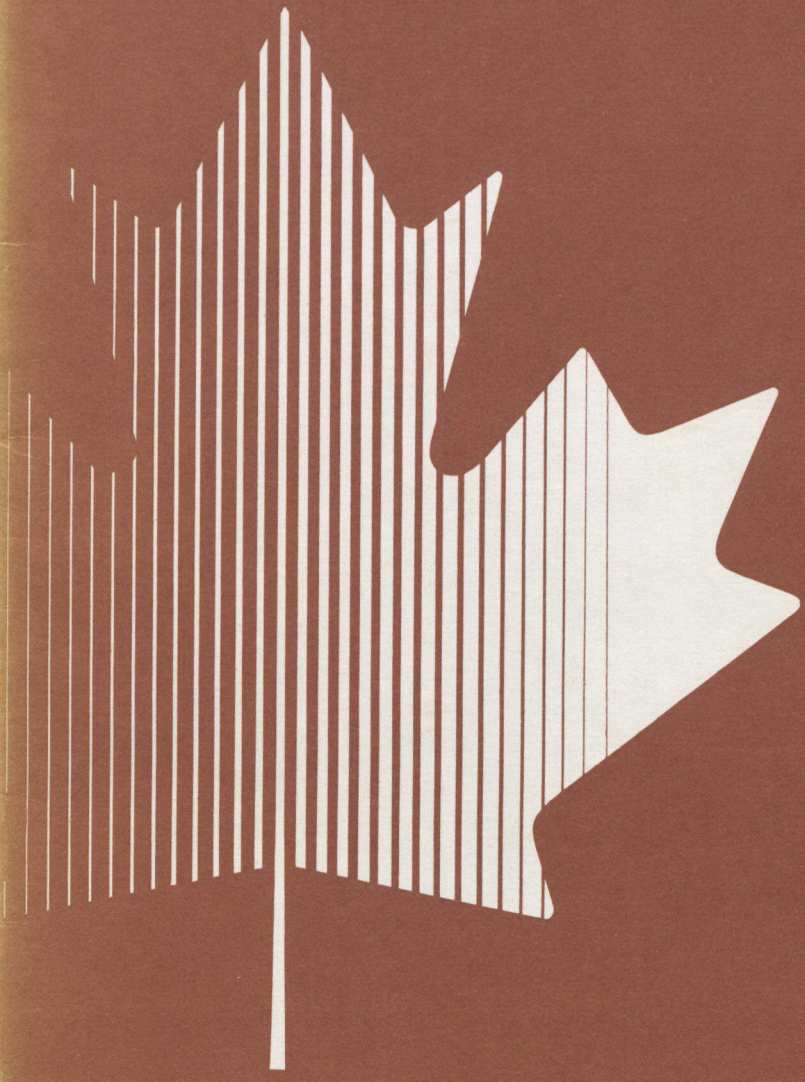
Canada's Water



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Canada's Water

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Canada is one of the world's most fortunate countries in the quantity of fresh surface-water it possesses. There are probably more lakes in Canada than in any other country in the world — so many that they have not all been counted, much less measured. Estimates, however, have placed the total lake area at 756,000 km^2 (291,000 sq. miles). Since the country's total area is almost 10 million km^2 (about 3.85 million sq. miles), this means that about 7.6 per cent of Canada is covered with fresh water.

True measure of water-supply

Not all the water in Canada's lakes is available for use. It would be unrealistic to suggest, for instance, that the entire 22,900 km^3 (5,500 cubic miles) of water in the Great Lakes, of which an estimated 7,500 km^3 (1,800 cubic miles) are in Canada, could be removed and used. The water is very valuable where it is, as storage that can be drawn on in time of drought to be replaced in time of plenty. But the true measure of a country's water-supply is its stream-flow rather than its storage capacity.

On an average annual basis, Canada's rivers discharge nearly 9 per cent of the world's renewable water-supply, roughly 107,000 m^3/s (3,780,000 cubic feet a second). Set against a population that is less than 1 per cent of that of the world this is a generous endowment indeed; set against a territorial area that is almost 7 per cent of the world's land-mass, however, it is not disproportionate. Even though the flow is not uniformly distributed throughout the country, or during the year (a large part of the annual supply is frozen for several months during the winter, to be released only when spring arrives), 3,130 km^3 (750 cubic miles) of water are available every year, replenished by the continual operation of the hydrologic cycle. *(See Appendix I.)*

Historical role of rivers

The country's first industry, the fur trade, depended on the ready access provided by the St. Lawrence River, the Great Lakes and their tributary streams and the many other great waterways that provided transportation to the interior.

The early settlement of the country depended on this ready means of access. The plentiful water-supplies of the flat, fertile plains of southern Ontario and Quebec, the river-borne transportation of lumber and, later, the power of water-driven turbines, all were vital factors in the building of a Canadian nation.

Today, more than ever, water is the key to Canada's development, providing the moisture needed for food production, supplying the renewable energy required in industrial growth, providing access to raw materials and playing a vital part in the processing of these materials. It also adds immensely to the beauty of the countryside and thus to the enjoyment of life.

Numerous uses for water

The classification of water-uses as "withdrawal" and "non-withdrawal", and their further sub-division into "consumptive" and "non-consumptive" indicate the basic differences among the uses. As the adjectives imply, the withdrawal uses remove water from its natural course whereas the non-withdrawal uses do not. Withdrawal uses are chiefly municipal, rural, agricultural and industrial. Non-withdrawal uses include hydroelectric power, transportation, recreation and fisheries.

All or part of the water withdrawn for use will generally be returned to its source. Estimates of the amounts withdrawn for various uses are given in the table that appears as Appendix II. Since estimates of non-withdrawals are not so easily arrived at, none is attempted here. Because the hydrologic cycle is a closed system when viewed on a global scale, it can be seen that water is never actually lost. For example, water evaporated from industrial cooling-towers becomes part of the atmosphere, falls as rain and eventually returns to increase the amount of water in and on the earth. Nevertheless water-consumption does occur, representing a measure of water-loss from a river basin or similar hydrologic unit. Water-consumption varies with its uses, being very large in agriculture and certain mineral-extraction processes but relatively small in manufac-

turing. In general, the consumption of water is estimated to be about 10 per cent of the amount withdrawn.

Withdrawal uses of water

Municipal and rural use

Canada's earliest settlers, who had to carry or pump their household water-supplies by hand, probably got by on 23 litres (5 gallons Imperial) or less a day for each person. Today, domestic water-use averages about 335 litres (74 gallons) a day for each city dweller across Canada and some 100 litres (22 gallons) a day for each country dweller. Bathing, washing clothes and dishes, disposing of wastes, watering lawns and washing cars require considerable quantities of water, and any curtailment of the supply causes surprise and resentment. Fortunately, in Canada shortages have usually been local and temporary. Few Canadians have had to worry seriously about water-shortages.

Despite its versatility, water is probably the least expensive household material. Compare the price of oil for heating (11 cents a litre or 50 cents a gallon) or gasoline for automobiles (18 cents a litre or 82 cents a gallon) with the cost of water piped to the house (about 7.4 cents a thousand litres or 34 cents a thousand gallons). At that price, water costs about 7 cents a tonne (or ton), delivered. No other material costs so little.

Ninety litres (20 gallons) to take a bath or to do the laundry, 45 litres (10 gallons) to wash dishes, 25 litres (5 or 6 gallons) to flush the toilet — all this water is used without much thought in the average household. Industries located within cities also use a very large amount of water, much of which comes from municipal supplies.

In 1974, water-uses for all purposes in Ottawa, Canada's capital, averaged 500 litres (110 gallons) a person every day. Montreal used 775 litres (170 gallons) a day; Vancouver 820 litres (180 gallons); and Toronto 545 litres (120 gallons). Industrial and municipal uses — including street-cleaning and use in parks and pools — account for most of the difference between these total-consumption figures and the domestic consumption (335 litres or 74 gallons a person every day). *Per capita* use for domestic purposes does not vary appreciably from city to city.

Agricultural use

Most of Canada's agriculture depends on the direct natural supply of water to the land in the form of rain and melted snow. Of the approximately 28 million hectares (69 million acres) of land devoted to crops each year, 448,200 hectares (1.1 million acres) are irrigated — fewer than two out of every 100 hectares (or acres). Most of the irrigated land is in Alberta, British Columbia and Saskatchewan.

In Alberta, over 245,000 hectares (600,000 acres) of the 5,310,000 hectares (13,100,000 acres) of land devoted to crops each year are irrigated (4 per cent). British Columbia, with a much smaller area of land devoted to crops — about 325,000 hectares (800,000 acres) — has over 81,000 irrigated hectares (or 200,000 acres) — 25 per cent.

In 1974, 5,920 million litres of water (or 1,303 million gallons) a day were used for irrigation in Canada, and another 1,350 million litres (or 296 million gallons) a day for stock-watering. Although not as large as other water-uses, the irrigation totals are of critical importance to Western agriculture and to new projects that are being developed. The South Saskatchewan River Project, for example, will permit the irrigation of 202,400 hectares (500,000 acres) in Saskatchewan and the Southwest Saskatchewan irrigation projects will permit irrigation of another 10,100 hectares (25,000 acres); the Waterton River Diversion, completed in 1964, has made irrigation water available to another 81,000 hectares (200,000 acres) in Alberta. In addition, there are at least another 10,000 hectares (25,000 acres) under individual farm-irrigation schemes in Saskatchewan and Alberta.

Owing to the importance of conserving water, efforts are being made to improve the efficiency of irrigation. Systems using gravity-flow have been improved through land-levelling and better irrigation methods. Pressure systems that distribute water through sprinklers have replaced some of the less-efficient gravity systems, and have made irrigation possible in areas that could not be flooded. In increasing acreage under irrigation, the restricting factor is usually the limited water-supply in areas that need it most.

Land-use practices can have a significant effect on stream-flow. Careless farming methods can speed the runoff of snow-melt and rainfall and cause soil erosion. Besides the loss of precious soil, this can have adverse effects on the streams that receive the runoff. It can increase flooding, cause streams to become turbid because of the

eroded material they are carrying, and create shoals wherever water velocity is reduced. More and more, farmers are recognizing the value of proper agricultural practices, which will conserve precipitation for crop-use, lessen soil-losses and preserve stream-quality.

Industrial water use

Industry has an enormous thirst for water. The largest quantity is used for cooling purposes, but considerable amounts are also used directly in many manufacturing processes; another important use is in plant-sanitation. Figures are frequently published to indicate how much water is used in various industries — for example, 10 litres (or gallons) of water to refine a litre (or gallon) of gasoline, 18 litres (or gallons) of water to refine a litre (or gallon) of oil, 250 tonnes (or tons) of water to produce a tonne (or ton) of sulphate wood pulp, 100 litres (or gallons) of water to produce a litre (or gallon) of alcohol. These figures are interesting as a general indication of the need for water, but they may be misleading. They often reflect the fact that water is easily available, inexpensive and therefore tempting to use inefficiently.

For example, the amount of water required to produce a tonne (or ton) of steel is about 270,000 litres (or 60,000 gallons), yet there is a steel-mill in California that, by cooling and recycling its water, uses only about 6,370 litres (1,400 gallons) a tonne (or ton) of steel produced. A wide variation like this is by no means unusual. When water becomes scarce, and therefore valuable, it is used more carefully than when it is plentiful and cheap.

The fact remains, however, that water is an essential material in most industrial operations and increasing industrialization inevitably leads to greater use of water.

Manufacturing

In 1974, primary manufacturing withdrew 25,780 million litres (5,677 million gallons) of water from lakes, rivers and wells — some 44 per cent of the industrial total. Only about 4.2 per cent of the total withdrawn was consumed in the process. Because recirculation allows much of the water to be used more than once, the quantity of water actually used each day during 1974 is reported to have met a requirement for 59,290 million litres (13,052 million gallons) a day.

While some industries purchase water directly from municipal sources, others find it more convenient, or more economical, to develop their own water-supplies by drilling wells or by employing fresh-water sources on adjacent lakes or rivers. In Canada, some 76 per cent of the water used in manufacturing is obtained by the manufacturers themselves.

Although water-uses in manufacturing are not highly consumptive, the water returned to the source is often untreated. As a result, it may contribute to pollution by the addition of undesirable process materials or waste by-products and may have a much higher temperature. This becomes a constantly-increasing problem whenever industry becomes concentrated in one locality.

Minerals

The place of the mineral industry in the Canadian economy is extremely important. One out of every nine employees in Canada holds a position attributable directly to the mineral industry. Also, the industry accounts for a large part of Canada's foreign-exchange earnings.

As a rule, mineral-extraction activities in Canada are seldom far from an ample supply of water; in fact, many mines require constant pumping to prevent flooding of their underground workings.

Appendix II shows that, during 1974, 2,890 million litres (636 million gallons) of water were required each day for mineral-extraction. Crude petroleum is the most valuable product of Canada's mineral industry, and this section of the industry used some 40 per cent of the water in 1974 for deep-well injection in order to maintain sufficient pressure to force the crude oil to the surface. The water injected in such a process cannot be recirculated and is considered as consumed. Elsewhere in mining, vast quantities of water are used for processing and cooling purposes within the mining and milling operations.

Electric-energy generation

Electric energy has been called the master tool of mankind. In Canada, it is the economy's mainspring — the efficient servant of life. Canadian industrial development since the turn of the century has depended on water-power as its principal source of energy and,

despite the current emphasis on thermally-generated power, water-power is still far in the lead.

Of the 281,000 million kilowatt hours of electrical energy generated in Canada in 1974, 211,000 million kilowatt hours (about 75 per cent) were generated by hydroelectric stations; the remainder were generated by conventional and nuclear-electric plants. Industry used almost half the total energy, with commercial operations, residences, farms and street-lighting accounting for most of the remainder.

Every year, new generating capacity is added to help satisfy modern Canada's rapidly-increasing demand. In recent years, there has been a marked trend to the installation of thermal plants because in many parts of Canada most of the hydroelectric sites within economical transmission distance of the population and industrial centres have been developed. Planners have, therefore, had to turn to other sources of electric energy. However, advances in extra-high-voltage transmission techniques, together with spiralling costs of fossil fuels, are providing a renewed impetus to the development of water-power sites previously considered too remote.

Thermal-electric generation

In thermal-electric generation, electrical energy is generated in fuel-fired steam-plants utilizing the combustion of fossil fuels (coal, oil and gas) or from heat generated by controlled nuclear fission of uranium (or other fissile material). Such plants require a convenient source of fuel at reasonable cost and adequate supplies of cooling water for steam condensers. As shown in Appendix II, thermal plants withdrew, during 1974, 29,720 million litres (6,538 million gallons) of water a day from lakes, rivers and wells — more water than all other types of industry combined. Besides discharging heat, fossil-fuelled plants also release combustion products into the environment, and both factors may place significant restrictions on the choice of sites for these plants.

All thermal plants, including nuclear plants, use fuel resources that, once employed, cannot be replaced, although, in terms of current consumption, reserves of coal and uranium are very large. As water-power sites are used up, considerable effort is being made to improve methods of turning these large reserves into electric power with minimal disturbance to the environment.

Non-withdrawal uses of water

Hydro-electric generation

Canada still has vast undeveloped water-power potential, which, if developed, would greatly increase the 36.8 million kilowatts of hydro capacity installed at the end of 1974. There are currently major hydro developments under way on the Nelson River in Manitoba, the Peace and Columbia Rivers in British Columbia, and the rivers flowing into James Bay in Quebec. Recently, construction at the 5,225,000-kw Churchill Falls site on the Churchill River in Labrador was completed, providing enough electrical generation for the needs of about 2.6 million Canadians.

By the year 2000, hydro capacity will probably be double the 1974 level. While this should not exhaust all the potential water-power sites in Canada, it reflects the economic and environmental limits to hydroelectric development and the increasing competitiveness of energy from nuclear fuels. By the end of the century, only about 30 per cent of electrical energy will be generated from water-power.

Transportation

Water provides the most economical means of transportation for the bulky raw materials of Canada's export trade — wheat, pulp and paper, lumber and minerals — on their way to world markets. The idea that inland transport by water was becoming obsolete has been contradicted by the continuing growth in the volume of waterborne goods, not only in Canada but also in the United States and Europe.

The major part of Canada's waterborne traffic moves on the St. Lawrence Seaway. This joint Canadian-American project, completed in 1959 at a cost of $470 million (Canada's share was $330 million), is a symbol of faith in the future of waterborne transportation. Over the decade from 1967 to 1976, cargo traversing both the Welland Canal section and the Montreal/Lake Ontario section averaged some 68.8 million tonnes (67.7 million tons). The year 1976, with a total traffic of 72.9 million tonnes (71.7 million tons), compared favourably with the average and represented a marked improvement over 1975 and 1974, when cargoes of 68 million tonnes (66.9 million tons) and 61.1 million tonnes (60.1 million tons) respectively were carried.

In 1974, mine products made up some 52 per cent of the goods moved on the Seaway. Agricultural products and manufactured goods — 30 per cent and 16.8 per cent respectively — made up most of the remainder. Large terminal facilities at Thunder Bay move vast quantities of grain from Western Canada to world markets through the Great Lakes and the Seaway.

In the Northwest Territories, the Northern Transportation Company Limited operates a fleet of tugs and barges, as well as coastal vessels and hovercraft, on the Mackenzie River and in the Western Arctic. Over the past two decades, the cargo carried has grown from 92,500 tonnes (91,000 tons) in 1954 to 342,000 tonnes (337,000 tons) in 1974. This waterway has played a substantial role in oil-exploration activity in the sub-Arctic and Arctic regions, and it is bound to play a continuing role in the further development of the Mackenzie region and Canada's North.

Rivers and lakes have been important transport-routes from forest to mill ever since logging first started commercially in Canada. There have been occasions when the economies of certain types of river-driving were challenged as water-transport costs increased at a rate greater than land-transport costs. Later still, free floating of wood came into conflict with the interests of recreationists and environmentalists. However, in terms of cost, water-transportation of wood for distances of 160 kilometers (100 miles) or more is still cheaper than any other form of transport. Also, because of distance and terrain, some mills have no alternative. All things considered, wood transport *via* Canada's rivers is still the least energy-consuming means of transport available.

Inland fisheries

In 1867, the year Canada became a nation, some 1.6 million kilograms (3.5 million pounds) of fish were taken from freshwater sources, primarily the Great Lakes/St. Lawrence system. After 1867, freshwater fisheries expanded to such a degree that by 1974 the annual landings had increased to 44.9 million kilograms (99 million pounds), with a landed value of about $19 million.

Although inland-fish landings represent only 4 per cent of the landings from all freshwater and ocean sources, and 6 per cent of the value from such landings, it should be remembered that the value of rivers lies not only in their yield of freshwater fish but also in the

fact that they provide the spawning-grounds for commercially-profitable anadromous ocean species. The salmon is Canada's most valuable sea fish, spawning in rivers, lakes and ponds, but spending most of its adult life in the sea.

Besides the commercial freshwater fishermen, there are millions of sports fishermen who each year cast their lures into lakes and rivers in all parts of Canada. In the 1973-74 season, the estimated number of persons (16 years of age and over) participating in this sport in Canada totalled more than four million. The income generated by sports fishing in 1970 is estimated to have exceeded $300 million, one-third from Canadians and the remainder from non-Canadians.

In view of such large economic returns, it is not surprising that, to an increasing extent, commercial and sport fishing are receiving important consideration in the preliminary design of water-use projects affecting fisheries. In some cases, such consideration has not only dictated the nature of the project but has also influenced the choice of location.

Fish require a pollution-free environment, and the increasingly polluted condition of many lakes and streams has had a serious effect on both the quantity and type of fish available for sport or commerce. In this regard, the current policy of comprehensive examination of water-resource activities in river basins is presenting new opportunities in freshwater-fish management.

Recreation

In 1941, little more than 50 per cent of Canada's population lived in towns and cities. In the 1970s, by contrast, town and city populations make up about 76 per cent of the total. Almost half Canada's people, in fact, live in the 19 cities with populations over 100,000.

The trend towards settling in large urban centres has been accompanied by a desire to return occasionally to non-urban surroundings as an escape from the pressures of modern city life. The annual exodus from the cities during the summer months is a direct result of the increase in leisure time enjoyed by most Canadians and the fact that many more people now own automobiles (car-ownership increased from one to every eight persons in 1949 to one for every three and a half in 1972).

Much of the recreation sought by holidaying Canadians needs water. Swimming, fishing, boating, waterskiing — all increasingly popular — require clean water. But many rivers and lakes close to urban centres are polluted to such an extent that they are useless for recreational purposes. This increases the use of those that are suitable and creates a demand for new recreational lakes — a demand so great that many large reservoirs have been built with recreation as one of their primary purposes.

Several of the flood-control and conservation dams built recently in Southern Ontario are designed so that their reservoirs can also be used for recreational purposes. Five reservoirs to be built in the Metropolitan Toronto region have recreation as their only purpose.

Recreational requirements are no longer overlooked in the development of water-use projects. The demands of recreational interests have in some cases been strong enough to affect decisions involving the location of hydro-electric projects. How an existing project is operated is frequently influenced by the effect it will have on recreation.

Pleasure-boating on natural and artificial waterways has shown a remarkable increase in the past few years. Thousands of pleasure craft travel the rivers of Canada every year, retracing the old *voyageur* routes that once carried the commerce of the young nation. The Rideau Canal from Ottawa to Kingston, built in 1830 for national defence, has for many years been a popular waterway for pleasure craft travelling between the Ottawa and St. Lawrence Rivers. The Trent Canal system also attracts pleasure-boats.

A growing awareness of the recreational value to the nation of clean water, to say nothing of the tourist dollars water-oriented recreation can attract, will undoubtedly give rise to many programs for the restoration of natural waterways that have become damaged or destroyed through indifference.

Waste disposal

Usually last to be mentioned but far from least in importance is the vital service water renders in diluting and carrying away the wastes of a modern society. Unfortunately, this use leads easily to abuse, as demonstrated by the condition of most of the rivers serving populated areas.

Because of the apparent abundance of water in Canada, there has been a tendancy to ignore or forget the fact that there is a limit to the amount of waste material that can be absorbed by a watercourse. The rapid growth of large population centres and the expansion of industry in certain areas of Canada have produced unpleasant evidence of what uncontrolled pollution can do to a river, and this is beginning to change the complacent attitude of Canadians to water. To a certain extent water can, by natural processes, dispose of some waste materials, but there is a limit, both in quantity and type, to what a stream can handle. The goal of wise water-management is the attainment of an acceptable, economic balance that takes into account the many and varied services a stream is called on to provide.

Flow of Canada's rivers

River	Drainage area		Mean flow	
	(km^2)	sq. miles	(m^3/s)	cu. ft. per sec.
St. Lawrence	1,030,000	396,000	9,850	348,000
Mackenzie	1,810,000	697,000	9,710	343,000
Niagara	660,000	255,000	5,550	196,000
Fraser	232,000	89,700	3,540	125,000
Slave	616,000	238,000	3,540	125,000
Koksoak	137,000	52,900	2,830	100,000
Columbia*	155,000	59,700	2,790	98,700
Nelson	1,070,000	414,000	2,660	93,900
Liard	277,000	107,000	2,580	91,200
Yukon*	282,000	109,000	2,320	82,000
Peace	303,000	116,800	2,110	74,400
Ottawa	146,000	56,500	1,950	69,000

*At the international boundary. All other figures apply to the mouth of the river.

Water use in Canada — 1974

(millions of litres a day — mld)

Regions	Municipal and rural	Agricultural	Industrial			Total
			Manufacturing	Minerals	Thermal electric	
Atlantic	773	55	3,100	459	546	4,933
Quebec	3,240	345	5,150	236	64	9,035
Ontario	3,550	550	12,000	423	21,750	38,273
Prairies	1,230	5,000	1,240	1,400	6,570	15,440
British Columbia	1,140	1,320	4,290	313	790	7,853
Yukon and Northwest Territories	27	—	—	59	—	86
Totals	9,960	7,270	25,780	2,890	29,720	75,620
	(millions of gallons a day — mgd)					
Atlantic	170	12	682	101	120	1,085
Quebec	713	76	1,133	52	14	1,988
Ontario	782	121	2,646	93	4,785	8,427
Prairies	270	1,100	273	308	1,446	3,397
British Columbia	250	290	943	69	173	1,725
Yukon and Northwest Territories	6	—	—	13	—	19
Totals	2,191	1,599	5,677	636	6,538	16,641

Recirculation permits some of the water to be used more than once. In manufacturing alone, this process has made it possible to extend the 25,780 mld (5,677 mgd) withdrawn to meet a gross requirement of 59,290 mld (13,052 mgd) and, as regards all water uses in Canada, 75,620 mld (16,641 mgd) have been stretched to meet a gross demand of 109,200 mld (24,016 mgd). This means that, on the whole, Canadians used nearly 4,900 litres (1,070 gallons) a day for each person for municipal, agricultural and industrial water-uses during 1974.

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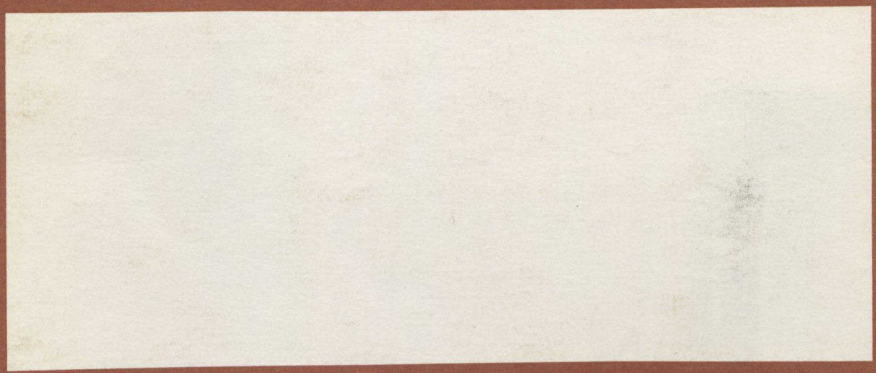

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