers' comments about the Primer. These can be sent to the address below. To obtain a list of other publications on water, contact:

Enquiry Centre
Environment Canada
Ottawa, ON K1A 0H3
Tel.: 819-997-2800
Toll free: 1-800-668-6767
Fax: 819-994-1412
E-mail: enviroinfo@ec.gc.ca
Web site: www.ec.gc.ca/water/en/info/pubs/e_pubs.htm



Selected Glossary with Index

A

acid mine drainage - Low pH drainage water from certain mines usually caused by the oxidation of sulphides to sulphuric acid. Mine drainage can also contain high concentration of metal ions. *(See: **Q66**)*

acid rain - Rainfall with a pH of less than 7.0. One source is the combining of rain and sulphur dioxide emissions, which are a by-product of combustion of fossil fuels. Also referred to as acid deposition and wet deposition. *(See: Q22 43 **64 65** 74 123; The pH Scale diagram)*

algae - Simple rootless plants that grow in sunlit waters in relative proportion to the amounts of nutrients available. They can affect water quality adversely by lowering the dissolved oxygen in the water. They are food for fish and small aquatic animals. *(See: Q57 69)*

algae blooms - Rapid growth of algae on the surface of lakes, streams, or ponds; stimulated by nutrient enrichment. *(See: Q59 74)*

alkali - Any strongly basic substance of hydroxide and carbonate, such as soda, potash, etc., that is soluble in water and increases the pH of a solution. *(See: The pH scale diagram)*

aquatic ecosystem - Basic ecological unit composed of living and nonliving elements interacting in an aqueous milieu. *(See: Q5 43 62 **63 69-76**)*

aquifer - The underground layer of water-soaked sand and rock that acts as a water source for a well; described as artesian (confined) or water table (unconfined). *(See: **Q14-17** 22 83; Groundwater System diagram)*

arid - Describes regions where precipitation is insufficient in quantity for most crops and where agriculture is impractical without irrigation. *(See: Q10 39 83)*

atmosphere - The layer of gases surrounding the earth and composed of considerable amounts of nitrogen, hydrogen, and oxygen. *(See: Q2-4 64 65)*

atmospheric water - Water present in the atmosphere either as a solid (snow, hail), liquid (rain) or gas (fog, mist). *(See: Q19 64)*

B

bioaccumulation (bioconcentation) - A term used to describe a process that occurs when levels of toxic substances increase in an organism over time, due to continued exposure. *(See: Q73; Bioaccumulation and Biomagnification diagram)*

biodegradable - Capable of being broken down by living organisms into inorganic compounds. *(See: Dos & Don'ts)*

biological diversity (biodiversity) - The variety of different species, the genetic variability of each species, and the variety of different ecosystems that they form. *(Q63 82)*

biomagnification (biological magnification) - A cumulative increase in the concentrations of a persistent substance in successively higher levels of the food chain. *(See: Q73; Bioaccumulation and Biomagnification diagram)*

biota - Collectively, the plants, microorganisms, and animals of a certain area or region. *(See: Q44 67)*

bog - A type of wetland that accumulates appreciable peat deposits. It depends primarily on precipitation for its water source and is usually acidic and rich in plant matter, with a conspicuous mat or living green moss. *(See: Q77)*

boundary water - A river or lake that is part of the boundary between two or more countries or provinces that have rights to the water. *(See: Q91* ***97*** *98 106 133)*

C

Canadian Environmental Assessment Act - *(See: Q106* ***108*** *109; Overview of the CEAA diagram)*

climate - Meteorological elements that characterize the average and extreme conditions of the atmosphere over a long period of time at any one place or region of the earth's surface. *(See:* ***Q4****-11 83 89)*

climate change - The slow variations of climatic characteristics over time at a given place. *(See: Preface;* ***Q5 6*** *59 123)*

coliform bacteria - A group of bacteria used as an indicator of sanitary quality in water. Exposure to these organisms in drinking water causes diseases such as cholera. *(See: Q74)*

combined sewers - A sewer that carries both sewage and storm water runoff. *(See: Q37 52 54; Dos & Don'ts)*

condensation - The process by which a vapour becomes a liquid or solid; the opposite of evaporation. In meteorological usage, this term is applied only to the transformation from vapour to liquid. *(See: Hydrologic Cycle diagram)*

conservation - The continuing protection and management of natural resources in accordance with principles that assure their optimum long-term economic and social benefits. *(See:* ***Q38-41*** *82 102 116)*

consumptive use - The difference between the total quantity of water withdrawn from a source for any use and the quantity of water returned to the source; e.g., the release of water into the atmosphere; the consumption of water by humans, animals, and plants; and the incorporation of water into the products of industrial or food processing. *(See: Q23 25 28 83 94 126)*

contaminant - Any physical, chemical, biological, or radiological substance or matter that has an adverse affect on air, water, or soil. *(See: Q20 21 47 62 67 113 121)*

cooling tower - A structure that helps remove heat from water used as a coolant; e.g., in electric power generating plants. *(See: Q40 59)*

cubic metre per second (m^3/s) - A unit expressing rate of discharge, typically used in measuring streamflow. One cubic metre per second is equal to the discharge in a stream of a cross section one metre wide and one metre deep, flowing with an average velocity of one metre per second. *(See: Q98; Typical River Flow diagram)*

D

dam - A structure of earth, rock, concrete, or other materials designed to retain water, creating a pond, lake, or reservoir. *(See: Q5 11 **26** 29 **60** 71 76 104 111 114 115 120; Number of Large Dams in Canada diagram)*

delta - A fan-shaped alluvial deposit at a river mouth formed by the deposition of successive layers of sediment. *(See: Q14 **89** 120; Mackenzie River Basin diagram)*

demand - The numerical expression of the desire for goods and services associated with an economic standard for acquiring them. *(See: Q10 15 16 39 41 76 92 93 100 121 123)*

depletion - Loss of water from surface water reservoirs or groundwater aquifers at a rate greater than that of recharge. *(See: Q15 16 113)*

dioxin - Any of a family of compounds known chemically as dibenzo-p-dioxins. Concern about them arises from their potential toxicity and contamination in commercial products. *(See: Q73)*

discharge - In the simplest form, discharge means outflow of water. The use of this term is not restricted as to course or location, and it can be used to describe the flow of water from a pipe or from a drainage basin. Other words related to it are runoff, streamflow, and yield. *(See: Q17-19 59 81 83 **84** 85 89; Dos & Don'ts; Groundwater System diagram)*

dissolved oxygen (DO) - The amount of oxygen freely available in water and necessary for aquatic life and the oxidation of organic materials. *(See: Q43 57)*

dissolved solids (DS) - Very small pieces of organic and inorganic material contained in water. Excessive amounts make water unfit to drink or limit its use in industrial processes.

diversion - The transfer of water from a stream, lake, aquifer, or other source of water by a canal, pipe, well, or other conduit to another watercourse or to the land, as in the case of an irrigation system. *(See: Q85 **92 93** 97-99 115 120 131 133; Great Lakes-St. Lawrence River Basin diagram)*

domestic use - The quantity of water used for household purposes such as washing, food preparation, and bathing. *(See: Preface; Q19 22 23 **30**-41 41 46-55; Dos & Don'ts)*

drainage basin - See: Watershed.

dredgeate - The material excavated from lake, river, or channel bottoms during dredging. *(See: Q63)*

dredging - The removal of material from the bottom of water bodies using a scooping machine. This disturbs the ecosystem and causes silting that can kill aquatic life. *(See: Q5 **61-63** 76 110)*

drought - A continuous and lengthy period during which no significant precipitation is recorded. *(See: Preface; Q3 5 **9 10** 15 39)*

dry deposition - Emissions of sulphur and nitrogen oxides that, in the absence of water in the atmosphere (i.e., rain), settle to the ground as particulate matter. *(See: Q64)*

dyke - An artificial embankment constructed to prevent flooding. *(See: Q5 110 115 120)*

E

ecosystem - A system formed by the interaction of a group of organisms and their environment. *(See: Q8 11 29 43 63 65 **69-82** 88 89 92 93 96 99 117 123 124)*

ecosystem approach - *See: Q111*

effluent - The sewage or industrial liquid waste that is released into natural water by sewage treatment plants, industry, or septic tanks. *(See: Q5 57 76 120)*

environment - All of the external factors, conditions, and influences that affect an organism or a community. *(See: Preface; Introduction; Q6 29 41 47 52 53 62 63 67 69 73 74 76 88 92 93 95 99 100 106 108-110 112 117 118 120; Dos & Don'ts)*

environmental assessment - The critical appraisal of the likely effects of a proposed project, activity, or policy on the environment, both positive and negative. *(See: Q108-110; Overview of CEAA diagram)*

environmental monitoring - The process of checking, observing, or keeping track of something for a specified period of time or at specified intervals. *(See: Q76 118)*

erosion - The wearing down or washing away of the soil and land surface by the action of water, wind, or ice. *(See: Q6 57 123 124 129 132 134)*

estuary - Regions of interaction between rivers and nearshore ocean waters, where tidal action and river flow create a mixing of fresh water and saltwater. These areas may include bays, mouths of rivers, salt marshes, and lagoons. These brackish water ecosystems shelter and feed marine life, birds, and wildlife. *(See: Q62 **71**)*

eutrophic lake - Shallow, murky bodies of water that have excessive concentrations of plant nutrients causing excessive algal production. *(See: **Q57 71**)*

eutrophication - The natural process by which lakes and ponds become enriched with dissolved nutrients, resulting in increased growth of algae and other microscopic plants. *(See: **Q57** 60 62 68 74)*

evaporation - The process by which a liquid changes to a vapour. *(See: Q3 4 6-8 28 126; Hydrologic Cycle diagram)*

evapotranspiration - The loss of water from a land area through evaporation from the soil and through plant transpiration. *(See: Q5 **58**)*

F

Federal Water Policy - *See: Q107*

fen - A type of wetland that accumulates peat deposits. Fens are less acidic than bogs, deriving most of their water from groundwater rich in calcium and magnesium. *(See: Q77)*

flood - The temporary inundation of normally dry land areas resulting from the overflowing of the natural or artificial confines of a river or other body of water. *(See: Preface; Q3 5 8 **11-13** 60 69 85 93 102 103 **114-116** 121 125 129 132 134; Flood diagram)*

flood damage - The economic loss caused by floods, including damage by inundation, erosion, and/or sediment deposition. Damages also include emergency costs and business or financial losses. Evaluation may be based on the cost of replacing, repairing, or rehabilitating; the comparative change in market or sales value; or the change in the income or production caused by flooding. *(See: Q5 115)*

flood forecasting - Prediction of stage, discharge, time of occurrence, and duration of a flood, especially of peak discharge at a specified point on a stream, resulting from precipitation and/or snowmelt. *(See: **Q114** 115 121)*

flood fringe - The portion of the floodplain where water depths are shallow and velocities are low. *(See: Q12; Flood diagram)*

flood peak - The highest magnitude of the stage of discharge attained by a flood. Also called peak stage or peak discharge. *(See: Q81)*

floodplain - Any normally dry land area that is susceptible to being inundated by water from any natural source. This area is usually low land adjacent to a stream or lake. *(See: **Q12** 13 69 85 115; Flood diagram)*

flood-proofing - Any combination of structural and nonstructural additions, changes, or adjustments to structures that reduce or eliminate flood damage. *(See: Q12 114 115)*

floodway - The channel of a river or stream and those parts of the adjacent floodplain adjoining the channel that are required to carry and discharge the base flood. *(See: Q12; Flood diagram)*

flow - The rate of water discharged from a source; expressed in volume with respect to time, e.g., m^3/s. *(See: Q5 6 8 17-20 43 71 78 **84** 87 **89** 90 92-94 96-98 101 102 116 120 131 134 136; Water Flow Comparisons and Typical River Flows diagrams)*

flow augmentation - The addition of water to a stream, especially to meet instream flow needs. *(See: Q116)*

food chain - A sequence of organisms, each of which uses the next, lower member of the sequence as a food source. *(See: Q62 74* ***72****; Dos & Don'ts)*

food web - The complex intermeshing of individual food chains in an ecosystem. *(See: Q72* ***73****)*

fresh water - Water that generally contains less than 1000 milligrams per litre of dissolved solids such as salts, metals, nutrients, etc. *(See: Introduction; Q1 3 7 14 19 83 87)*

G

glacier - A huge mass of ice, formed on land by the compaction and re-crystallization of snow, that moves very slowly downslope or outward due to its own weight. *(See: Q8 11 87)*

greenhouse effect - The warming of the earth's atmosphere caused by a build-up of carbon dioxide or other trace gases; it is believed by many scientists that this build-up allows light from the sun's rays to heat the earth but prevents a counterbalancing loss of heat. *(See: Q5)*

groundwater - The supply of fresh water found beneath the earth's surface (usually in aquifers) that is often used for supplying wells and springs. *(See: Q3 6 9* ***14-22*** *30 37 39 43 54 58 66 83 113)*

groundwater recharge - The inflow to an aquifer. *(See:* ***Q17****; Groundwater System diagram)*

H

habitat - The native environment where a plant or animal naturally grows or lives. *(See: Q6 29 60 62 63 69 77 79 81 82 85 104 110-112 118 124)*

hazardous waste - Waste that poses a risk to human health or the environment and requires special disposal techniques to make it harmless or less dangerous. *(See:* ***Q52 53****; Dos & Don'ts)*

hydroelectricity - Electric energy produced by water-powered turbine generators. *(See: Q26* ***27 29*** *60 92 122 134)*

hydrologic cycle - The constant circulation of water from the sea, through the atmosphere, to the land, and back to the sea by over-land, underground, and atmospheric routes. *(See:* ***Q3****-5 8 19 87 89 110; Hydrologic Cycle diagram)*

hydrology - The science of waters of the earth; water's properties, circulation, principles, and distribution. *(See: Q6 117)*

I

infiltration - The movement of water into soil or porous rock. Infiltration occurs as water flows through the larger pores of rock or between soil particles under the influence of gravity, or as a gradual wetting of small particles by capillary action. *(See: Q14 17)*

inflow - The entry of extraneous rainwater into a sewer system from sources other than infiltration, such as basement drains, sewer holes, storm drains, and street washing. *(Q38 126)*

inorganic - Matter other than plant or animal and not containing a combination of carbon, hydrogen, and oxygen, as in living things.

instream use - Uses of water within the stream channel, e.g., fish and other aquatic life, recreation, navigation, and hydroelectric power production. *(See: **Q23**)*

integrated resource planning - The management of two or more resources in the same general area; commonly includes water, soil, timber, grazing land, fish, wildlife, and recreation. *(See: Q82)*

interbasin transfer - The diversion of water from one drainage basin to one or more other drainage basins. *(See: **Q92**-94 99)*

irrigation - The controlled application of water to cropland, hayland, and/or pasture to supplement that supplied through nature. *(See: Q7 14 19 **23**-26 33 34 42 **58** 60 85 92 93)*

J

jökulhlaup - Destructive flood that occurs as the result of the rapid ablation of ice by volcanic activity beneath the ice of a large glacier. *(See: **Q11**)*

K

kilowatt (kW) - A unit of electrical power equal to 1000 watts or 1.341 horsepower.

kilowatt hour (kWh) - One kilowatt of power applied for one hour. *(See: Q28)*

L

lagoon - (1) A shallow pond where sunlight, bacterial action, and oxygen work to purify wastewater. (2) A shallow body of water, often separated from the sea by coral reefs or sandbars. *(See: Q22)*

lake - Any inland body of standing water, usually fresh water, larger than a pool or pond; a body of water filling a depression in the earth's surface. *(See: Q2 11 14 17 30 42-44 49 52 54 **57** 58 63 65 67-**71** 74 75 **86** 87 89 90 93 95 96 **106** 122-135; Largest Lakes diagram)*

leaching - The removal of soluble organic and inorganic substances from the topsoil downward by the action of percolating water. *(See: Q21 58)*

litre - The basic unit of measurement for volume in the metric system; equal to 61.025 cubic inches or 1.0567 liquid quarts. *(See: Q3 28 32 36 48; Dos & Don'ts)*

M

marsh - A type of wetland that does not accumulate appreciable peat deposits and is dominated by herbaceous vegetation. Marshes may be either fresh water or saltwater and tidal or non-tidal. *(See: Q77 124 129)*

megawatt - A unit of electricity equivalent to 1000 kilowatts. *(See: Q27)*

model - A simulation, by descriptive, statistical, or other means, of a process or project that is difficult or impossible to observe directly. *(See: Q6 **118-121**)*

N

NAPLs - Nonaqueous phase liquids; i.e., chemical solvents such as trichloroethylene (TCE) or carbon tetrachloride — often toxic. Many of the most problematic NAPLs are DNAPLs — dense nonaqueous phase liquids.

natural flow - The flow of a stream as it would be if unaltered by upstream diversion, storage, import, export, or change in upstream consumptive use caused by development. *(See: Q18 97)*

navigable waters - Traditionally, waters sufficiently deep and wide for navigation by all, or specific sizes of, vessels. *(See: Q5 6 61 75 89 98 104 106 129 131)*

non-renewable resources - Natural resources that can be used up completely or else used up to such a degree that it is economically impractical to obtain any more of them; e.g., coal, crude oil, and metal ores. *(See: Q82)*

northern water resources - *See: Preface; Q5 6 8 19 20 30 37 45 **67** 83 86 **87** 89 92 **101-103***

nutrient - As a pollutant, any element or compound, such as phosphorus or nitrogen, that fuels abnormally high organic growth in aquatic ecosystems (e.g., eutrophication of a lake). *(See: Q43 44 55 57 62 69 70 72 74 135)*

O

oligotrophic lake - Deep, clear lakes with low nutrient supplies. They contain little organic matter and have a high dissolved oxygen level. *(See: Q71)*

organic - (1) Referring to or derived from living organisms. (2) In chemistry, any compound containing carbon. *(See: Q51 55 60 67)*

organism - A living thing. *(See: Preface; Q5 46 62 66 69-70 72-74 82)*

P

parts per million (PPM) - The number of "parts" by weight of a substance per million parts of water. This unit is commonly used to represent pollutant concentrations. Large concentrations are expressed in percentages. *(See: Bioaccumulation and Biomagnification diagram)*

pathogenic microorganisms - Microorganisms that can cause disease in other organisms or in humans, animals, and plants. *(See: Q43 56)*

percolation - The movement of water downward through the subsurface to the zone of saturation. *(See: Q54; Hydrologic Cycle diagram)*

permafrost - Perennially frozen layer in the soil, found in alpine, arctic, and antarctic regions. *(See: Q6 **20** 30 87)*

pesticide - A substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture of substances intended to regulate plant or leaf growth. Pesticides can accumulate in the food chain and/or contaminate the environment if misused. *(See: Q21 43 44 53 58 67 73; Dos & Don'ts)*

pH - An expression of both acidity and alkalinity on a scale of 0 to 14, with 7 representing neutrality; numbers less than 7 indicate increasing acidity and numbers greater than 7 indicate increasing alkalinity. *(See: Q44* ***64*** *65 74; The pH Scale diagram)*

photosynthesis - The manufacture by plants of carbohydrates and oxygen from carbon dioxide and water in the presence of chlorophyll, using sunlight as an energy source. *(See: Q72)*

phytoplankton - Usually microscopic aquatic plants, sometimes consisting of only one cell. *(See: Bioaccumulation and Biomagnification diagram)*

plankton - Tiny plants and animals that live in water. *(See: Q70)*

polychlorinated biphenyls (PCBs) - A group of chemicals found in industrial wastes. *(See: Q67 73)*

pond - A small natural body of standing fresh water filling a surface depression, usually smaller than a lake. *(See: Q70 71)*

precipitation - Water falling, in a liquid or solid state, from the atmosphere to a land or water surface. *(See: Q3 4 6-10 57 64 65 71 83 126; Hydrologic Cycle diagram)*

R

rain - Water falling to earth in drops that have been condensed from moisture in the atmosphere. *(See: Q2 7 8 11 17 43 64 65 114)*

receiving waters - A river, ocean, stream, or other watercourse into which wastewater or treated effluent is discharged. *(See: Q5 55 59 66 67)*

recharge - The processes involved in the addition of water to the zone of saturation; also the amount of water added. *(See: Q7 15* ***17*** *18 22 83; Groundwater System diagram)*

recyclable - Refers to such products as paper, glass, plastic, used oil, and metals that can be reprocessed instead of being disposed of as waste. *(See: Dos & Don'ts)*

renewable resource - Natural resource (e.g., tree biomass, fresh water, fish) whose supply can essentially never be exhausted, usually because it is continuously produced. *(See: Q29 82 83)*

reservoir - A pond, lake, or basin (natural or artificial) that stores, regulates, or controls water. *(See: Q7 60 93 94 110 115* ***116*** *120 121)*

resource - A person, thing, or action needed for living or to improve the quality of life. *(See: Preface; Q4-8 14 15 31 33-35 38 39 41 82 85 88 92 96 97 102 106 107 109 110 112 113 118 119; Dos & Don'ts)*

river - A natural stream of water of substantial volume. *(See: Q2-4 6 8 11 12 14 17 19 30 42 43 49 52 57 58 60 62 63 65 67 69* ***71*** *75 83 84* ***86****-90 94* ***105-106*** *121; Typical River Flows and Longest Rivers in Canada diagrams)*

river basin - A term used to designate the area drained by a river and its tributaries. *(See: **Q90**-93 118; Mackenzie River Basin, Saint John River Basin, and Great Lakes-St. Lawrence River Basin diagrams)*

runoff - The amount of precipitation appearing in surface streams, rivers, and lakes; defined as the depth to which a drainage area would be covered if all of the runoff for a given period of time were uniformly distributed over it. *(See: Q6 8 43 55 87 118 126 130)*

S

saltwater intrusion - The invasion of fresh surface water or groundwater by saltwater. *(See: Q21; Groundwater System diagram)*

sanitary sewers - Underground pipes that carry off only domestic or industrial waste, not storm water. *(See: Q37 54; Dos & Don'ts)*

sediment - Fragmented organic or inorganic material derived from the weathering of soil, alluvial, and rock materials; removed by erosion and transported by water, wind, ice, and gravity. *(See: Q6 15 43-45 57 58 60-62 67 89 124)*

sedimentation - The deposition of sediment from a state of suspension in water or air. *(See: Q78)*

seiche - A periodic oscillation, or standing wave, in an enclosed water body the physical dimensions of which determine how frequently the water level changes. *(See: Q127)*

septic tank - Tank used to hold domestic wastes when a sewer line is not available to carry them to a treatment plant; part of a rural on-site sewage treatment system. *(See: Q37 54)*

sewage - The waste and wastewater produced by residential and commercial establishments and discharged into sewers. *(See: Q5 22 33 38 52 54 55 115; Dos & Don'ts)*

sewage system - Pipelines or conduits, pumping stations, force mains, and all other structures, devices, and facilities used for collecting or conducting wastes to a point for treatment or disposal. *(See: Q33; Dos & Don'ts)*

sewer - A channel or conduit that carries wastewater and storm water runoff from the source to a treatment plant or receiving stream. *(See: Q30 37 39 52 54; Dos & Don'ts)*

sewerage - The entire system of sewage collection, treatment, and disposal. *(See: Q37)*

silt - Fine particles of sand or rock that can be picked up by the air or water and deposited as sediment. *(See: Q14 62)*

sludge - A semi-solid residue from any of a number of air or water treatment processes. *(See: Q54)*

solvent - Substances (usually liquid) capable of dissolving or dispersing one or more other substances. *(See: Q1 52; Dos & Don'ts)*

spoils - Dirt or rock that has been removed from its original location, destroying the composition of the soil in the process, as with strip-mining or dredging. *(See: Q61-63)*

spring - An area where groundwater flows naturally onto the land surface. *(See: Q14* ***18*** *19 69 71)*

storm sewer - A system of pipes (separate from sanitary sewers) that carry only water runoff from building and land surfaces. *(See: Q52; Dos & Don'ts)*

stream - Any body of running water moving under gravity flow through clearly defined natural channels to progressively lower levels. *(See: Q17 23 43 44 54 58 71 84 106 112 130; Dos & Don'ts)*

streamflow - The discharge that occurs in a natural channel. Although the term "discharge" can be applied to the flow of a canal, the word "streamflow" uniquely describes the discharge in a surface stream. The term "streamflow" is more general than the term "runoff", as streamflow may be applied to discharge whether or not it is affected by diversion or regulation. *(See: Q7 9 19 84 93: Hydrologic Cycle diagram)*

surface water - All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.); also refers to springs, wells, or other collectors that are directly influenced by surface water. *(See: Q16 19 22 66 77 83 113)*

suspended solids - Defined in waste management, these are small particles of solid pollutants that resist separation by conventional methods. Suspended solids (along with biological oxygen demand) are a measurement of water quality and an indicator of treatment plant efficiency. *(See: Q44 55)*

sustainable development - Development that ensures that the use of resources and the environment today does not restrict their use by future generations. *(See: Q41 76* ***88*** *108)*

swamp - A type of wetland that is dominated by woody vegetation and does not accumulate appreciable peat deposits. Swamps may be fresh water or saltwater and tidal or nontidal. *(See: Q77)*

T

temperature - The degree of hotness or coldness. *(See: Q5 6 8 43 59 69 126)*

thermal pollution - The impairment of water quality through temperature increase; usually occurs as a result of industrial cooling water discharges. *(See: Q59)*

toxic - Harmful to living organisms. *(See: Preface; Q22 43 52 62 67 68* ***73*** *74 78 82 121 123 135; Dos & Don'ts)*

transpiration - The process by which water absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface, principally from the leaves. *(See: Q5 58; Hydrologic Cycle diagram)*

tributary - A stream that contributes its water to another stream or body of water. *(See: Q130)*

tsunami - A Japanese term that has been adopted to describe a large seismically generated sea wave capable of considerable destruction in certain coastal areas, especially where sub-marine earthquakes occur. *(See: Q11)*

turbidity - Cloudiness caused by the presence of suspended solids in water; an indicator of water quality. *(See: Q44)*

U

underground storage tank - A tank located all or partially underground that is designed to hold gasoline or other petroleum products or chemical solutions. *(See: Q21)*

urban runoff - Storm water from city streets and adjacent domestic or commercial properties that may carry pollutants of various kinds into the sewer systems and/or receiving waters. *(See: Q43)*

V

vapour - The gaseous phase of substances that are liquid or solid at atmospheric temperature and pressure, e.g., steam. (See: Q1 4)

W

waste disposal system - A system for the disposing of wastes, either by surface or underground methods; includes sewer systems, treatment works, and disposal wells. *(See: Q37)*

wastewater - Water that carries wastes from homes, businesses, and industries; a mixture of water and dissolved or suspended solids. *(See: 39 55)*

wastewater treatment plant - A facility containing a series of tanks, screens, filters, and other processes by which pollutants are removed from water. *(See: **Q55**)*

water (H_2O) - An odourless, tasteless, colourless liquid formed by a combination of hydrogen and oxygen; forms streams, lakes, and seas, and is a major constituent of all living matter. *(See: **Q1**…)*

water conservation - The care, preservation, protection, and wise use of water. *(See: **Q38**-41; Dos & Don'ts)*

water contamination - Impairment of water quality to a degree that reduces the usability of the water for ordinary purposes or creates a hazard to public health through poisoning or the spread of diseases. *(See: Preface; Q5 **21** 22 67 75 113; Groundwater System diagram)*

water management - The study, planning, monitoring, and application of quantitative and qualitative control and development techniques for long-term, multiple use of the diverse forms of water resources. *(See: Q100-121)*

water pollution - Industrial and institutional wastes and other harmful or objectionable material in sufficient quantities to result in a measurable degradation of the water quality. *(See: Q30 42 47 50 **55** 57 59 67 94 97 135)*

water quality - A term used to describe the chemical, physical, and biological characteristics of water with respect to its suitability for a particular use. *(See: Preface; Q5 **42-68** 82 85 93 97 98 102 107 118 120 123 124 133 **135**)*

water quality guidelines - Specific levels of water quality that, if reached, are expected to render a body of water suitable for its designated use. The criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes. *(See: Q42 46 47 51 56 112)*

water supply system - The collection, treatment, storage, and distribution of potable water from source to consumer. *(See: Q30)*

water table - The top of the zone of saturation. *(See: Q14 15 39; Hydrologic Cycle and Groundwater System diagrams)*

watershed - The land area that drains into a stream. *(See: Q65* ***90*** *92 93 97 99)*

well - A pit, hole, or shaft sunk into the earth to tap an underground source of water. *(See: Q14 15 30 54; Groundwater System diagram)*

wet deposition - See acid rain. *(Q64)*

wetlands - Lands where water saturation is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the surrounding environment. Other common names for wetlands are bogs, ponds, estuaries, and marshes. *(See: Q4-6 63* ***77-82*** *94 110 123 124 129 130)*

withdrawal use - The act of removing water from surface water or groundwater sources in order to use it. *(See:* ***Q23*** *39)*

X,Y,Z

zooplankton - Tiny aquatic animals eaten by fish. *(See: Q79; Bioaccumulation and Biomagnification diagram)*

zone of saturation - A subsurface zone in which all the pores or the material are filled with groundwater under pressure greater than atmospheric pressure.

Sources

Durrenberger, Robert W. *Dictionary of the Environmental Sciences*. Palo Alta, California: National Press Books, 1973.

Government of Canada. "Glossary of selected terms," in *The State of Canada's Environment*. Ottawa, 1991.

North Dakota State Water Commission. *Water Words: A Glossary of Water-Related Terms*. Bismark, North Dakota, 1988.

Parker, Sybil P. (ed). *McGraw-Hill Dictionary of Scientific and Technical Terms*. 3rd ed. New York: McGraw-Hill, 1984.

UNESCO and World Meteorological Organization. *International Glossary of Hydrology*. Geneva, 1974.

U.S. Environmental Protection Agency. *Glossary of Environmental Terms and Acronym List*. Washington, D.C., 1989.

Whittow, John. *The Penguin Dictionary of Physical Geography*. Markham, Ontario: Penguin Books, 1984.

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