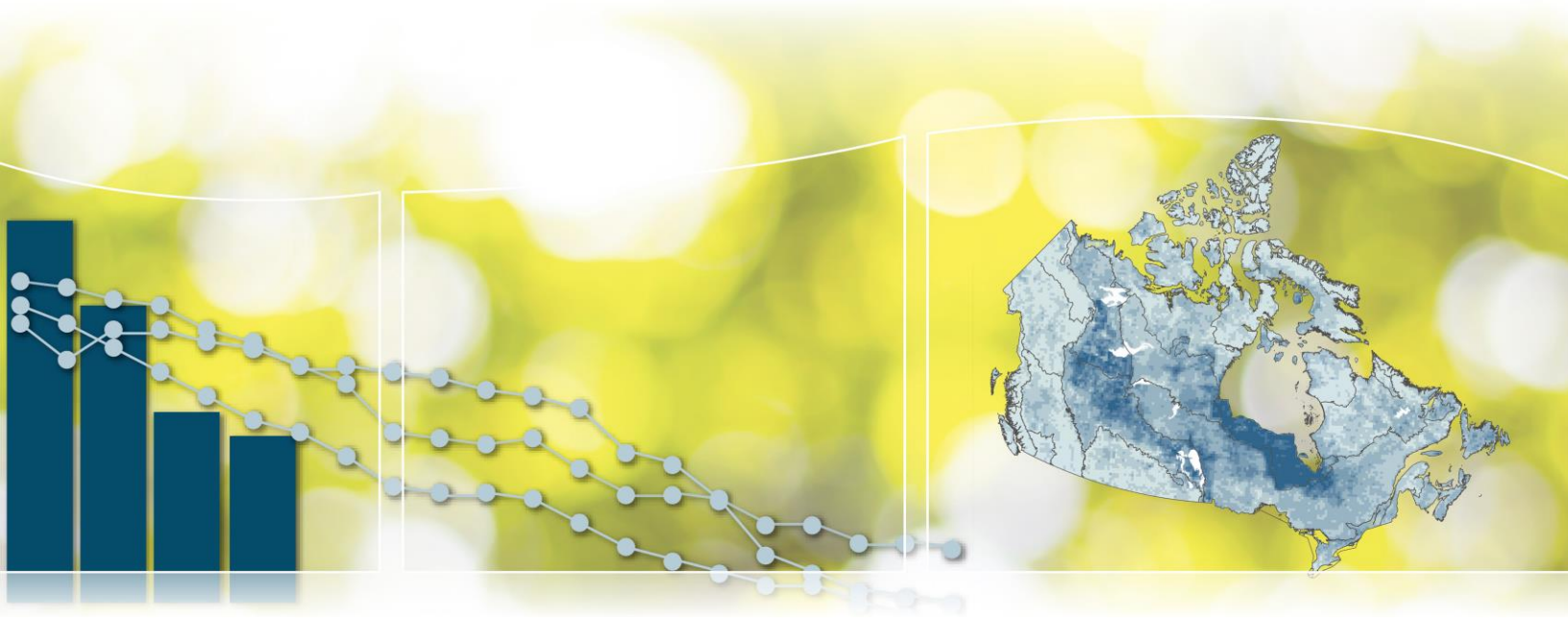
Environment and Climate Change Canada
Environnement et Changement climatique Canada

Canadian Environmental Sustainability Indicators

Water Quantity in Canadian Rivers



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Canadian Environmental Sustainability Indicators

Water Quantity in Canadian Rivers

April 2016

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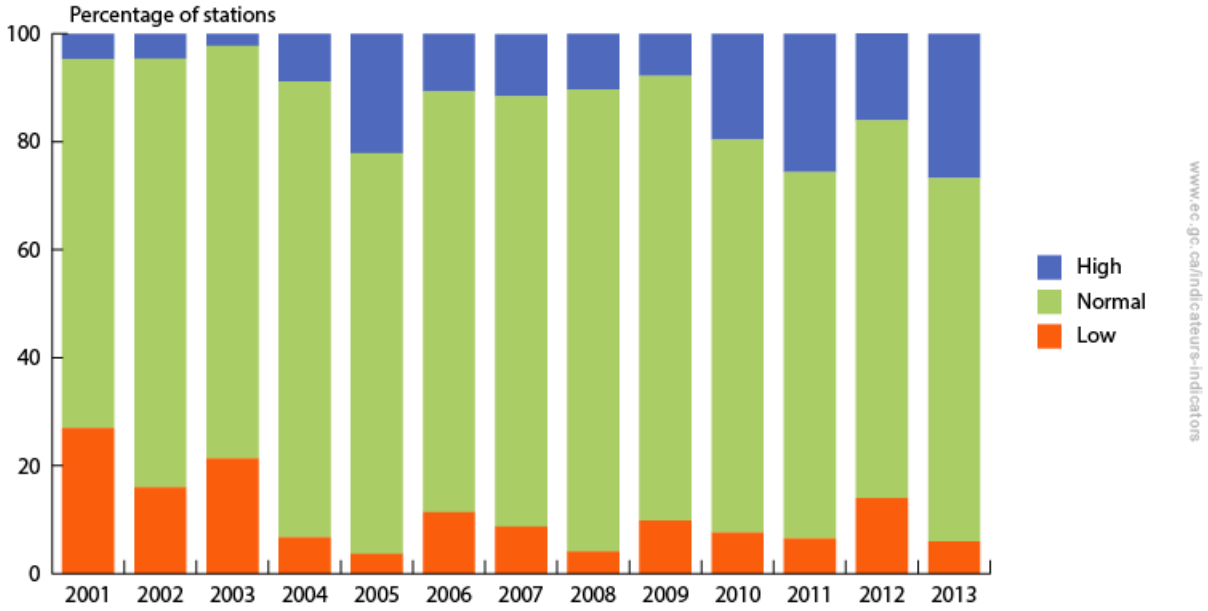
Part 1. Water Quantity in Canadian Rivers Indicators

In 2013, 27% of 866 water quantity stations were classified as having higher-than-normal quantity, 6% had lower-than-normal quantity and 67% had normal quantity.

From 2001 to 2013, Canada's rivers typically had normal water quantity with an increasing tendency for higher-than-normal quantity starting in 2010. The percentage of stations with lower-than-normal quantity has declined since 2001.

Figure 1. Water quantity at monitoring stations, Canada, 2001 to 2013



Data for Figure 1

Note: The water quantity classification for a station is based on a comparison of the most frequently observed flow condition in a given year with typical water quantity at that station between 1981 and 2010. The normal period for the Northern Quebec drainage region was 1971–2000, instead of 1981–2010, because of a data gap in the drainage region. The 2013 data has fewer stations contributing to the results because of delays getting data into the HYDAT database. Normal water quantities are specific to each region and do not refer to the same amount of water in each drainage region (e.g., normal water quantity in the Prairies is different from normal water quantity in the Maritimes).
Source: Environment and Climate Change Canada (2015) Water Survey of Canada, HYDAT Database.

Canada is a water-rich country, with its rivers and lakes accounting for 7% of the world's renewable freshwater.[1] However, even with all this water, shortages are a serious problem for regions of Canada when natural water supplies do not meet human demand.

[1] Renewable freshwater refers to the total amount of freshwater available for use in Canadian rivers, lakes and groundwater. It is calculated as the total volume of water flowing in a river plus the volume of water returned to it from groundwater, rainfall and snowfall, plus water originating from outside the country.

Water quantity in Canadian rivers is measured as water flow, or the volume of water moving over a point, over a fixed period of time. Water flows in rivers, lakes and reservoirs generally follow changes in temperature, rainfall and snowfall throughout the year. In general, the landscape is wettest right after snow melt in the early spring and gradually dries out through the late summer and early fall. In any given year, more precipitation increases the amount of water in rivers, lakes or reservoirs, whereas warmer temperatures and less rain or snowfall will result in less water.

Over longer time scales, water quantity is also affected by weather patterns and ocean surface temperatures. In any given year, ocean surface waters interact with weather patterns to influence the amount of rain or snow that falls, which can bring about years with too much, or too little, water. For example, extended summer droughts on the Prairies, which cause lower-than-normal water flows, tend to take place when the southern Pacific Ocean warms during El Niño Southern Oscillation events. In contrast, the Prairies experience more rain and snow, causing higher-than-normal flows, when the ocean cools during La Niña events.[2] Climate change may increase the strength and occurrence of the El Niño Southern Oscillations.

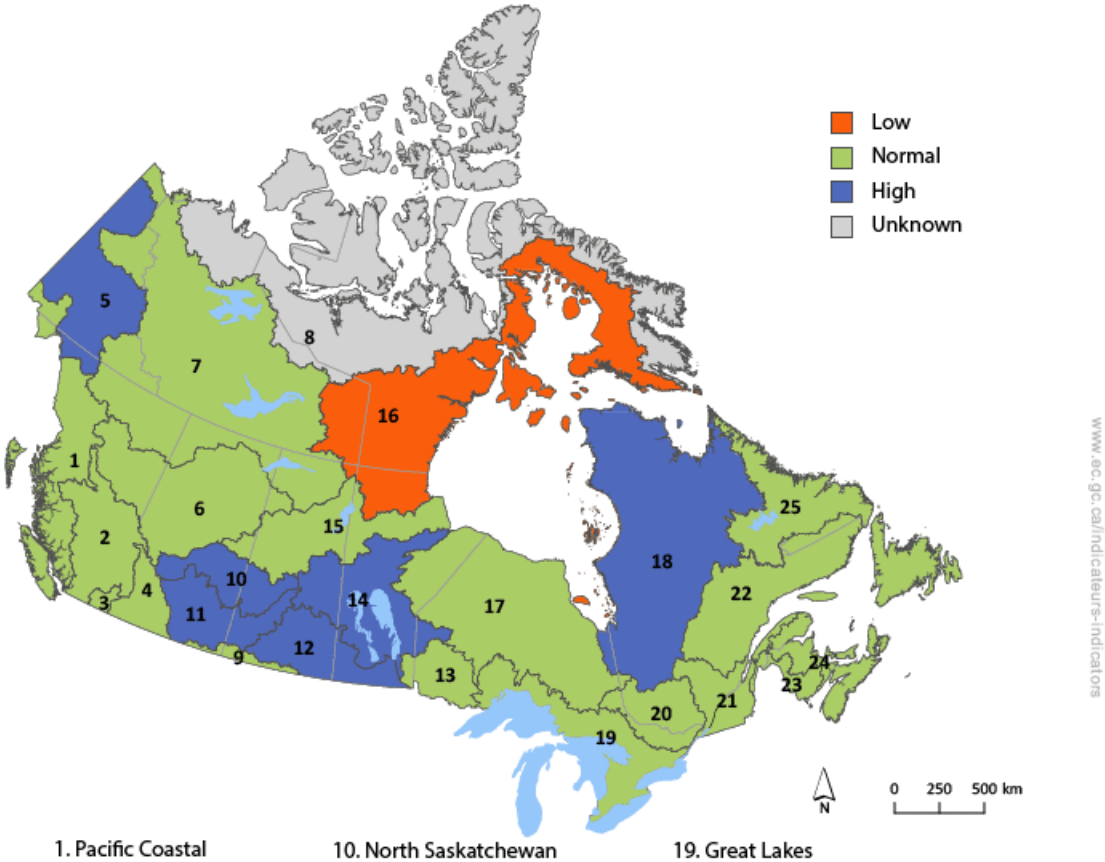
This indicator is used to measure progress toward Goal 3: Water Quality and Water Quantity – Protect and enhance water so that it is clean, safe and secure for all Canadians and supports healthy ecosystems of the Federal Sustainable Development Strategy 2013–2016.

[2] Bonsal B and Shabbar A (2010) Large-scale climate oscillations influencing Canada, 1900–2008. Canadian Biodiversity: Ecosystem Status and Trends 2010, Technical Thematic Report No. 4. Retrieved on November 4, 2015.

Regional Water Quantity in Canadian Rivers

In 2013, water quantity conditions in most drainage regions across Canada were normal. Lower-than-normal water quantity was observed in the Keewatin–Southern Baffin (16) drainage region. Higher-than-normal flows were observed in the Yukon (5), North Saskatchewan (10), South Saskatchewan (11), Assiniboine–Red (12), Lower Saskatchewan–Nelson (14), and Northern Quebec (18) drainage regions. Alberta's super-flood in June 2013 and a wetter-than-normal fall contributed to the higher water quantity on the Prairies.

Figure 2. Water quantity status of drainage regions, Canada, 2013



1. Pacific Coastal
2. Fraser Lower–Mainland
3. Okanagan–Similkameen
4. Columbia
5. Yukon
6. Peace–Athabasca
7. Lower Mackenzie
8. Arctic Coast–Islands
9. Missouri
10. North Saskatchewan
11. South Saskatchewan
12. Assiniboine–Red
13. Winnipeg
14. Lower Saskatchewan–Nelson
15. Churchill
16. Keewatin–Southern Baffin
17. Northern Ontario
18. Northern Quebec
19. Great Lakes
20. Ottawa
21. St. Lawrence
22. North Shore–Gaspé
23. Saint John–St. Croix
24. Maritime Coastal
25. Newfoundland–Labrador

Data for Figure 2

Note: The 2013 water quantity classification for a drainage region is based on the category (low, normal, high) for the most downstream monitoring station in the drainage region with greater than 30 years of data (long-term station). The flows are for the Canadian portions of the drainage regions. There were not enough data to describe the Arctic Coast–Islands (8) drainage region. The normal period for the Northern Quebec (18) drainage region was 1971–2000, instead of 1981–2010, because of a data gap in that drainage region.

The results for this indicator vary slightly from those in the Local Water Quantity in Canadian Rivers indicator because of differences in the methods used to calculate the indicator. For more information, please see the Data Sources and Methods section.
Source: Environment and Climate Change Canada (2015) Water Survey of Canada, HYDAT Database.

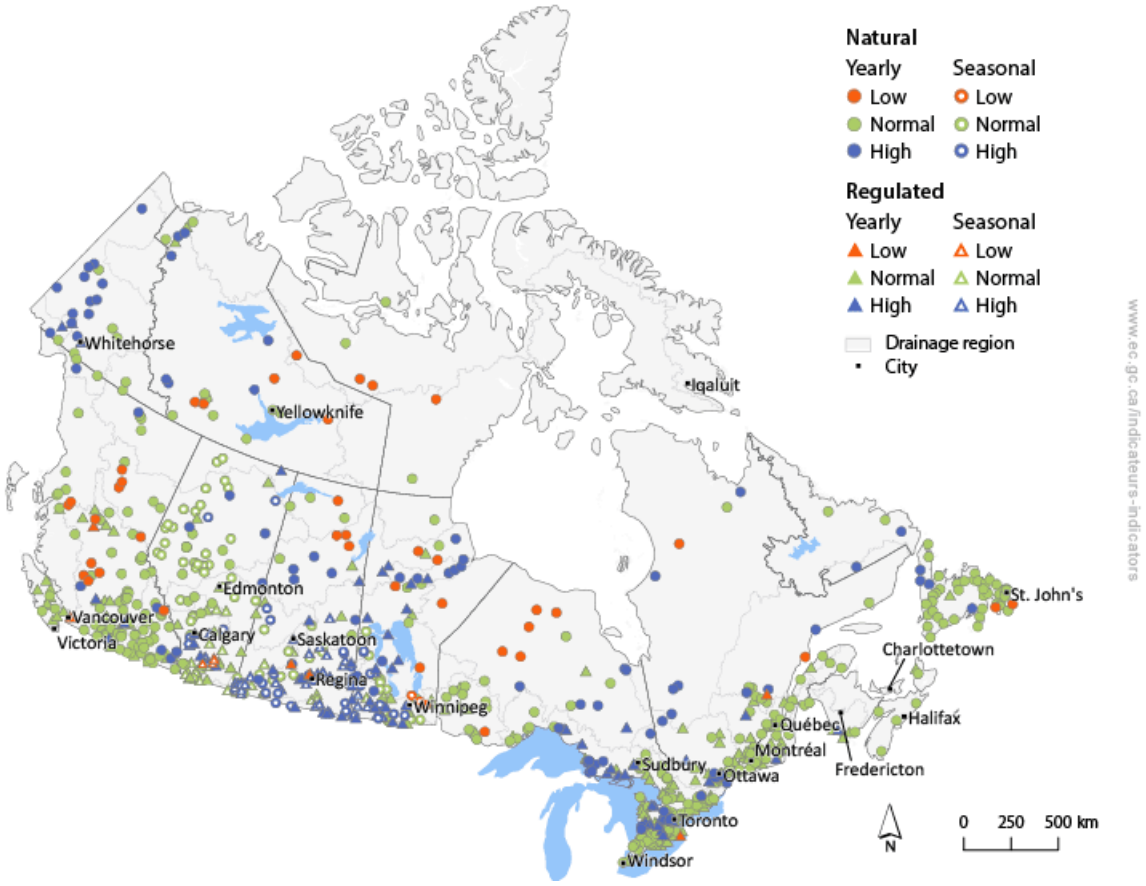
A drainage region is an area of land that drains all the water to a common outlet, such as the mouth of a bay, the outflow of a reservoir, or a larger river. The drainage region contains lakes, streams, reservoirs, wetlands, and all the underlying groundwater.

Canada's land mass can be divided into 11 major drainage areas and 25 drainage regions. The drainage regions are large and generally named for the major river or lake systems in Canada. Changes in temperature, rainfall and snowfall each year affect the water quantity in a river for that year.

Local Water Quantity in Canadian Rivers

In 2013, higher-than-normal water quantity was more frequently observed in Manitoba, Saskatchewan, and Yukon than in other parts of Canada. The higher-than-normal water quantity across the Prairies reflects the influence of Alberta's super-flood in June 2013. Lower-than-normal water quantity was observed more frequently at monitoring stations in north-western Ontario, the Northwest Territories, and central British Columbia than in the rest of Canada.

Figure 3. Water quantity at monitoring stations, Canada, 2013



Data for Figure 3

Navigate data using the Interactive Map or an Internet Earth Browser (e.g., Google Earth)

Note: The 2013 water quantity classification for a station is based on a comparison of the most frequently observed condition in that year with typical water quantity at that station between 1981 and 2010. The normal period for the Northern Quebec drainage region was 1971–2000, instead of 1981–2010, because of a data gap in that drainage region. Normal water quantities are specific to each region and do not refer to the same amount of water in each drainage region (e.g., normal water quantity on the Prairies is different from normal water quantity in the Maritimes). The results for this indicator vary slightly from those in the Regional Water Quantity in Canadian Rivers indicator because of differences in the methods used to calculate the indicator. For more information, please see the Data Sources and Methods section.
Source: Environment and Climate Change Canada (2015) Water Survey of Canada, HYDAT Database.

Changes in temperature, and rainfall and snowfall cause water quantities in rivers to rise and fall throughout the year, sometimes resulting in flooding or water shortages. Where water quantity is classified as low, drought conditions likely exist. In Canada, droughts normally last for one or two seasons and can be very damaging. Sectors relying on water, such as agriculture, industry and municipalities are especially affected by long-term droughts. Droughts can also affect the water quality in lakes and rivers, and threaten fish survival and reproduction rates.

High water quantity at a water quantity monitoring station indicates a wet year, but does not mean flooding occurred. Floods tend to be short-lived, lasting on average about 10 days,[3] and may not change the water quantity classification in this indicator. For example, in 2013, Toronto, Ontario, experienced a flash flood in July, yet the overall rating for the year for that station was low.

[3] Dartmouth Flood Observatory (2004) Interannual Evolution of Flood Duration (since 1985). Retrieved July 23, 2015.

Part 2. Data Sources and Methods for the Water Quantity in Canadian Rivers Indicators

Introduction

The Water Quantity in Canadian Rivers indicators are part of the Canadian Environmental Sustainability Indicators (CESI) program, which provides data and information to track Canada's performance on key environmental sustainability issues. The national indicator is also used to measure progress towards the goals and targets of the Federal Sustainable Development Strategy 2013–2016.

Description and rationale of the Water Quantity in Canadian Rivers indicators

Description

The Water Quantity in Canadian Rivers indicators classify water flow data from water quantity monitoring stations across Canada as high, normal or low. The national indicator summarizes ratings for 2001–2013, while the regional and local indicators report results for 2013 only. Water quantity classifications are determined by comparing water flows for each day of the reported year to the associated daily normal values for 1981–2010 from each monitoring station.

Rationale

Canada has 0.5% of the world's population and its landmass contains approximately 7% of the world's renewable freshwater supply. The Water Quantity in Canadian Rivers indicators provide information about the state of, and changes in, current surface water quantity to inform management of water resources.

Recent changes to the indicators

The methodology for these indicators have been reviewed and updated since it was last published in 2014. Changes to the indicators include the following:

- While both water levels and flows were previously used in the calculation of the water quantity indicators, the methodology now uses data from flow stations only. Stream flow refers to the volume of water that moves over a designated point (e.g., stream gauge) over a fixed period of time. It is expressed in cubic metres per second (m^3/s). This change was made to produce indicators that are more comparable between locations.
- The regional water quantity indicator is now calculated by accounting for the upstream area represented by a water quantity monitoring station within a drainage region. Water quantity in a drainage region is classified based on the amount of water leaving the drainage region, rather than using a statistical descriptor as is done in the national and local indicators. The previous calculation method for the regional water quantity indicator involved grouping water quantity stations by drainage region and counting the number of stations within each category (low, normal, high) for each drainage region. The mode, or most common classification, was used to categorize the water quantity in each drainage region.
- The national indicator has been redesigned to track trends in water quantity across Canada. The indicator now summarizes the percentage of local stations classified as

low, normal or high from 2001 to 2013. In previous publications, a count of the number of drainage regions classified as low, normal or high was used.

- Additionally, data for some stations in the Northern Quebec drainage region are unavailable between 1999 and 2008. This data gap affects the completeness of the 1981–2010 normal period and daily percentile values cannot be calculated due to a lack of data. The normal period was changed to 1971–2000, instead of 1981–2010, for the calculation of the local and regional water quantity indicators in the Northern Quebec drainage region only.

Data

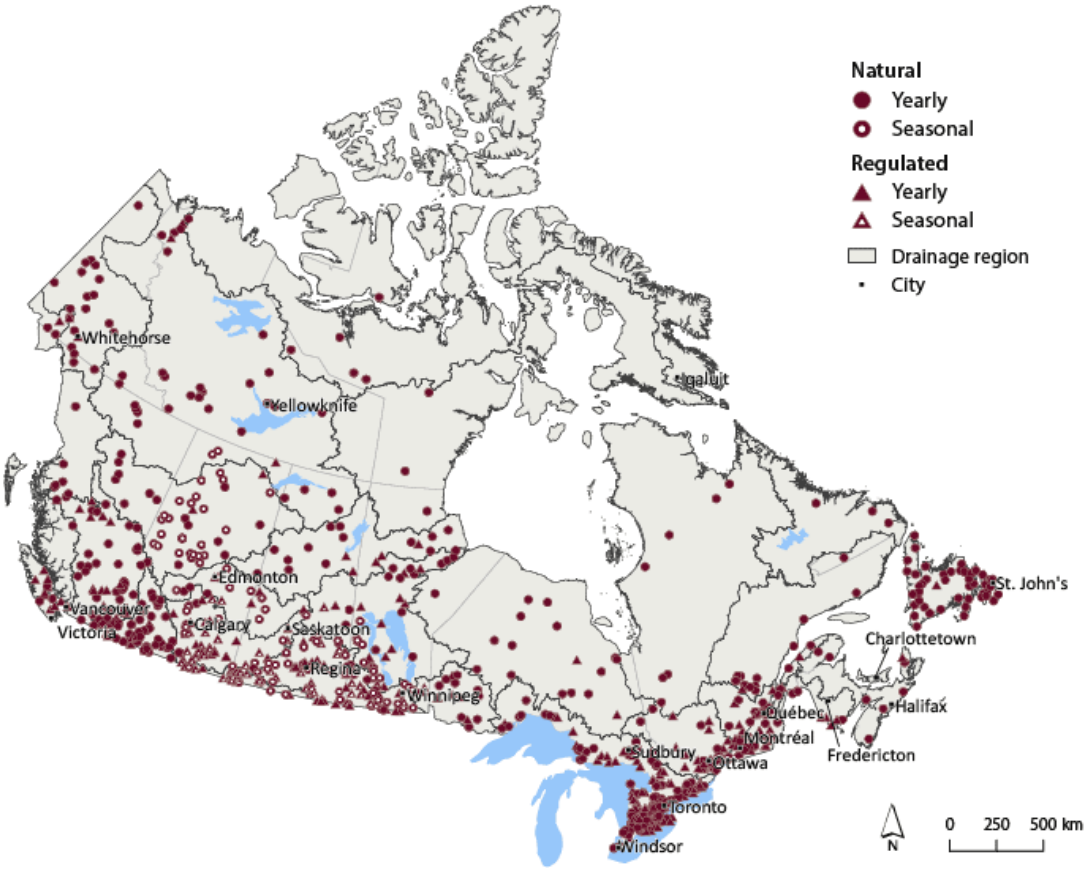
Data source

The Water Survey of Canada collects data for approximately 2700 active hydrometric stations across Canada through different partnerships. The daily water flow values included in the indicators were taken directly from the Water Survey of Canada's hydrological database (HYDAT).

Spatial coverage

Water quantity monitoring stations active from 1981–2013 were chosen for this analysis. To ensure an adequate number of stations with data of a sufficient time span, both natural and regulated rivers and all basin sizes were included. These criteria resulted in the selection of 866 water quantity monitoring stations across Canada for 2013.

Figure 4. Location of water quantity monitoring stations used for the Water Quantity in Canadian Rivers indicators, 2013



Note: Natural stations are those where human activity upstream of the station has little impact on water quantity. Regulated stations have water withdrawals, dams, diversions or other structures upstream that may change the water quantity in the river. Water quantity data for seasonal stations are only collected for part of the year**.**
Source: Environment and Climate Change Canada (2015) Water Survey of Canada.

Temporal coverage

The Water Quantity in Canadian Rivers indicators include data from 1981–2013 for both yearly and seasonal stations. At continuous stations, water flow data are collected 365 days per year. In general, seasonal stations operate six months of the year for a maximum of 217 days per year.

Data completeness

Water flow data from each monitoring station is managed by its respective Environment and Climate Change Canada regional office and stored in the federal HYDAT database. The data used in the indicators are subject to quality assurance and quality control procedures to ensure that they adhere to Environment and Climate Change Canada's national standards. There is reduced certainty in water flow data when ice cover is present.

Basic station information (e.g., name and location) and water flow data were extracted from HYDAT. The HYDAT database allows for station selection according to input parameters (e.g., record length, data type, drainage area, etc.). Environment and Climate Change Canada Data Explorer's Historical Analysis tool was used to set the parameters for running statistics calculations and to calculate the percentiles.

There are gaps in the water flow datasets due to periodic instrument failure. Where possible, regional offices use standardized protocols to estimate flow data to fill these gaps. Estimated flow values are considered to be reliable and are included in the calculation of the water quantity indicators. Only when data cannot be estimated is it considered missing. A complete dataset was defined as missing no more than 20% of the year: 73 days out of 365 for yearly stations and 43 days out of 217 for seasonal stations. Stations not meeting these criteria for a year were not included in the calcukation of the indicators.

The Regional Water Quantity in Canadian Rivers indicator for the Maritimes is partially based on preliminary data that has not undergone the full quality assurance and quality control process.

Data for many stations in the Northern Quebec drainage region are unavailable between 1999 and 2008. To accommodate this data gap, the normal period was changed to 1971–2000, instead of 1981–2010, for the calculation of the indicator in the Northern Quebec drainage region only.

Data timeliness

There is a time lag of about two years between the last year reported and the publication of the indicators. This time lag is due to several factors, including the time required to verify the raw data, compile the data at the national level from all partners, and analyze, review and report the data.

Methods

Categorizing Water Quantity at a Monitoring Station

Water quantity at a monitoring station is defined based on historical data recorded for Water Survey of Canada hydrometric stations. To start, frequency distributions for each day of the year were calculated using water flow data collected from 1981 to 2010 at each monitoring station. A 30-year period is used to provide a picture of the hydrologic characteristics of a station, while maximizing the number of stations included in the indicators.

Water quantity categories were defined from the frequency distributions:

$$\text{Low} < 25^{th} \text{ percentile}$$

$$25^{th} \text{ percentile} \leq \text{Normal} \leq 75^{th} \text{ percentile}$$

$$\text{High} > 75^{th} \text{ percentile}$$

Daily water quantity records for 2001 to 2013 were categorized as low, normal or high by comparing the measured value to the percentiles calculated for the corresponding station and day of the year over the normal period. Thus, a station described as having a low water level on, for example January 31, had a measured value ranking among the lowest 25% of values observed for each January 31 from 1981 to 2010.

A station's status for a year is the category most often observed (the mode) at a given station in a given year. Thus, a low classification does not mean that water quantity was consistently low throughout the year; it only means that low water quantity conditions were most often observed.

For the national indicator, the percentage of stations classified as low, normal and high was calculated for each year from 2001 to 2013.

Table 1. Number of water quantity monitoring stations grouped by drainage region, 2013

Drainage region	Number of stations
Pacific Coastal (1)	31
Fraser–Lower Mainland (2)	42
Okanagan–Similkameen (3)	19
Columbia (4)	50
Yukon (5)	18
Peace–Athabasca (6)	42
Lower Mackenzie (7)	36
Arctic Coastal–Islands (8)	6
Missouri (9)	39
North Saskatchewan (10)	16
South Saskatchewan (11)	55
Assiniboine–Red (12)	85
Winnipeg (13)	18

Drainage region	Number of stations
Lower Saskatchewan–Nelson (14)	42
Churchill (15)	18
Keewatin–Southern Baffin (16)	3
Northern Ontario (17)	17
Northern Quebec (18)	7
Great Lakes (19)	163
Ottawa (20)	28
St. Lawrence (21)	46
North Shore–Gaspé (22)	17
Saint John–St. Croix (23)	8
Maritime Coastal (24)	8
Newfoundland–Labrador (25)	52

Calculating the Regional Water Quantity in Canadian Rivers indicator

The Regional Water Quantity in Canadian Rivers indicator generalizes the water quantity classification across Canada's drainage regions.[4] For this indicator, where possible, the most downstream monitoring station of an inland drainage region was chosen to determine the water quantity category for that drainage basin. Where more than one most downstream station was identified for a drainage region, such as in coastal areas, the classification representing the greatest percentage of the drainage region was used. For example, one water quantity monitoring station at the most downstream point of the North Saskatchewan Drainage Region is sufficient to characterize water flowing out of this drainage region. In contrast, four stations were necessary to characterize water quantity in the Saint John–St. Croix drainage region (Figure 5).

Although all water flowing from a drainage basin may not be captured by this collection of long-term stations, the percentage area of the basin gauged provides an estimation of the level of certainty associated with the results.

[4] Statistics Canada (2003) Standard Drainage Area Classification. Retrieved on August 20, 2015.

Figure 5. Illustration of regional station selection

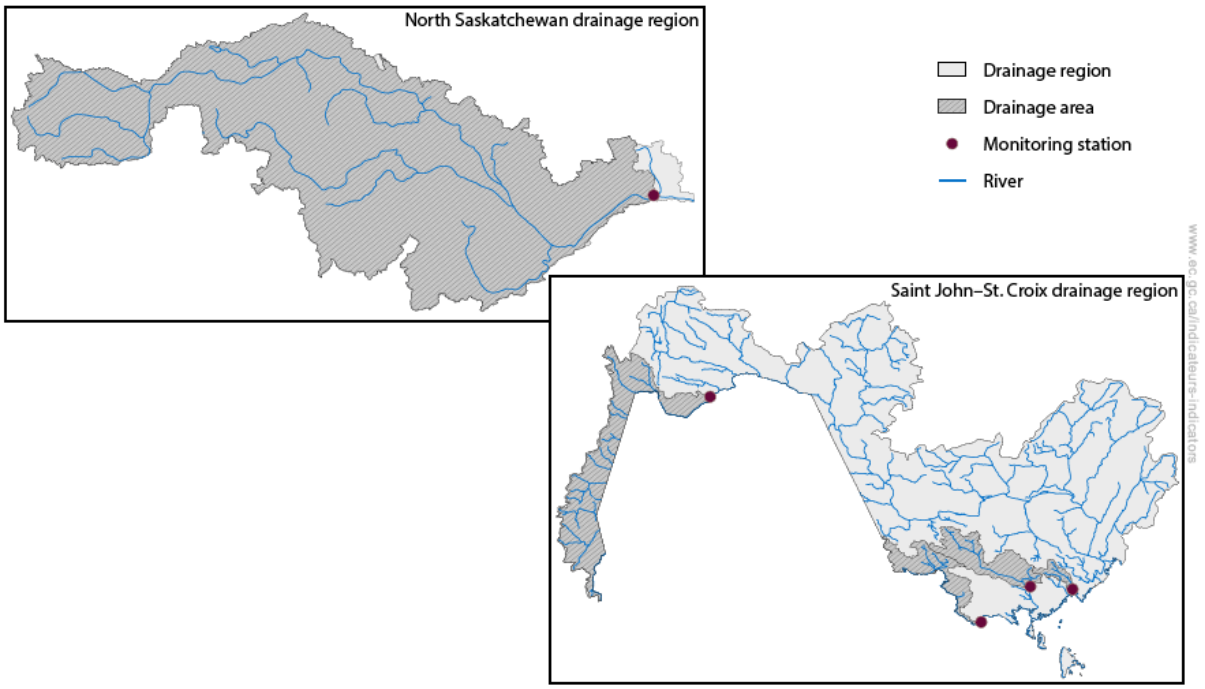


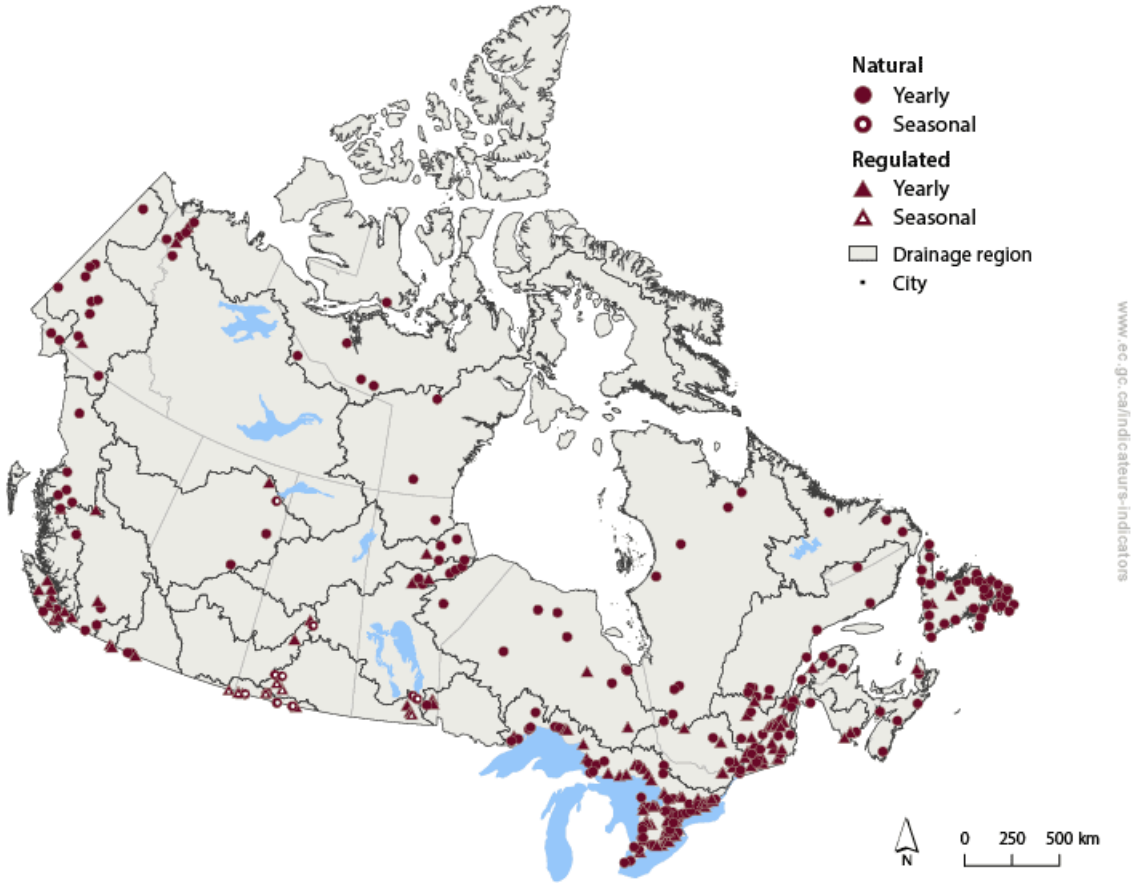
Table 2. Number of most downstream, long-term water quantity monitoring stations used to classify water quantity for each drainage region, 2013

Drainage region	Regional water quantity category	Number of monitoring stations used	Percentage of drainage region area gauged
Pacific Coastal (1)	Normal	24	25
Fraser–Lower Mainland (2)	Normal	4	90
Okanagan–Similkameen (3)	Normal	2	99
Columbia (4)	Normal	3	100
Yukon (5)	High	11	51
Peace–Athabasca (6)	Normal	4	83
Lower Mackenzie (7)	Normal	6	97
Arctic Coastal–Islands (8)	n/a	6	4
Missouri (9)	Normal	9	77
North Saskatchewan (10)	High	1	87
South Saskatchewan (11)	High	2	79
Assiniboine–Red (12)	High	9	86
Winnipeg (13)	Normal	3	94

Drainage region	Regional water quantity category	Number of monitoring stations used	Percentage of drainage region area gauged
Lower Saskatchewan–Nelson (14)	High	8	88
Churchill (15)	Normal	4	90
Keewatin–Southern Baffin (16)	Low	3	24
Northern Ontario (17)	Normal	10	37
Northern Quebec (18)	High	7	19
Great Lakes (19)	Normal	96	33
Ottawa (20)	Normal	10	89
St. Lawrence (21)	Normal	38	52
North Shore–Gaspé (22)	Normal	14	21
Saint John–St. Croix (23)	Normal	4	22
Maritime Coastal (24)	Normal	13	11
Newfoundland–Labrador (25)	Normal	46	14

Note: The percentages of the drainage regions gauged are based on the number of water quantity monitoring stations with more than 30 years of data (long-term station) used for this analysis and do not reflect the actual percentage of the drainage region gauged by Environment and Climate Change Canada's water quantity monitoring network. Values are based on the Canadian portion of the drainage basins only. Provisional data for the Maritime Coastal drainage region were used for this indicator, resulting in data for 13 stations, compared to 8 stations for the local indicator. n/a = not available.

Figure 6. Location of water quantity monitoring stations used to calculate the Regional Water Quantity in Canadian Rivers indicator, 2013



Note: Natural stations are those where human activity upstream of the station has little impact on water flows. Regulated stations have water withdrawals, dams, diversions or other structures upstream that may change the water quantity in the river. Water quantity data for seasonal stations are only collected for part of the year.
Source: Environment and Climate Change Canada (2015) Water Survey of Canada.

Caveats and limitations

Extreme short-term events may not be detected with the indicators, since the focus is on frequency of observations in different categories through the year. Large events of short duration, such as a flood, may not influence the final classification of a station.

The number of water quantity monitoring stations included in these indicators fluctuates from year to year because stations may be closed as monitoring networks are optimized. Whether or not the data have been verified and uploaded into HYDAT by the time the data are extracted to calculate the indicator also influences whether the station is included in the calculation that year.

While 30-years represents a long time series for water quantity data, it represents a relatively short historical time frame for a given river and does not account for all natural variability in a river system. The status of water quantity assessed by the present indicators are a reflection of its time period and do not necessarily reflect longer-term trends at the station.

The water quantity for the Great Lakes drainage region is based on rivers draining into the Great Lakes and not on the water contained within the Great Lakes themselves.

Most water quantity monitoring stations in Canada are located in populated areas and do not represent the country's entire geographic extent or all its watersheds. There are insufficient stations in areas such as the North to compute complete, nationally representative indicators.

Water flow data collected at a hydrometric station are representative of the average conditions of the upstream drainage area. The variability of conditions across this area may not be reflected, and water quantity classifications of tributaries may differ from that described by the indicators. Professional judgment is used to determine whether there were sufficient stations to describe a drainage region. For example, the six stations in the Arctic Coast Islands drainage region were considered insufficient to categorize water quantity for the region in 2013.

Water quantity generally follows a predictable seasonal pattern with natural, year-to-year variability. The indicators compare daily values to the 30-year normal and assume that water quantity is approximately the same from one year to the next for the same calendar day. A shift in the predictable seasonal pattern (the hydrograph) one year will influence the results.

Part 3. Annexes

Annex A. Data tables for the figures presented in this document

Table A.1. Data for Figure 1. Water quantity at monitoring stations, Canada, 2001 to 2013

Year	Total number of stations	High quantity (percentage of stations)	Normal quantity (percentage of stations)	Low quantity (percentage of stations)
2001	1241	5	68	27
2002	1237	5	79	16
2003	1254	2	77	21
2004	1253	9	85	7
2005	1247	22	74	4
2006	1242	11	78	11
2007	1248	12	80	9
2008	1245	10	86	4
2009	1256	8	82	10
2010	1252	20	73	8
2011	1226	26	68	7
2012	1145	16	70	14
2013	866	27	67	6

Note: The water quantity classification for a station is based on a comparison of the most frequently observed flow condition in a given year with typical water quantity at that station between 1981 and 2010. The normal period for the Northern Quebec drainage region was 1971–2000, instead of 1981–2010, because of a data gap in the drainage region. The 2013 data has fewer stations contributing to the results because of delays getting data into the HYDAT database. Normal water quantities are specific to each region and do not refer to the same amount of water in each drainage region (e.g., normal water quantity in the Prairies is different from normal water quantity in the Maritimes).
Source: Environment and Climate Change Canada (2015) Water Survey of Canada, HYDAT Database.

Table A.2. Data for Figure 2. Water quantity status of drainage regions, Canada, 2013

Drainage region name	Drainage region number	Water quantity classification
Pacific Coastal	1	Normal
Fraser–Lower Mainland	2	Normal
Okanagan–Similkameen	3	Normal
Columbia	4	Normal
Yukon	5	High
Peace–Athabasca	6	Normal
Lower Mackenzie	7	Normal
Missouri	9	Normal
North Saskatchewan	10	High
South Saskatchewan	11	High
Assiniboine–Red	12	High
Winnipeg	13	Normal
Lower Saskatchewan–Nelson	14	High
Churchill	15	Normal
Keewatin–Southern Baffin	16	Low
Northern Ontario	17	Normal
Northern Quebec	18	High
Great Lakes	19	Normal
Ottawa	20	Normal
St. Lawrence	21	Normal
North Shore–Gaspé	22	Normal
Saint John–St. Croix	23	Normal
Maritime Coastal	24	Normal
Newfoundland–Labrador	25	Normal

Note: The 2013 water quantity classification for a drainage region is based on the category (low, normal, high) for the most downstream monitoring station in the drainage region with greater than 30 years of data (long-term station). The flows are for the Canadian portions of the drainage regions. There were not enough data to describe the Arctic Coast–Islands (8) drainage region. The normal period for the Northern Quebec (18) drainage region was 1971–2000, instead of 1981–2010, because of a data gap in that drainage region. The results for this indicator vary slightly from those in the Local Water Quantity in Canadian Rivers indicator because of differences in the methods used to calculate the indicator. For more information, please see the Data Sources and Methods section.
Source: Environment and Climate Change Canada (2015) Water Survey of Canada, HYDAT Database.

Annex B. References and additional information

References and further reading

Environment and Climate Change Canada (2015) Water Survey of Canada. Retrieved on August 20, 2015.

Environment and Climate Change Canada – Water Office (2015) Real-time Hydrometric Data. Retrieved on August 20, 2015.

Statistics Canada (2003) Standard Drainage Area Classification. Retrieved on August 20, 2015.

Related information

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