

Drainage Patterns

Abstract

A drainage basin is an area that drains all precipitation received as a runoff or base flow (groundwater sources) into a particular river or set of rivers. Canada's major drainage regions are the Atlantic Ocean, Hudson Bay, Arctic Ocean, Pacific Ocean, and Gulf of Mexico. A lake can be defined as any inland body of water, usually fresh water, larger than a pool or pond. Canada is covered by as many as two million lakes. The largest set of lakes, the Great Lakes, straddle the Canada-US boundary and contain 18% of the world's fresh water in lakes. Most Canadian rivers have developed since the last ice age. Almost 75% of the Canadian landmass contains water that drains northward into either the Arctic Ocean or into Hudson and James bays.

The easiest way to describe the pattern of rivers and lakes on a small-scale map is to show the pattern of drainage basins. In Canada, there is a detailed hierarchy of drainage basins, ranging from the largest (drainage into oceans and their equivalents), down to very detailed patterns. When a user sees the initial view map, it will show the ocean drainage areas, and then will expand to a more detailed network as he or she zooms in.

The notes below describe the main drainage basins, major lakes, and rivers in Canada.

Drainage Basins

A drainage basin is an area that drains all precipitation received as either runoff or base flow (groundwater sources) into a particular river or set of rivers. The boundary of a drainage basin is defined as the ridge beyond which water flows in the opposite direction. A drainage basin is also known as a catchment area or a watershed. Canada's major drainage regions are as follows:

Table 1. Ocean Drainage Areas of Canada

Ocean Drainage Areas	Surface Area (square kilometres)
Atlantic Ocean	1 520 000
Hudson Bay	3 861 400
Arctic Ocean	3 583 300
Pacific Ocean	1 009 100
Gulf of Mexico	21 600

Source: Canada. Natural Resources Canada. The Atlas of Canada. Facts About Canada: Fresh Water. Ottawa, 1999.

The location and main component rivers of each of these regions is as follows:

- The **Pacific Ocean drainage area** drains the area west of the Rocky Mountains. The Fraser, Yukon and Columbia rivers are the largest rivers draining this region. It is separated from all other drainage areas by the continental divide. This is defined as the north-south line along the western Cordillera separating rivers flowing ultimately into the Pacific Ocean from those flowing into other oceans.
- The **Arctic Ocean drainage area** is the area flowing directly into the Arctic Ocean or into the channels of the Arctic Islands. Hudson, James and Ungava bays are considered to be part of the Arctic Ocean, but for most purposes their drainage area is usually considered as a separate entity. The Mackenzie River dominates the Arctic Ocean drainage area.
- The **Hudson Bay drainage area** is a huge area that captures about 30% of total Canadian runoff. Many of its river systems such as the Nelson and Churchill River (of Manitoba) drain eastwards from the continental divide to Hudson Bay. As well, many large rivers drain from the south and east into Hudson Bay or James Bay. The extensive area of drainage into Ungava Bay is also considered to be part of the Hudson Bay drainage area.
- The **Atlantic Ocean drainage area** is dominated by the Great Lakes-St. Lawrence system but there are other significant drainage basins such as those of the Churchill River (of Labrador) and the Saint John River in New Brunswick.
- **Gulf of Mexico drainage area** is a small portion of southern Alberta and Saskatchewan drains south into the Mississippi system which ultimately drains into the Gulf of Mexico. (The Gulf is part of the Atlantic Ocean, but because of the Mississippi, it is often studied as a separate entity).
- Parts of Alberta and Saskatchewan have areas of **internal drainage**: these are river systems that do not drain into any ocean. Maps often assign these areas to one or other of the drainage areas noted above.

Lakes

A lake may be defined as any inland body of standing water, usually freshwater, larger than a pool or pond. Canada is famous for its number of lakes. There are as many as two million lakes covering, in total, 8.9% of the country.

In order to discuss the pattern of lake distributions, users may find it useful to turn on the layer called Geological Provinces. This layer shows all 17 geological provinces of Canada. However, for ease of use as a base layer, the layer colour-codes them

into a small number of types: thus, all seven of the provinces making up the Canadian Shield units are in the same colour, as are all platform areas, and all mountainous (orogen) areas.

Most of the larger lakes are found either within the Canadian Shield, or in the line of contact between the Canadian Shield and the two platform areas to its south, the Interior Plains, and the St. Lawrence Lowlands. Other than on the Shield, nearly all the lakes in Canada owe their origin to glacial activity. Lakes such as Great Bear, Great Slave, Athabasca, Winnipeg, and the Great Lakes are all found along the line separating the Shield from platform areas to its south and west. These lake depressions were formed by glaciers from the Shield carrying hard granitic debris and gouging deeply onto the softer sedimentary rock. Lakes in the highly resistant rocks of the Shield tend to be clear and long-lived. By contrast, Prairie lakes, which are often formed by melted-out glacial deposits, tend to be shallower and contain more sediment. Lakes in the mountainous areas of British Columbia and the Yukon are typically confined to deep glaciated valleys.

Canada probably has more lakes than any other country in the world. Canada has 563 lakes having an area greater than 100 square kilometres. A complete list is given in the Facts about Canada section of The Atlas of Canada. The largest set of lakes, the Great Lakes, straddle the Canada-US boundary and contain 18% of the world's freshwater in lakes.

Table 2 indicates that many of the largest lakes in the world are either wholly or partly within Canada.

Table 2. The World's Largest Lakes

Rank (by area)	Name	Location (Canadian locations bolded)	Maximum Area (km ²)	Greatest Depth (metres)
1	Caspian Sea	Russia/ Kazakhstan/ Uzbekistan / Iran/ Azerbaijan	378 400	1025
2	Superior	USA/ Ontario	83 300	401
3	Victoria	Kenya/Uganda/ Tanzania	69 900	92
4	Huron	Ontario /USA	59 800	229
5	Michigan	USA	58 100	285
6	Tanganyika	Tanzania/ Zambia/ Democratic Republic of the Congo/ Burundi	34 000	1470
7	Baikal	Russia	31 500	1741
8	Great Bear	Northwest Territories	31 792	445
9	Great Slave	Northwest Territories	28 570	614
10	Erie	Ontario /USA	25 720	64
11	Winnipeg	Manitoba	24 600	28

13	Ontario	Ontario/USA	19 480	273
22	Athabasca	Saskatchewan/ Alberta	8 080	124
31	Winnipegosis	Manitoba	5 470	124

Source: Adapted from Peter H. Gleick. *Water in Crisis*. New York: Oxford University Press, 1993.

Note: The Aral Sea is not listed as its area has shrunk drastically in recent years.

The importance of lakes lies in their ability to store water during times of plenty and release it gradually. Thus lakes perform an extremely valuable task in balancing the flow of the rivers on which they are located. For example, the Saskatchewan River, with few lakes, has a maximum recorded flow of 59 times its minimum flow. On the other hand, the St. Lawrence River, which drains the Great Lakes, has a maximum flow of only twice its minimum flow. The difference in flow patterns in these two rivers is partly due to precipitation differences, but results mainly from the vast storage provided by the Great Lakes for the St. Lawrence River compared with the negligible lake storage on the Saskatchewan River.

The Great Lakes

The Great Lakes basin (the lakes plus the area of land draining into the lakes) is home to 8.5 million Canadians and 30.7 million Americans. As well as providing drinking water, these lakes have played a major role in the development of both countries. They allow goods to be shipped to and from the heart of North America; they are a source of hydroelectricity; and they are the site of immense industrial, commercial, agricultural, and urban development. The Great Lakes also provide an array of recreational opportunities. The overall management of many aspects of the Great Lakes is handled by the International Joint Commission, which is based in Detroit.

Figure 1 shows the elevations and depth profiles of the Great Lakes, and route of the St. Lawrence Seaway.

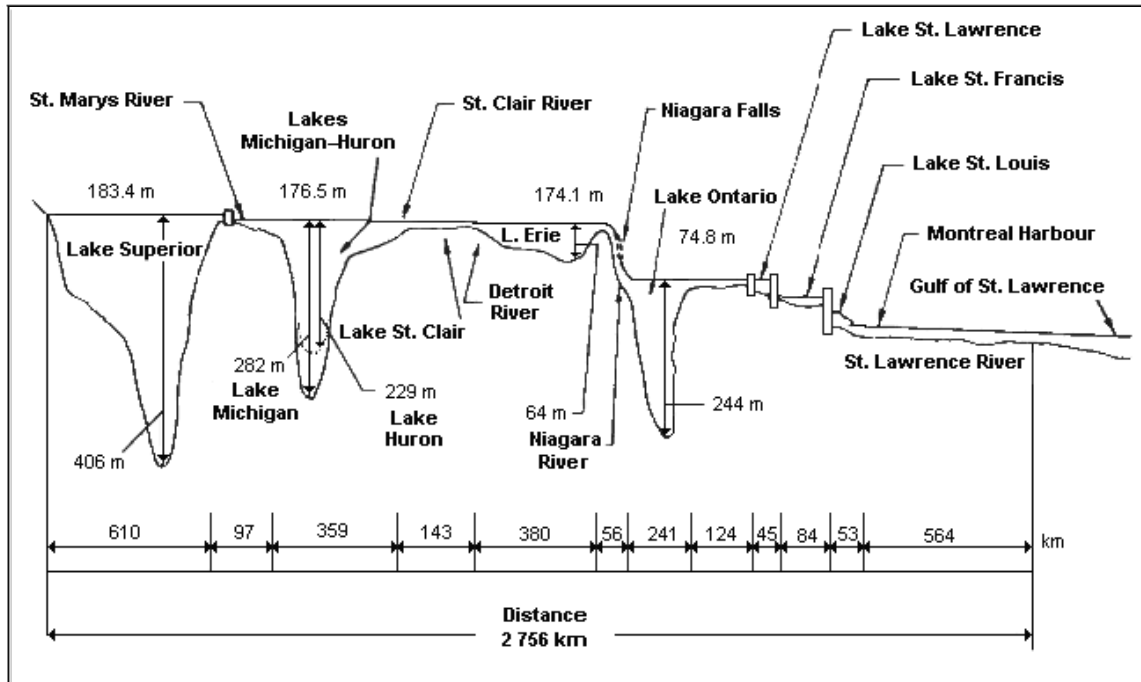


Figure 1. Cross-sectional Profile of the Great Lakes and the St. Lawrence Seaway
Source: Modified from: Levels Reference Study Board (1993). Burlington, Ont.: Environment Canada, Ontario Region (unpublished).

Rivers and Runoff

Aside from glaciers, running water has had the most impact on shaping the earth's landscape. Most Canadian rivers have developed since the last ice age. Almost 75% of the Canadian landmass contains water that drains northward into either the Arctic Ocean or into Hudson and James bays. This flow involves almost half (47.9%) of the total flow of Canadian rivers.

Most rivers in Canada have a substantial seasonal variation in runoff. There are different patterns for flow variations:

- Most high flows in Canada are caused by snowmelt, which usually peaks in the spring. Consequently, this is the season when floods due to rivers are most likely to occur in Canada.
- Rainstorms can also cause sudden high flows and floods in almost any season, especially on small streams.

- Glacier meltwater provides the high-water flow in mid-summer for rivers that drain from mountainous regions of BC and Alberta. Fortunately for these regions, this causes these rivers to have a peak flow in mid-summer.
- In many other parts of Canada, natural water storage in lakes, wetlands and aquifers, provides more consistent sources of water for rivers throughout the year. A good example of this is the St. Lawrence River, which has a relatively even flow year-round due to the storage capacity of the Great Lakes.
- The lowest flows on rivers in Canada generally occur at two times of the year: in late summer, when precipitation is low, and evaporation along with water consumption by plants is high; and in late winter, when rivers are ice-covered and the precipitation is stored until spring in the form of ice and snow.

A map in The National Atlas of Canada, 4th Edition, Seasonal Runoff shows the timing of peak runoff for a large selection of rivers across Canada.

As with large lakes, many of the largest rivers in the world are wholly or partly within Canada as shown in Table 3 below.

Table 3. The World's Largest River Drainage Basins

Rank (by area)	Name	Location	Drainage basin Area ('000 km ²)	Discharge rate (km ³ /yr)
1	Amazon	South America	6915	6923
2	Congo	Africa	3680	1320
3	Murray	Australia	3520	N/A
4	Plata-Parana-Grande	South America	3100	811
5	Ob'	Asia	2990	302
6	Mississippi-Missouri	USA / Canada	2980	510
7	Nile	Africa	2870	100
8	Yenisei	Asia	2580	539
9	Lena	Asia	2490	404
10	Niger	Africa	2090	302
11	Amur	Asia	1855	360
12	Yangtze	Asia	1855	1006
13	Mackenzie	Canada	1790	330
14	Ganges - Brahmaputra	India	1730	1386
15	Volga	Russia	1380	255
16	Zambezi	Africa	1330	18
17	St Lawrence	Canada / USA	1030	318

Source: Adapted from: World Water Resources and Their Uses. Joint SHI/UNESCO Product, prepared by Igor A. Shiklomanov, [place], 1999.

More detailed data about the length, drainage area and discharge of Canadian rivers is given in the Rivers section of Facts About Canada.

Measuring Freshwater in Lakes and Rivers

Environment Canada's Water Survey of Canada measures the rate of flow (discharge) in rivers at more than 2600 locations in Canada. Useful geographical summaries of flow data are found in the Rivers section in Facts about Canada as noted above, and the 5th Edition Streamflow map.

Gauging stations also collect data on the water level (its height above or below a datum) of their particular lake or river location. Water level and discharge information is essential for the wise management of Canada's water resources. Some uses of these data are the following:

- Allocating water between various users.
- Managing water resources, in particular for minimizing the impacts of extreme flows. This involves a variety of activities such as flood protection, floodplain mapping or building diversion canals.
- Designing and constructing specific structures to use or to function alongside normal water flows. Examples are water supply facilities, irrigation facilities, bridges and culverts.
- Planning and conducting environmental programs and assessments related to water quality, fisheries, and wildlife habitat.
- Ensuring that the nation's water resources are developed in a manner that conserves and protects the environment.

Definitions of underlined terms

Drainage basin: A drainage basin is the area that drains all precipitation received as runoff and base flow (groundwater sources) into a river or stream system into a common outlet such as a lake or sea.

Lake : Any inland body of standing water, usually of fresh water, filling a depression in the earth's surface. Small lakes are usually called pools or ponds.

River: A natural stream of water, usually of substantial volume.

Map Sources

Drainage Basins

River flow (discharge) was the critical factor used to delineate basin boundaries. All rivers with an annual mean flow higher than 10 000 cubic feet per second were

depicted. However, land areas containing river basins that did not meet this annual mean flow threshold were assigned to the generic category "seaboard". The major river basins are the rivers that directly flow into the ocean. Within each major river basin, up to three levels of component basins were identified. In addition, water diversions larger than 1000 cubic feet per second were mapped. Natural Resources Canada. 1985. Canada--Drainage Basins [map]. National Atlas of Canada, 5th Edition.

References

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Federal-Provincial Task Force on the Importance of Nature to Canadians. 1999. The Importance of Nature to Canadians: Survey Highlights. Ottawa: Environment Canada (<http://www.ec.gc.ca/nature/highlights/highlite.html>).

Marsh, James H. (ed. in chief). 1985. The Canadian Encyclopedia. Edmonton: Hurtig.

Stanké, Alain (ed.). 2000. L'Encyclopédie Canada 2000. Montréal, Québec: Éditions internationales Alain Stanké.

Related Web sites (1999 – 2009)

Federal Government

Environment Canada. Freshwater Web Site
<http://www.ec.gc.ca/eau-water/>

This web site gives access to the nature of water, water policy and legislation, the management of water, water and culture, and informational resources and services.

Environment Canada. Quebec Region. The St. Lawrence Centre
<http://www.qc.ec.gc.ca/csl/index.html>

The St. Lawrence Centre studies the ecosystems of the St. Lawrence River and conduct research programs with the aim of better understanding how these ecosystems function, and maintaining knowledge of the St. Lawrence River up to date.

Environment Canada. The National Water Research Institute
<http://www.ec.gc.ca/inre-nwri/>

The National Water Research Institute (NWRI) is Canada's largest freshwater research establishment. NWRI conducts a comprehensive program of research and

development in the aquatic sciences, in partnership with the Canadian and international science communities.

Fisheries and Oceans Canada. Canadian Hydrographic Service (CHS)

<http://www.charts.gc.ca/>

The CHS is responsible for charting Canada's 243,792 kilometres of coastline (the longest of any country in the world) and 6.55 million square kilometres of continental shelf and territorial waters (the second largest in the world) and an extensive system of inland waterways.

Other

University of Guelph. Canada's Aquatic Environments

<http://www.aquatic.uoguelph.ca/index.htm>

This site, at the University of Guelph, gives information on lakes, rivers, wetland regions and aquatic animals and plants.

Inter-agency

International Joint Commission

<http://www.ijc.org/>

The International Joint Commission is an independent binational organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions.