Environmental Citizenship

A Primer on Fresh Water

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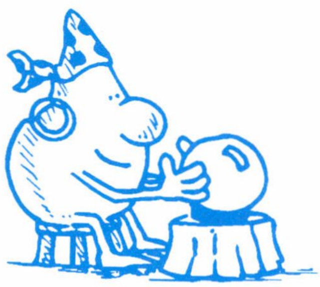


Water is the lifeblood of the environment. Some very simple organisms can survive without air, but none can grow without water. Although Canada has more water than most nations, changes in water availability in terms of quantity and quality greatly affect Canadian life. The impacts of droughts have been most severe in the Prairies, while those of flooding have been experienced more profoundly in British Columbia 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, 26% 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 upon 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 Canadian government introduced its own environmental action plan in 1990 - the Green Plan. Its goal is the achievement of a safe and healthy environment and a sound and prosperous economy. The Green Plan is Canada's national strategy for sustainable development.

Achieving the Green Plan goal will require more than just governmental action. The involvement and commitment of the Canadian people is essential. What is required is that Canadians become active environmental citizens. Many already are active - the challenge is to build upon their example. The Environmental Citizenship Initiative is designed to help Canadians do so.

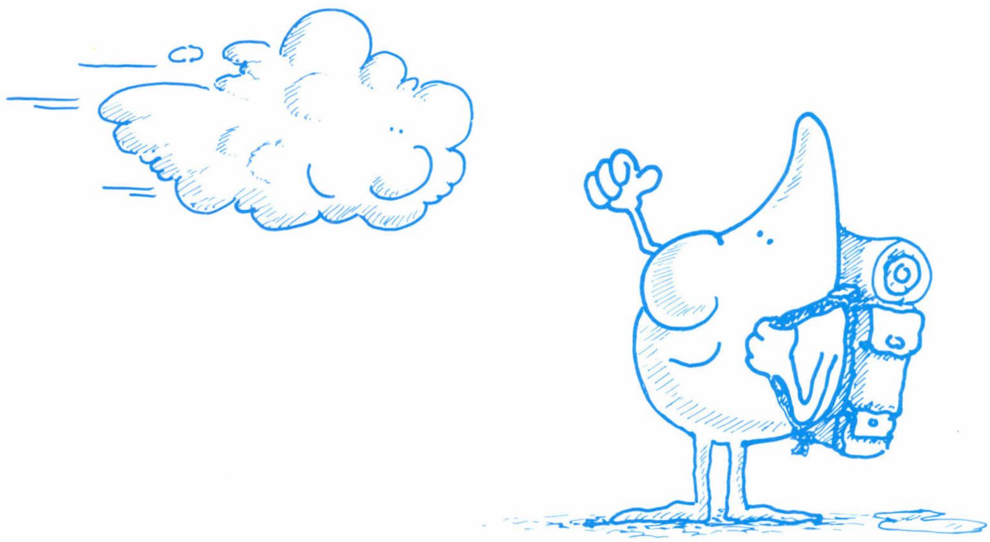
Canadians citizens enjoy both rights and responsibilities. The idea behind environmental citizenship is that one of these responsibilities is to care for Canada's environment. An environmental citizen is someone who has accepted this responsibility and is committed to acting upon it.

Environmental citizenship emphasizes voluntary action by all sectors of society, complementing the regulatory initiatives and economic incentives put in place by government. It applies to all Canadians; individuals, communities, and organizations all have a role to play.

Learning is the key to environmental citizenship. In addition to awareness and concern, effective environmental action requires knowledge. For this reason, the Environmental Citizenship Initiative includes learning campaigns on specific topics to help Canadians gain a better understanding of their environment.

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 are in a position to develop the learning resources that will enable Canadians to improve their understanding of the environment.

The contents of this 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, turns to a solid at 0°C and a vapour at 100°C. 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 two thirds 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 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.

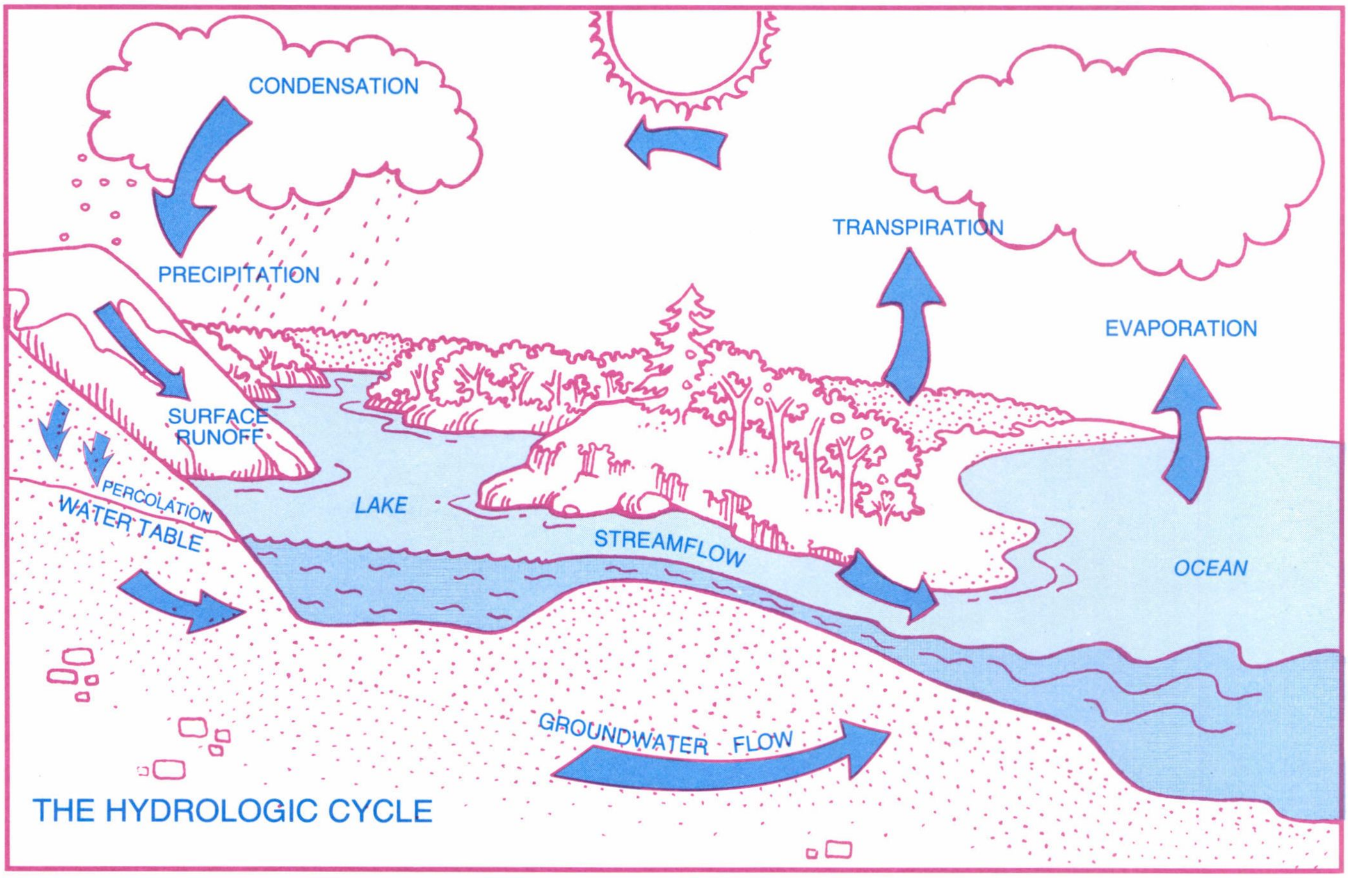
Over time, the earth cooled and a mass of molten lava became the soils and bedrock we know today. This process began when water was formed in the atmosphere and fell to the ground as rain. The rain continued for many, many years. While the earth cooled from the falling rain, forces from within created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

About 83% of our blood is water. It helps digest our food, take in oxygen, transport body wastes, and control body temperature.

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 oceans into the atmosphere by evaporation, dropped upon 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.



4. Is water related to climate?

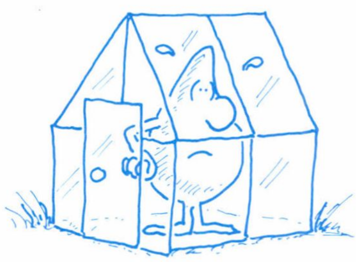
Water and climate are intimately related. It is obvious, from a water resource perspective, how the climate of a region to a large extent determines the water supply in that region based on the precipitation available and on the evaporation loss. Perhaps less obvious is the role of water in climate. 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. When water vapour in the atmosphere condenses to precipitation, this energy is released into the atmosphere. Thus water acts as an energy transfer and storage medium for the climate system.

Glacier ice over 100 000 years old is found at the base of many Canadian Arctic ice caps.

5. Some 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 century. 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. There is considerable debate among scientists and researchers on whether climate change has already begun and how severe it will be in the future.



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 seasonal distribution. For example, greater climatic variability would mean changing the frequency of extreme weather events and increase the incidences of dry and wet year sequences. Water availability would fluctuate due to uncertain water supplies as well as to unknown water use response to climate change. Therefore current design criteria for hydrologic structures 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 impair navigation and increase the backup of upstream waters, would require increased dredging activities, thus harming bottom-dwelling organisms and contaminating surrounding 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 2°C to 4°C in summer, with the smaller increases in the Yukon. Higher temperatures would probably lead to longer periods of open water, giving boat travel a longer season. However, they might also cause some areas of permafrost (permanently frozen ground) to melt, resulting in erosion or "slumping." This could affect docks, highways, pipelines and buildings.

Changes in precipitation have not been so well defined by models, but experience from recent mild northern winters 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.

A five-year study of the effects of climate change on the Mackenzie River Basin, involving various government agencies at all levels, business, industry and academia, under the lead of Environment Canada and Green Plan funding, is presently under way. The findings will be available by 1996.

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 is low, the relative contribution of its meltwaters to streamflow in some regions may be greater than for rainfall. Snow supplies at least one third of the water used for irrigation in the world and

The average annual flooding and erosion damage along the Canadian shore of the Great Lakes is about $2 million.

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, water bodies remain ice-covered for six to ten months of the year; little evaporation or precipitation occurs in winter due to the low moisture capacity of air at low temperatures; and runoff from winter snowfall is concentrated in the brief period of spring snowmelt, breakup and flooding.

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 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 which have occurred throughout history and may be considered as temporary features caused by fluctuations in the climate system.

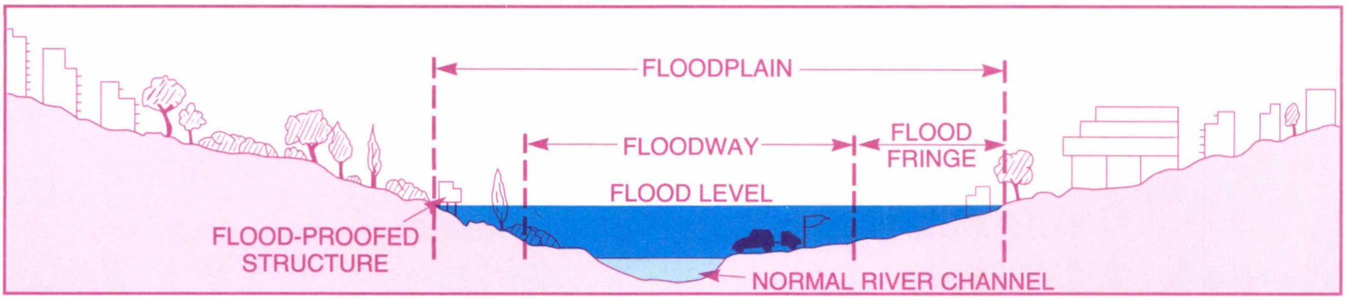
10. Where do droughts occur?

Droughts can occur anywhere. However, regions with a semi-arid or arid climate and which have only marginal annual precipitation to meet the 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 snowcover, particularly when accompanied by rainfall. Heavy rainfall itself can also cause floods. Severe storms 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 only affect 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 called "jökulhlaups" and can be devastating to the local ecosystem, as they can attain levels of up to 100 times greater than those of normal rain or snowmelt floods.



In Canada, the wettest place, on average, is Ocean Falls, B.C., with 4386.8 millimetres precipitation per year. The place with the least amount of precipitation, on average, is Eureka, N.W.T., with 64 millimetres per year.

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

It depends! The floodplain is usually divided into two categories: the floodway and the flood fringe. Damage is most extensive in the floodway where the water volumes 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 floodproofing.

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 (Ecosystem Sciences and Evaluation Directorate) offices in your region to determine whether flood risk maps have been produced for your area.

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

The largest lake entirely in Canada: Great Bear, N.W.T. - 31 328 square kilometres.

WATER - Underground

14. What is groundwater?

Two thirds 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.

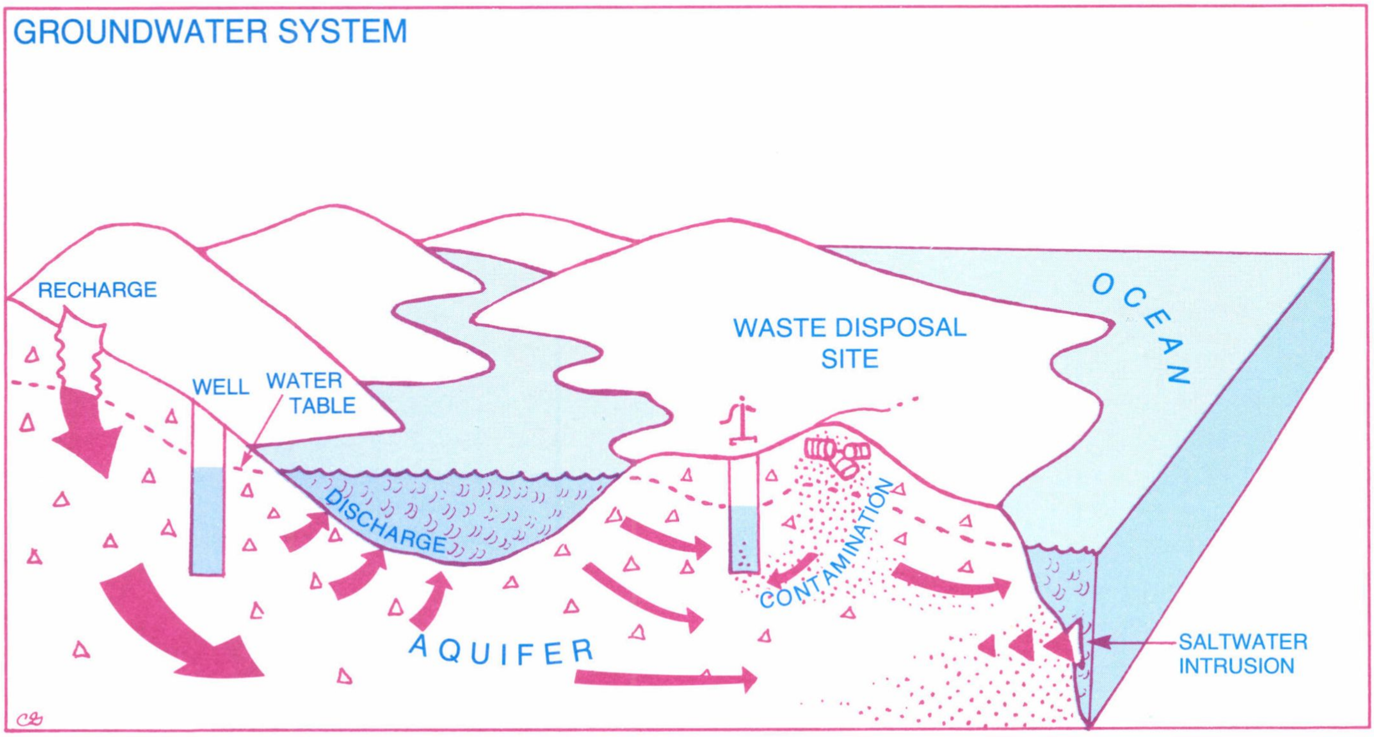
Groundwater occurs in the tiny spaces between soil particles (silt, sand and gravel) or in cracks in bedrock, much like a sponge holds water. The underground areas of soil or rock where substantial quantities of water are found are called "aquifers." These aquifers are the source of wells and springs. It is the top of the water in these aquifers that forms the "water table."

The origin and composition of aquifers are varied. Many important Canadian aquifers are composed of thick deposits of sands and gravels previously laid down by periglacial 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 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 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 are fractured rocks that are used for industrial water supply.

However, to concentrate only on major (i.e. large) aquifers is misleading. Many individual farms and rural homes depend on relatively small aquifers such as thin sand

Freshwater lakes, rivers and underground aquifers hold only 3.5% of the world's water. By comparison, saltwater oceans and seas contain 95.1% of the world's water supply.

and gravel deposits in the till. Although these aquifers are individually not very significant, in total they comprise 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: (1) by overpumping or (2) by decreasing recharge due to drought, for example. 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;
- Plugging of the screen at the opening of the pipe at the bottom of the well by mineral and/or bacterial deposits (very common) can occur.

Aquifer depletion is a more serious problem in the United States than in Canada. Although it happens in Canada, the permanent depletion of aquifers due to pumping is much less important than well failures in terms of impact on groundwater supplies. 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.

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

In Canada, there is no major problem with aquifer depletion because most major 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

Most communities lose a considerable portion of their piped water (up to 30%) in pipeline leaks, saying it is cheaper to waste than to repair or replace.

managed accordingly. Some places where groundwater was used for municipal supply earlier this century 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, Alberta, 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 is the result of the melting snow-pack or from streams in mountainous regions where the water table is usually below the bottom of the stream bed. It can also occur during local heavy rainstorms. Often ground-water 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 dis-charged from a spring may have travelled many kilometres before reaching the surface. Usually, spring water discharges occur or increase when rain or snowmelt has recharged the groundwater system in upland areas.

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 three million Canadians residing in urban areas rely on groundwater for their domestic water supply. At least another three 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 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, aquaculture, and mining.

20. What is the relationship between groundwater and permafrost?

Most of the Northwest Territories is covered by either the Canadian Shield or permafrost (permanently frozen ground), both of which inhibit the flow of groundwater. The major exceptions include the Mackenzie Mountains in the western Northwest Territories and 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.

21. How does groundwater become contaminated?

Groundwater becomes contaminated when anthropogenic, or people-created, substances are dissolved in waters recharging the groundwater zone. 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.

It is estimated that approximately 1 to 2 million water wells are in use in Canada at the present time. Approximately 38 000 new water wells are drilled each year in Canada

Contamination also results from an overabundance of naturally occurring iron, 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 but isolated problem in coastal areas. It is referred to as saltwater intrusion.

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

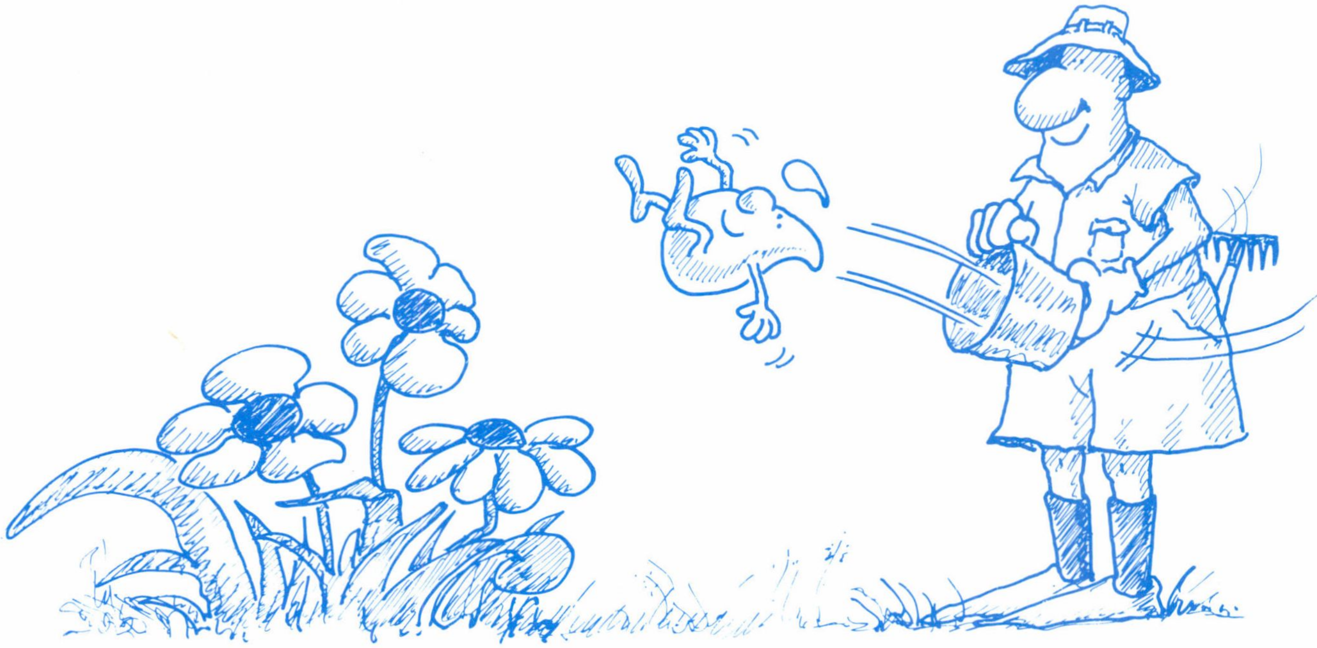
Groundwater is generally safer than surface water for drinking because of the filtration and natural purification processes which take place in the ground. These processes become ineffective owing to sewage, fertilizers, toxic chemicals and road salt, which seep into the ground.

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.

Worldwide water withdrawals from water bodies have risen from 250 cubic metres per person (per year) in 1900 to over 700 cubic metres today. In Canada, the number is much higher - about double that amount.

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 water returned to the source is water "consumed" (for example, by evaporating and not returning to the local source).

In 1986, thermal power generation used over 60% of total withdrawals, with manufacturing coming next with nearly 19% of the total intake. Municipal, agricultural and mineral extracting activities withdrew 11.2%, 8.4% and 1.4% of the total, respectively.

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

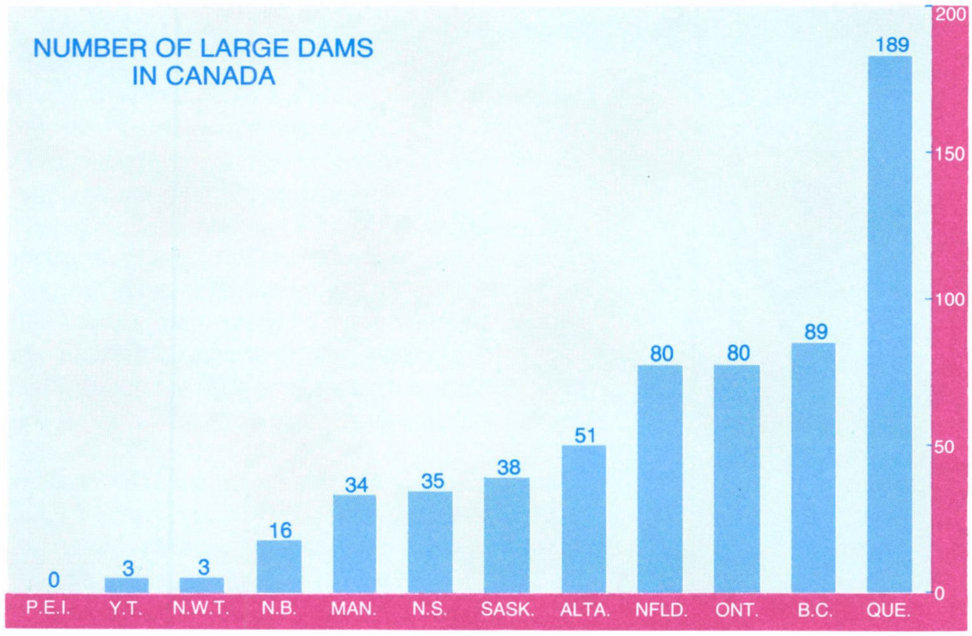
Much of the land producing fruits and vegetables as well as a significant amount of the land used to grow tobacco is irrigated. In western Canada, irrigated forage crops help stabilize the livestock industry.

According to the 1986 Census, over 678 000 hectares (about 2%) of the crop and pasture land of the four western provinces is irrigated. Only about 70 000 hectares of the rest of the provinces and territories is irrigated.

Much less than 1% of the water produced at a large municipal water treatment plant is used for drinking purposes.

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 3.5 million cubic decametres (1 $dam^3 = 1000\ m^3$). Due to incomplete data, only information on the irrigated areas of Western Canada is available; water use for irrigation in Atlantic Canada is known to be very small and has not been estimated.



26. How many dams are there in Canada?

Canada now ranks as one of the world's top ten dam builders. Although the Register of Dams presently reports 618 large dams - higher than 10 metres - in the country, there are many thousands of small dams.

Large dams are used primarily for hydroelectric power generation and also for irrigation purposes. Quebec has proportionately more large dams (189) than any other province, with most of them owned by Hydro-Québec. British Columbia is next, with 89 large dams, 33 of them owned by B.C. Hydro.

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

During 1987, 67% of the total power generated in Canada came from hydro sources, but it varied from highs of over 94% for Newfoundland and Labrador, Quebec, Manitoba, British Columbia, and the Yukon, to lows of 10% for Nova Scotia, 3.9% for Alberta, and 0% for Prince Edward Island.

In 1985, the United Nations ranked Canada as the world's largest hydroelectric producer, with 15% of the global output. The Churchill Falls plant in Labrador generates about 4500 megawatts of power - enough to light 45 million light bulbs, or run 80 million home computers.

Annually, Canada's rivers discharge 9% of the world's renewable water supply - 105 000 cubic metres per second.

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 input 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 condensing cooling purposes. Large amounts are required in the condensing and cooling phase.

29. Which form of energy production - solar, hydro, nuclear, gas or oil - is the most compatible with 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 mobilized. 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. Nuclear energy (fission) is a non-combustible form of energy production, but disposal of the radioactive waste and possible major accidents remain as problems.

Surprisingly, nuclear energy (fission) is also a non-combustible clean form of energy, although disposal of the highly toxic by-products of the fission process presents major problems, and many people perceive the threat of a major accident.

Finally, natural gas and refined, light fuel oil are relatively clean fuel sources of energy, although they do produce toxic emissions and some other by-products.

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

Across Canada, 10% of the water used in Canadian municipalities comes from groundwater; 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 obtained from wells. Water supply systems typically have intake, treatment, storage, and distribution components. There are many different treatment types, depending upon the characteristics of the source water. Likewise, the storage and distribution systems vary greatly between municipalities, depending upon 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 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 deeper, 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 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 which are generally installed on piles or blocking.

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

First, water is a managed, government-owned resource with licence and administrative fees attached. 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. All of these services cost money.

On the Prairies, irrigation is the largest consumer of water.

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 about $18 per month, and uses about 27 000 litres per month, for water delivered to the residence. Monthly bills range between $10 and $36, the lowest being in areas of the West and East coasts, and highest in the Prairie provinces and northern Canada.

Both consumer and actual costs are higher in the territories than in southern Canada. More water is used as well: about 500 litres per capita per day in the Northwest Territories and 1000 in the Yukon, well above the Canadian average of about 390. This may be because in the North water often has to be kept running to keep the pipes from freezing.

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 trucked service, about 200 litres per capita per day in the Northwest Territories.

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.

Maintenance (repair and upgrading) costs of municipal water supply and sewage systems may be as high as $8 billion to $10 billion over the next ten 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. Like with most commodities, the amount of water used decreases as 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 one half of American domestic and industrial water prices. This supports the conclusion that water in Canada is underpriced. However, this general conclusion may not be applicable in specific cases.

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 0.000 47¢, while the same amount of bottled water would cost 50¢; cola, 79¢; milk, 95¢; and table wine, $8.00.

Canada has built over 600 large dams, and about 60 large domestic interbasin diversions. To date, only about 40% of Canada's hydroelectric potential has been developed. Water power meets about two thirds of the nation's electrical needs.

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

Over 90% of the urban households are serviced by municipal water and sewer systems. The remainder, as well as most of the rural population, is serviced by private systems (usually groundwater), septic tanks and/or tile fields, or is delivered by trucks.

In the Northwest Territories, for example, 16% of the communities have centralized piped 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 honey buckets.

38. What is water conservation?

Water conservation activities are essentially designed to do two things: (1) to reduce the *absolute* amounts of water we use (less water per person or given product or service); and/or (2) to 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. 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: (1) Some regions of Canada are water-short due to semi-arid conditions. Dry summers place these areas of the country under additional stress. (2) 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. (3) And, finally, in many urban areas in Canada, municipal water utilities are experiencing limits on supply due to infrastructure problems either due to summer peak demands exceeding system capacities, or due to older sewer and water systems which 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). 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.

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, 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.

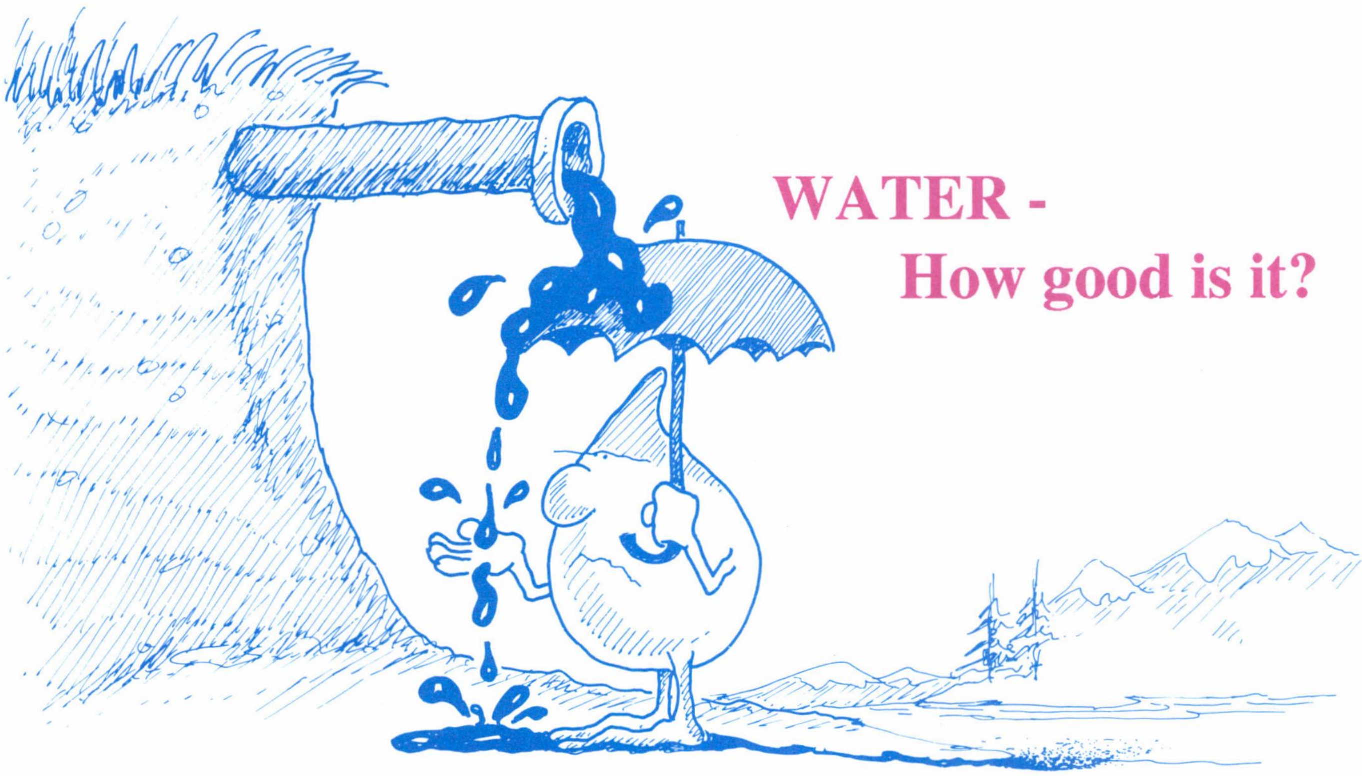
The last section of this Primer, "Water: Do's and Don'ts," provides many examples of actions which individual water users can take to implement conservation.

Although two thirds of urban Canadians are served by sewage treatment systems, that proportion is much lower east of the Ottawa River.

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 in water heating costs. Furthermore, conservation retrofitting of an existing building could generate benefits ranging between 15 and 20 times the costs incurred presently. Finally, water conservation lessens the demands made on a vital natural resource, thereby contributing to the sustainability of the Canadian environment.

The Great Lakes constitute one of the largest systems of fresh water reservoirs on earth, with 18% of the world's fresh surface water.



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. The quality of water appropriate for recreational purposes differs from that used for industrial processes.

The quality requirements of major water uses are given in the *Canadian Water Quality Guidelines*. These guidelines are summarized in the pamphlet "How Safe is our Water?" which is available from:

Director
Eco-Health Branch
Environment Canada
Ottawa, Ontario
K1A 0H3
Tel. (819) 997-1920

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.

Estimates vary, but it is commonly believed that there are up to 100 000 chemicals in commercial use worldwide, with about 1000 new chemicals entering the market every year.

Rain reaches the earth's surface and, as runoff, it 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 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, nitrogen), sediments, animal wastes, 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, while 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 Yukon water quality 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. 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), while the Northwest Territories is dominantly made up of the Canadian Shield, which is much older and already highly eroded. The extreme seasons in the Yukon, combined with its complex geology, glaciation and sources of erodible material, are also a contributing factor.

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 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.

Globally, approximately 34 000 deaths occur daily from water, faeces and dirt related diseases. (This is equivalent to 100 jumbo jets crashing daily!)

For copies of the *Guidelines for Canadian Drinking Water Quality*, contact:
Canada Communication Group
Ottawa, Canada
K1A OS9
Tel. (819) 956-4802
Fax (819) 994-1498

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, or fluoride used to reduce dental cavities.

48. Some of my friends buy bottled water for drinking and cooking. But I have heard that it is not safe either. Is that true?

In 1987, Canadians spent $110 million on bottled water; this figure is expected to double by 1995. Many consumers claim that their concerns about contaminants in tap water are a major reason for using such a product.

In a 1990 study by the Consumer's Association of Canada, 12 of the 16 domestic and imported bottled waters tested contained potentially harmful contaminants at concentrations above the acceptable levels indicated in the *Guidelines for Canadian Drinking Water Quality*.

Bottled water is not regularly tested for many pollutants, including pesticides, found in some waters because it is considered a "food" and not bound by drinking water guidelines specified by health and environmental departments. Consumers buying bottled water to avoid health hazards from tap water may not get the desired benefits, and may be paying up to 3000 times more for bottled water than regular tap water.

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, lake 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 chemicals.

33% of Canada's population live in municipalities that do not provide sewage treatment.

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 the turn of the century. 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?

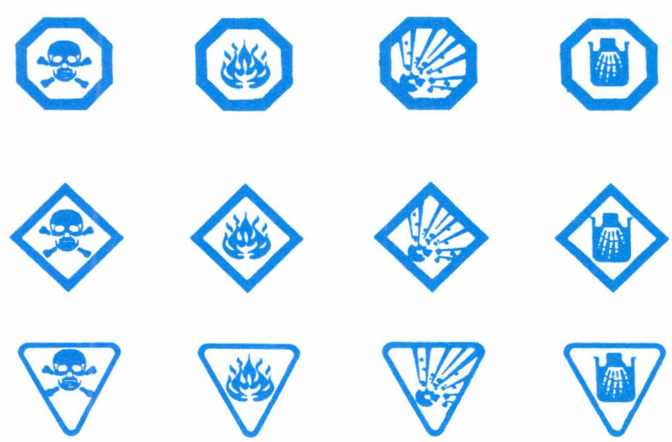
While chemical household products are generally safe for the uses they are designed for, some may become harmful to the environment as they accumulate in it. For this reason you should not put these products down the drain. Most sewage treatment facilities are not capable of removing such toxic substances. Anything put into the storm sewers is going directly to the receiving lake or river completely untreated. So, before you dump anything down the drain, 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 labelled 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 which are hazardous do not require warning labels. Canadian laws for hazardous household chemicals are regulated by Consumer and Corporate Affairs Canada. The laws for pesticides (such as mothballs, house and garden pesticides or insect repellents) are controlled by Agriculture Canada. Health and Welfare Canada regulates cosmetics. The symbols used on hazardous household chemical products are shown below:



The most severe flooding and erosion losses along the shores of the Great Lakes occurred during 1985-1986.

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.

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 utilized 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.

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 practices. Laundry detergents were once a major source of phosphorus, but regulations controlling its use in detergent manufacture 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 *Canadian Guidelines for 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, posters are installed in visible locations.

For further information and copies of the *Canadian Guidelines for Recreational Water Quality,* contact:

Chief, Monitoring and Criteria Division
Bureau of Chemical Hazards
Health and Welfare Canada
Ottawa, Ontario
K1A 0L2
Tel. (613) 997-3128

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

Eutrophication is the process of becoming better nourished either naturally or artificially. In terms of a lake, eutrophication occurs naturally with the gradual input of nutrients and sediment through erosion and precipitation resulting in a gradual aging of the lake. Man speeds up this natural process by releasing nutrients, particularly phosphorus, into rivers and lakes through municipal and industrial effluent and through increased soil erosion by poor land use practices. Eventually, a lake has 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 upon the original water quality, the type of soil, the underlying geology, the type of irrigation, the crop grown, and the farming methods used.

During the summer about half of all treated water is sprayed onto lawns.

Although a large portion of irrigation water is used by plants or evaporates from the soil (evapotranspiration), 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 enters 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 1981, thermal and nuclear power plants in Canada discharged 19 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.

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 townsites. 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.

61. What is dredging?

Dredging is the removal of sediments or earth from the bottom of water bodies using a type of scoop or 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 the transport of larger volumes of water.

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 and sea water are mixed) oyster beds can be destroyed, and 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 habitat.

Furthermore, contaminants accumulate over long periods of time in the sediments. Some toxic substances, such as mercury, deposit in the sediments but 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 death of fish and other aquatic organisms.

63. Can dredging be beneficial to the aquatic ecosystem?

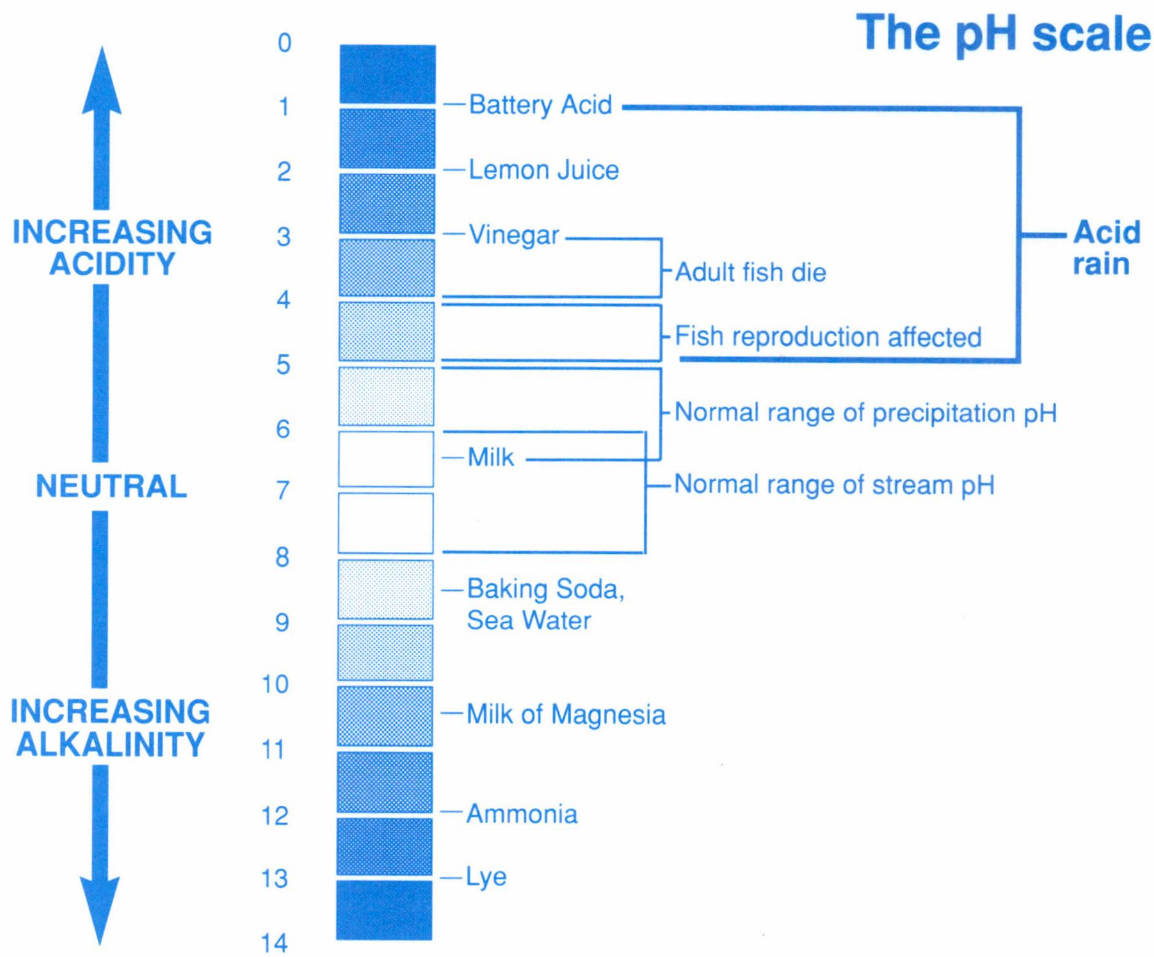
Yes, in many instances, dredging is beneficial to the environment. Dredging can be used to enlarge or create wetlands and provide more habitat opportunities and greater biological diversity in a given geographic area. In some cases, disturbed lake and river bottoms can be recolonized once the actual dredging activities have stopped. Dredged spoils can be used to create islands and contoured shorelines, provide nursery habitat for fish, nesting and staging habitat for waterfowl, and winter habitat for furbearers.

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

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 from that of clean rainwater. Acidity is measured on a pH scale. For example,



The acidity of a water sample is measured on a pH scale. This scale ranges from **0** (maximum acidity) to **14** (maximum alkalinity). The middle of the scale, **7**, represents the neutral point. The acidity increases from neutral toward **0**.

Because the scale is logarithmic, a difference of one pH unit represents a tenfold change. For example, the acidity of a sample with a pH of **5** is ten times greater than that of a sample with a pH of **6**. A difference of 2 units, from **6** to **4**, would mean that the acidity is one hundred times greater, and so on.

Normal rain has a pH of **5.6** — slightly acidic because of the carbon dioxide picked up in the earth's atmosphere by the rain.

295 000 litres of water is required to produce 910 kilograms of paper. 86 300 litres of water is required to produce 910 kilograms of steel.

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 various sources enter the atmosphere as substances which can produce acids. 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.

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 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 not 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 few limestone-type materials and, consequently, has only 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. 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 good in comparison with the extensively exploited watercourses in 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 and other metals, which have led to the development of a number of mining operations throughout the Northwest Territories. By-products from the mines include metals such as copper, lead and zinc, arsenic and cyanide, which are discharged into receiving waters.

The oil and gas industry, located in northern Alberta and in the Mackenzie Valley, can also degrade water quality by accidental spills from refineries and along transportation routes. 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.

A long-term commitment to a comprehensive monitoring program for northern rivers and lakes is essential to keep governments, the public, developers, and industry users informed on the quality of northern rivers and lakes. This information is required

Between 1972 and 1981, Canada's water withdrawal increased from 24 billion cubic metres per year to over 37 billion cubic metres per year - a rise of over 50%; in the same period, population increased only 5%.

by regulatory agencies to ensure that water quality concerns can be addressed before they become problems. However, the marine water system in the North, in contrast to the freshwater one, has been contaminated from various global sources, including air and sea transport. This is of particular concern to the Inuit, many of whom live near the sea and depend on it for their food.

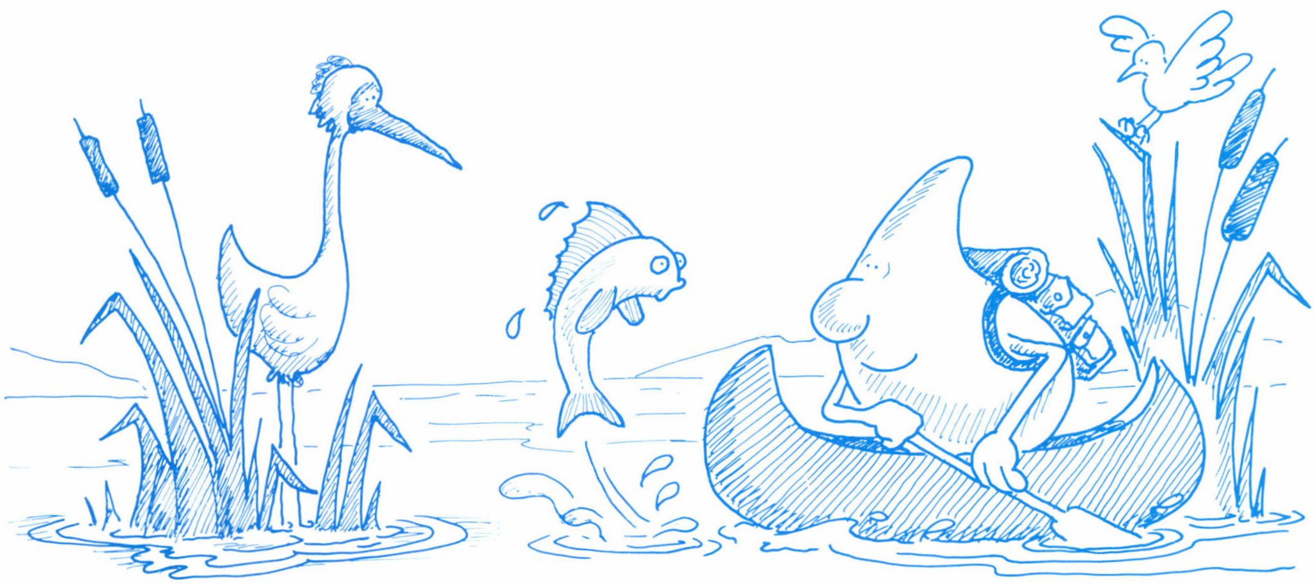
67. Has water quality in Canada improved or deteriorated in the last ten years?

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 eutrophication has not disappeared and we still must take great care in limiting the discharges of phosphorus to the lakes, we can say that this problem is now under control in the Great Lakes basin. Regulations to prevent eutrophication have proved effective there. Attention is now being directed toward toxic chemicals.

Today, 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.

The Great Lakes, straddling the Canada-U.S. boundary, contain 25% of the world's fresh water in lakes (tying for "first place" with Lake Baykal, U.S.S.R.).

WATER - An ecosystem perspective



68. 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 floodplain marshes, which are flooded with water for only parts of the year. Seemingly inhospitable aquatic ecosystems can sustain life. Thermal springs, for instance, support algae and some insect species at temperatures near the boiling point; tiny worms live year-round on 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.

69. 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.

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

One litre of oil can contaminate up to two million litres of water.

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

Canada contains an abundance of freshwater (non-saline) ecosystems including lakes, ponds, rivers, streams, and wetlands.

A *lake* is a sizeable 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 dominated by cold-water bottom fish such as lake trout; and eutrophic lakes, which are shallower, are more productive and dominated by warm-water fish such as bass. Great Slave Lake (N.W.T.) 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 resulting from dams built 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 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 salt-water bodies that cover 70% of the earth's surface. The tidal areas where salt water 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.

71. 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, sedges) and gleyed (poorly drained) or peaty soils.

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

72. Where are wetlands found in Canada?

Wetlands cover about 14% of Canada. They were once abundantly distributed throughout the country. Today, however, wetlands have become a scarce resource in the settled parts of the country. Throughout Canada, wetlands have been adversely affected by land use practices which 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.

73. 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.

Since the beginning of the 19th century, marshes along the Canadian shore of Lake Ontario have been reduced in area by 40%.

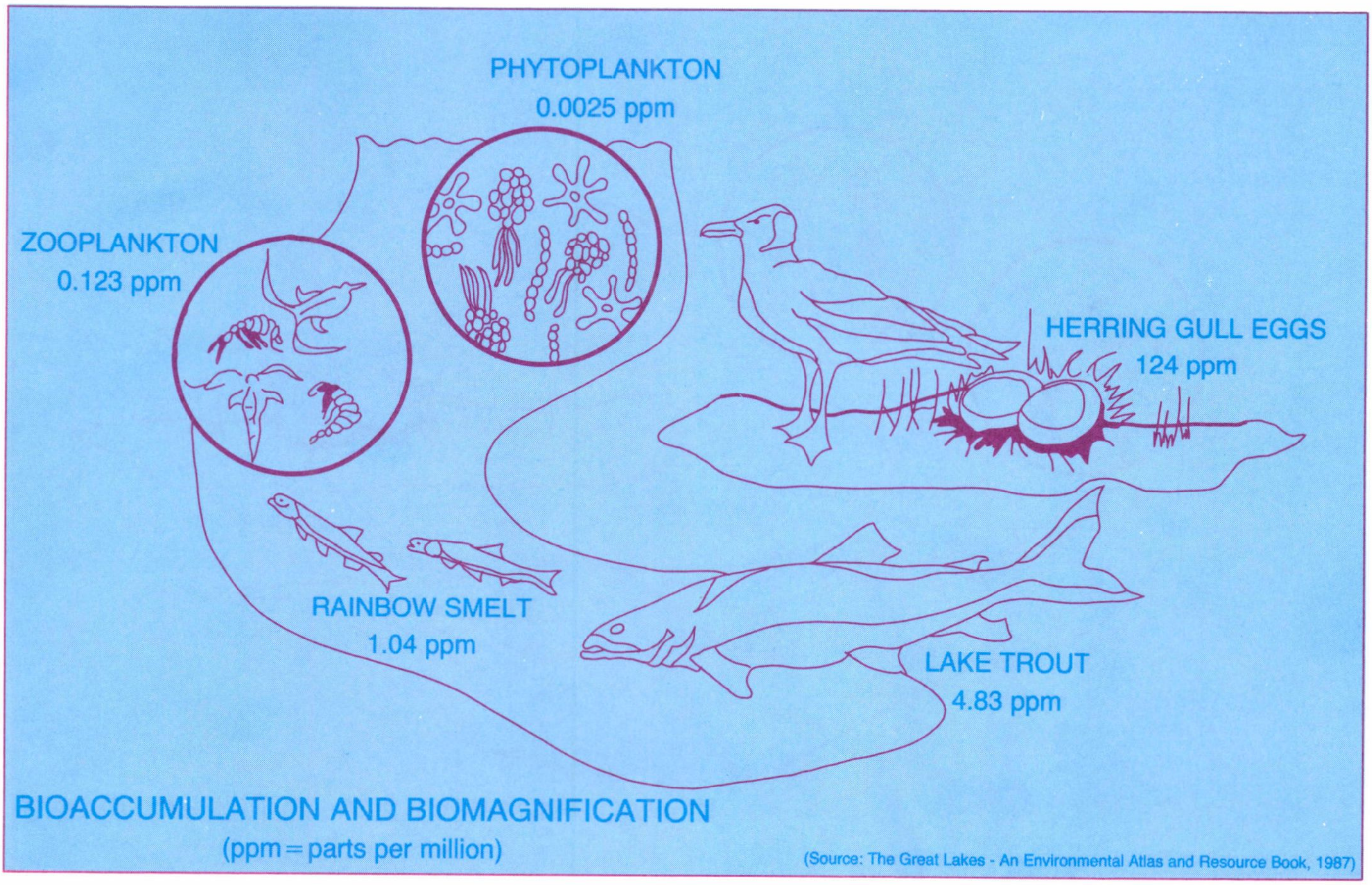
74. How do wildlife species use wetlands?

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 which have been deposited in the water. Wetland vegetation provides 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 food for birds of prey. Each species has adapted to using the wetland and its surrounding area in a particular way.

75. 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.



Wetlands: Canadians are the trustees of almost 25% of all of the world's wetlands, currently covering 14% of the land area of Canada.

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.

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.

76. 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.

77. 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.

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 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.
- The presence of certain organisms which 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 diarrhoea, typhoid, and cholera.
- A change in chemical properties. Perhaps one of the most significant has been a reduction of pH in water caused by acid rain.

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.

Sports fishing accounted for $1.76 billion in expenditures and investments in 1980, of which $300 million was contributed by foreign anglers.

78. Why is aquatic ecosystem health important to humans?

Human 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.

For example:

- 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 faeces and medical waste.
- Navigation problems, caused by the rapid expansion of bottom-rooted aquatic plants, have increased for pleasure craft.
- The proliferation of non-native species has created problems. One recent example is the rapidly expanding zebra mussel population, introduced from the ballasts 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.

79. 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. They play a critical role in making development environmentally sustainable. 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 and 10 billion dollars annually in economic returns to Canadians. Wetlands support commercial and sports fishing, waterfowl hunting, trapping, recreation, peatland forestry, water purification, groundwater discharge, and flood peak modification.

80. 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.

81. 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 reestablish themselves. In other cases, more severe disturbances (e.g. dam construction) may cause local extinctions 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. Some of these mechanisms are:

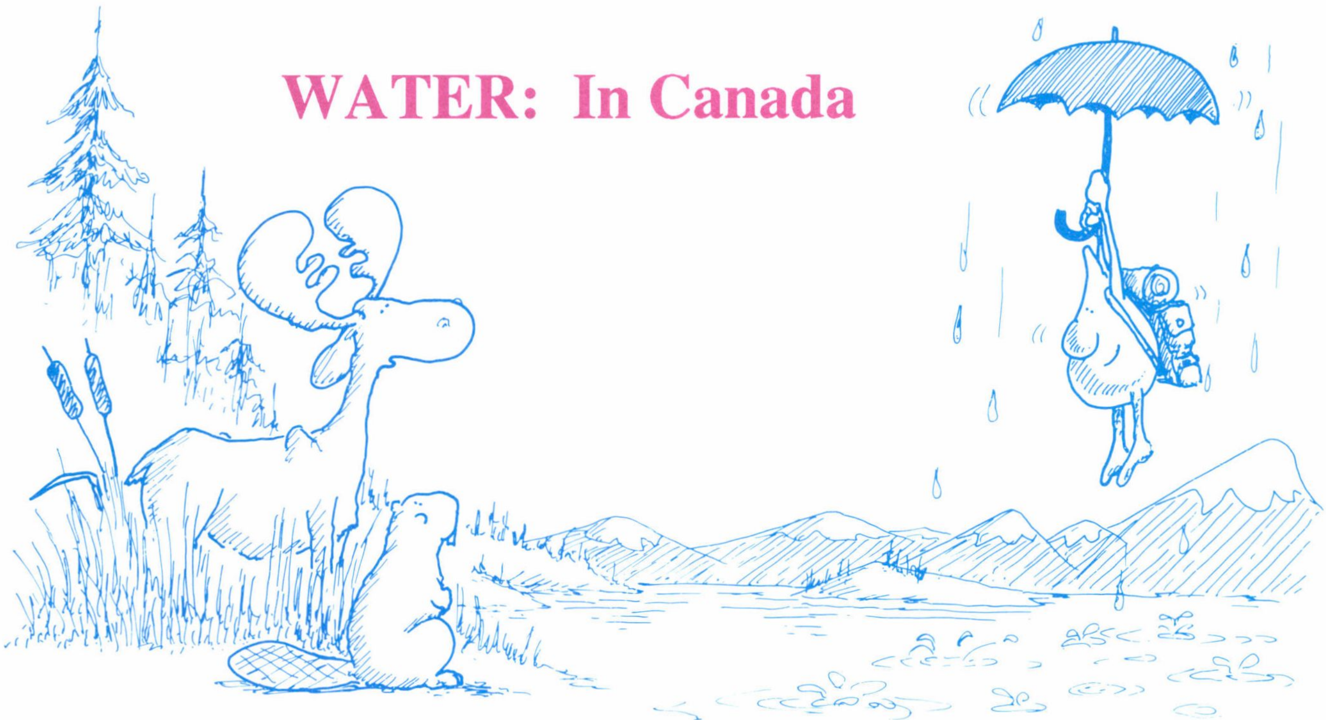
- Environmental Legislation: Legislation such as the Canadian Environmental Protection Act (CEPA) is designed to ensure that Canadians and the aquatic environment are protected from exposure to toxic substances and from the risks associated with the use of chemicals.

About 7.6% of Canada is covered by fresh water in lakes and rivers - 755 165 square kilometres. To this can be added 195 059 square kilometres of perennial snow and ice. Canada's rivers and lakes contain enough water to flood the entire country to a depth of more than 2 metres.

- Integrated Resource Planning: This approach ensures that relationships among land use, development, water flows, water quality, and aquatic ecosystems are considered prior to the land use designations for areas.
- Technology: Measures to improve the quality of waste discharges and to lower both water demands and effluent loadings are being implemented in response to environmental and water use concerns.
- Environmental Monitoring: Monitoring of chemicals in the water, sediment and organisms helps us to identify potential ecosystem problems and to track existing problems.
- Compensatory Measures: For example, a fish hatchery operation can produce young fish which a disturbed habitat can no longer supply.

Canada holds 20% of the world's fresh water, but has only 9% of the world's fresh renewable water; the rest is "fossil water," a legacy of the melting Pleistocene ice sheets.

WATER: In Canada



82. 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 9% 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, 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 90% of the population lives within 300 kilometres of the Canada-U.S. 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.

Canada has about 9% of the world's renewable freshwater supply, compared with 18% for Brazil, 13% for the USSR, 9% for China, and 8% for the United States.

WATER FLOW COMPARISONS

1 cubic metre per second (m^3/s)
=31 536 cubic decametres per year (dam^3/yr)
=86 400 cubic metres per day (m^3/d)
=fills 2000 backyard swimming pools per day
=1000 rail tank cars per day

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

The Water Survey of Canada, Environment Canada, along with many contributing agencies presently measure the rate of flow (discharge) in rivers and record the levels of lakes and rivers at more than 3100 locations in Canada.

- Water levels are read manually by gauge readers or continuously recorded either digitally or on graph paper.
- 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 from a bridge, by wading in a stream, by boat or from a cableway strung across the river. In winter, the measurements are made through the ice.
- 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 7700 active and discontinued sites permit the estimation of streamflow at ungauged locations.

TYPICAL RIVER FLOWS
(from lowest to highest daily average, m^3/s)

Location	River	Annual Average	Daily	
			Highest	Lowest
P.E.I.	Dunk River at Wall Road	2.63	84.7	0.212
Sask.	Qu'Appelle River near Lumsden	5.20	436	0
N.B.	Lepreau River at Lepreau	7.37	340	0.028
Man.	Manigotagan River near Manigotagan	8.25	103	0.065
Ont.	Rideau River at Ottawa	38.9	583	1.48
N.S.	St. Mary's River at Stillwater	43.0	974	0.15
Ont.	Saugeen River near Port Elgin	56.5	1 030	5.72
Nfld.	Gander River at Big Chute	117	1 170	2.78
Alta.	Athabasca River at Hinton	173	1 200	10.8
Y.T.	Yukon River at Whitehorse	242	646	32.6
Sask.	South Saskatchewan River at Saskatoon	259	3 940	14.2
Que.	Rivière aux Outardes at Chute-aux Outardes	385	2 830	10.5
N.B.	Saint John River below Mactaquac	810	11 100	21.5
Ont.	Ottawa River at Britannia (Ottawa)	1 290	5 060	334
Nfld.	Churchill River above Upper Muskrat Falls	1 740	6 820	253
B.C.	Fraser River at Hope	2 710	15 200	340
Ont.	Niagara River at Queenston	6 010	9 760	2 440
Ont.	St. Lawrence River at Cornwall	7 540	10 200	4 500
N.W.T.	Mackenzie River at Norman Wells	13 200	33 300	3 680

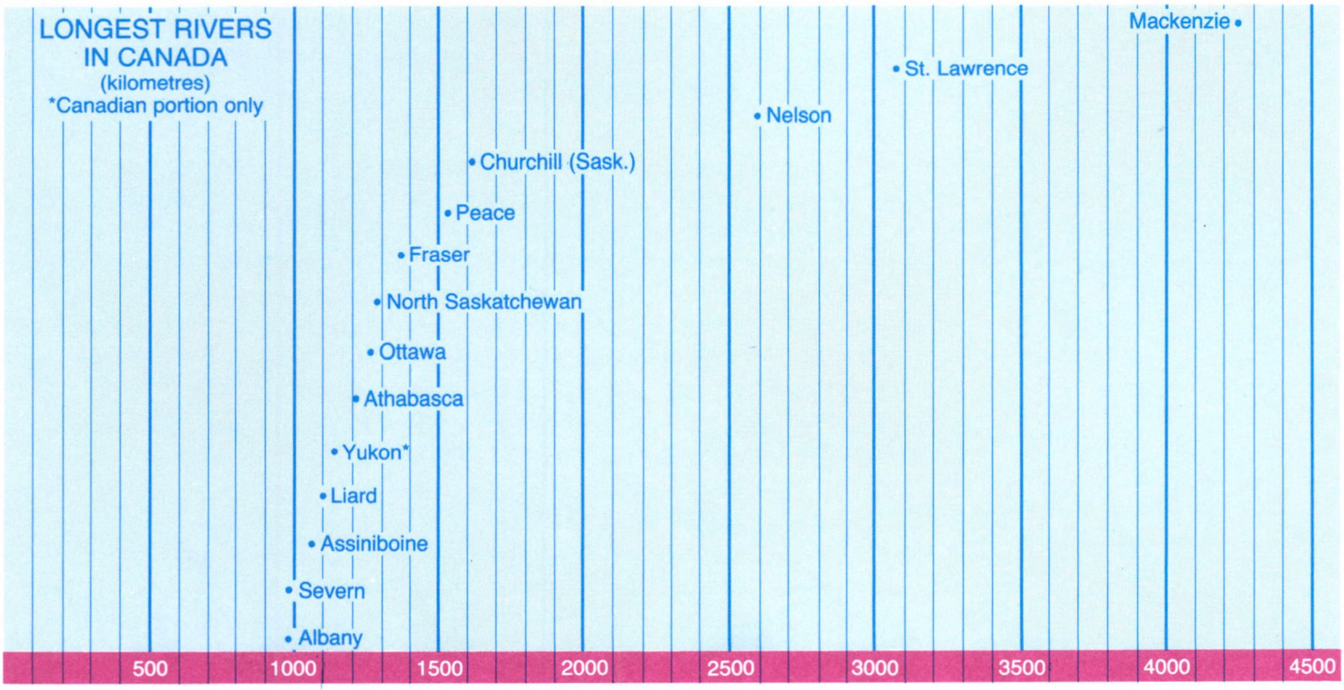
Source: *Water Survey of Canada*, 1990.

The highest waterfall in Canada: Della Falls, B.C. - 440 metres. The greatest waterfall by rate of flow, on average, in Canada: Niagara (Horseshoe Falls), Ontario - 5365 cubic metres per second.

84. 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.



Our rivers and lakes north of 60° 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, N.W.T., is the world's ninth largest (by area) lake. The St. Lawrence - Great Lakes drainage basin is the largest in southern Canada.

The Northwest Territories covers 34% of Canada's landmass, and has 18% of its lake area. Average annual runoff produced within the Northwest Territories is 18% of the total for Canada, and another 5% of that total flows into the Northwest Territories from the south.

The Northwest Territories' 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, underground and in glaciers are unavailable. However, northern runoff is less

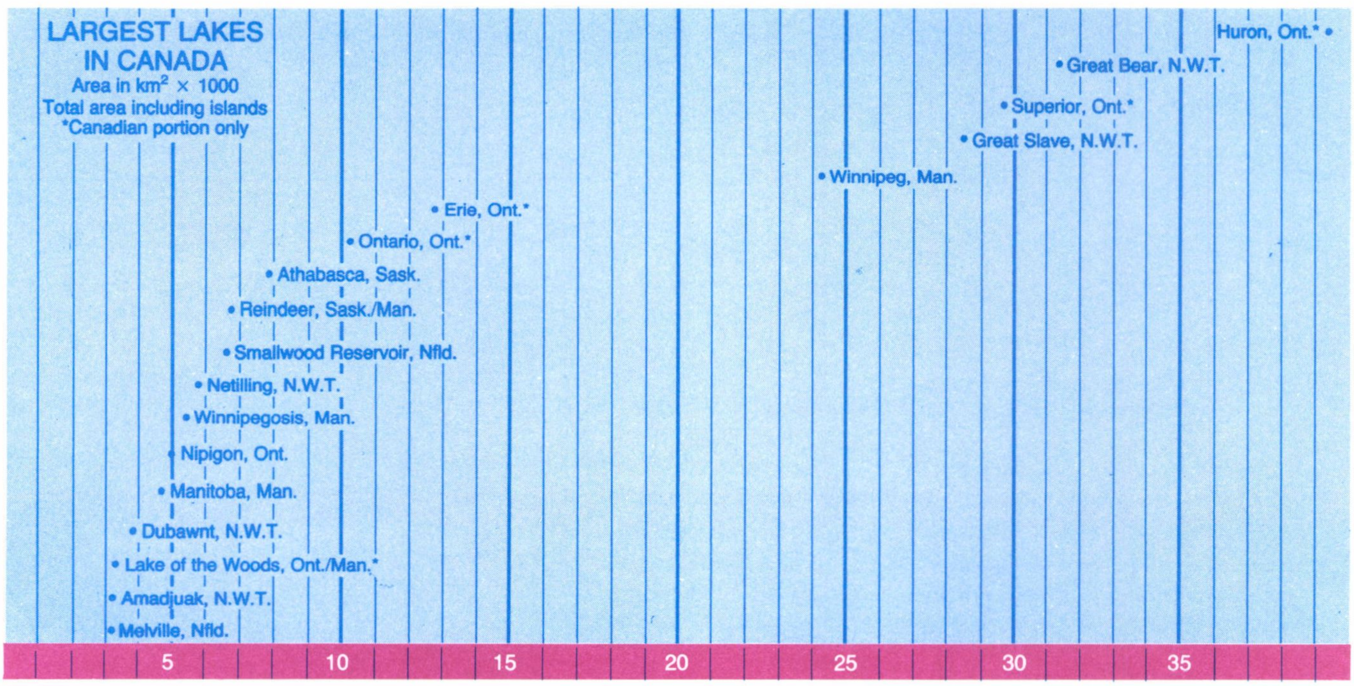
The Great Lakes' coastline accounts for 4% (10 000 kilometres) of the total length of Canada's coasts.

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.

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

Sustainable development is 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." For example, development such as building a pulp and paper mill on a river may involve activities that damage or destroy our soil, water and atmospheric systems as well as our genetic resources.

To make the development "sustainable," environmental 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.

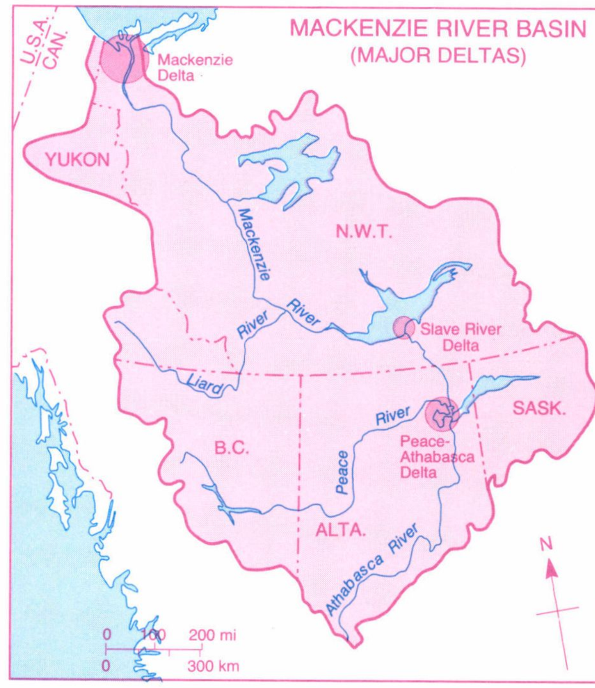


88. Is the water that flows into the oceans from lakes and rivers wasted?

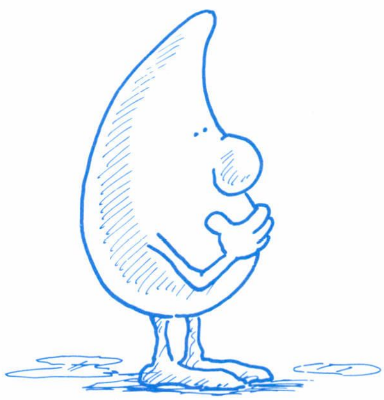
Not at all. It is an essential part of the global hydrologic cycle. This water is vital to navigation, recreation, fish and wildlife support and waste dilution, and so sustains the lifestyles of large and small communities across Canada. Even in the least populated northern reaches of this country, the 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.)

Approximately 57% of Canadians (1980-81 data) are served by wastewater treatment plants, compared with 75% of Americans, 86.5% of Germans, and 99% of Swedes.

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.



Twenty-six percent of all Canadians rely on groundwater for domestic use. Large areas of the country are dependent on groundwater such as Prince Edward Island, New Brunswick, Saskatchewan and southwestern Ontario.



WATER: How we share it

89. What is a river basin?

A river basin is the total land area drained by a river and its tributaries.

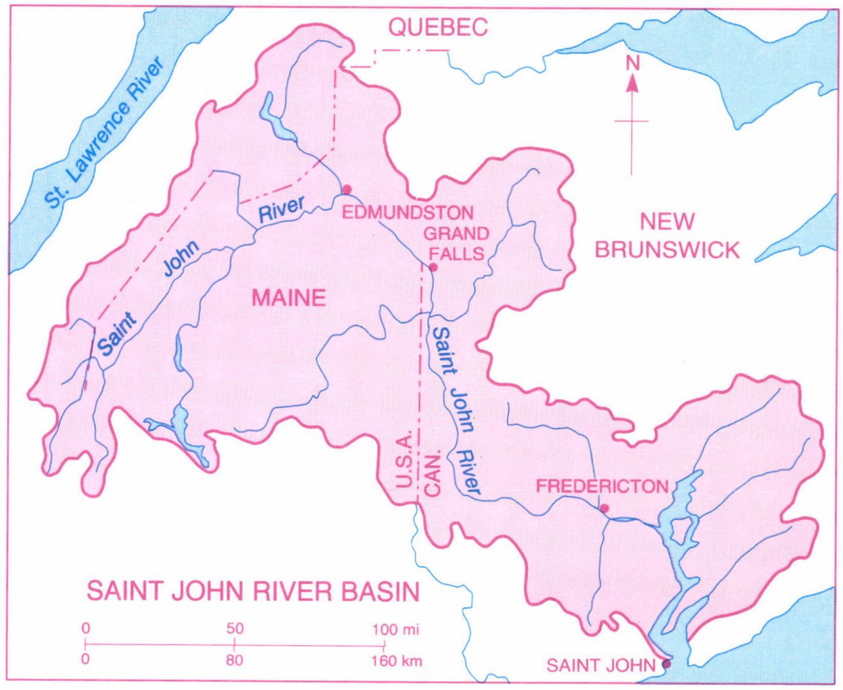
90. Do most river basins fall within provincial, territorial or national boundaries?

River basins are defined by topography. Smaller basins (sub-basins of the larger basins) often fall within political-administrative boundaries. However, most larger basins extend well beyond 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 (often referred to as Canada-U.S. "boundary waters") extend beyond the Canadian border, such as the Saint John River basin. The Great Lakes are an example of a very large trans-boundary basin.

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

More water is diverted between drainage basins in Canada than in any other country in the world. This amounts to approximately 4400 cubic metres per second or the equivalent flow of a river the size of the Ottawa River. Unlike other countries which divert from where water is abundant to where it is scarce, or from where there are few people to where there are many, Canada diverts water mostly to concentrate flows for hydroelectric development, especially in northern projects such as on the Nelson River Program in Manitoba and in the James Bay area in Quebec.

A five-minute shower with a standard shower head uses 100 litres of water, whereas a five-minute shower with a low-flow shower head uses 35 litres of water.



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

Diverting flow from one basin to another leads to economic development through energy generation, irrigation and industrial output.

On the other hand, disadvantages are likely to appear in terms of social and environmental consequences, especially in the immediate vicinity of project construction and flow regime change. Sometimes communities are flooded out or people are forced to change their livelihood or otherwise modify their traditional way of life. For example, the native 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 their commercial fishing on the lake, as mercury from flooded soils accumulated in the whitefish to dangerous levels.

Interbasin water transfers may also result in the introduction of incompatible and undesirable organisms in receiving water bodies, leading to degradation of the aquatic ecosystem.

Decisions on interbasin diversion must rest upon a consideration of the balance between benefits and costs to society over the long term and upon how these may be fairly shared.

Each day humans must replace 2.4 litres of water, some through drinking and the rest taken by the body from the foods we eat.

93. How do problems arise over sharing water?

We are all downstream from somebody else! If water is removed *upstream*, it will not be available *downstream*. If the river flow is reduced, even temporarily, by upstream storage, ferry traffic, wetlands 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 they can use it.

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

The biggest hurdle often is to obtain *willingness* on the part of all parties to study the problems, and to negotiate a solution. A number of studies are required (technical, economic, environmental, sociological, legal).

Public involvement at various stages during the process is vital. Above all, what is needed is a real commitment from all parties to maintain and protect the water resource.

95. Are there any rules governing how two or more provinces/ territories share the use of water from the same river or lake?

Not 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 arising in or flowing through Alberta is reserved for Saskatchewan, and that one half of the eastward flow arising in or flowing through Saskatchewan is reserved for Manitoba.

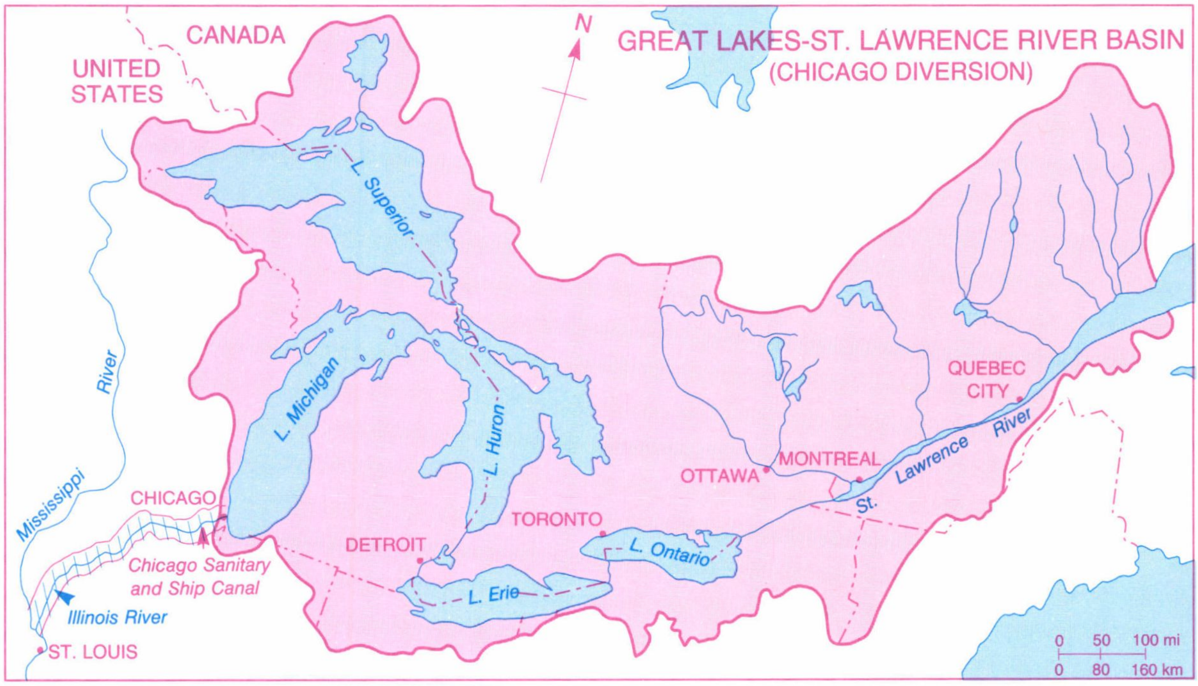
Negotiations are also under way for a broad water management agreement for the huge Mackenzie River basin.

96. What arrangements do Canada and the U.S. have for the sharing of boundary waters?

The oldest and most important agreement between Canada and the United States is the Boundary Waters Treaty of 1909. The basic principles for the use, obstruction and diversion of boundary and transboundary waters are established by the Treaty and administered by the International Joint Commission (IJC). Under the Treaty's "umbrella," many other agreements have been negotiated for specific water bodies. The studies leading to these agreements and the subsequent implementation of the agreements are done either under the auspices of the IJC or bilaterally by Canada and the United States. Today, over 30 international water boards exist between Canada and the United States each with equal representation of both countries.

Some neighbouring provinces and states also enter into voluntary arrangements for managing and protecting boundary water resources. The best known example 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, respectively. 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 1986, Canadians spent $80 million on bottled water. The bottled water business grew to sales of $130 million in 1988 and $150 million in 1989.



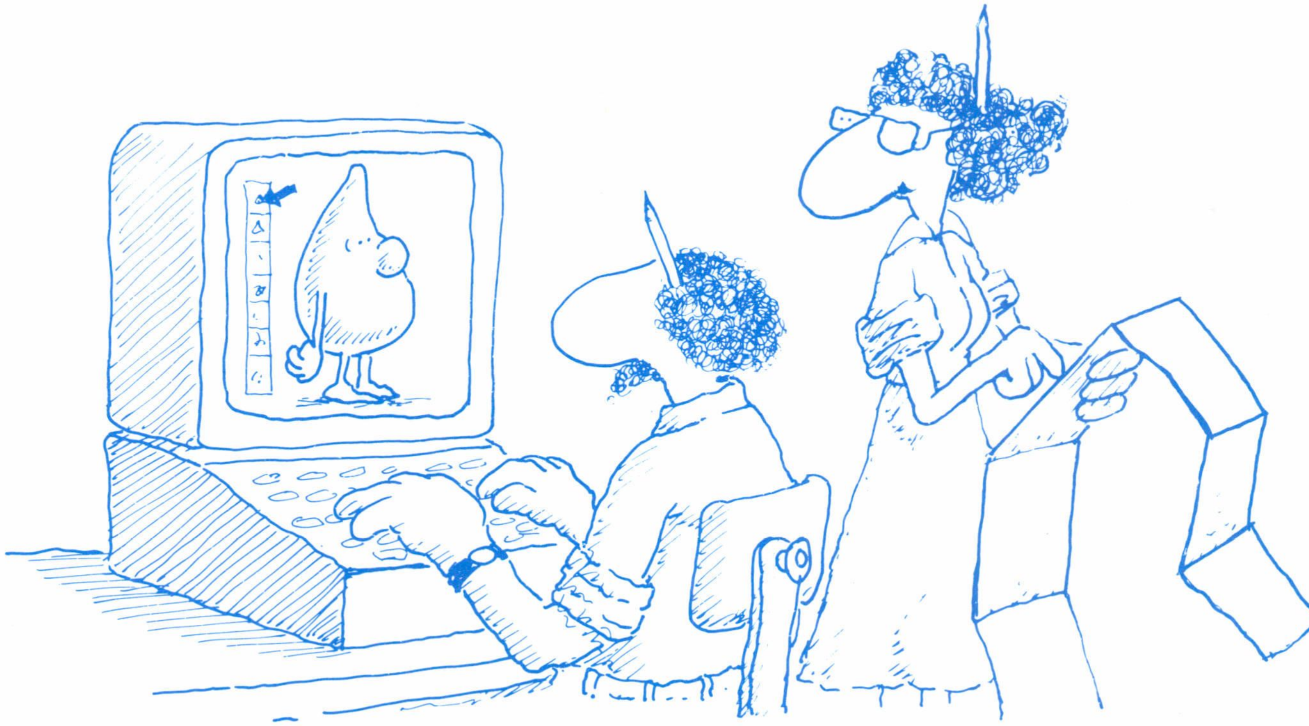
97. Why is the Chicago Diversion from Lake Michigan of interest to Canada?

The Chicago Diversion originated in 1848 as a means of connecting the Great Lakes and the Mississippi River for navigation purposes. It has since been modified and adapted for municipal water supply and for disposal of effluents. Under a U.S. Supreme Court order, the rate of diversion of water from Lake Michigan into the Illinois-Mississippi system is limited to 90 cubic metres per second. Periodically, pressures develop within the United States to increase the rate of diversion, but these are resisted by Canada and by most of the Great Lakes states because of the adverse effects such increases would have on hydropower, navigation and other economic and environmental aspects throughout the St. Lawrence drainage basin.

98. A lot has been written about water exports. Does Canada export any water now?

At present, Canada's water exports are negligible. They amount to less than 0.0001% of the national supply. Exports are in the form of bottled water and water used in beverages and as piped supply in transboundary communities such as St. Stephen, New Brunswick, and Calais, Maine, where water supplies are exchanged in both directions across the border. Bulk water exports by ocean tanker await the development of foreign markets. Large-scale river diversions across the Canada-U.S. boundary have never been approved.

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.



WATER - How we manage it

99. 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 resource to support them.

100. Who is responsible for water management in Canada?

In Canada, the responsibility for water management is shared by the federal, provincial and municipal governments. For the most part, waters solely within the provinces are their property and hence their responsibility. The waters flowing in the national parks, Indian reserves, and other federal lands in the provinces 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 and Yukon territories.

Shared federal-provincial responsibilities encompass interprovincial water-related issues, agriculture, health and significant national water issues such as interbasin tranfers.

101. Who is responsible for water management in the North?

The federal government, specifically the Department of Indian and Northern Affairs (DIAND), manages the water resources in the Yukon and Northwest Territories under The Northern Inland Waters Act. The Act provides an unique framework for managing water resources. Among other things, it establishes a water board in each territory, which is responsible for conservation, development and use of water resources. The Water

Thirty percent of the earth's fresh water exists as ice in the form of glaciers and ice caps.

Resources Division of DIAND is responsible for enforcing the Act, and for resource planning, forecasting floods, collecting data, and supplying information to territorial water boards and the public. The Department's Indian and Inuit Affairs Program is concerned with water quality and the effect of polluted water on the health of the native peoples. Furthermore, under its Northern Affairs Program, DIAND's Water Resources Division shares responsibility with the 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.

Specifically, Environment Canada's Northwest Territories Programs Branch, in cooperation with the Department of Indian and Northern Affairs and other government and private sector agencies, operates about 142 water level gauges in streams and lakes, and about 36 water quality sites. Similarly, in the Yukon Territory, data are monitored at 74 water level gauges and about 7 water quality sites.

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

As 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. From a management point of view, transboundary questions are also relevant, as water flows across Yukon's borders with Alaska, British Columbia, and the Northwest Territories.

103. What are Canadian Heritage Rivers?

The Canadian Heritage Rivers System is a cooperative program of the Government of Canada and, to date, eight provinces - Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Ontario, Manitoba and Saskatchewan - and the Yukon and Northwest Territories. 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.

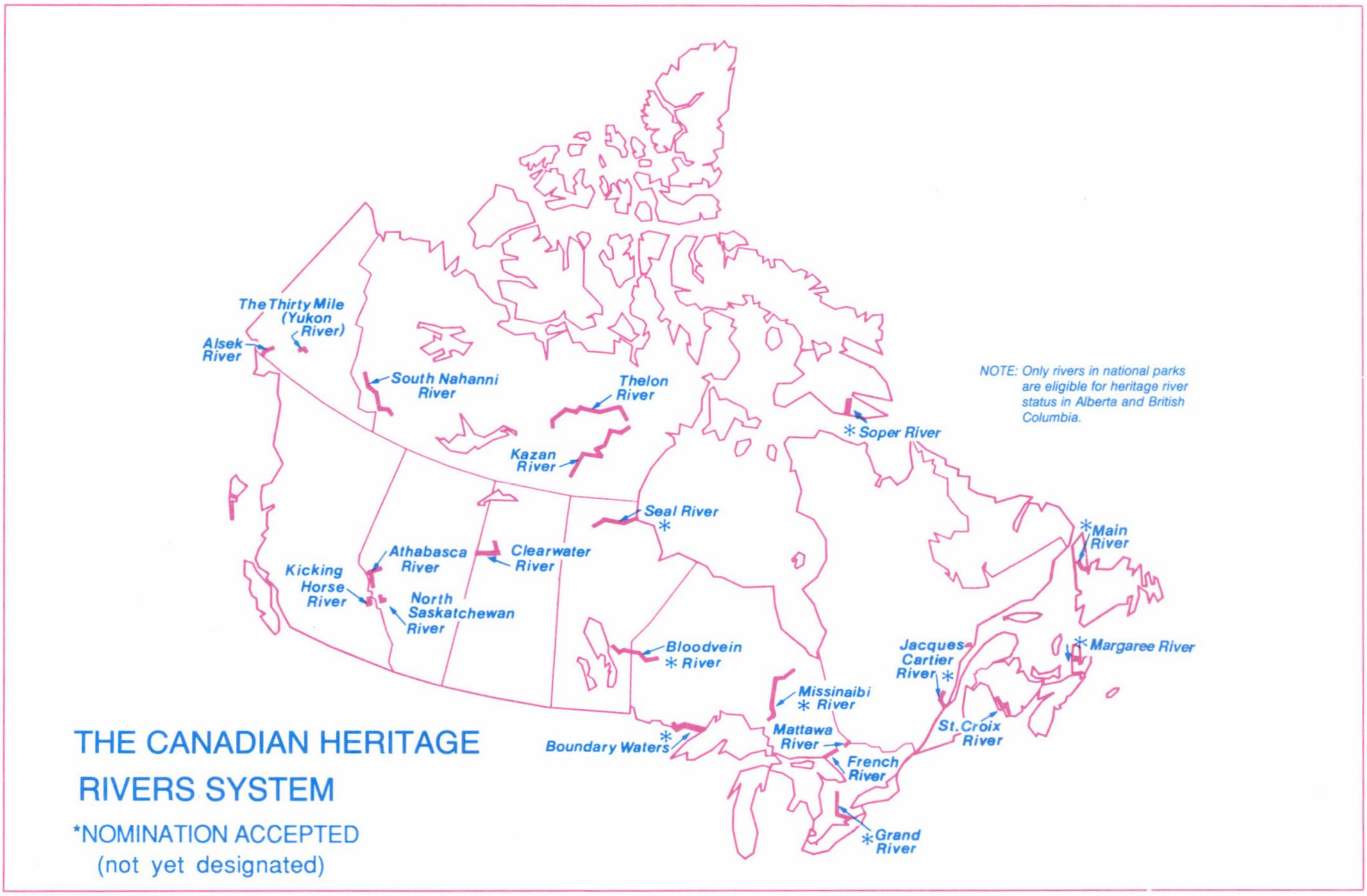
Since 1984, sections of 23 rivers, with a total length of more than 4858 kilometres, have been added to the system. These include the following:

- the Main and Bay du Nord in Newfoundland;
- the Margaree in Nova Scotia;
- the St. Croix in New Brunswick;
- the Jacques-Cartier in Quebec;
- the Mattawa, French, Grand, Boundary Waters and Missinaibi in Ontario;
- the Bloodvein in both Ontario and Manitoba;
- the Seal in northern Manitoba;
- the Clearwater in Saskatchewan;
- the Athabasca, North Saskatchewan and Kicking Horse in the Mountain National Parks in Alberta and British Columbia;
- the Alsek and the Thirty Mile Section of the Yukon River in the Yukon;
- the South Nahanni, Kazan, Thelon, Soper and Arctic Red in the Northwest Territories.

Rivers currently being considered by their managing governments for possible nomination include:

- the Back in the Northwest Territories;
- the Churchill in Saskatchewan;
- the Tatshenshini, Bonnet Plume, and Big Salmon in the Yukon;
- the Hayes in Manitoba;
- the St. Marys in Ontario;
- the St. Marys and Shelburne in Nova Scotia.

The value of Canadian water treatment and delivery systems totals $100 billion.



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 the 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, 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.

Passage of a major storm on Lake Erie can cause short-term lake level changes of as much as 5 metres.

Natural landscapes and habitats along the canals complement the cultural resources and contribute to the environmental 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.

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

As water resources in Canada are primarily the responsibility of the provinces, most of the laws used to protect lakes and rivers are passed and enforced by the provinces. Examples of provincial legislation include Manitoba's Clean Environment Act, Ontario's Water Resources Act, and Newfoundland's Waters Protection Act.

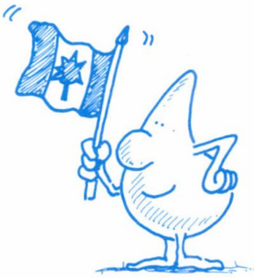
The federal government does, however, maintain involvement to protect Canadian lakes and rivers where an issue affects a large number of Canadians or when it involves more than one province, territory or other countries. The federal government's legislation related to the protection of our lakes and rivers includes:

- the Canada Water Act;
- the International River Improvements Act;
- the International Boundary Waters Treaty Act;
- the Fisheries Act;
- the Northern Inland Waters Act;
- the Navigable Waters Protection Act;
- the Canadian Environmental Protection Act;
- the Arctic Waters Pollution Prevention Act;
- the Canada Shipping Act;
- the Government Organization Act;
- the Lake of the Woods Control Board Act;
- the Dominion Water Power Act.

The federal government's role of protecting lakes and streams in the Yukon and Northwest Territories includes responsibility similar to the provincial governments' function in the south.

Water legislation is now being updated, consolidated and strengthened in support of implementation of the federal government's policy on water.

106. What is the Federal Water Policy?



The Federal Water Policy, the first of its kind in Canada, was formulated after several years of intensive consultation, both within and outside government. It addresses the management of water resources, balancing water uses with the requirements of the many interrelationships within our ecosystem.

The policy takes into account the needs of all Canadians in its overall objective:

- 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.

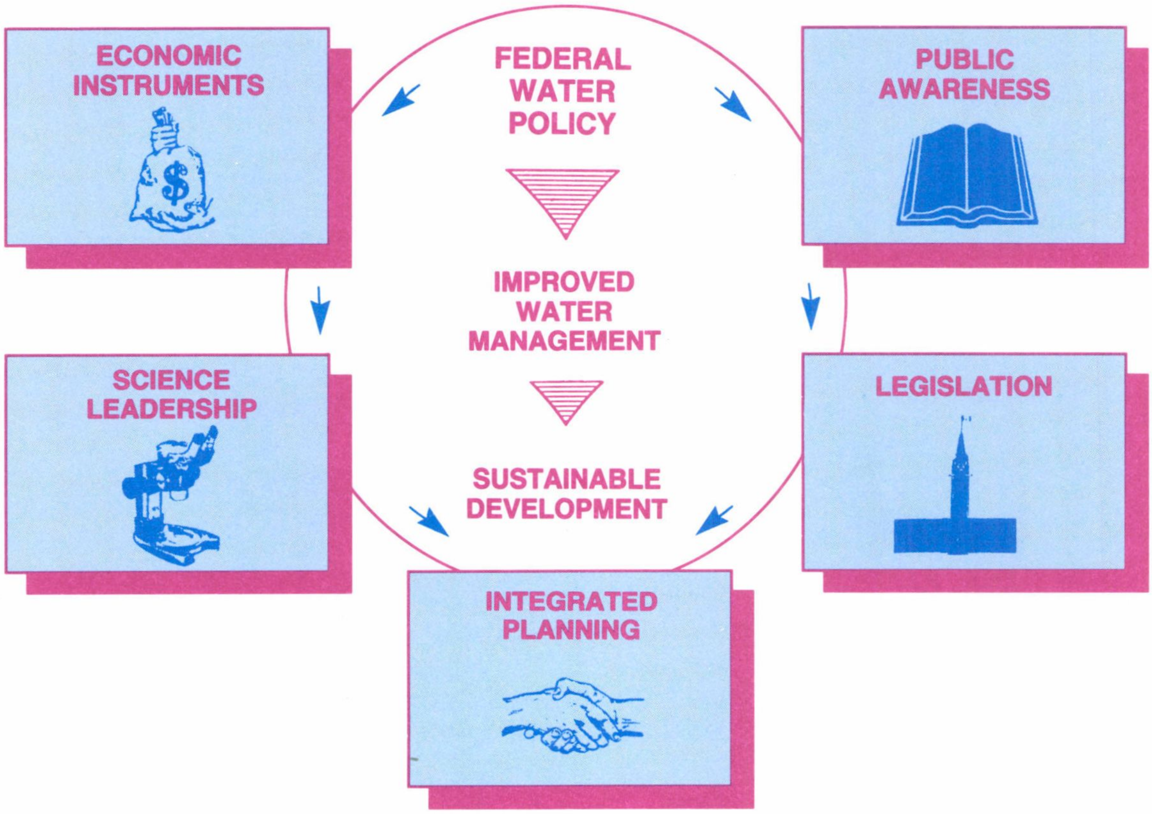
To manage Canada's water resources, the federal government has defined two main goals with respect to water:

- to protect and enhance the quality of the water resource;
- 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.

Canada has more lake area than any other country in the world.

THE 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 measurable contribution of water to the Canadian economy is estimated to range between $7.5 billion and $23 billion per year.

Copies of the Federal Water Policy are available from:

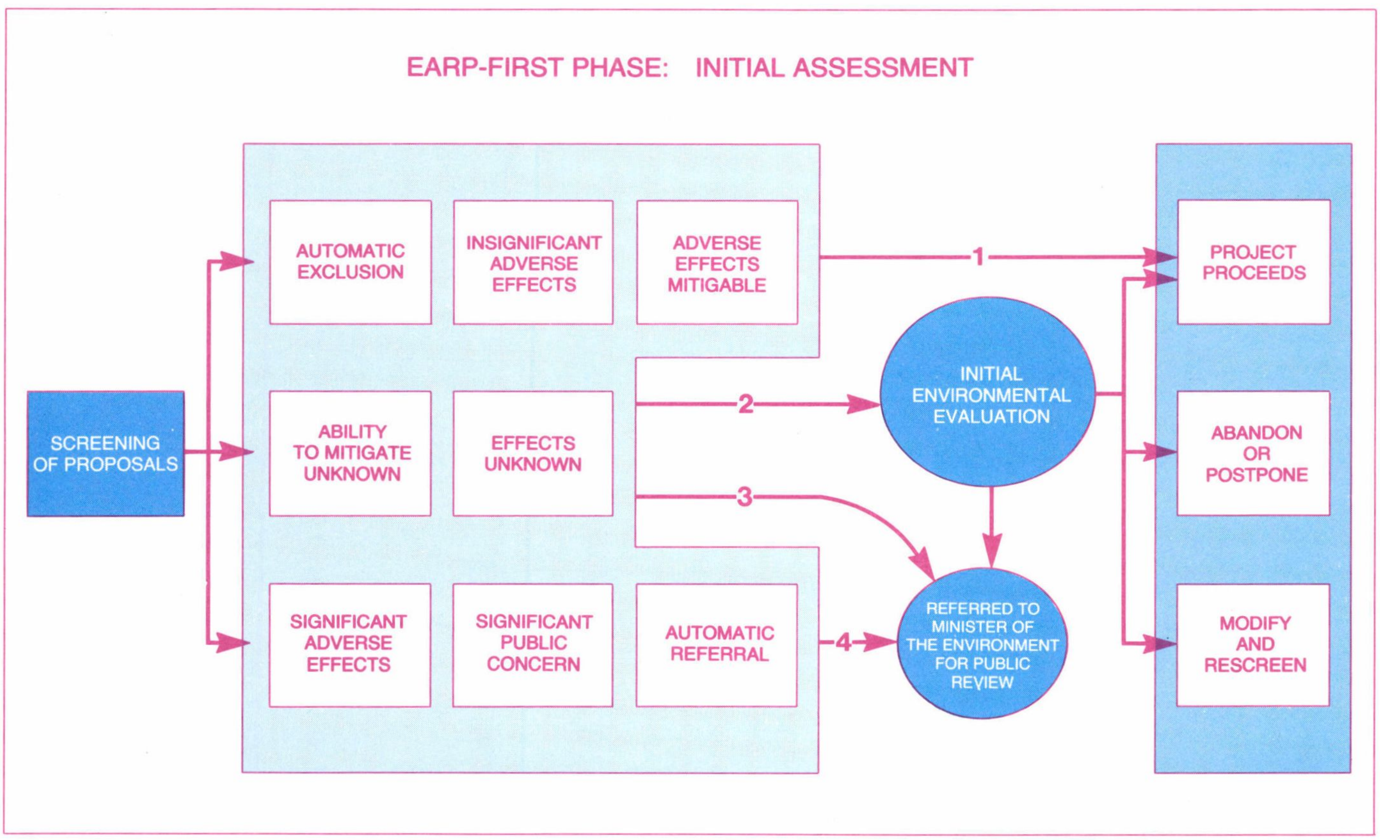
Enquiry Centre
Environment Canada
Ottawa, Ontario
K1A 0H3
Tel. (819) 997-2800
Toll free 1-800-668-6767
Fax (819) 953-2225

To determine the environmental consequences of any federally sponsored water-related development or project, the government will apply the "Environmental Assessment and Review Process."

107. What is the Environmental Assessment and Review Process?

The Federal Environmental Assessment and Review Process (EARP) requires that the environmental implications of any projects, programs and activities for which the federal government has decision-making authority be considered prior to taking irrevocable decisions, and as early in the planning process as possible.

The 1984 EARP Guidelines Order, which is a law of general application, establishes the process and sets out the requirements, procedures and responsibilities of the participants. The process is one of self-assessment - every federal department, and therefore every federal Minister, is responsible for applying EARP to proposals that affect their decision-making responsibility.



In the developing countries, 80% of illnesses are water-related.

Four courses of action are possible (see diagram)

(1) no potentially adverse environmental effects will result from a proposal, or if its effects are insignificant or can be mitigated with known technology, the proposal may proceed.

(2) If the potentially adverse environmental effects are significant or if public concern is such that a public review is desirable, the Minister of the initiating department must refer the proposal to the Minister of the Environment for a review by an independent panel.

(3) If the potential adverse environmental effects are unknown the initiating department must undertake a more detailed study, known as an initial environmental evaluation, then reassess whether the proposal warrants a public review; if so, the Minister of the initiating department must refer it to the Minister of the Environment for an independent panel review.

(4) If the potential adverse environmental effects of the proposal are unacceptable, the initiating department must either modify and reassess it, or abandon it.

The department which initiates the review retains the decision-making power either to proceed to the next step of the process, to abandon the project or to approve the project if environmental, social and economic criteria are satisfied during any particular phase of the review.

Departments with specialized knowledge, such as Environment Canada, are obligated to provide, upon request, to other departments and agencies, information, data and advisory assistance for their review of proposals.

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

Under the self-assessment role federal departments hold themselves accountable for following the steps described for EARP. These steps require 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 and stores large quantities of water.

However, the impacts of such a megaproject can be reduced. After a site has been chosen, field studies 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 Impacts Statements, which are produced for a project under EARP. Based on these predictions, design engineers working with other professionals such as biologists can mitigate or minimize impacts by adjusting the project design.

109. What does environmental screening try to achieve?

Screening determines whether a water resource project proposal, such as building dykes, filling a reservoir or dredging a harbour, will have 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 protective measures.

For water development projects, these measures might include the construction of fish ladders for migrating fish, replacement of wetland habitat for waterfowl nesting, and 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.

Toilets (while consuming nearly one quarter of our municipal water supply) use over 40% more water than needed

110. Is the federal role in environmental assessment under reform?

Yes. In June 1990, the Minister of the Environment tabled a Bill in Parliament entitled the Canadian Environmental Assessment Act (CEAA) as the dominant initiative among a series of environmental assessment reforms. The Act sets out the government's responsibilities and procedures for the environmental assessment of projects under federal jurisdiction. The Bill received Royal Assent on June 23, 1992 and is expected to be proclaimed in 1993.

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 which 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 non-government organizations and universities. Also guidelines such as the *Canadian Water Quality 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 from time to time to protect more comprehensively the ecological resources from the impacts of development.

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

To share the resource equitably, a licence is required to define the allowable quantity and timing for each use. Although seemingly abundant, the groundwater supplies in North America in certain regions are coming close to depletion and are under siege from contaminants.

114. Can floods be predicted?

To some extent. Flood forecasting and warning systems minimize flood damage effects including the prevention of the loss of life.

There are a number of forecasting centres across Canada which 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.

To reduce the amount of damage and suffering caused annually by floods, the federal government, in cooperation with the provincial and territorial governments, initiated the National Flood Damage Reduction Program. One of the main aims of the program is to produce maps outlining the floodplain and its boundaries. Once the

Approximately 60% of Canada's fresh water drains north, while 90% of our population lives within 300 kilometres of our southern border.

floodplain is identified and designated a flood-risk area, development in this area is discouraged.

Existing buildings or new construction may be protected by various floodproofing methods. For example, buildings may be elevated on posts, piers or landfill. Floodwalls 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 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."

Environment Canada has two national water research institutes - the National Water Research Institute in Burlington, Ontario, and the National Hydrology Research Institute in Saskatoon, Saskatchewan. They 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.

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

To protect and conserve our aquatic environment, and to manage it in ways that will continue to make it available for use by our generation and future generations.

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, biological characteristics of the water; and the economic, social and institutional makeup of the system of which the water resource is a part. For example, the information includes data on water quantity and quality, runoff characteristics, water user needs, fish and waterfowl numbers, vegetation distributions and habitat inventories. This computerized information is stored in data banks (e.g. ENVIRODAT, a national water quality database).

Other information is obtained by studying changes in the resource over time. For this, an understanding of the cause-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, 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

Ten litres of water is required to manufacture 1 litre of gasoline.

development of river basins and operate water facilities such as dams for the greatest benefit to all users.

119. Why is computer modelling 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. Is artificial intelligence used in water management?

Yes. Expert Systems (ES), a special field of artificial intelligence, is used in water management for decision-making. ES uses a collection of facts, rules of thumb, and other knowledge to help make inferences on how to deal with the water management problem under consideration. Expert Systems differ substantially from conventional computer programs in that their goals may have no mathematical solution, and they must make inferences based on incomplete or uncertain information. They are called expert systems because they address problems normally thought to require human specialists for solution. Their success lies in their ability to analyze large amounts of information according to some pre-established rules, resembling the reasoning of a human expert or group of experts.

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

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 modelling programs are, for example, assisting in reservoir operation, flood forecasting and municipal water demand.

123. Where is water-related information available?

Canada, being a large and regionally diverse country, has many centres and agencies involved in water-related research activities. This results in several thousand published and unpublished reports being produced each and every year. It is a complex and time-consuming task for a researcher to identify and locate this material.

To simplify the task, the Ecosystem Sciences and Evaluation Directorate, offers quick and easy access to full bibliographic citations, keywords and abstracts for Canadian

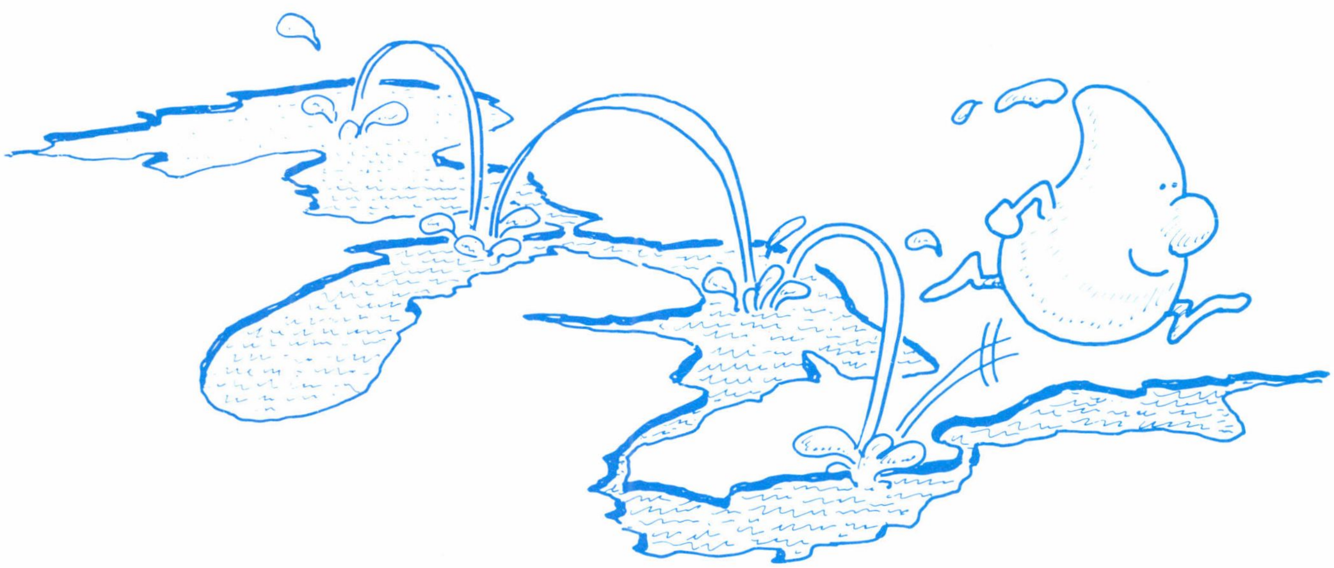
Permission for any shoreline construction that extends into the water of the Great Lakes must be obtained from four levels of government - federal, provincial, municipal, and local conservation authority.

water and environment-related documents. Its database, AQUAREF, is available for public online searching through CAN/OLE, a retrieval system offered by the Canada Institute for Scientific and Technical Information (CISTI) of the National Research Council. For information on the system, contact:

Ecosystem Sciences and Evaluation Directorate
Environment Canada
Ottawa, Ontario
KlA 0H3
Tel. (819) 953-1565
Fax (819) 994-1691

On average, most shore-protection structures designed by property owners have a useful life of ten years.

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 and St. Lawrence River basin, which straddles the Canada-United States border, contains 18% of the world's fresh surface water; its coastline accounts for 4% of the total length of Canada's coasts and is home to over 35% of the Canadian population.

124. 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 32.5 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 are also an important source of recreation.

For every 1 centimetre decline in Great Lakes water levels, 93 metric tonnes must be subtracted from the total load a Great Lakes boat can carry.

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

The Great Lakes - St. Lawrence River basin is a huge ecosystem unto itself. 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 demand on shoreline recreation facilities, the sale and diversion of its waters, and climate change.

126. 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 shoreline 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 upon 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 upon Great Lakes basin wetlands. Sixteen mammal and 20 reptile species are heavily dependent upon the wetlands of southern Ontario.

Wetlands are also important to humans. We use them for observing wildlife, water supplies, sports fishing, 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 half of the original wetlands in the Great Lakes basin have already been lost, and they continue to disappear at a rate of 8100 hectares per year. Today, about 170 000 hectares of wetlands remains along the shores of the Great Lakes. As the area of Great Lakes wetlands shrinks, the importance of remaining wetlands becomes even greater.

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

Recreation is an increasingly important social and economic activity in the Great Lakes basin as more people gain greater amounts of leisure time. 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, sports fishing, hunting, bird watching, camping, swimming, windsurfing, hiking, picnicking, and driving along the shoreline.

All of these recreational uses created the need for provincial and federal parks, marinas, hotels, motels, resorts, campgrounds and nearby land-based recreational establishments. In addition, many people who use the Great Lakes for recreation have cottages or homes along the shoreline.

128. 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 on their drainage basins and then runs off 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, the levels of the lakes also vary seasonally. 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.

One out of every three Canadians and one out of every seven U.S. residents depend on the Great Lakes for their water, using almost 140 000 litres of water a second.

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

129. 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."

130. 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.

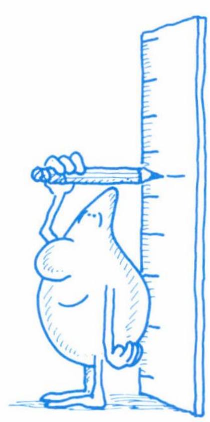
Levels of some of the Great Lakes fell to record lows in the late 1920s, mid-1930s and in the mid-1960s. Extremely high levels occurred in the early 1950s and early 1970s, as well as in the mid-1980s. The most recent long-term extremes in levels occurred between 1985 and 1987 when all of the lakes, except Lake Ontario, reached their highest levels recorded in this century. Over the following two years, lake levels dropped rapidly to their long-term averages.

131. 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 exceeds their capacity.

Erosion of shoreline at one point will supply the sand that helps build a beach farther downshore. 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 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 upon 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 upon 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.



Many homes lose more water from leaky taps than they need for cooking and drinking.

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

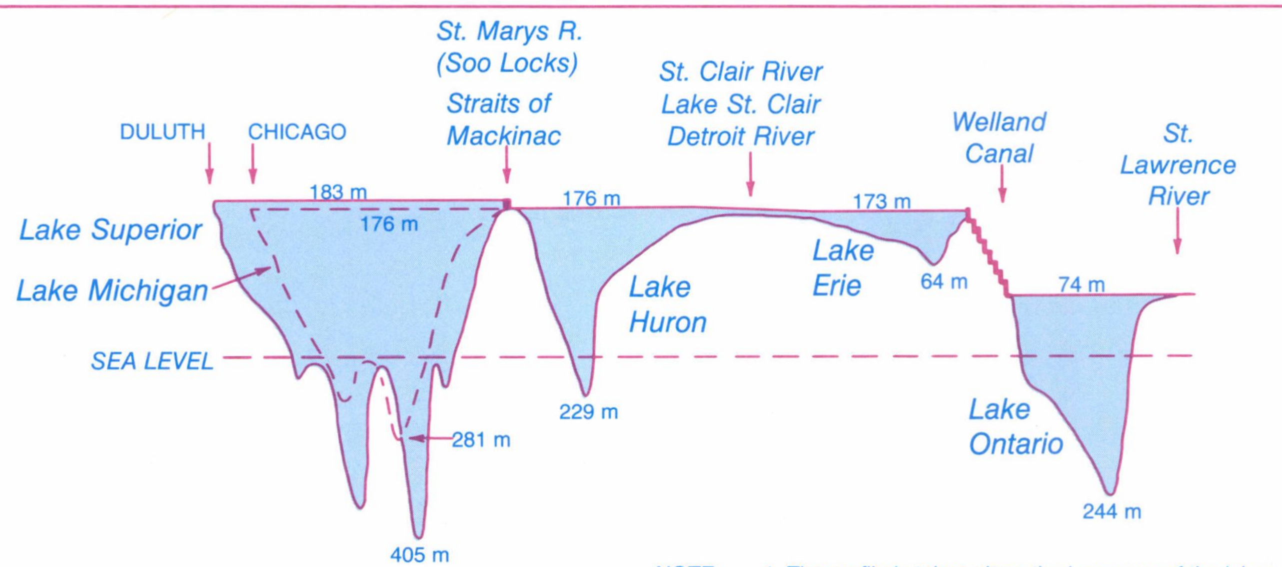
Since early in this century, significant changes in land use have occurred such as deforestation, urbanization and drainage of wetlands. These activities have changed the runoff characteristics of the drainage basin. Although the extent to which these changes affect lake levels is not yet clear, research to date suggests that land use changes have increased flows into the Great Lakes from some tributary streams.

133. 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 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.



NOTE:
1. The profile is taken along the long axes of the lakes.
2. The vertical exaggeration is 2 000 times.
3. Lake surface elevations are given above sea level, and maximum depths are below surface level.

GREAT LAKES PROFILE

(Source: The Great Lakes - An Environmental Atlas and Resource Book, 1987)

1000 kilograms of water is required to grow 1 kilogram of potatoes.

However, human effects upon lake levels are small compared to the changes caused by the natural factors described earlier.

134. Who is responsible for flooding and shoreline erosion on properties along 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.

135. 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 and issues thereof are federal matters.

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 which may give or withhold approval for the use, obstruction or diversion of boundary waters. When requested, it investigates matters of concern to one or both governments, and upon 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 Office of the International Joint Commission
100 Metcalfe Street
Ottawa, Ontario, K1P 5M1
Tel. (613) 995-2984
Fax (613) 993-5583

136. 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 upon flow conditions in the St. Marys, Niagara and St. Lawrence rivers. The Commission has also carried out three major Reference studies on Great Lakes levels and is currently engaged in another bilateral study of ways to lessen the adverse effects of fluctuating Great Lakes water levels. This Reference study was requested by the Canadian and United States governments in 1986, when Great Lakes water levels were at record highs for the century.

The current IJC Reference study is examining all lake level interests in the basin, including owners of shoreline property, fishermen, boaters, shippers, wildlife, and producers of hydroelectricity. An interim report describing measures that could be taken under crisis conditions to alleviate problems associated with high water levels on the lakes was transmitted to the Governments on November 22, 1988. A report dealing with progress through the first of two phases of the current five-year Reference study was sent to the Governments on August 25, 1989. Among the findings to date was the recommendation that federal governments should not at present undertake commitments to further regulate Great Lake levels as a means of reducing shoreline flooding and erosion on the lakes.

Of the total world's freshwater supply, over two thirds is found underground.

The Government of Canada through Environment Canada has also established a Great Lakes Water Level Communications Centre in Burlington to act as a focal point for information and public contact regarding fluctuating Great lakes water levels. In times of extreme high or low water levels, the Centre is instrumental in providing important information and warnings of events to the many Great Lakes interests affected by lake levels. Environment Canada is also cooperating with and providing 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.

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

Canada-U.S. agreements provide the framework for resolving water quality concerns in the Great Lakes.

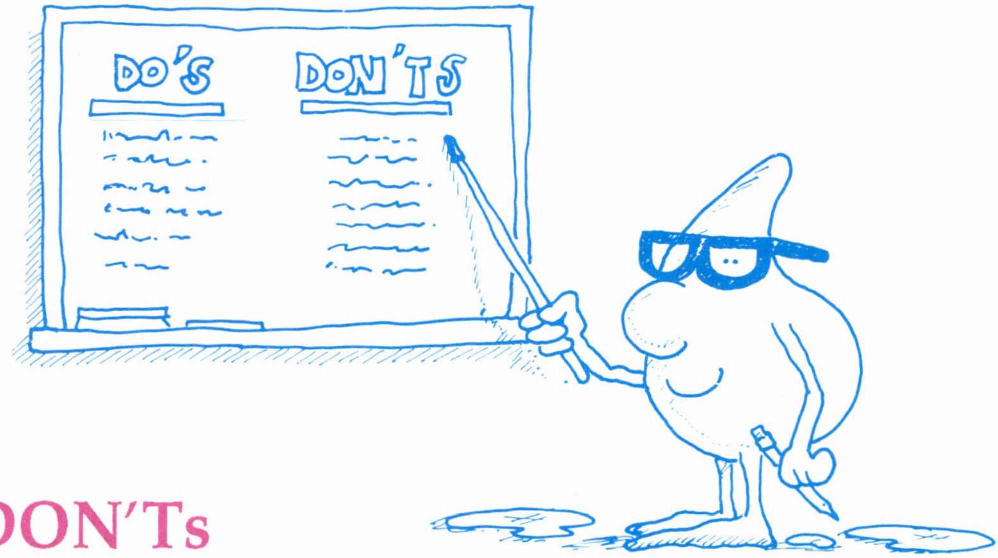
The first Great Lakes Water Quality Agreement (GLWQA) was signed in 1972 and has been amended and strengthened on two occasions in 1978 and by Protocol in 1987. The 1972 GLWQA prescribed, among other things, standards designed to achieve certain water quality objectives. The 1978 Agreement placed more emphasis on industrial pollutants and toxic substances and set water quality objectives for specific chemicals.

The main goal of the 1987 Protocol to the 1978 Great Lakes Water Quality Agreement between Canada and the United States is to advance the cleanup of the Great Lakes by dealing with all sources of pollution entering them. The Protocol has also strengthened the public accountability of the Parties to the Agreement, which must now report publicly to the International Joint Commission on the progress of implementation of specific annexes to the Agreement.

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

International Joint Commission
100 Ouellette Ave.
Windsor, Ontario
N9A 6T3
Tel. (519) 256-7821
Fax (519) 256-7791

Residential indoor water use in Canada is as follows: Toilet - 40%; Bathing and personal - 35%; Laundry and dishes - 20%; Drinking and cooking - 5%.



Water:
DOs AND DON'Ts

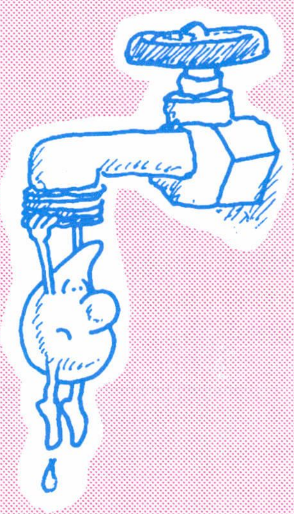
1. Individuals *Can* Do Something About Conserving and Using Water Wisely!

Surrounded by seemingly unlimited freshwater resources, Canadians are the world's most profligate 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 in your sink faucets, to reduce your water usage.
- Be sure to always turn taps off tightly so they do not drip.
- Promptly repair any leaks in and around your taps and faucets. (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 faucet.
- 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 pot 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 2-3 days.



In the Bathroom

About 75% 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 basin 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.)
- Be sure to always turn taps off tightly so they do not drip.
- Promptly repair any leaks in and around taps and faucets.
- Use aerators and/or water flow-reducer devices in all your faucets.
- Use either low-flow shower heads or adjustable flow-reducer devices in 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 which allows you to maintain the water pressure and temperature when you stop the flow.
- Short showers use less water than baths, but if you still 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. You can reduce water usage by 40% to 50% by installing low-flush toilets.
- 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. For information and availability of water conserving devices, write to:

  National Water Programs Division
  Economics and Conservation Branch
  Ecosystem Sciences and Evaluation Directorate
  Environment Canada
  Ottawa, Ontario
  K1A 0H3

- 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, and 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

- Only wash 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 (1/5 inch) 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. Apply 5 millimetres of water for each day since the last watering in warm weather.
- 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 which 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 (2.5 inches). 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.

Editor's Note: Part 1 of this section was taken with permission from "What Atlantic Canadians Can Do For Their Environment," which was produced by the Atlantic Region Departmental Communications Unit of Environment Canada.

Now Available...

Water: No Time to Waste - A Consumer's Guide to Water Conservation is a new Environment Canada publication. The guide is a valuable tool for assessing how we use water and how savings can be achieved. The theme of the publication is that water conservation doesn't mean doing without, it simply means reducing the amount of water we waste. The guide is available at bookstores throughout Canada or can be ordered from:

Canada Communication Group - Publishing
Ottawa, Canada
K1A 0S9
Tel. (819) 956-4802
Fax (819) 994-1498

2. Avoid 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 non-hazardous household products and their uses can be obtained from the following and similar organizations:

Canadian Manufacturers of
Chemical Specialties Association
56 Sparks - Suite 702
Ottawa, Ontario
K1P 5A9
Tel. (613) 232-6616
Fax (613) 233-6350

Consumers Association of Canada
307 Gilmour Street
Ottawa, Ontario
K2P 0P7
Fax (613) 238-2533
Tel. (613) 563-2254

The federal government endorses products that are environmentally responsible. Look for the Environmental Choice^{M} 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
Environment Canada
107 Sparks Street, 2^{nd} Floor
Ottawa, Ontario
K1A 0H3
Tel. (613) 952-9463

3. Don't Misuse Your Household's Sewerage 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.
- Your local fire department will normally accept unwanted leftovers of barbeque 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 Pesticides/Hazardous Materials In Your Garden/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.

- The use of pesticides to control household or garden pests can be reduced or avoided 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 to get traction on winter ice on your sidewalks and driveways.

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/lake. Therefore:

- Dispose of oils, detergents, paints and 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 sites. You may 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.

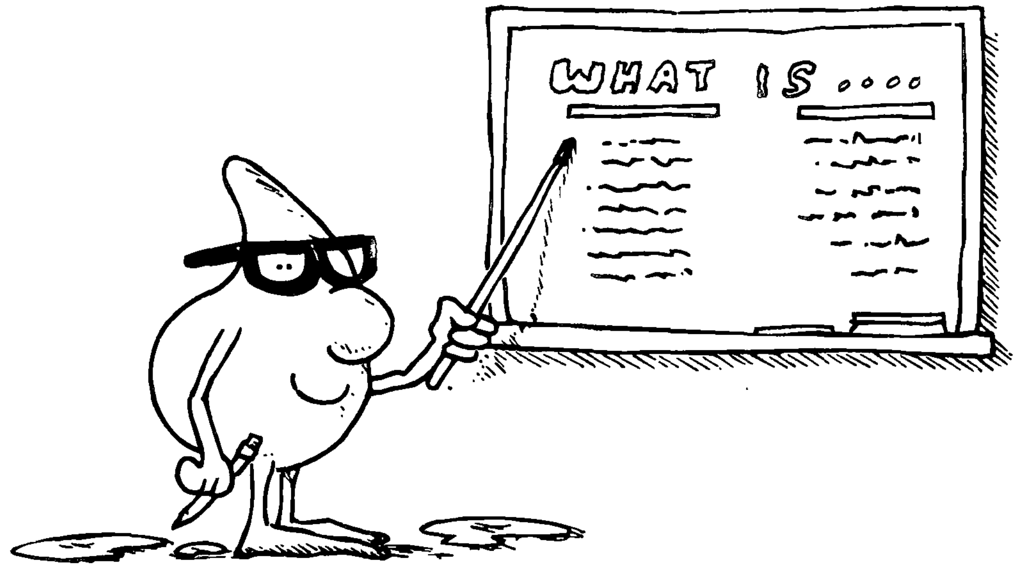
6. Don't Sit Back and Just Let Things Happen

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

- Become informed.
- Trust in the ability of the individual to take action 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 and lobby governments and industry to make changes 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.
- Boycott products that are harmful to the environment. Urge stores to abandon wasteful packaging and to use biodegradable materials.
- Exercise your rights as citizens: 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 the Canada Water Act, the Canadian Environmental Protection Act, and the National Flood Damage Reduction Program. There are others...
- 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 this Primer. These can be sent to the address below. To obtain copies of the Primer and/or a list of other publications on water, contact:

Enquiry Centre
Environment Canada
Ottawa, Ontario
K1A 0H3
Tel. (819) 997-2800
Toll free 1-800-668-6767
Fax (819) 953-2225



SELECTED GLOSSARY

A

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 64 77 125)*

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 68 75)*

algae blooms - Rapid growth of *algae* on the surface of *lakes, streams,* or *ponds*; stimulated by *nutrient* enrichment. *(See: Q59 77)*

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: pH scale diagram)*

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 82; Groundwater System diagram)*

arid - Describes regions where *precipitation* is insufficient in quantity for most crops and where agriculture is impractical without *irrigation*. *(See: Q10 82)*

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 - A general term describing a process by which chemical substances are consumed and retained by *organisms*, either from the *environment* directly or by eating food containing the chemicals. *(See: Q76; Bioaccumulation and Biomagnification diagram)*

biodegradable - Capable of being broken down by living *organisms* into *inorganic* compounds. *(See: Water - Dos and Don'ts, 6)*

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

biomagnification (biological magnification) - A cumulative increase in the concentrations of a persistent substance in successively higher levels of the *food chain*. *(See: Q76; Bioaccumulation and Biomagnification diagram)*

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

bog - A type of wetland that accumulates appreciable peat deposits. They depend primarily on *precipitation* for their water source, and are usually acidic and rich in plant matter with a conspicuous mat or living green moss. *(See: Q71)*

C

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 5 8-10 82 88)*

climate change - The slow variations of climatic characteristics over time at a given place. *(See: Preface; Q5 6 125)*

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: Q77)*

combined sewers - A sewer that carries both sewage and storm water runoff.

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 80 101 116 136)*

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 man, animals, and plants; and the incorporation of water into the products of industrial or food processing. *(See: Q82 128)*

contaminant - Any physical, chemical, biological, or radiological substance or matter that has an adverse affect on air, water, or soil. *(See: Q20 21 47 48 62 112 122)*

cooling tower - A structure that helps remove heat from water used as a coolant; e.g., in electric power generating plants. *(See: Q59)*

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: Q91 97; 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: Q11 26 29 60 70 81 104 111 114 115 118 120)*

delta - A fan-shaped alluvial deposit at a river mouth formed by the deposition of successive layers of *sediment*. *(See: Q14 88 120; 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 16 81 122)*

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: Q76)*

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 31 54 59 66 79 80 82-84 88; 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 limits 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: Q84 92 96-98 115 120 125 133 135; 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)*

dredging - The removal of mud 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*** *81 109)*

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

dry deposition - Emissions of sulphur and nitrogen oxides which, 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: Q109 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 68-70* ***75-79*** *81 87 88 92 102 106 111 117 125 126)*

effluent - The *sewage* or industrial liquid waste which is released into natural water by sewage treatment plants, industry, or *septic tanks*. *(See: Q57 81 97 120)*

environment - All of the external factors, conditions, and influences which affect an *organism* or a community. *(See: Preface; Introduction; Q29 47 52 62 63 68 76 84 87 88 99 108 112 118 120; Dos & Don'ts)*

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

environmental monitoring - The process of checking, observing, or keeping track of something for a specified period of time or at specified intervals. *(See:* ***Q81*** *118)*

erosion - The wearing down or washing away of the soil and land surface by the action of water, wind or ice. *(See: Q6 57 125 126 131 134 136)*

estuary - Regions of interaction between *rivers* and nearshore ocean waters, where tidal action and river flow create a mixing of fresh and salt water. 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 *wetlands*. *(See: Q62* ***70****)*

eutrophic lake - Shallow, murky bodies of water that have excessive concentrations of plant *nutrients* causing excessive algal production. *(See: Q57* ***70****)*

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 62 67 77)*

evaporation - The process by which a liquid changes to a *vapour*. *(See: Q1 4 6-8 23 58 128; Hydrologic Cycle diagram)*

evapotranspiration - The loss of water from a land area through *evaporation* from the soil, and through plant *transpiration*. *(See: Q58)*

F

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: Q68)*

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: Q3 8 11-13 60 68 84 92 102 114 115 125 131 134 136)*

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; or the comparative change in market or sales value; or on the change in the income or production caused by flooding. *(See: Q5 114; Flood diagram)*

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: Q101 114 122; Flood diagram)*

flood fringe - The land on which water is stored as dead water during flooding, and which does not contribute to the downstream passage of *flow*. *(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: Q79)*

floodplain - Any normally dry land area that is susceptible to being inundated by water from any natural source. This area is usually lowland adjacent to a *stream* or *lake*. *(See: Q12 13 68 84 115; Flood diagram)*

floodproofing - Any combination of structural and nonstructural additions, changes, or adjustments to structures which reduce or eliminate flood damage. *(See: Q115; Flood diagram)*

floodway - The channel of a *river* or *stream* and those parts of the adjacent *floodplain* adjoining the channel which 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 17-20 43 69 72 81 83 84 86 88 91-93 95 101 102 116 120 122 131-133 136; Dos & Don'ts; River Flow diagram)*

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 73 75; Dos & Don'ts)*

food web - The complex intermeshing of individual *food chains* in an *ecosystem*. *(See: Q75 76)*

fresh water - Water that generally contains less than 1000 milligrams per litre of *dissolved solids* such as metals, *nutrients*, etc. *(See: Introduction; Q14 62 71 78 82 117; Dos & Don'ts)*

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: Q11 86)*

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*) which is often used for supplying *wells* and *springs*. *(See: Preface; Q3 9 14-22 30 37 43 49 58 82 113; Dos & Don'ts)*

groundwater recharge - The *inflow* to an *aquifer*. *(See: Q17)*

H

habitat - The native *environment* where a plant or animal naturally grows or lives. *(See: Q29 60 62 63 69 73 79 84 104 109 111 112 118 126; Dos & Don'ts)*

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)*

hydroelectricity - Electric energy produced by water-powered turbine generators. *(See: Q29 124 136)*

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 86 88 109; Hydrologic Cycle diagram)*

hydrology - The science of waters of the earth; water's properties, circulation, principles, and distribution. *(See: Q117)*

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.

inflow - The entry of extraneous rain water into a sewer system from sources other than *infiltration*, such as basement drains, manholes, storm drains, and street washing. *(See: Q128)*

inorganic - Matter other than plant or animal, and not containing a combination of carbon/hydrogen/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: Q81)*

interbasin transfer - The *diversion* of water from one drainage basin to one or more other drainage basins. *(See: Q92 100)*

irrigation - The controlled application of water to cropland, hayland, and/or pasture to supplement that supplied through nature. *(See: Q7 14 23-26 33 34 42 58 60 84 92)*

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 66-70 77 78 82 83 85 86 88 92 95 101 104 105 122 124-137; Dos & Don'ts; 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; 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 or salt water and tidal or non-tidal. *(See: Q68 71 131)*

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 118-120)*

N

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.

navigable waters - Traditionally, waters sufficiently deep and wide for navigation by all, or specific sizes of vessels. *(See: Q105)*

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, metal ores. *(See: Q80)*

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 68 72 75-77; Dos & Don'ts)*

O

oligotrophic lake - Deep clear *lakes* with low *nutrient* supplies. They contain little *organic* matter and have a high *dissolved oxygen* level. *(See: Q70)*

organic - (1) Referring to or derived from living *organisms*. (2) In chemistry, any compound containing carbon. *(See: Q51 55 60 66)*

organism - A living thing. *(See: Preface; Q5 46 62 68-70 75-77 81 92)*

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: Q56)*

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

periglacial river - A *river* in the "periglacial zone"; i.e., the area adjacent to the margin of a *glacier*. *(See: Q14)*

permafrost - Perennially frozen layer in the soil, found in alpine, arctic, and antarctic regions. *(See: Q6 20 30 86)*

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 48 58 76; Dos & Don'ts)*

pH - An expression of both acidity and alkalinity on a scale of 0-14, with 7 representing neutrality; numbers less than 7 indicate increasing acidity and numbers greater than 7 indicate increasing alkalinity. *(See: Q44 64 65 77; pH 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: Q75)*

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: Q69)*

polychlorinated biphenyls (PCBs) - A group of chemicals found in industrial wastes. *(See: Q66)*

pond - A small natural body of standing *fresh water* filling a surface depression, usually smaller than a *lake*. *(See: Q69 70)*

precipitation - Water falling, in a liquid or solid state, from the *atmosphere* to a land or water surface. *(See: Q3 4 6-10 57 65 82 128; Hydrologic Cycle diagram)*

R

rain - Water falling to earth in drops that have been condensed from moisture in the *atmosphere*. *(See: Q2 7 11 18 43 64)*

receiving waters - A *river*, ocean, *stream*, or other watercourse into which *wastewater* or treated *effluent* is discharged. *(See: Q55 59 66 92)*

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 82; 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: Q80)*

reservoir - A *pond, lake*, or basin (natural or artificial) that stores, regulates, or controls water. *(See: Q7 60 92 109 115 **116** 120 122)*

resource - A person, thing, or action needed for living or to improve the quality of life. *(See: Preface; Introduction; Q4-8 14 15 31 33 34 72 80 84 87 94 96 99 101 104-106 108 109 112 113 118 119 122; Dos & Don'ts)*

river - A natural stream of water of substantial volume. *(See: Q2 3 6 11 12 14 17 19 30 42 43 49 52 57 58 60 62 63 65 66 68-70 78 82 83 85-93 95 98 103-105 114 122 133)*

river basin - A term used to designate the area drained by a *river* and its tributaries. *(See: **Q89-91** 118)*

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: Q8 43 55 86 128 132)*

S

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

sanitary sewers - Underground pipes that carry off only domestic or industrial waste, not storm water. *(See: 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: Q15 43-45 57 58 60-62 66 81 88 126)*

sedimentation - The deposition of *sediment* from a state of suspension in water or air. *(See: Q72)*

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: Q129)*

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)*

sewage - The waste and *wastewater* produced by residential and commercial establishments and discharged into *sewers*. *(See: Q22 52 54 55 115)*

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)*

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 52 54; Dos & Don'ts)*

sewerage - The entire system of sewage collection, treatment, and disposal. *(See: Q37; Dos & Don'ts)*

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; 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 68 70)*

storm sewer - A system of pipes (separate from *sanitary sewers*) that carry only water *runoff* from building and land surfaces. *(See: 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 70 77 83 101 105 112 132; 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 92; 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 which are directly influenced by surface water. *(See: Q16 19 22 71 123)*

suspended solids (SS) - Defined in waste management, these are small particles of solid pollutants that resist separation by conventional methods. SS (along with BOD) is a measurement of *water quality* and an indicator of treatment plant efficiency. *(See: Q43 55 66)*

sustainable development - Development that ensures that the use of *resources* and the *environment* today does not restrict their use by future generations. *(See: Introduction; Q87)*

swamp - A type of wetland that is dominated by woody vegetation and does not accumulate appreciable peat deposits. Swamps may be fresh or salt water and tidal or non-tidal. *(See: Q71)*

T

temperature - The degree of hotness or coldness. *(See: Q5)*

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 29 43 44 52 62 66 67 72 76 77 81 122 125 137; 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: Hydrologic Cycle diagram)*

tributary - A *stream* that contributes its water to another stream or body of water. *(See: Q132)*

tsunami - A Japanese term which has been adopted to describe a large seismically generated sea wave which is 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*.

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 which reduces the usability of the water for ordinary purposes, or which creates a hazard to public health through poisoning or spread of diseases. *(See: Q21 78; 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: Q82 95 99-101 111 115-119 121)*

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: Q55)*

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: Q42-47 49 58 60 65-67 81 84 101 112 118 120 125 126 137)*

water quality guidelines - Specific levels of water quality which, 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: Q46-48 51 56 112 137)*

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 17; Hydrologic Cycle and Groundwater System diagrams)*

watershed - The land area that drains into a *stream*. *(See: Q65 96)*

well - A pit, hole, or shaft sunk into the earth to tap an underground source of water. *(See: Q15 30; 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: Q70-74)*

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

X - Y - Z

zooplankton - Tiny aquatic animals eaten by fish. *(See: Q70; 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.

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