

Canada's Waterscape in Context

Introduction

This backgrounder explores a number of fundamental questions concerning water in Canada: What is the natural waterscape of Canada? How much water does Canada have? How is it distributed throughout the country? What are some of the critical features of the nation's water supply? What are the current and future stress points?

Water

Water is one of the most common substances on earth and is essential to all life. Water governs the global ecosystem by acting as the "universal solvent" that carries essential nutrients in solution to living organisms. As such, water is perhaps the most important substance on earth. Water is also very unique. First, only water can naturally exist under normal climatic conditions as a solid, a liquid and a gas. And in doing so, water plays a critical role in controlling and regulating the global climate. Second, water is both renewable and finite. Viewed from a broad hydrological perspective, freshwater is a renewable resource in that the water cycle continually produces new freshwater. Oceanic saltwater evaporates into the atmosphere, condenses over land and then precipitates as freshwater in the form of snow or rain. As the precipitation runs-off the landscape and heads back to the ocean, it occupies underground aquifers and surface water bodies such as rivers, streams, lakes and ponds. But viewed from a local and temporal perspective, water is finite. In other words, there is only so much freshwater available in any one place at any point in time.

The World's Water

The surface area of the earth is approximately 510 million km². Of this total area, about 70% is water and 30% is land. The earth's water is a story of maddening scarcity in the face of apparently abundant supply. This paradox results from the fact that water comes in various forms, with most of it being either unfit for use or simply inaccessible. The earth is estimated to hold 1.4 billion km³ of water (Figure 1). This is equivalent to a cube of water about 1,100 kilometers long, 1,100 wide and 1,100 kilometers tall. But 97.5% of this vast expanse is saltwater; only 2.5% is freshwater (Gleick 1996).

FIGURE 1: Earth's Water Resources

Water Form	Amount (km ³)	% of Total
Oceans and Seas	1,338,000,000	96.5379
Groundwater	12,870,000	0.9286
Lakes	85,400	0.0062
Total Saltwater Sources	1,350,955,400	97.4726
Ice, Snow, Permafrost	24,364,000	1.7579
Groundwater	10,530,000	0.7597
Lakes	91,000	0.0066
Soil Moisture	16,500	0.0012
Atmosphere	12,900	0.0009
Swamps	11,470	0.0008
Rivers	2,120	0.0002
Biota	1,120	0.0001
Total Freshwater Sources	35,029,110	2.5274
Total Water Resources	1,385,984,510	100.0000

Source: Gleick, P. H. (Peter). 1996. "Water Resources." *Encyclopedia of Climate and Weather*. S.H. Schneider (ed.).

WATER PRICING

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CANADIAN
WATER POLICY
BACKGROUND

2

SEPTEMBER 2011

FIGURE 2: Canada's Drainage Basins and Major River Systems

Drainage Basin	Examples of Major River Systems
Pacific Ocean	<i>Columbia River</i> <i>Fraser River</i> <i>Yukon River</i>
Arctic Ocean	<i>Peace River</i> <i>Athabasca River</i> <i>Slave River & Great Slave Lake</i> <i>Great Bear Lake</i> <i>Mackenzie River</i>
Gulf of Mexico	<i>Milk River</i>
Hudson Bay	<i>South Saskatchewan River</i> <i>North Saskatchewan River</i> <i>Churchill River</i> <i>Nelson River</i>
Atlantic Ocean	<i>Niagara River</i> <i>Ottawa River</i> <i>Gatineau River</i> <i>Saguenay River</i> <i>Churchill River</i> <i>Great Lakes System</i> <i>St. Lawrence River</i>

Source: Derived by Canada West Foundation from the *Atlas of Canada*, 2007. Natural Resources Canada.

Of the 2.5% of water that is fresh, 69.6% is inaccessible. This water is either trapped in polar ice caps, glaciers, snow and permafrost, or it exists in the atmosphere, in soil moisture or in living biota. Scientists estimate that 30.1% is groundwater of varying quality that may or may not be readily accessible depending on local conditions. That leaves only 0.3% of the remaining freshwater—only 0.01% of all water on earth—in lakes, ponds, wetlands, rivers, streams, sloughs and swamps (Gleick 1996). What is more, much of that water is often located away from where it is needed or flowing in the opposite direction. As a result, humans have always had to grapple with the physical and geographical scarcity of freshwater.

Accessible freshwater is generally found in precipitation (e.g., rain and snow), groundwater (e.g., underground aquifers) or surface water (e.g., rivers, streams, lakes, ponds, wetlands,

swamps, sloughs). All three sources of accessible freshwater are highly interrelated. For example, precipitation replenishes surface water sources either directly or indirectly through run-off water. But precipitation also seeps into the ground and recharges groundwater. Aquifers discharge water which helps maintain stream flow and lake levels. Thus, groundwater and surface water are highly “conjunctive.” However, surface water is generally easier to locate and access than groundwater.

Canada's Water

Canada has five major drainage basins (see map on page 8 and Figure 2). A drainage basin is an area that drains all precipitation received as run-off into a particular river or set of rivers that together empty into the same sea or ocean. Moving from west to east, the five major drainage basins are the Pacific Ocean, the Arctic Ocean, the Gulf of Mexico, Hudson Bay, and the Atlantic Ocean. Canada's five major drainage basins are generally seen as being comprised of 23 major river systems or basins. Almost three-quarters of these major river basins are shared between provinces and territories. Canada also shares ten of its major river basins with the US (Figure 3).

FIGURE 3: Shared Water Systems Between Canada and the US

Shared River Basin	Canadian Province	US State
Yukon River Basin	British Columbia	Alaska
Columbia River Basin	British Columbia	Washington, Idaho, Montana
Oldman River Basin	Alberta	Montana
Milk River Basin	Alberta, Saskatchewan	Montana
Souris River Basin	Saskatchewan, Manitoba	North Dakota
Red River Basin	Manitoba, Ontario	North Dakota, South Dakota, Minnesota
Rainy River Basin	Manitoba, Ontario	Minnesota
Great Lakes-St. Lawrence River Basin	Ontario, Quebec	Wisconsin, Illinois, Michigan, Indiana, Ohio, Pennsylvania, New York
Lake Champlain Basin	Quebec	New York, Vermont
St. Croix River Basin	New Brunswick	Maine

Source: Derived by Canada West Foundation from *IJC Activities*, 2009. International Joint Commission.

WATER PRICING

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CANADIAN
WATER POLICY
BACKGROUND

2

SEPTEMBER 2011

Compared to many countries, Canada is often considered to have an abundance of water. For example, Canada holds 20% of the world's total freshwater. Canada also has more lake area than any other country in the world—enough to flood the entire country to a depth of more than two meters. Canada is home to more than a million lakes that together cover almost 7.6% of the country's total area. In fact, nearly 15% of all the world's lakes with a surface area over 500 km² are located in Canada (National Water Research Institute 2004). Canada also has the largest wetland area in the world, containing 25% of the world's wetlands. The Great Lakes Basin, straddling the Canada-US border, is the largest freshwater reservoir on earth. It holds 18% of the world's total fresh surface water. When rivers, wetlands, lakes and all other fresh surface waters are added, almost one-tenth of Canada's total area is comprised of water (Environment Canada 2009).

Canada has two particularly notable sources of freshwater. The first source is the Great Lakes which provide water for 33 million people (about 10 million Canadians in Ontario and Quebec plus 13 million Americans). The Great Lakes are critical to the Canadian economy—they “allow goods to be shipped to and from the heart of the continent, they are a key source of hydroelectricity and they are the major North American site of significant commercial, agricultural, industrial and urban development” (Environment Canada 2006).

Glacial melt and annual run-off from the Canadian Rockies is the second notable source of freshwater. This source provides water for some 11 million western Canadians in British Columbia, Alberta, Saskatchewan and Manitoba. Water that supplies the western provinces flows from the river basins of the North and South Saskatchewan, the Nelson, the Churchill and the Assiniboine. All of these major river systems are supplied by glaciers and snowpack in the Rocky Mountains. Combined, the Great Lakes and the Canadian Rockies are the water source for almost two-thirds of Canadians.

Canada is often perceived to have an endless supply of water, but a number of features suggest otherwise:

Supply: Much of Canada's water is found in polar ice, permanent snow, mountain glaciers, permafrost and underground aquifers that are not readily accessible. When this is taken into account, Canada only has about 6.5% of the world's renewable freshwater supply. Canada lays claim to 6.8% of the globe's total land surface area. Thus, Canada's 6.5% share of global renewable freshwater is roughly proportionate to its land base.

Flow: It is also important to understand that the majority of Canada's freshwater is found or flows into the sparsely populated northern regions of the country (Program on Water Governance 2010). Approximately 60% of Canada's freshwater drains into Hudson Bay and the Arctic Ocean while most Canadians live in the southern reaches of the country. The reality is that most Canadians live quite far from the majority of the country's freshwater.

Distribution: Fresh water availability differs greatly by region and province. Some parts of the country, such as the area around the St. Lawrence River and the Great Lakes or the Pacific seaboard in British Columbia, have relatively few water supply concerns. This stands in stark contrast to the drought-prone and semi-arid regions of the BC interior and the southern reaches of the three prairie provinces, some of which are already experiencing water shortages. When it comes to Canada's waterscape, it is very important to understand the extreme variability in how water is distributed across the regions and provinces. The province of Quebec has almost 20% of Canada's surface freshwater supplies, while Alberta has only 2% (Figure 4). There are also significant differences in the primary sources of water used in the regions in Canada (Figure 5). In western and central Canada, the great bulk of water used is from surface water sources such as lakes and rivers.

WATER PRICING

Seizing a Public Policy Dilemma by the Horns

CANADIAN
WATER POLICY
BACKGROUND

2

SEPTEMBER 2011

FIGURE 4: Surface Freshwater Sources Across Canada

Province or Territory	Land Area (km ²)	Freshwater Area (km ²)	Freshwater Area as a % of Total Area	% of Canada's Freshwater Area	2006 Population	% of Canada's Population
British Columbia	925,186	19,549	2.1	2.2	4,113,487	13.0
Alberta	642,317	19,531	3.0	2.2	3,290,350	10.4
Saskatchewan	591,670	59,366	9.1	6.7	968,157	3.1
Manitoba	553,556	94,241	14.5	10.6	1,148,401	3.6
Ontario	917,741	158,654	14.7	17.8	12,160,282	38.5
Quebec	1,365,128	176,928	11.5	19.9	7,546,131	23.9
New Brunswick	71,450	1,458	2.0	0.2	729,997	2.3
Nova Scotia	53,338	1,946	3.5	0.2	913,462	2.9
PEI	5,660	6	0.1	0.0	135,851	0.4
Newfoundland	373,872	31,340	7.7	3.5	505,469	1.6
Yukon Territory	474,391	8,052	1.7	0.9	30,372	0.1
Northwest Territories	1,183,085	163,015	12.1	18.3	41,464	0.1
Nunavut Territory	1,936,113	157,077	7.5	17.6	29,474	0.1
Canada	9,093,507	891,163	8.9	100.0	31,612,897	100.0

Source: Derived by Canada West Foundation from Statistics Canada.

Note: Percentage of freshwater area may not necessarily reflect total freshwater supplies as land area alone fails to account for depth of water bodies, and hence, total volume.

FIGURE 5: % of Population Dependant on Surface & Ground Water

Province	Surface Water	Ground Water
British Columbia	28.5	71.5
Alberta	23.1	76.9
Saskatchewan	42.8	57.2
Manitoba	30.2	69.8
Ontario	28.5	71.5
Quebec	27.7	72.3
New Brunswick	66.5	33.5
Nova Scotia	45.8	54.2
Newfoundland and Labrador	33.9	66.1
Prince Edward Island	100.0	0.0
Yukon Territory	47.9	52.1
Northwest Territories	28.1	71.9
Nunavut Territory	28.1	71.9
Total Canada	30.3	69.7

Source: Derived by Canada West Foundation from various sources.

Only about 25% to 30% of the population in those regions use groundwater sources. In Atlantic Canada, the use of groundwater is much higher. Prince Edward Island is completely dependant on groundwater sources. Most major urban areas in Canada rely on surface water sources with

the rural areas of the country tending to rely more heavily on groundwater supplies. Across Canada as a whole, 70% of the population uses surface water sources. At the same time, it is generally believed that there is more groundwater in Canada than surface water, but many underground aquifers have yet to be mapped and quantified.

Suitability: Not all water in Canada is equally suitable for its intended purpose. Water *quality* is just as important a consideration as water quantity. For example, Canadian groundwater supplies vary in quality with some of them being poor quality brackish water. There is also wide variation among the river systems in Canada with respect to dissolved solids (Figure 6). As such, water fit for one use such as irrigation may not be fit for another use such as drinking.

At best, Canada can be considered to be relatively water rich. With 6.5% of the world's renewable freshwater and only 0.5% of the world's global population, Canada does have more water per capita than many other countries, and can be considered generously supplied (McFarlane and Nilson 2003). But this does not mean that Canada is water rich in an absolute sense, particularly when considering how that water is distributed among the various regions of the country and the localized water profile and climate within those provinces.

WATER PRICING

Seizing a Public Policy Dilemma by the Horns

CANADIAN
WATER POLICY
BACKGROUND

2

SEPTEMBER 2011

FIGURE 6: Total Dissolved Solids in Selected Canadian Rivers

Major River System	Dissolved Solids (mg/L)
Fraser River (British Columbia)	95
Okanagan River (British Columbia)	215
Mackenzie River (Northwest Territory)	208
Athabasca River (Alberta)	224
South Saskatchewan River (Alberta)	294
Saskatchewan River (Saskatchewan)	299
Red River (Manitoba)	484
Nelson River (Manitoba)	192
Goulais River (Ontario)	30
Thames River (Ontario)	422
Niagara River (Ontario)	220
St. Lawrence River (Quebec)	222
St. John River (New Brunswick)	44
Morell River (Prince Edward Island)	107
Margaret River (Nova Scotia)	81
Exploits River (Newfoundland and Labrador)	16

Source: Derived by Canada West Foundation from *Introduction to Water Quality*, 2010. Environment Canada.

So while it may indeed be true that Canada has the largest surface area of freshwater of any country, this is—taken on its own—a somewhat misleading fact. The real question is not how much water there is in Canada. The more relevant question is whether there is enough water where it is needed, whether that water is readily accessible and whether that water is of sufficient quality.

Stress Points

Canada's water supply is facing a number of current issues and potential future threats:

Growing demand: Canada's population is expected to grow 25% by 2050 and the economy is projected to grow 55% by 2030 (National Round Table on the Environment and Economy 2010). This growth will lead to increased demand and competition for a relatively fixed supply of water. Global demand for water is also projected to increase. Continued population and economic growth—as well as increasing urbanization and the swelling ranks of the middle class—are sure to stress water supplies globally. More water will be needed

to grow food for expanding populations. The UN has predicted that 40% of the world's population could be living with serious "water stress" by 2040 (Maxwell 2010). These global water developments are likely to affect Canada in some shape or form.

Aging infrastructure: Aging infrastructure in Canada results in two problems. First, it can lead to leakages. An average of 13% of municipal piped water is lost due to leaks (Environment Canada 2006). Water leaked is water wasted. Second, it can increase the risk of water contamination, which increases treatment costs. Yet, current municipal water charges barely cover the basic costs of operation and maintenance. It is estimated that about half of all water supply lines in Canada are in need of repair (McFarlane and Nilsen 2003). More revenue is required to fix Canada's water infrastructure.

Over-Use: Some water sources are strained due to over-pumping or excessive withdrawals. If the amount being withdrawn cannot be matched by natural recharge, water sources can become over-taxed.

Pollution: Non-point contamination comes in the form of run-off from urban areas such as petroleum, road salts and other debris. In some areas of the country, there is also non-point contamination in the form of agricultural run-off as well such as phosphorus and nitrogen from fertilizers, pesticides and animal wastes. This has led to concerns over excessive nutrient loading in some water bodies, particularly Lake Winnipeg. One of Canada's largest lakes, Lake Winnipeg is suffering from a growing eutrophication problem largely stemming from intense agricultural activities in Alberta, Saskatchewan and Manitoba. There are also point contamination concerns from industrial production, manufacturing, processing, pulp and paper, oil and gas development, mining and forestry. These activities can affect water quality by increasing concentrations of metals and toxic chemicals, adding suspended sediments in the water and lowering dissolved oxygen levels. There are more than 23,000 different chemicals and substances currently used in the production of consumer goods and industrial processes in Canada (Environment Canada 2009). Even relatively green uses of water such as electrical generation are not without their effects, particularly if they involve dams. But even using water for cooling in electrical generation—a major use in Canada—can result in water being returned at higher than

WATER PRICING

Seizing a Public Policy Dilemma by the Horns

CANADIAN
WATER POLICY
BACKGROUND

2

SEPTEMBER 2011

normal temperatures which, in turn, impairs normal ecosystem functioning. There are concerns that the Great Lakes and the St. Lawrence are currently having difficulty cleansing and purifying themselves.

Climate change: Future water supplies will almost certainly be affected by climate change. Uncertainty surrounding water supply is increasing as changes in global temperatures affect “average annual water flow, variability and distribution” (Environment Canada 2006). The uncertainty that characterizes Canada’s future water supply is another reason why efficiently managing water is so crucial. Although Canada may well have a more vast and secure freshwater supply than many other countries, the nation’s water resources are not unlimited and neither are they as abundant or secure as many believe.

Conclusion

Compared to many other international jurisdictions, Canada is “relatively water rich.” However, Canada’s waterscape is also characterized by significant regional differences—both the quantity and the quality of water resources vary depending on the region in view. Some regions (e.g., the interior of British Columbia and southern Alberta) are currently faced with immediate water supply challenges. Other regions (e.g., Ontario and Quebec) have few supply problems, but water quality is a growing concern.

Although there is no national water crisis, many areas of the country are seeing the parallel pressures of increased water demand due to growing populations and economic expansion, and destabilizing and shrinking supply due to aging and substandard water infrastructure, over-use of water supplies, growing threats of contamination and climate change. For many Canadians, these stresses and strains on supply can be managed through more effective water resources management. Market-based mechanisms have the potential to play a significant role in achieving the better management that is required.

For more information and to access the Canada West Foundation’s water policy research visit: www.cwf.ca

WATER PRICING

Seizing a Public Policy Dilemma by the Horns

CANADIAN
WATER POLICY
BACKGROUND

2

SEPTEMBER 2011

FIGURE 7: Overview of the Canadian Provincial Waterscape

Province	Major Sources and Supplies	Features, Issues and Challenges
British Columbia	Abundant rainfall & surface water along the West Coast. Much drier & arid areas in the interior. Rivers originate on the west side of the Rocky Mountains.	Hydropower generation is a major factor in the province. Water shortages in the BC interior. Growing conflicts over groundwater.
Alberta	Heavily reliant on surface waters, especially rivers. Rivers originate on the east side of the Rocky Mountains. Most water flows north while population is in the south.	Very good growing climate in the south, but also very dry. Largest irrigated land mass in Canada. No new surface water licenses in the South Saskatchewan Basin. Concerns over pollution threats with oil sands development.
Saskatchewan	Generally freshwater abundant. Most water flows north while population is in the south.	Drought is a common occurrence.
Manitoba	Freshwater abundant (e.g., Lake Winnipeg). Drains water from three provinces & four US states.	Hydropower generation is a major factor in the province. Excess nutrient loading in Lake Winnipeg (eutrophication). Prone to flooding during spring & subject to occasional drought.
Ontario	Freshwater abundant (e.g., Great Lakes). Great Lakes are earth's largest source of freshwater.	Natural replenishment of Great Lakes is slow. Increasing competition for water between economic sectors. Manufacturing heartland of Canada & pollution threats. Quality issues & concerns in light of Walkerton water tragedy.
Quebec	Relatively water abundant. Access to St. Lawrence Seaway.	Hydropower generation is a major factor in the province.
New Brunswick	Heavily reliant on groundwater sources.	Water quality remains a concern.
Nova Scotia	Freshwater abundant.	Some problems with water quality.
PEI	Entirely dependent on groundwater sources.	Potential water quality problems.
Territories	YK, NT & NU are all freshwater abundant.	Potential quality problems in YK & NU. Wastewater spills from sewage in NT. Salty groundwater brought to surface by oil, gas & mining in NT.

Sources: Policy Research Initiative. 2005. *Economic Instruments for Water Demand Management in an Integrated Water Resources Management Framework*.
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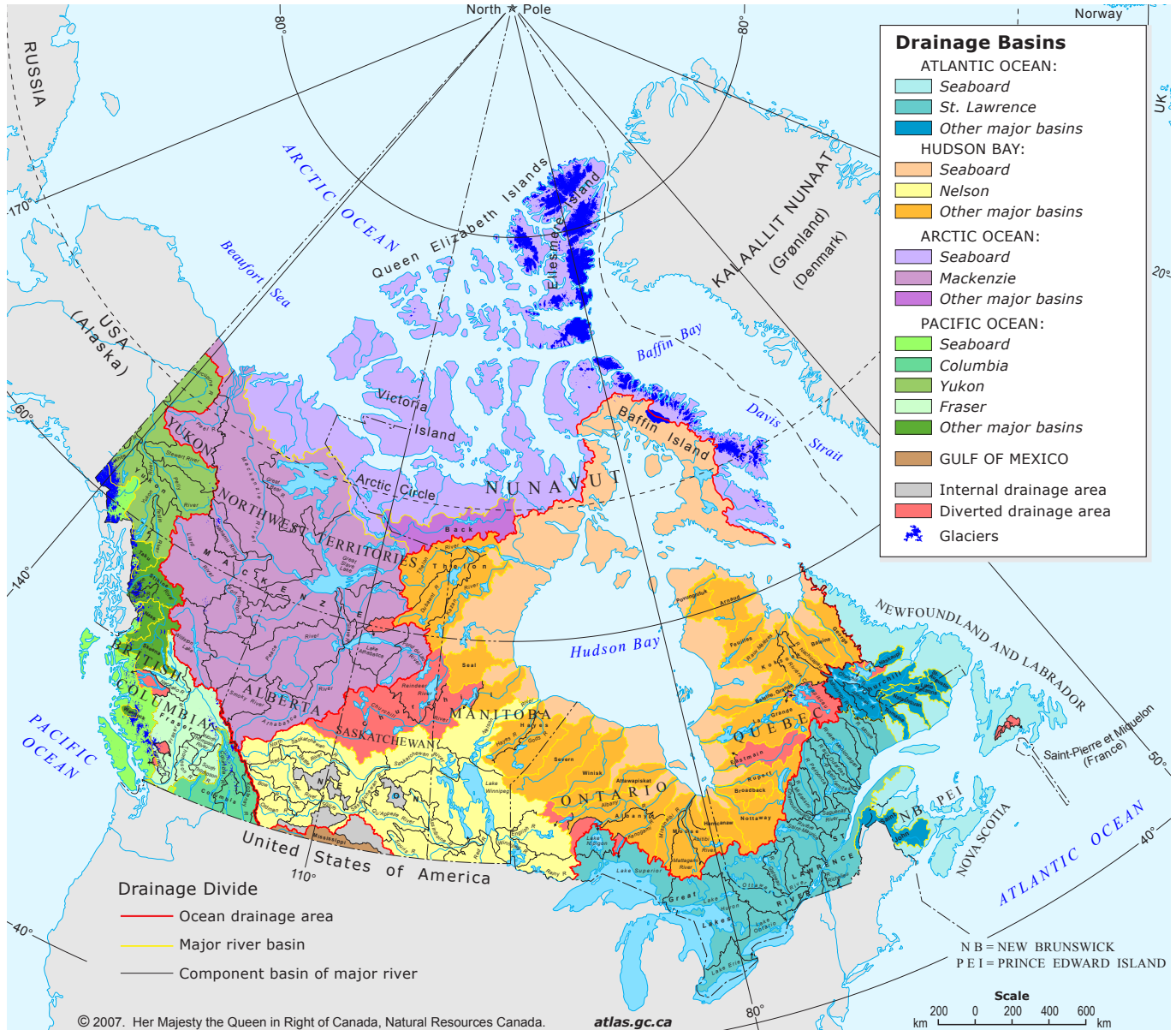
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CANADIAN
WATER POLICY
BACKGROUND

SEPTEMBER 2011

2

MAP: Canada's Drainage Basins



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CANADIAN
WATER POLICY
BACKGROUNDERS

2

SEPTEMBER 2011

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