

Building Preliminary Accounts with Actual Data : Water Asset Account



Regional Training Workshop on the System of Environmental-Economic Accounting with a Focus on Water Accounting

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Putrajaya, Malaysia

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Statistics Canada

Outline of presentation



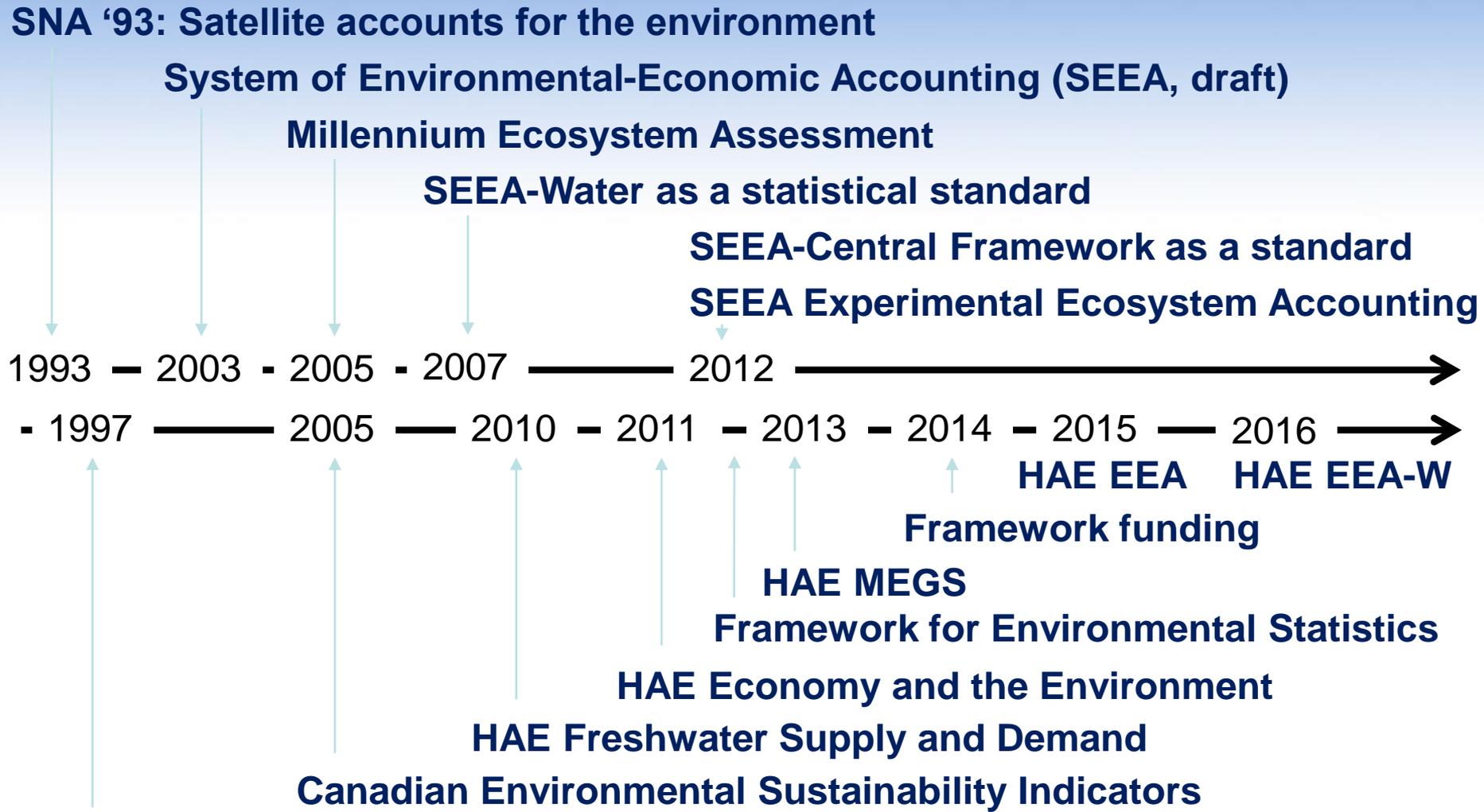
1. Background information
2. First attempts at water asset accounting
3. Water yield model
4. Water yield analysis
5. Other related water assets data

Background



1. Work on material flows at StatCan dates back to the 1970s (focus was on energy)
2. 1991 Green Plan included funding for the development of the Canadian System of Environmental and Resource Accounts (CSERA)
3. Accounts for energy and emissions were first published in 1993
4. Concept, sources and methods documents published in 1997

Water accounting timeline



Environment Accounts and Statistics



- Environmental accounts
 - Stock and flows
 - Physical and monetary
 - Land, minerals, timber, energy, GHG, **water**
- Environmental surveys
 - 8 surveys, including water surveys (covering manufacturing, mining, thermal-electric, agricultural, drinking water plants, households).
- Spatial data infrastructure
 - Standardized boundaries (Census, Ecozones, Drainage Areas), spatial data sets.
- Publications
 - HAE, EnviroStats, Survey Reports, technical reports, CANSIM, PUMF, Special Tabulations, etc.

- First attempt at water asset accounting in Canada

- No official statistics were derived, but allowed identification of the path forward.

Working Paper

Water accounting at Statistics Canada:

The inland fresh water assets account

Paper produced for the

London Group of Environmental Accounting

Rome, November 2003

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Experimental asset account, 2003

EA.131 Surface water								
	EA.1311 Artificial reservoir ³	EA.1312 Lakes ²	EA.1313 Rivers	EA.1314 Snow, ice and glaciers ¹	EA.132 Groundwater	EA.133 Soil water	Total	
1. Opening stocks	880	17398	3315	35000	.	.	56593	
Increase in stocks								
2. Returns	.	25	10	...	.	.	35	
3. Precipitation	.	.	.	.		.	6178	
4. Inflows	.	.	52				52	
4.a. From upstream territories	.	.	.	.
4.b. From other resources in the territory	.	.	.	.
Decreases in stocks								
5. Abstraction ⁴	.	35	5	0	1		41	
6. Evaporation / Actual evapotranspiration	.	365	.	.		2678	3043	
7. Outflows	.	.	3315	.	.	.	3315	
7.a. To downstream territories			192	.	.		192	
7.b. To the sea			3123	.	.		3123	
7.c. To other resources in the territory	.	.	.	.	.	.
8. Other changes in volume	.	.	.	.	.	.
9. Closing stocks							40 655	
1: Selected glaciers only							↓	
2: Great-Lakes only							28%	
3: Reservoir capacity								
4: Only includes intake								

Draft – do not quote

Basin-based water balance equation

$$\text{Water Asset Account} = \text{CWB} - \text{SWB} - \text{EWB}$$

CWB = precipitation - evapotranspiration

SWB = surface (inflow - outflow)

EWB = economic consumption (intake - discharge)

CWB: Climatic Water Balance

SWB: Surface Water Balance

EWB: Economic Water Balance (Municipal, Institutional, Commercial, Industrial)

Water balance



Precipitation

- Evapotranspiration
- Storage

$$= \text{Run-off} \longrightarrow \textcircled{R} = P - ET - \textcircled{S}$$

Run off = flows to lakes, rivers, reservoirs, base flow

Storage = flows to groundwater aquifers, consumption

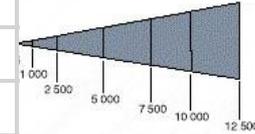
Setting data priorities

Num	IRWS code	Name of Flow	Relevance	Availability of estimates	Availability of reliable statistics
1	B.1 	Precipitation.	High	High	High
2	B.2 	Inflows from other countries	Depends	Depends	Medium
3	C.1 	Evapotranspiration	High	Medium	Low
4	H.1	Returns to Inland Water Resources	Medium	Low	Low
5	E.1	Abstractions of Inland Water Resources	High	High	Medium
6	E.2	Collection of precipitation	Low	Medium	Low
7	E.3	Abstractions from the sea	Depends	Medium	High
8	I.1	Losses	High	Medium	Low
9	F.2	Exported water	Depends	High	High
10	G.2	Imported water	Depends	High	High
11	F.1/G.1	Water supplied/Water Received	Medium	High	High
12	F.3.2/G.3.2	Reused water	Depends	Medium	Low
13	“Water consumption”	Final Water Use in SEEA-CF	Medium	Medium	Low
14	H.2	Returns to the sea	Medium	Low	Low
15	C.2.1 	Outflows to neighboring countries	Depends	Medium	Medium
16	C.2.2	Outflows to the sea	Medium	Medium	Low

Average Annual Streamflow for Large Rivers by Drainage Basin

Major Drainage basin	Average annual streamflow	
	m ³ per second	km ³ per year
Pacific Ocean	24100.00	760.02
Arctic Ocean	16400.00	517.19
Hudson Bay	30900.00	974.46
Atlantic Ocean	33400.00	1055.80
Gulf of Mexico	25.00	0.79
Canada	104825.00	3305.76

Flow (m³ per second)

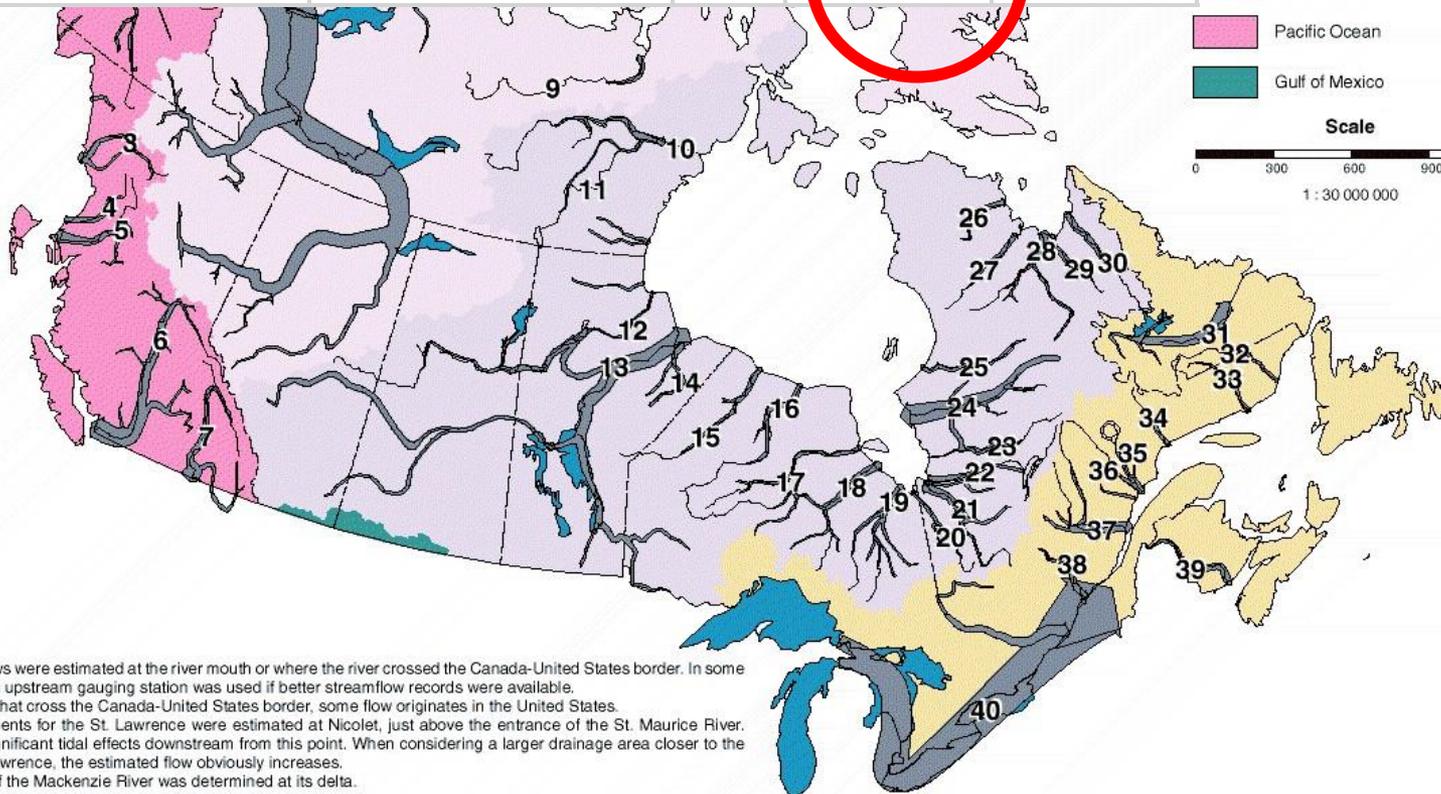
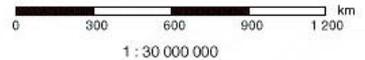


I-40 River Codes (see Table 5.5.1)

Major drainage basins



Scale



Notes:

- Streamflows were estimated at the river mouth or where the river crossed the Canada-United States border. In some instances, an upstream gauging station was used if better streamflow records were available.
- For rivers that cross the Canada-United States border, some flow originates in the United States.
- Measurements for the St. Lawrence were estimated at Nicolet, just above the entrance of the St. Maurice River. There are significant tidal effects downstream from this point. When considering a larger drainage area closer to the Gulf of St. Lawrence, the estimated flow obviously increases.
- The flow of the Mackenzie River was determined at its delta.

Source:

Fisheries and Environment Canada, 1978, *Hydrological Atlas of Canada*, Catalogue No. En 37-26/1978, Ottawa.

Canadian Climatic Water balance



$$R = P - ET - S$$

$$S = P - ET - R$$

$$S = 3158 \text{ Km}^3 - R$$

$$S = 3158 \text{ Km}^3 - 3306 \text{ Km}^3$$

$$S = -148 \text{ KM}^3, \text{ or } 5\% \text{ of CWB}$$

Strategic accounting investments



- Given geographical conditions in Canada
 - Large landmass, complex hydrography, varied hydrologic regimes, overall large amount of precipitation, accumulated stocks of non-renewable water, etc.
 - Low population density, concentrated populations, importance of hydroelectricity, reliance of agriculture

- It was decided to initiate the water accounts with
 1. Renewable water assets portion of Water Assets
 2. Water intake portion of MEFA

Renewable water assets a.k.a. water yield



1. Develop a methodology to generate estimates of renewable freshwater (water yield) for Canada and regions
2. Provide a denominator against which compare water intake data
3. Track change over time and space in the amount of water being renewed by nature.

Water yield definition



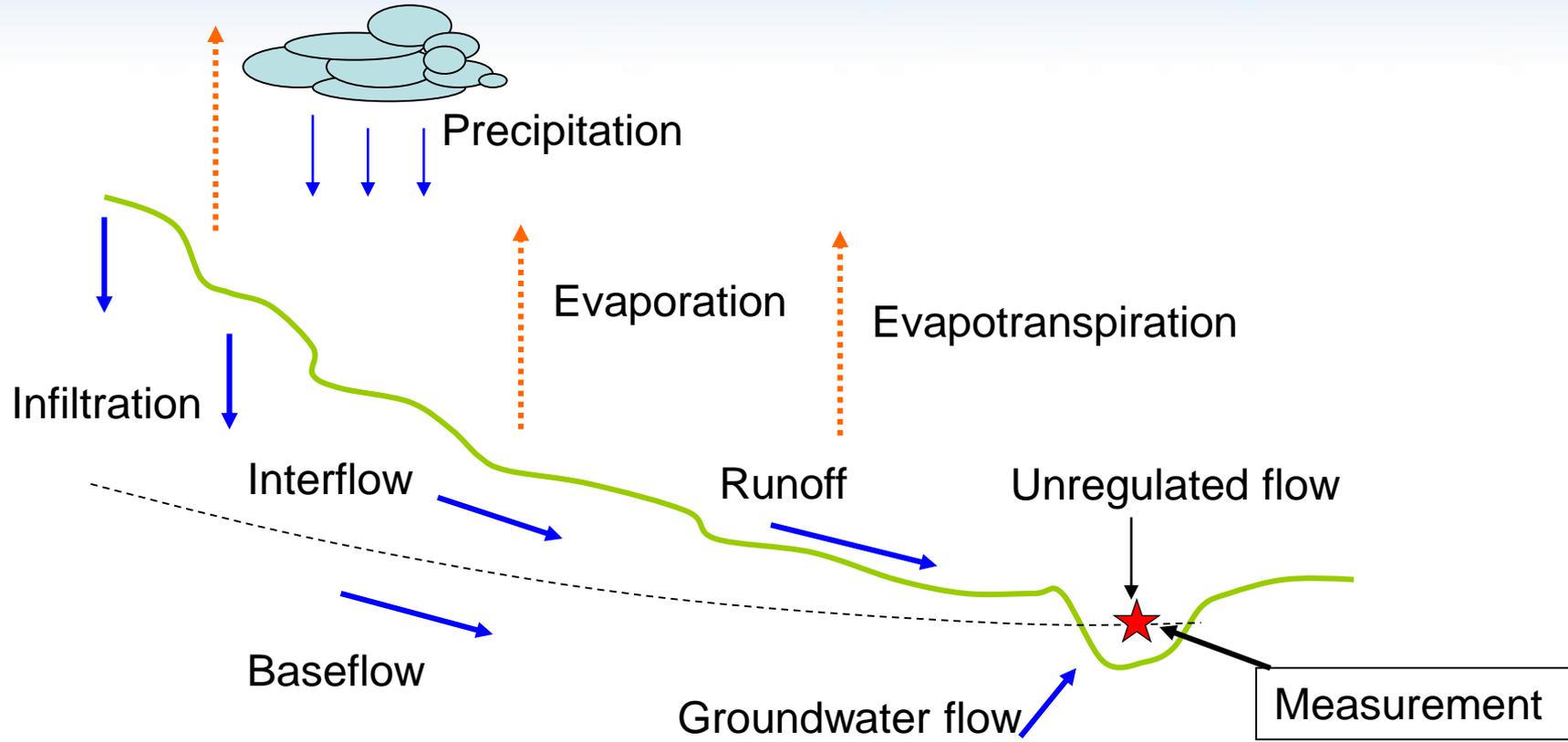
Water yield is the amount of freshwater derived from unregulated flow (m^3/s) measurements for a given geographic area over a defined period of time.

- only measurements exhibiting unregulated flow (that is not dammed or diverted) are used in its computation.
- unregulated flow is a combination of baseflow, interflow and overland flow originating from groundwater, precipitation and/or snowpack.

Overview of methodology

Statistics Canada water yield

defined as, “the amount of freshwater derived from unregulated flow ($m^3 s^{-1}$) measurements for a given geographic area over a defined period of time” and that “... is generated from a combination of baseflow, interflow and overland flow originating from groundwater, precipitation and/or snowpack”



Overview of methodology

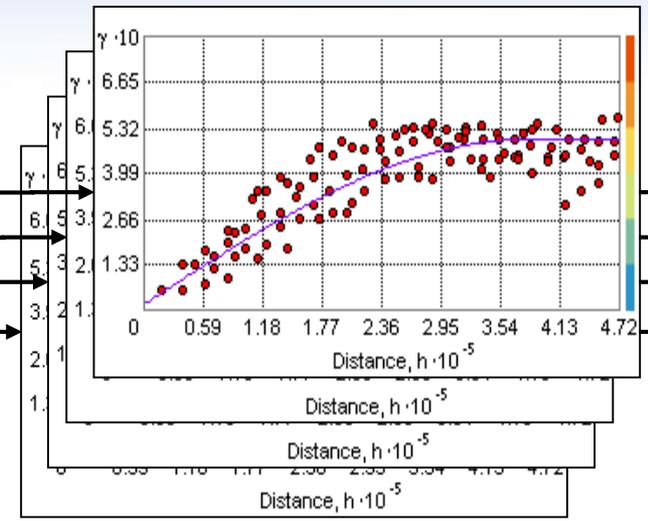
Filter HYDAT streamflow data

Filtered HYDAT Streamflow Data								
STATION_N	Hydr	Drainag	Effe	Reg	Year	Jan	Feb	Mar
01AA002	Q	598	N	1974	8.17	5.61	13.	
01AA002	Q	598	N	1977	2.35	1.55	9.7	
01AA002	Q	598	N	1975	3.5	1.86	5.38	
01AA002	Q	598	N	1973	6.45	11	33.	
01AA002	Q	598	N	1972	4.01	2.35	4.68	
01AA002	Q	598	N	1971	2.04	1.38	2.68	
01AA002	Q	598	N	1970	3.95	5.49	2.98	
01AA002	Q	598	N	1969	4.1	3	2.1	
01AA002	Q	598	N	1968	2.27	4.37	16.2	
01AA002	Q	598	N	1967				
01AA002	Q	598	N	1976	4.41	8.02	24.4	
01AD002	Q	14700	N	1973	125	212	282	
01AD002	Q	14700	N	1980	79.6	37.7	48.8	
01AD002	Q	14700	N	1988	70.7	59.1	46.	
01AD002	Q	14700	N	1987	86.5	38.4	118	
01AD002	Q	14700	N	1986	79	179	82.4	
01AD002	Q	14700	N	1985	70.7	34.7		

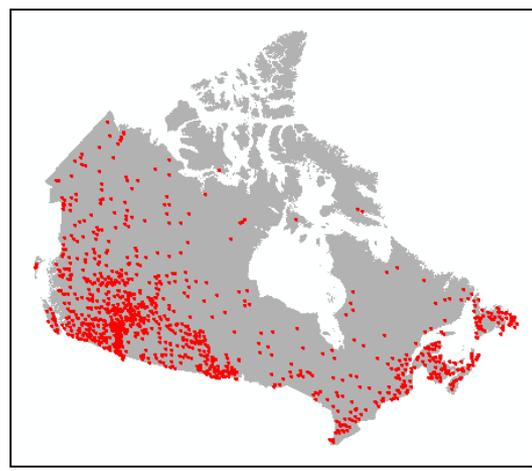
Derive monthly runoff values

Monthly Input Runoff Data						
Shape *	STHNBR	SOURCE	AREA	JUL	CRUNOFF	RUNOFFLT
Point	02XD001	Stlawsb	206	14.3	69.417476	1.84768
Point	02YD002	Stlawsb	200	1.96	9.8	1.033424
Point	02YA001	Stlawsb	306	14.1	46.078431	1.672822
Point	02XB002	Stlawsb	1060	45.5	42.924528	1.642707
Point	02XA004	Stlawsb	2060	74.4	36.116505	1.569567
Point	02YC001	Stlawsb	624	21.5	34.455128	1.549679
Point	02YR002	Stlawsb	399	4.15	10.401003	1.056943
Point	02YR003	Stlawsb	554	7.07	12.761733	1.138673
Point	02XA003	Stlawsb	4540	159	35.022026	1.556568
Point	02YR001	Stlawsb	275	5.45	19.818182	1.318443
Point	02YK005	Stlawsb	391	5.41	13.836317	1.171326
Point	02YS005	Stlawsb	2000	35.1	17.55	1.268344
Point	02ZH001	Stlawsb	764	22.9	29.973822	1.490995
Point	02YL001	Stlawsb	2110	56.3	26.682464	1.442205
Point	02YO008	Stlawsb	773	10.2	13.195343	1.152146
Point	02ZK001	Stlawsb	301	13.2	43.853821	1.651799
Point	02YG004	Stlawsb	2200	39.7	18.045455	1.279791
Point	02ZK001	Stlawsb	301	13.2	43.853821	1.651799
Point	02YG004	Stlawsb	2200	39.7	18.045455	1.279791
Point	02ZK001	Stlawsb	301	13.2	43.853821	1.651799
Point	02YG004	Stlawsb	2200	39.7	18.045455	1.279791

Develop monthly semi-variograms

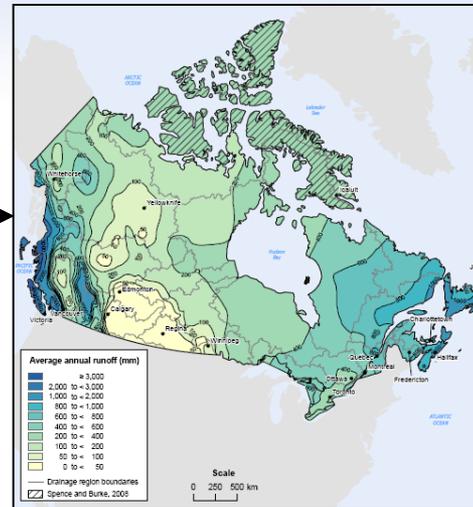
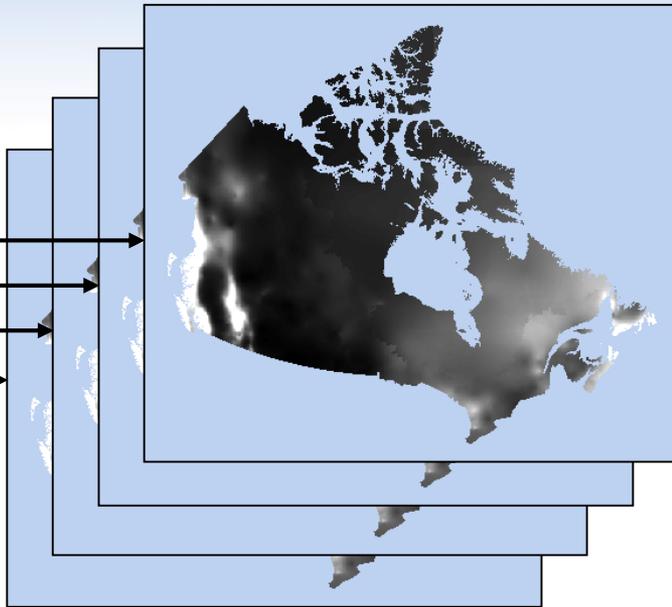


Generate basin centroids



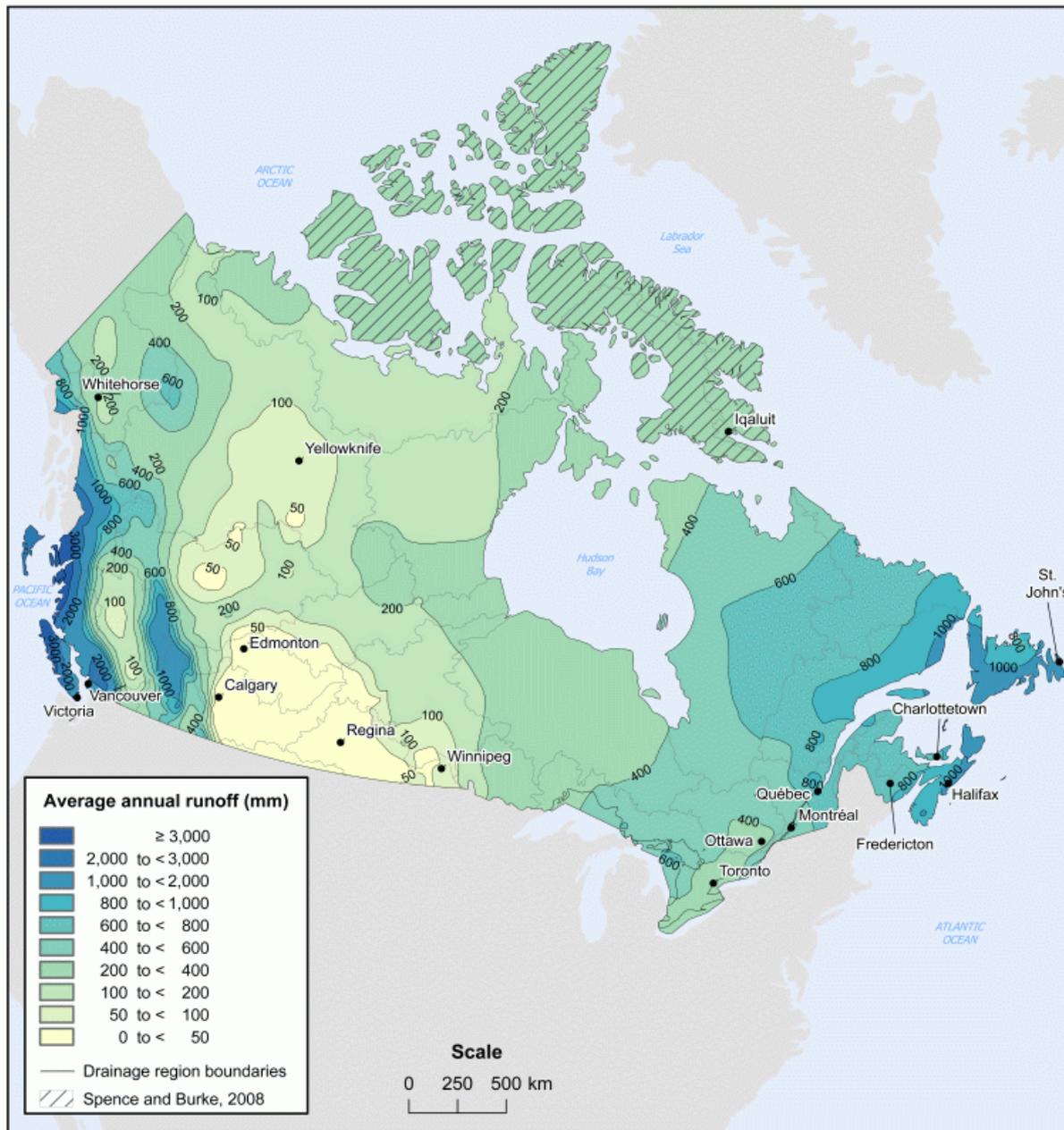
Interpolate monthly surfaces

Summarize to generate outputs



Average annual water yield by drainage region, 1971 to 2004

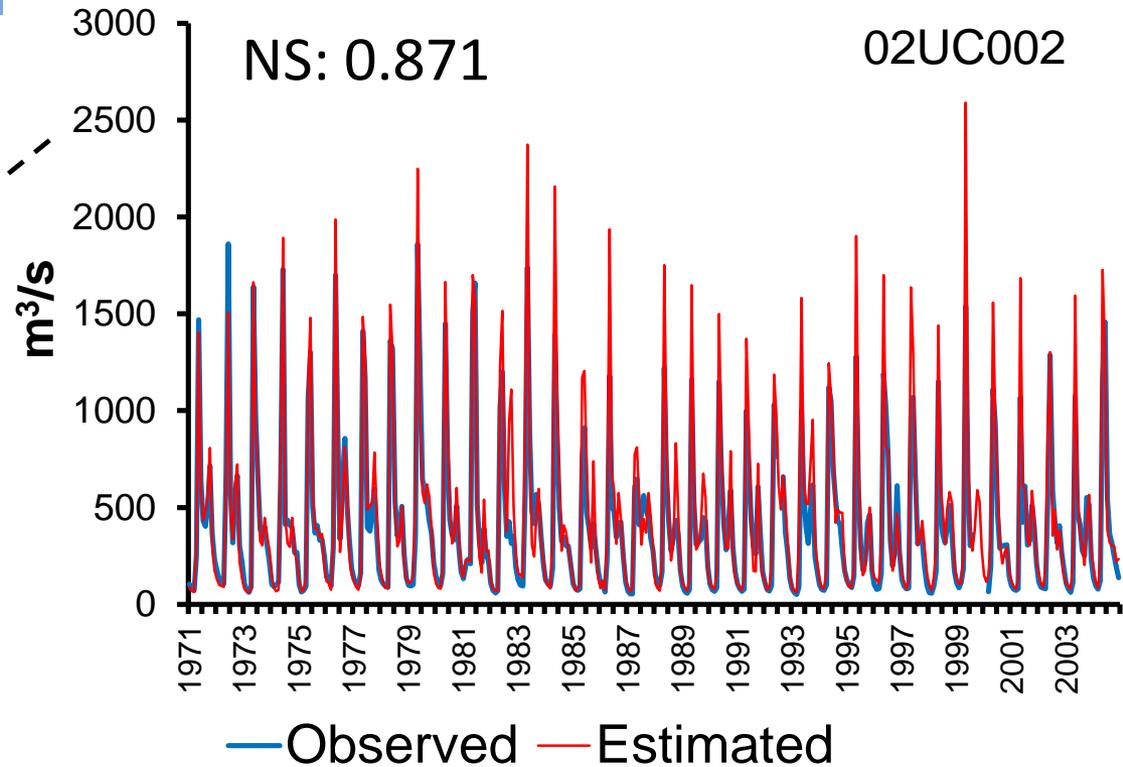
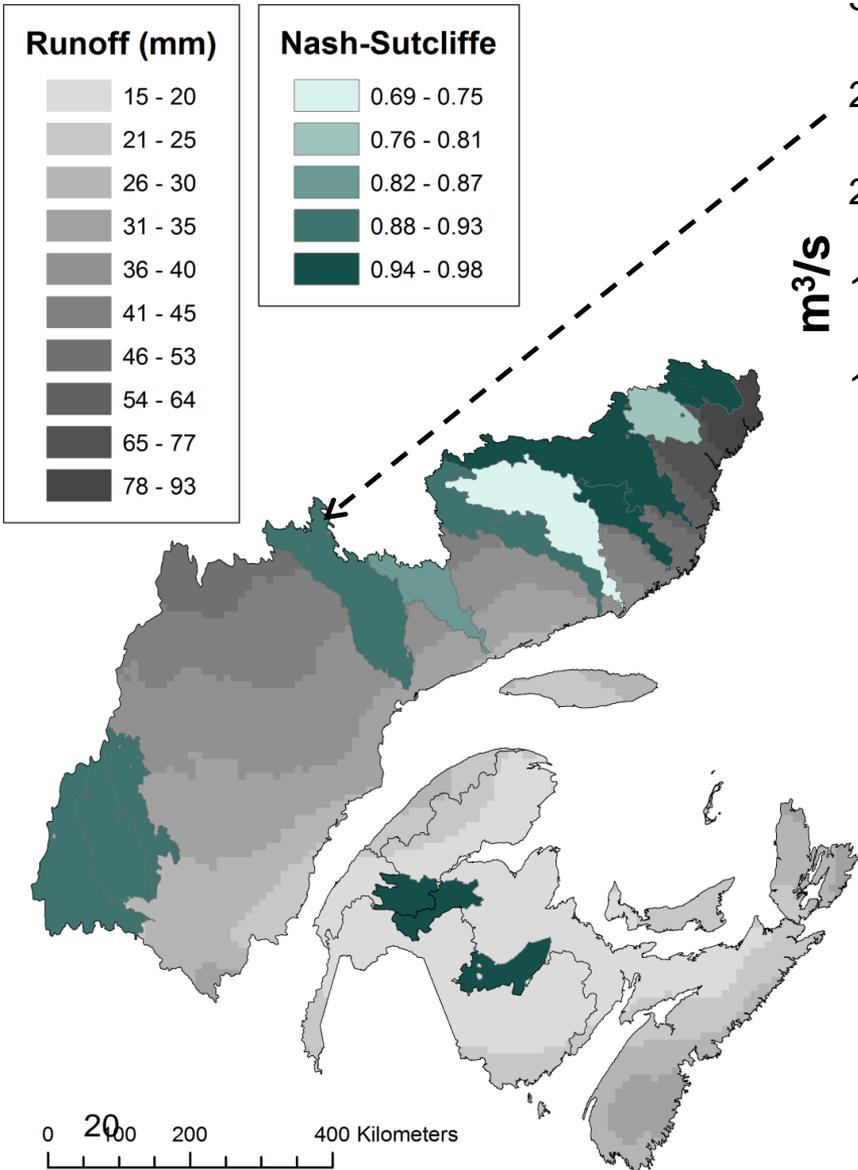
Drainage region code	Water yield	
	Volume 1	Volume per unit area
number	km ³	m ³ per m ²
Canada	3,472.3	0.348
Pacific Coastal	513.7	1.536
Fraser-Lower Mainland	128.6	0.552
Okanagan-Simikameen	4.2	0.270
Columbia	67.7	0.776
Yukon	106.0	0.318
Peace-Athabasca	99.9	0.206
Lower Mackenzie	246.3	0.185
Arctic Coast-Islands	231.3	0.131
Missouri	0.5	0.019
North Saskatchewan	10.2	0.088
South Saskatchewan	9.6	0.054
Assiniboine-Red	8.9	0.036
Winnipeg	25.4	0.236
Lower Saskatchewan-Nelson	47.6	0.132
Churchill	49.4	0.158
Keewatin-Southern Baffin Is	192.0	0.204
Northern Ontario	199.2	0.288
Northern Quebec	516.3	0.548
Great Lakes	133.1	0.419
Ottawa	62.6	0.428
St. Lawrence	71.3	0.600
North Shore-Gaspé	292.2	0.792
Saint John-St. Croix	29.2	0.697
Maritime Coastal	103.6	0.849
Newfoundland-Labrador	325.4	0.856



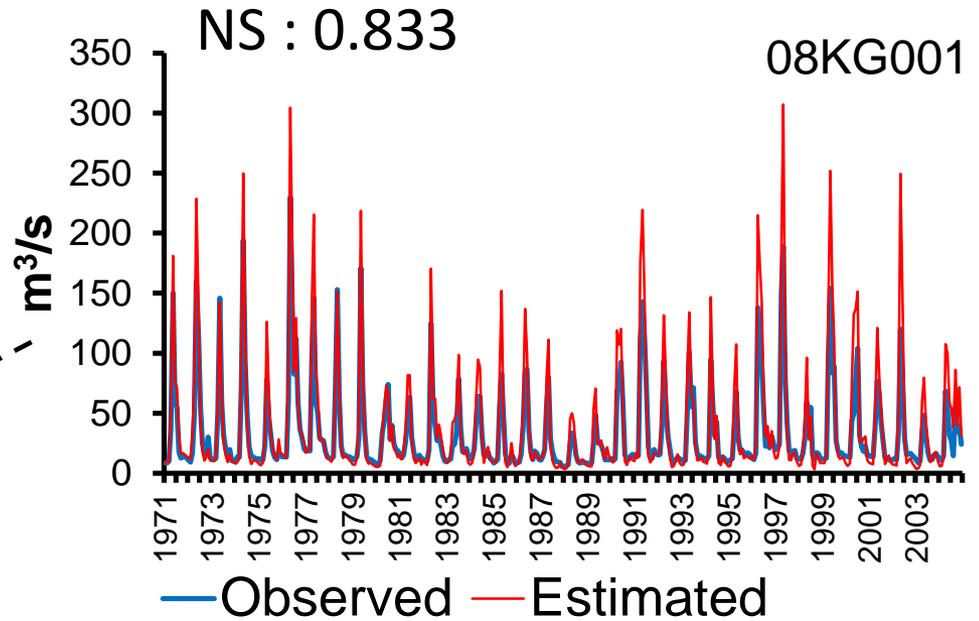
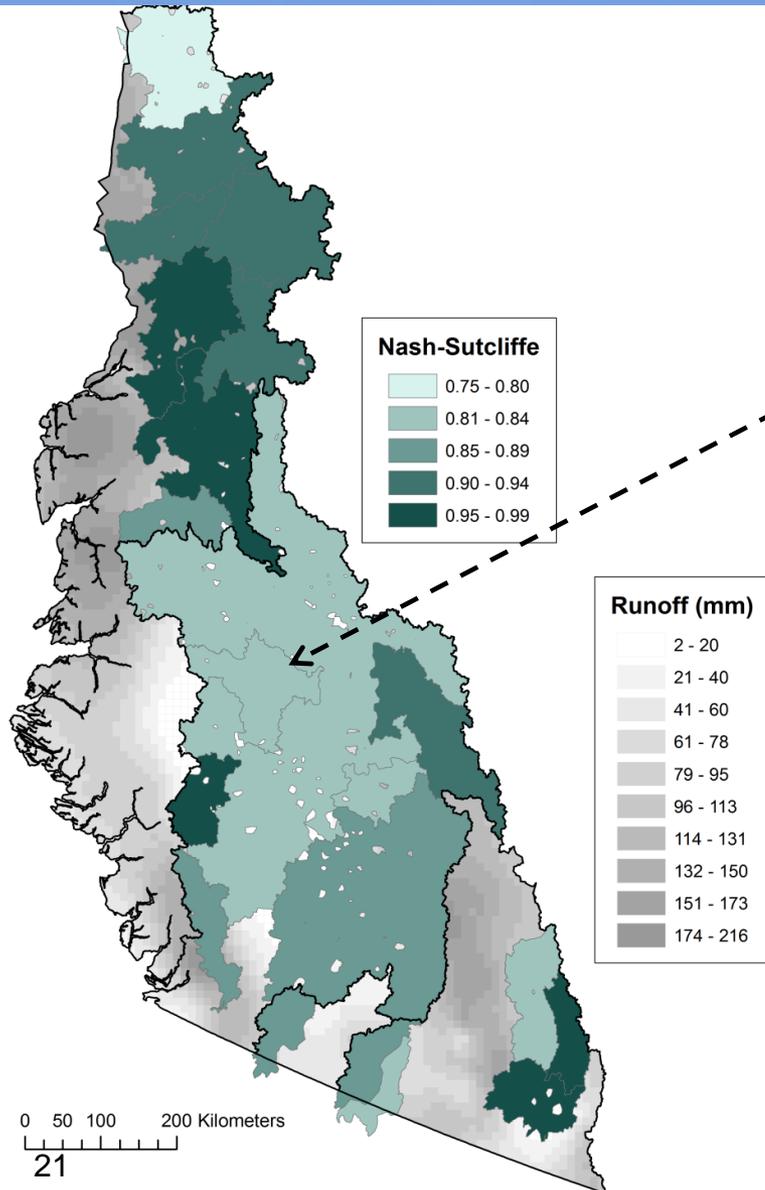
Note(s): Data were derived from discharge values contained in Environment Canada, 2010, Water Survey of Canada, Archived Hydrometric Data (HYDAT) (www.wsc.ec.gc.ca/hydat/H2O/index_e.cfm?cname=main_e.cfm).

Source(s): Spence C., and A. Burke, 2008, "Estimates of Canadian Arctic Archipelago Runoff from Observed Hydrometric Data," *Journal of Hydrology*, Vol. 362, pages 247 to 259.
 Statistics Canada, Environment Accounts and Statistics Division, 2010, special tabulation.

Estimated vs observed

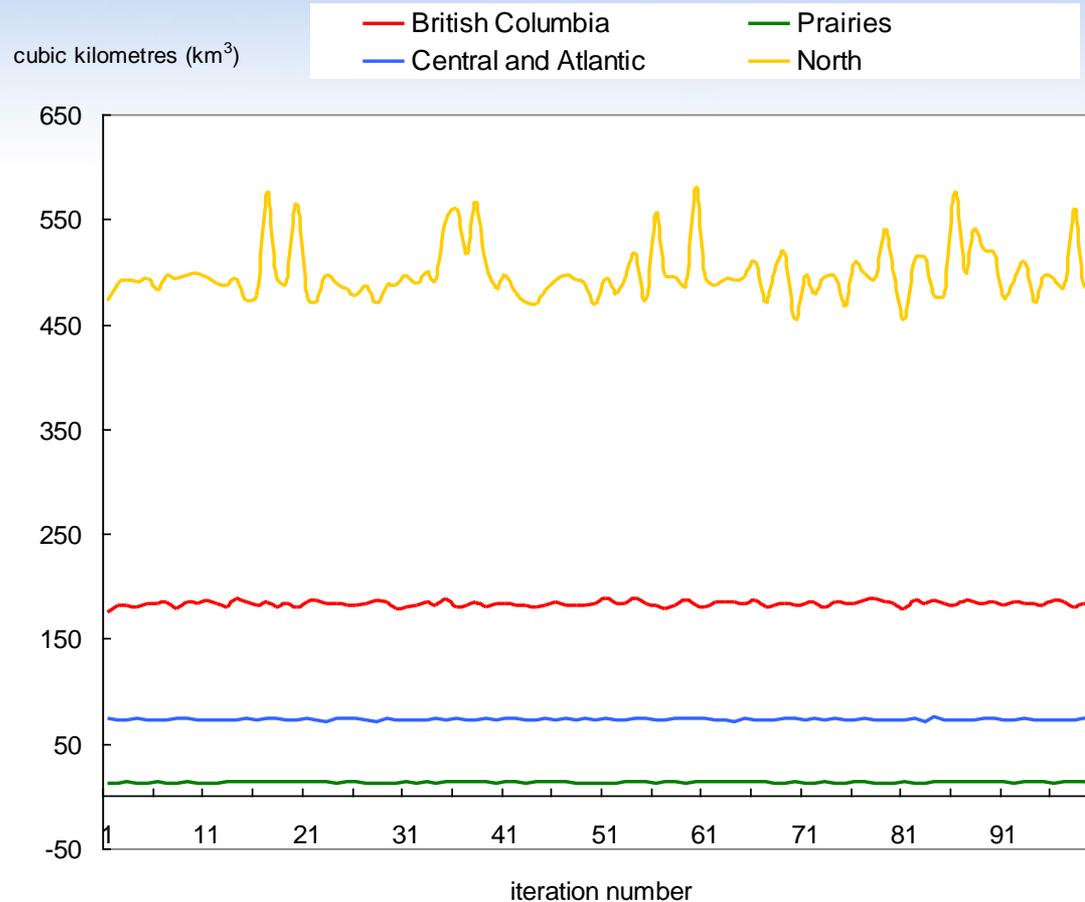


Estimated vs observed



Stability assessment

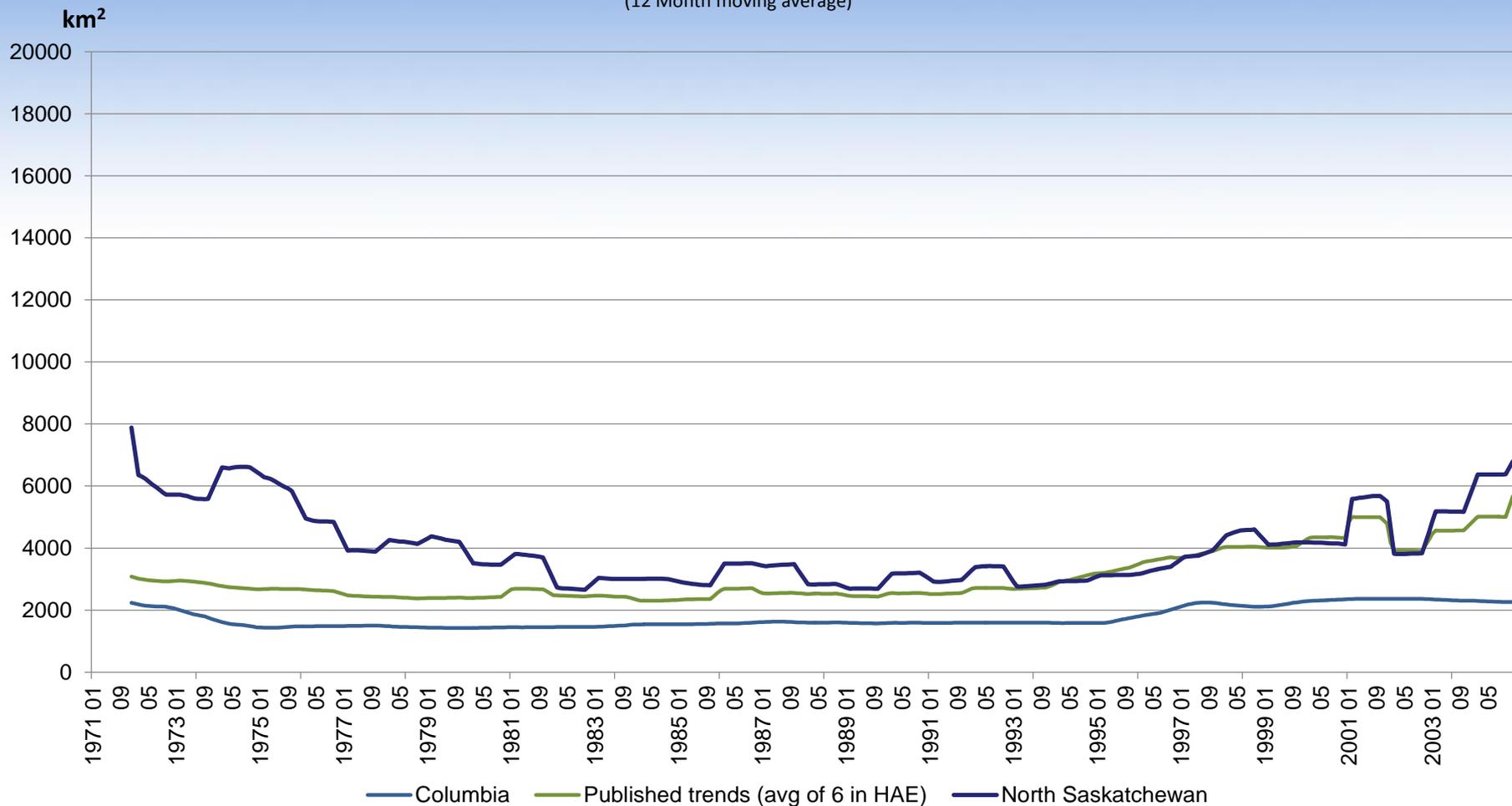
- model run 100 times with random 10% hold out



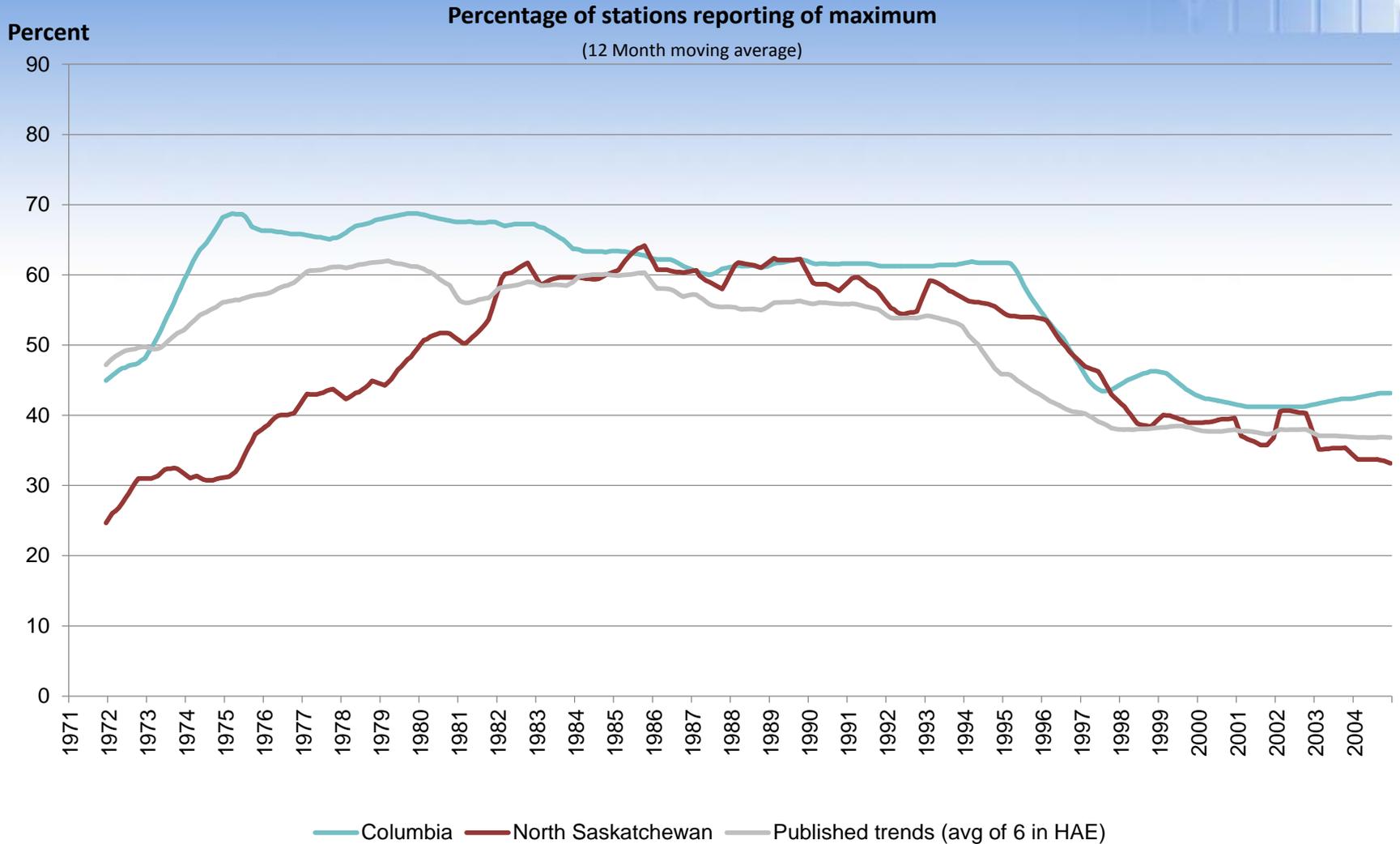
Sampling statistics

Average area per station

(12 Month moving average)

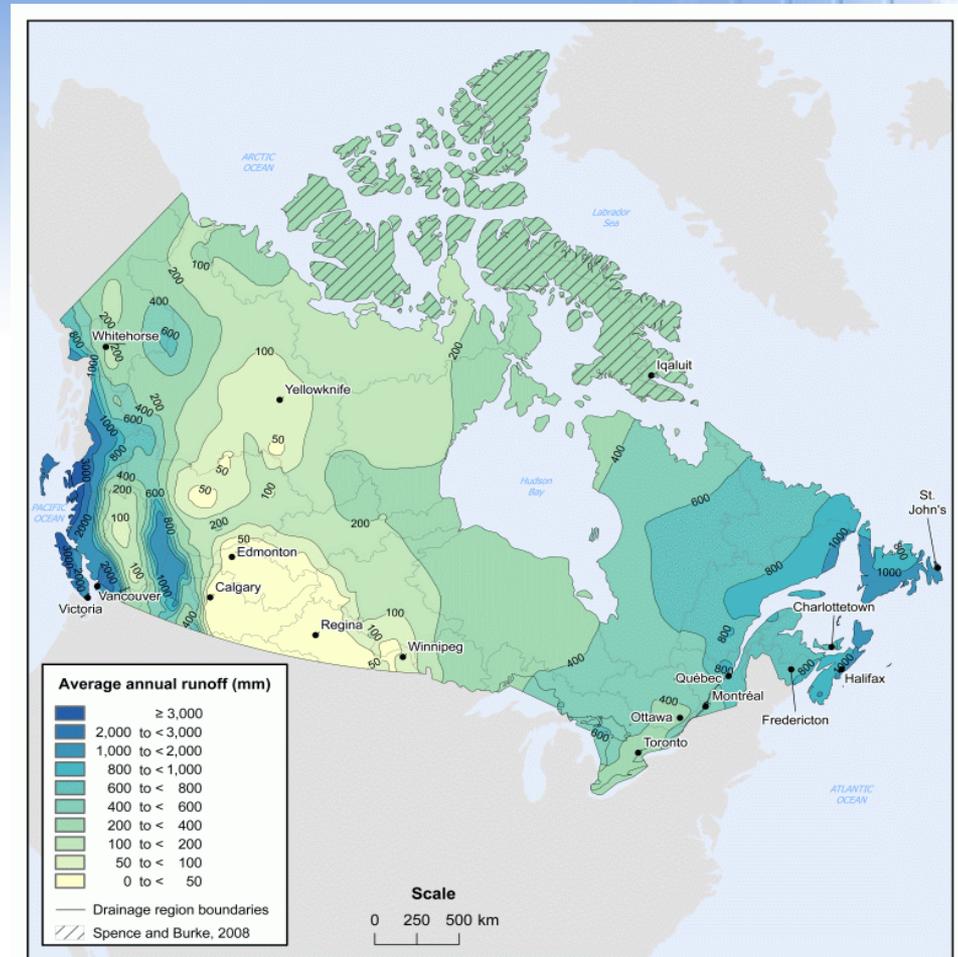


Sampling statistics



Average annual runoff (1971-2004)

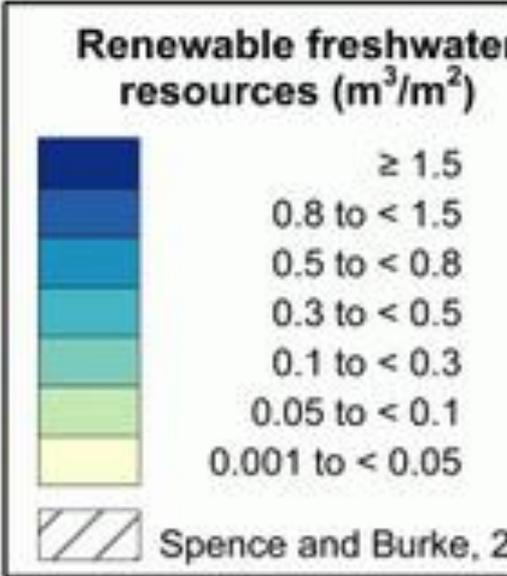
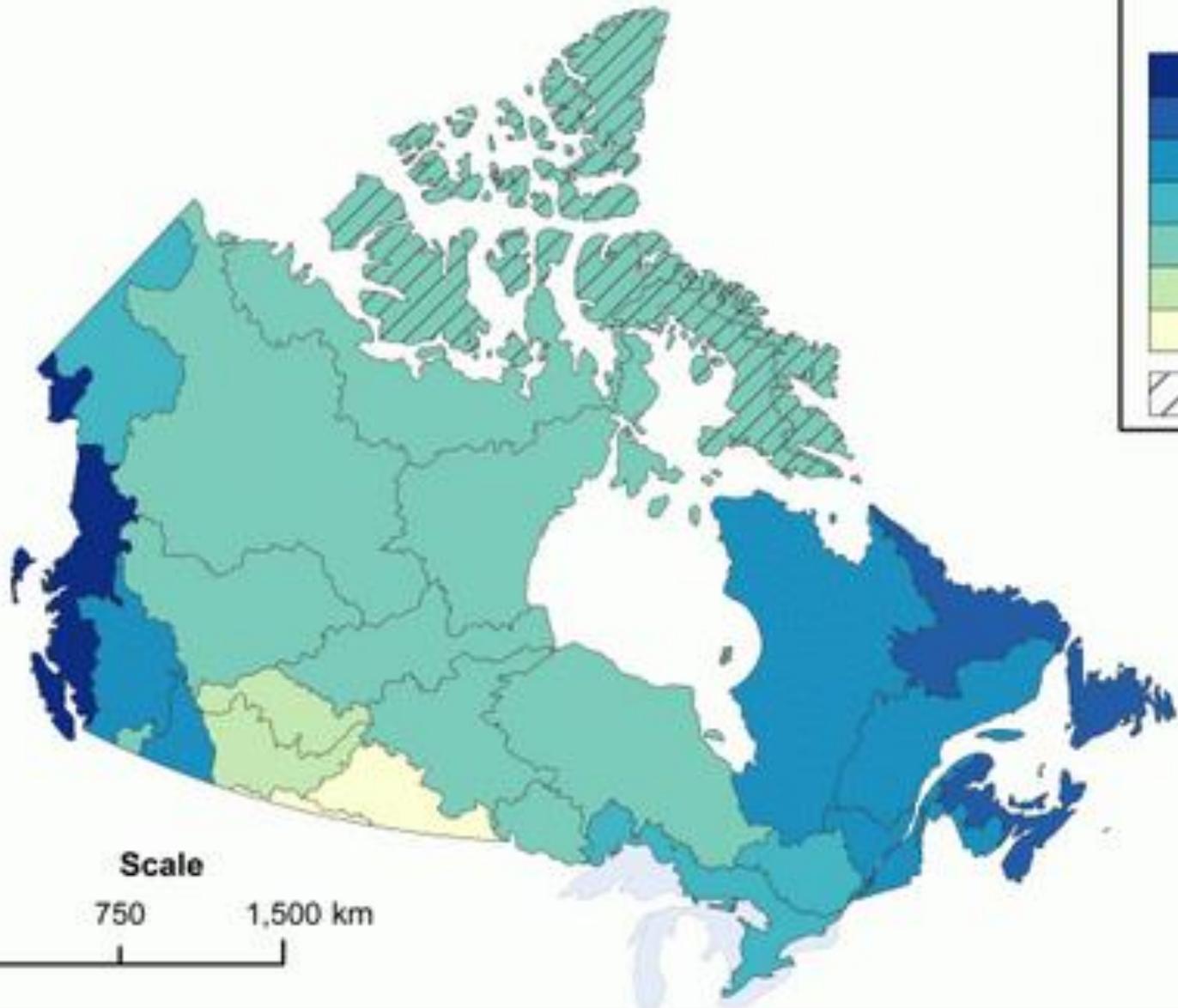
- Average annual yield = **3472 km³**
- Distributed unevenly across Canada



Note(s): Data were derived from discharge values contained in Environment Canada, 2010, Water Survey of Canada, Archived Hydrometric Data (HYDAT) (www.wsc.ec.gc.ca/hydat/H2O/index_e.cfm?cname=main_e.cfm).

Source(s): Spence C., and A. Burke, 2008, "Estimates of Canadian Arctic Archipelago Runoff from Observed Hydrometric Data," *Journal of Hydrology*, Vol. 362, pages 247 to 259.
Statistics Canada, Environment Accounts and Statistics Division, 2010, special tabulation.

0 3,000 6,000 km



Scale

0 750 1,500 km

Statistics Canada's North-line in relation to the land mass of Canada



Note(s): The North-line is a statistical area classification of the North based on 16 social, biotic, economic and climatic variables that delineates the North from the South in Canada.

Source(s): McNiven C., and H. Puderer, 2000, "Delineation of Canada's North: An Examination of the North-South Relationship in Canada," *Geography Working Paper Series*, Statistics Canada Catalogue no. 92F0138MIE.

- 98% of Canadians live in southern Canada

- Only 38% of the water yield is in southern Canada



Table 153-0109 [1](#), [2](#), [3](#), [4](#)

Annual water yield for selected drainage regions and Southern Canada

occasional (cubic kilometres)

[Data table](#) [Add/Remove data](#) [Manipulate](#) [Download](#) [Related information](#) [Help](#)

The data below is a part of CANSIM table 153-0109. Use the [Add/Remove data](#) tab to customize your table.

Selected items [\[Add/Remove data\]](#)

Annual water yield = Annual volume

Geography	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Southern Canada ⁴	1,228.2	1,200.1	1,260.0	1,284.7	1,344.8	1,408.6	1,291.7	1,329.5	1,449.6	1,311.7	1,243.0	1,491.7	1,293.3	..
Pacific Coastal drainage region [101]	455.1	490.0	517.1	521.2	511.3	535.6	436.9	583.9	466.7	456.7	461.9	500.0	518.7	..
Fraser-Lower Mainland drainage region [102]	129.1	108.6	138.4	116.4	128.4	138.4	111.2	153.5	131.6	117.3	118.3	152.6	150.2	116.3
Columbia drainage region [104]	70.2	50.8	73.4	65.0	66.5	70.3	66.8	69.4	65.7	51.2	57.5	74.8	83.2	78.3
Peace-Athabasca drainage region [206]	91.8	93.6	93.2	93.0	97.4	..	..	..	..	..	..	..	..	..
North Saskatchewan drainage region [410]	7.8	5.7	6.1	7.3	7.6	13.7	10.1	12.0	8.8	5.9	8.7	14.0	10.9	19.3
South Saskatchewan drainage region [411]	6.8	4.9	9.3	8.5	8.2	13.8	10.1	11.4	9.5	6.6	11.3	17.6	10.7	24.0
Assiniboine-Red drainage region [412]	4.5	11.3	3.0	5.9	7.0	14.3	11.1	8.2	3.4	10.1	14.7	42.8	7.0	14.1
Great Lakes drainage region [519]	109.8	145.5	117.8	124.5	133.5	117.7	140.1	109.3	178.2	152.9	95.2	141.5	103.2	167.2



Home > CANSIM > Search results >

Table 153-0110 [1](#), [2](#), [3](#), [4](#)

Median monthly water yield for selected drainage regions occasional (cubic kilometres)

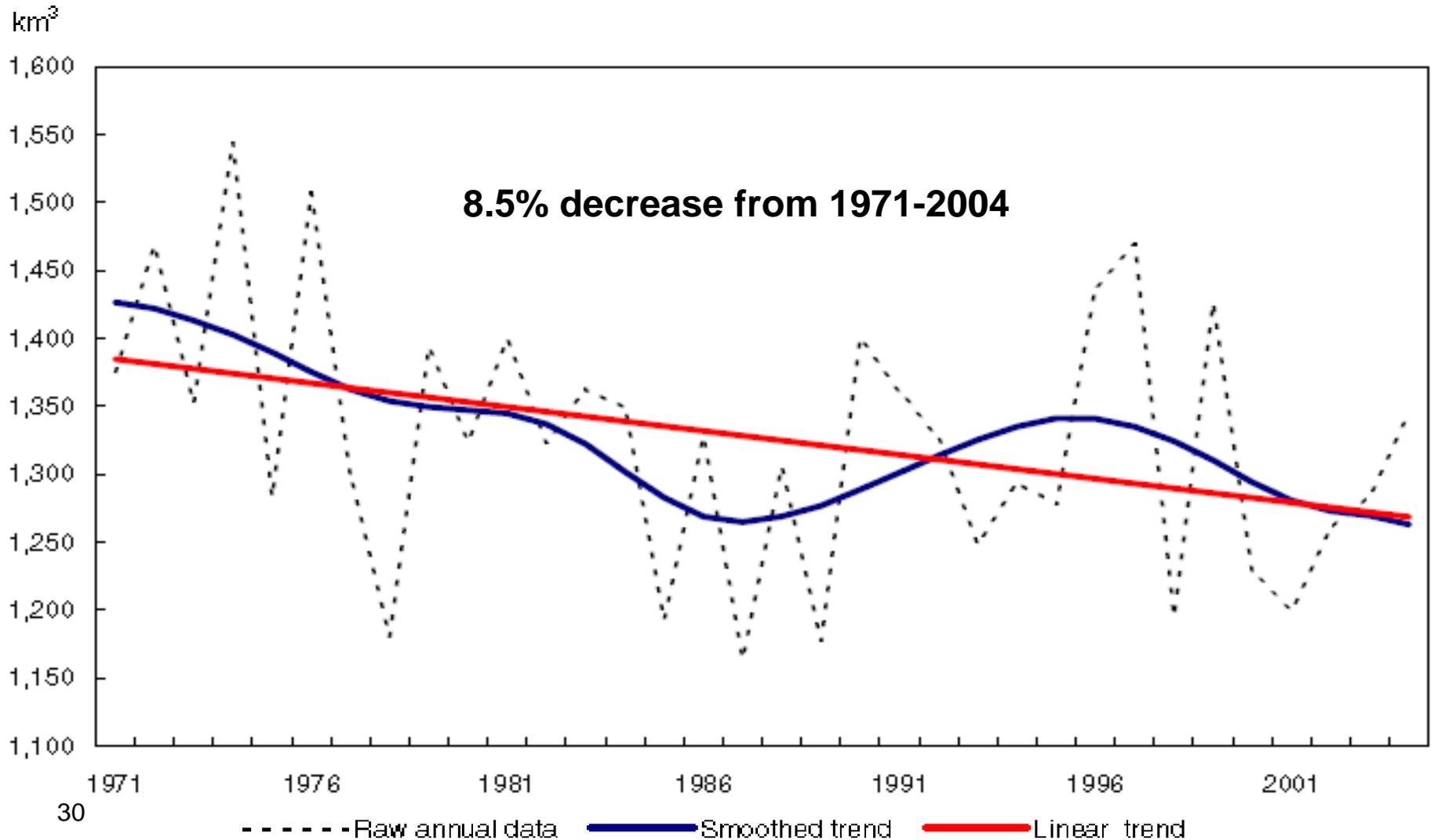
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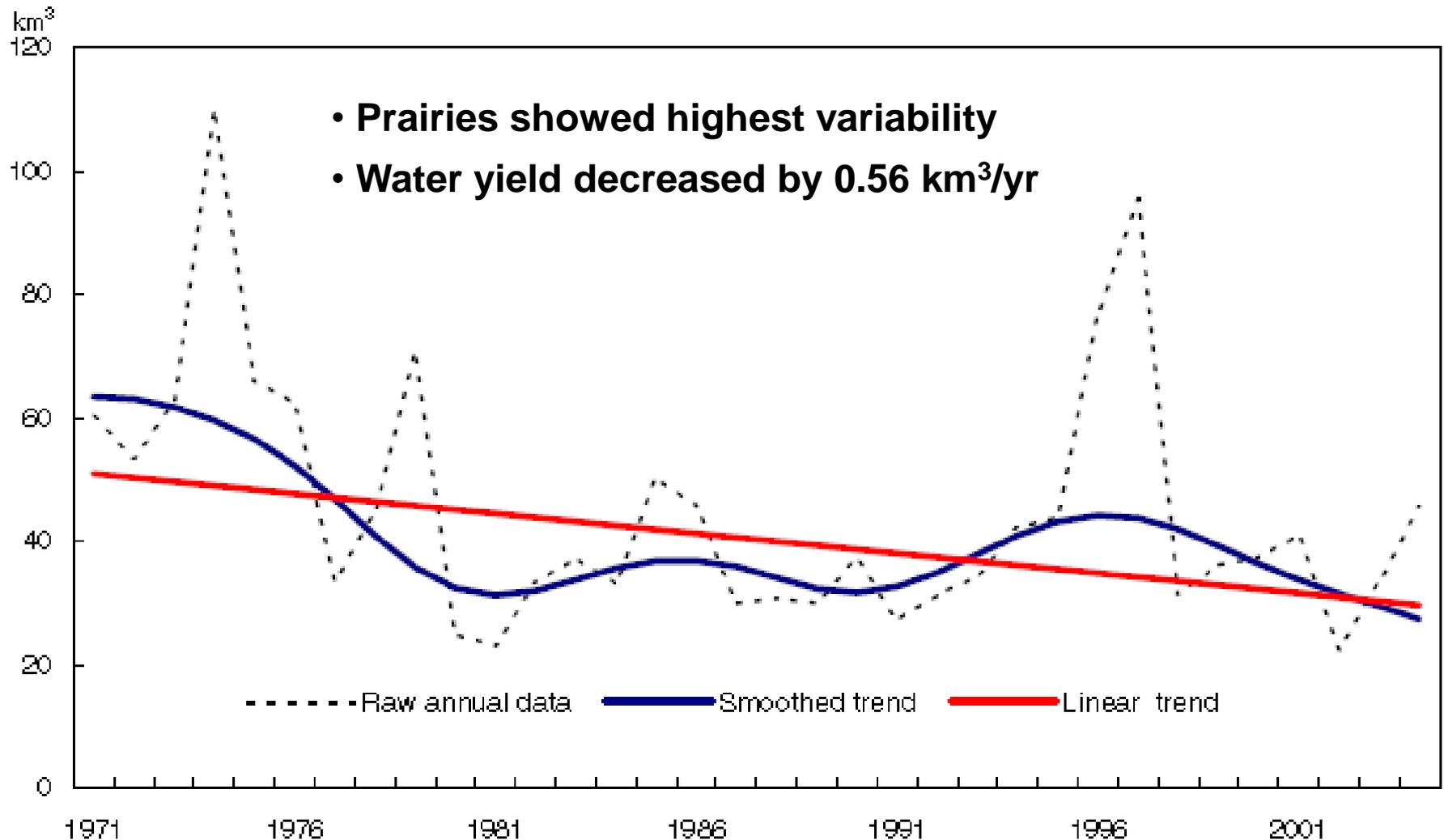
Selected items [[Add/Remove data](#)]

Geography	Median monthly water yield	1971-2004
Pacific Coastal drainage region [101]	January, median monthly	28.39
	February, median monthly	18.83
	March, median monthly	19.14
	April, median monthly	24.76
	May, median monthly	55.01
	June, median monthly	79.28
	July, median monthly	65.60
	August, median monthly	43.30
	September, median monthly	42.84
	October, median monthly	49.75
	November, median monthly	41.89
	December, median monthly	34.11
29	January, median monthly	3.80

Trends in water yield for Southern Canada, 1971-2004

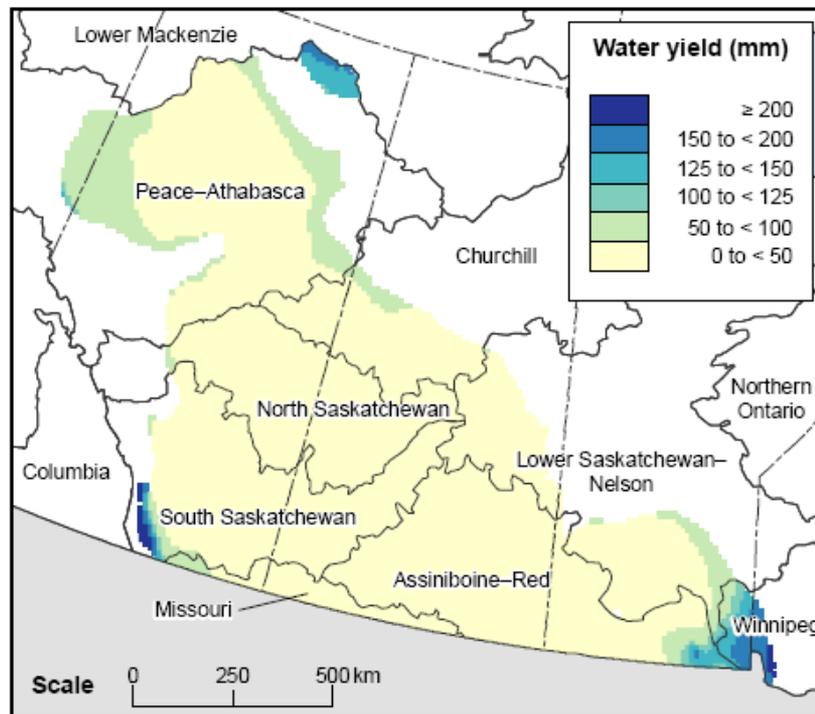


Trends in water yield for the Prairies, 1971-2004



Water yield variability in the Prairies

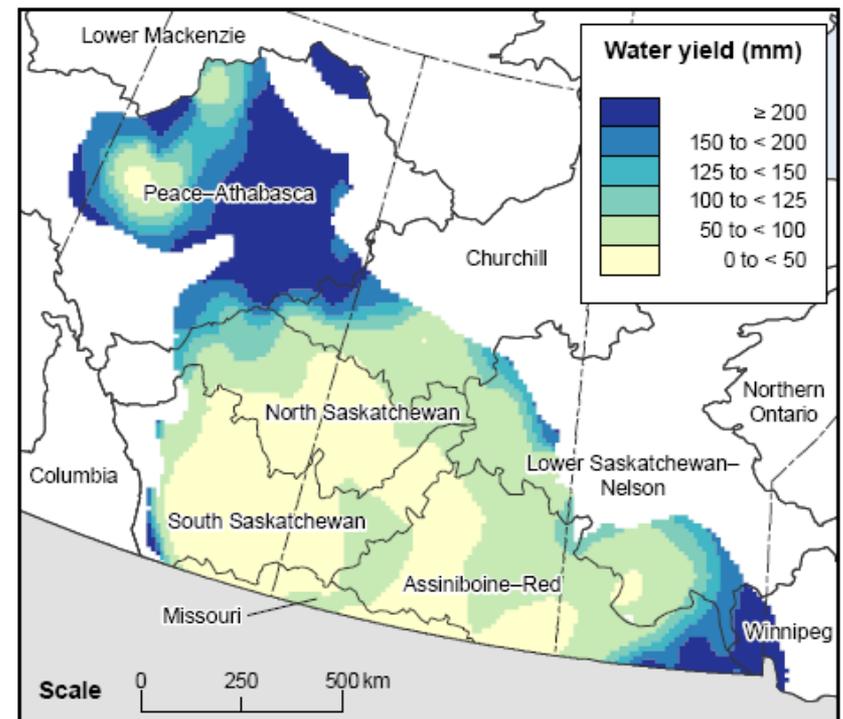
Annual water yield in the Canadian Prairies, drought of 2002



Note(s): Includes all or part of drainage regions 6, 9, 10, 11, and 12, the Peace-Athabasca, Missouri, North Saskatchewan, South Saskatchewan, and Assiniboine-Red.

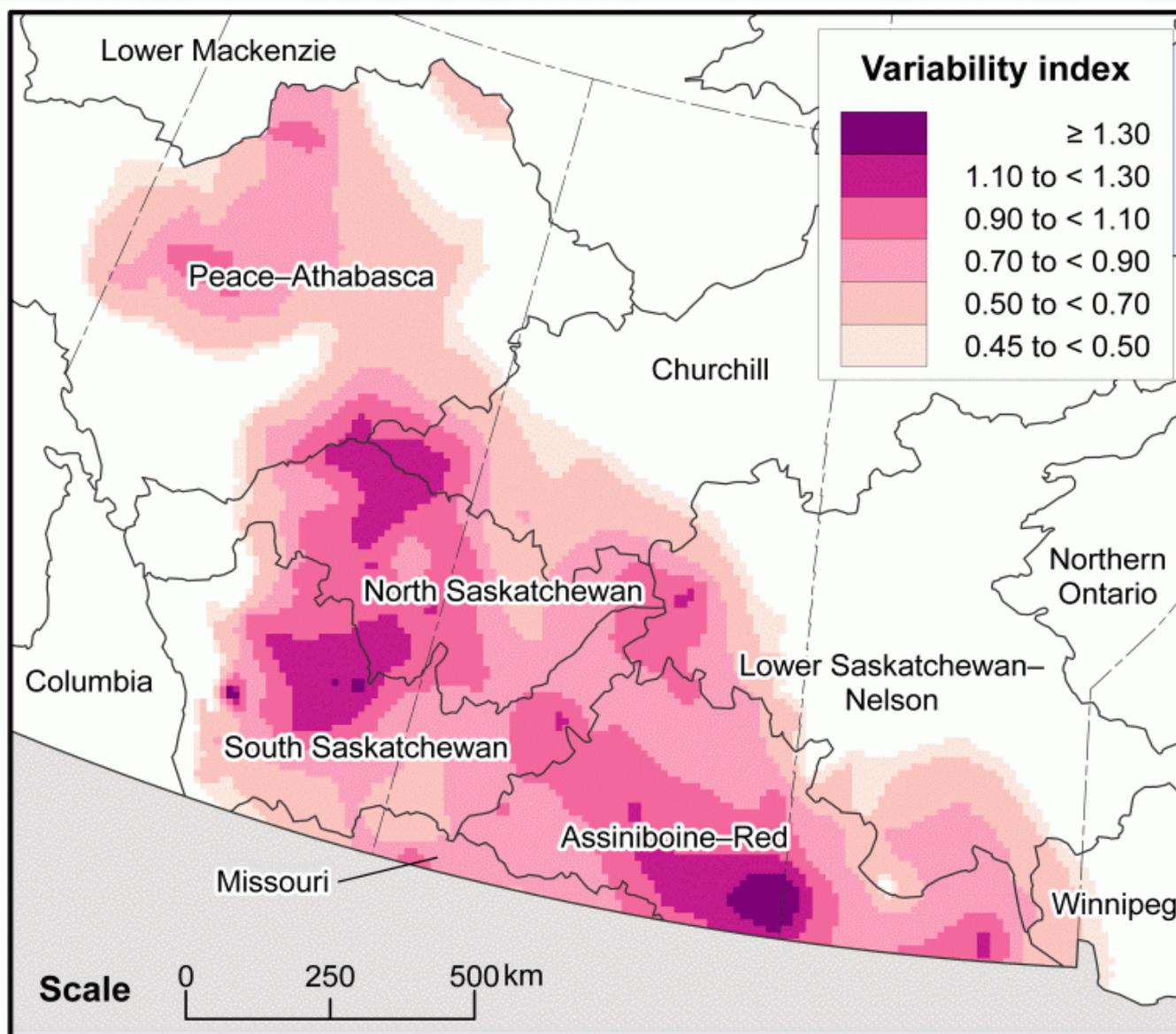
Sources(s): Statistics Canada, Environment Accounts and Statistics Division, 2010, special tabulation.

Annual water yield in the Canadian Prairies, Red River flood of 1997



Note(s): Includes all or part of drainage regions 6, 9, 10, 11, and 12, the Peace-Athabasca, Missouri, North Saskatchewan, South Saskatchewan, and Assiniboine-Red.

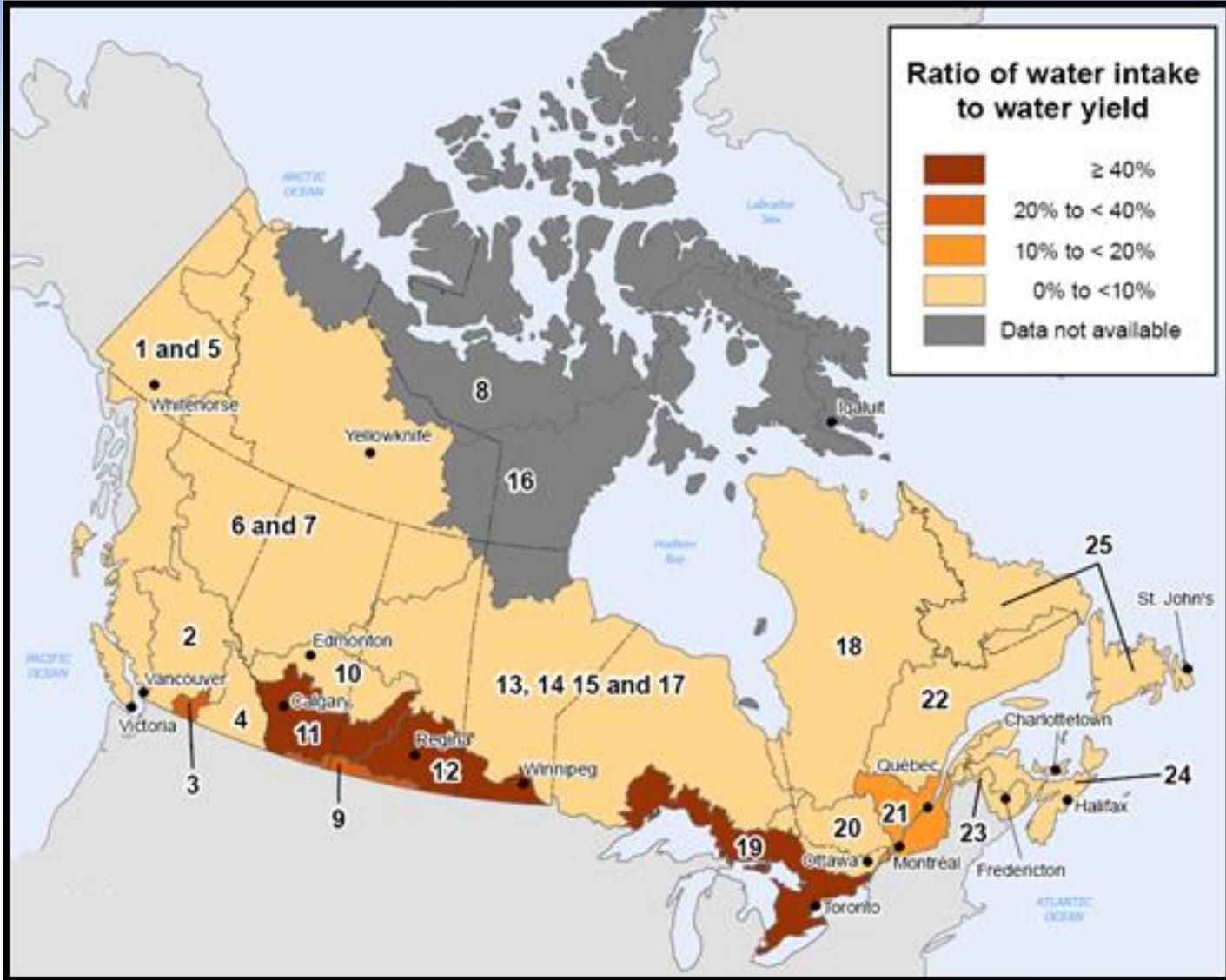
Sources(s): Statistics Canada, Environment Accounts and Statistics Division, 2010, special tabulation.



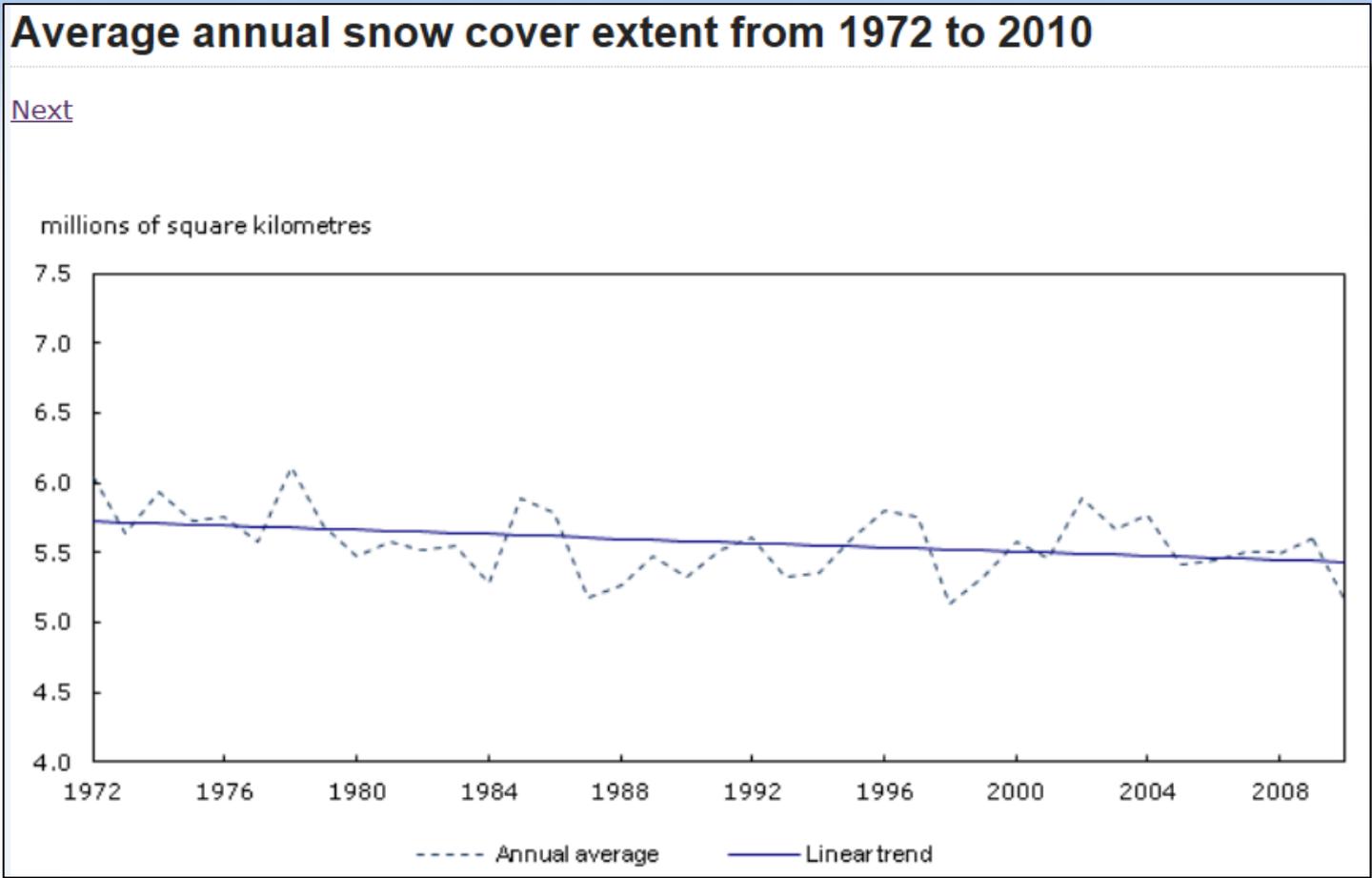
Note(s): Includes all or part of drainage regions 6, 9, 10, 11, and 12, the Peace–Athabasca, Missouri, North Saskatchewan, South Saskatchewan, and Assiniboine–Red.

Sources(s): Statistics Canada, Environment Accounts and Statistics Division, 2010. special tabulation.

Water supply and demand: August 2005



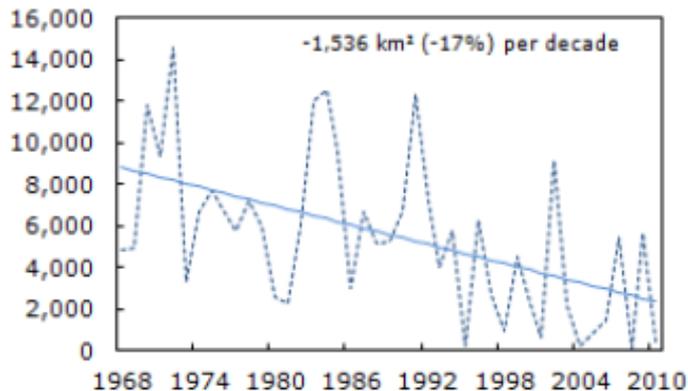
Other water asset work includes...



Average area covered by total (all) sea ice during summer

Northern Labrador Sea

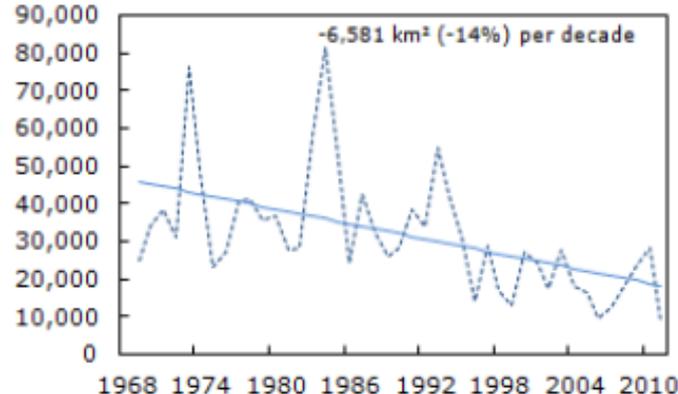
square kilometres



----- Raw data — Linear trend

Davis Strait

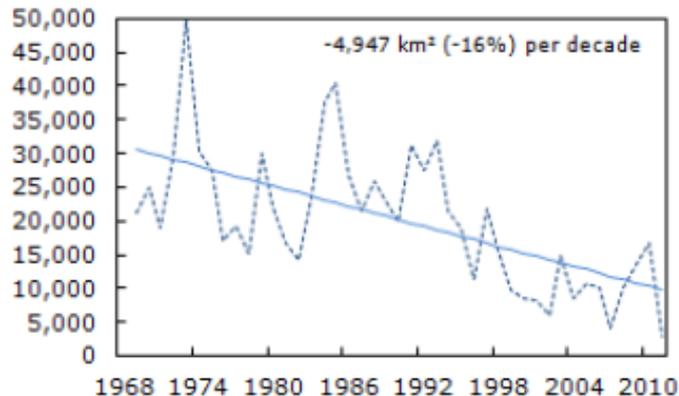
square kilometres



----- Raw data — Linear trend

Hudson Strait

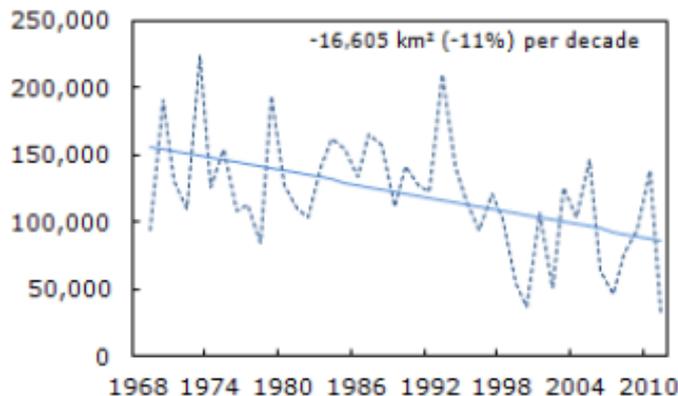
square kilometres



----- Raw data — Linear trend

Hudson Bay

square kilometres



----- Raw data — Linear trend

Total water requirements for agricultural production in Canada



	Total water supplied by the environment	
	2005	2007
	Mm ³	
Total	89,590.3	80,120.8
Crop production (except greenhouse, nursery and sod)	89,077.5	79,612.0
Wheat	38,390.4	29,900.5
Feed grain	19,357.2	20,264.8
Oilseed	22,863.3	21,793.6
Potatoes	470.0	529.9
Fruits and vegetables	5,964.4	5,100.0
Other Crops	2,032.1	2,023.1
Greenhouse, nursery and sod	191.5	202.5
Animal production (excluding aquaculture)	321.3	306.4
Dairy	44.2	42.2
Cattle	192.6	182.6
Hogs	55.3	52.4
Poultry and eggs	12.6	12.9
Other livestock	16.6	16.2

Other water accounting work: Water use to satisfy final demand, 2005

...including Hydro

Including precipitation and hydro-electric power generation

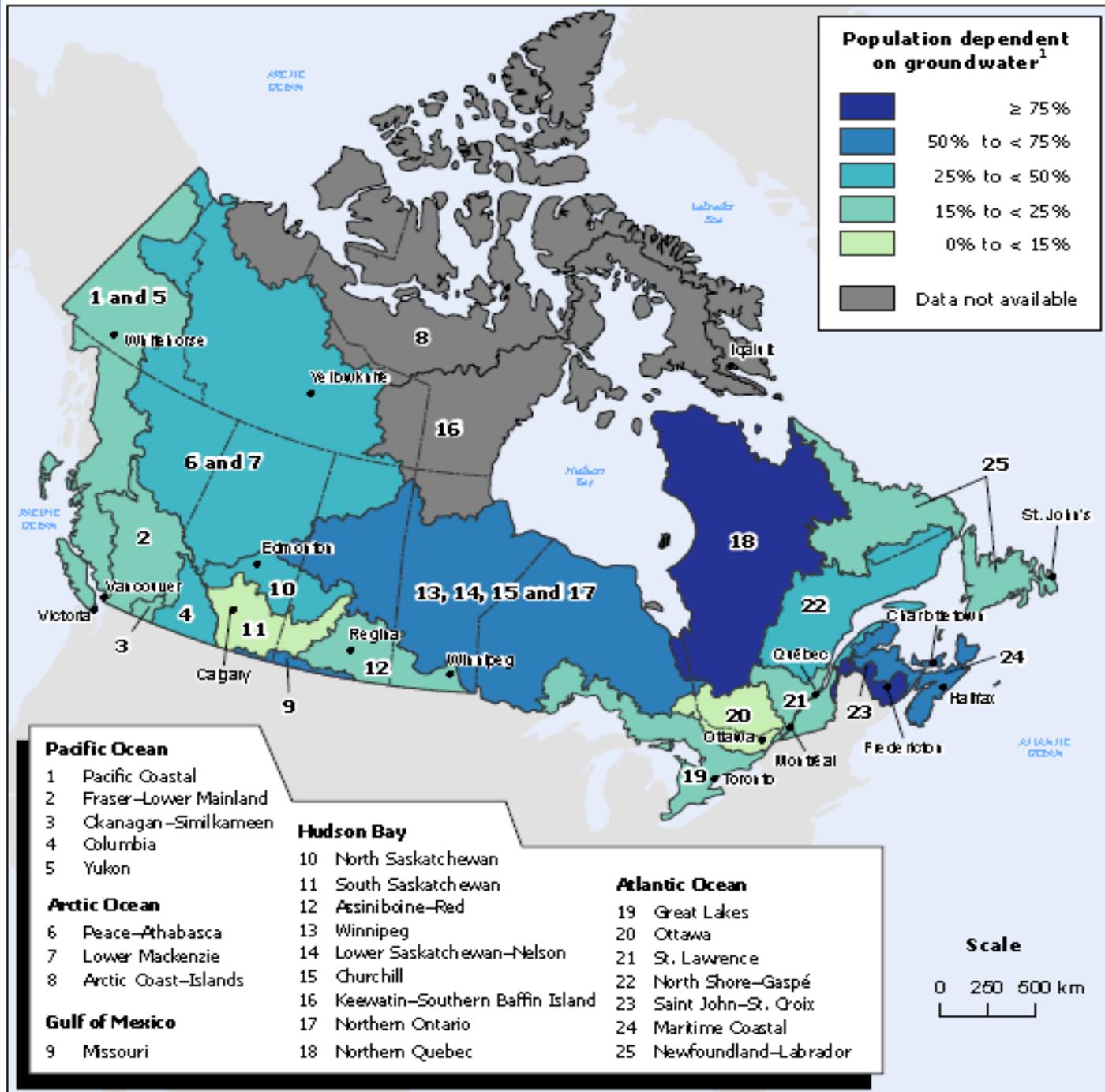
	Mm ³	percent
Internal demand	2,043,138	58.0
Personal expenditure	1,516,777	43.1
Machinery and equipment	57,978	1.6
Inventories	181,986	5.2
Construction	42,693	1.2
Government	243,703	6.9
External demand		
Exports	1,476,898	42.0
Total demand for water	3,520,036	100.0

...excluding Hydro

Including precipitation

Excluding precipitation

	Including precipitation		Excluding precipitation	
	Mm ³	percent	Mm ³	percent
Internal demand	211,068	33.7	24,118	63.0
Personal expenditure	98,727	15.8	18,003	47.0
Machinery and equipment	6,890	1.1	731	1.9
Inventories	71,107	11.4	1,732	4.5
Construction	19,417	3.1	483	1.3
Government	14,927	2.4	3,169	8.3
External demand				
Exports	414,857	66.3	14,169	37.0
Total demand for water	625,925	100.0	38,287	100.0



1. Includes groundwater under the direct influence of surface water.

Building Preliminary Accounts with Actual Data : Water Asset Account

Regional Training Workshop on the System of Environmental-Economic Accounting with a Focus on Water Accounting

Thank You for your attention

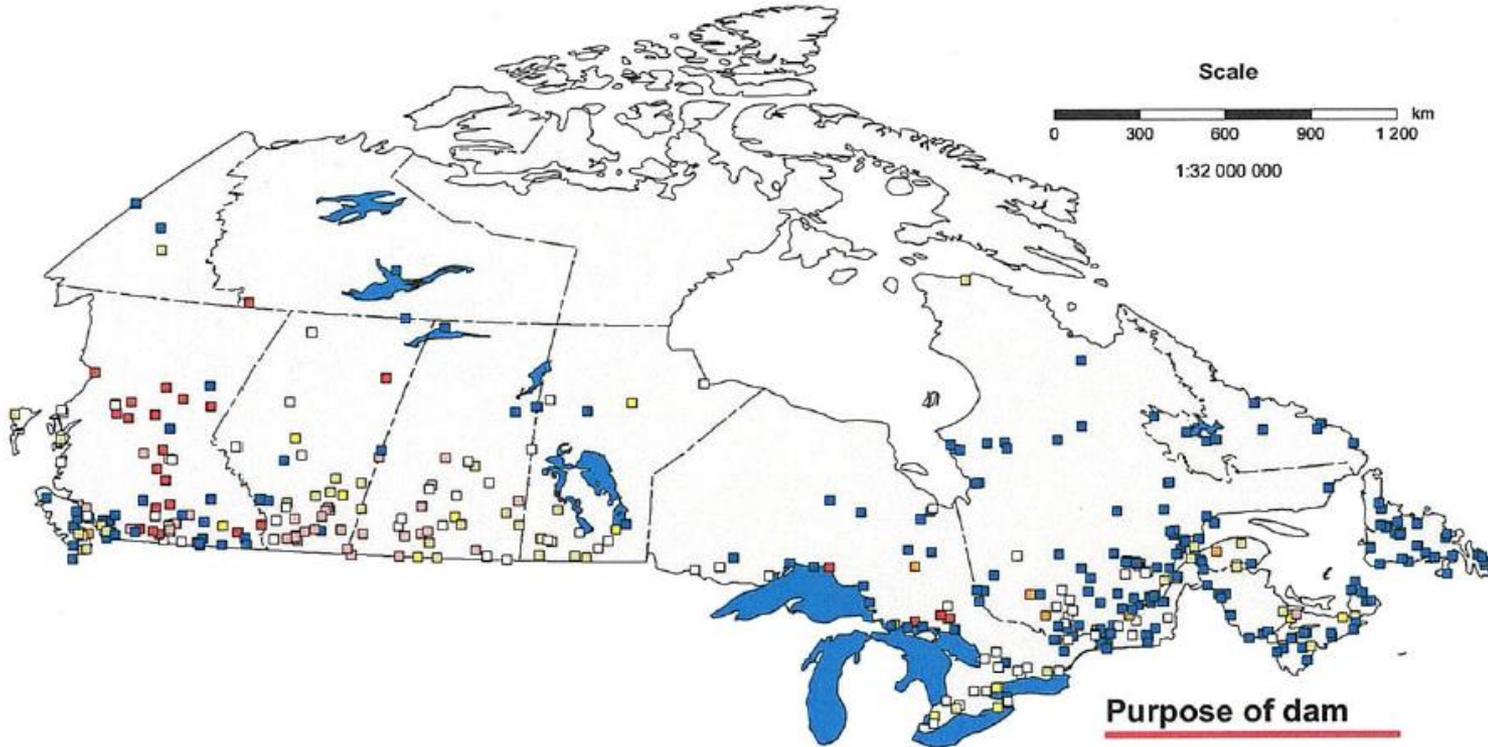
September 26-30, 2016
Putrajaya, Malaysia

François Soulard Ph.D.

Environment, Energy and Transportation Statistics Division

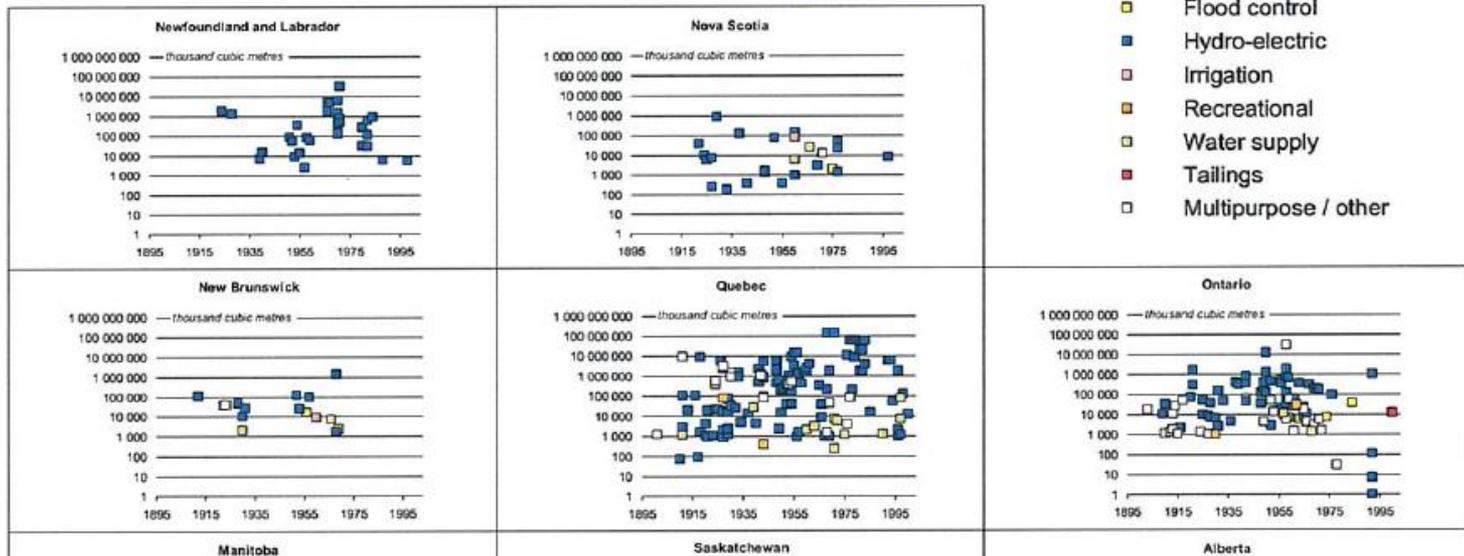
Statistics Canada

Large dams by gross capacity of reservoir, year of completion and by province and territory



Purpose of dam

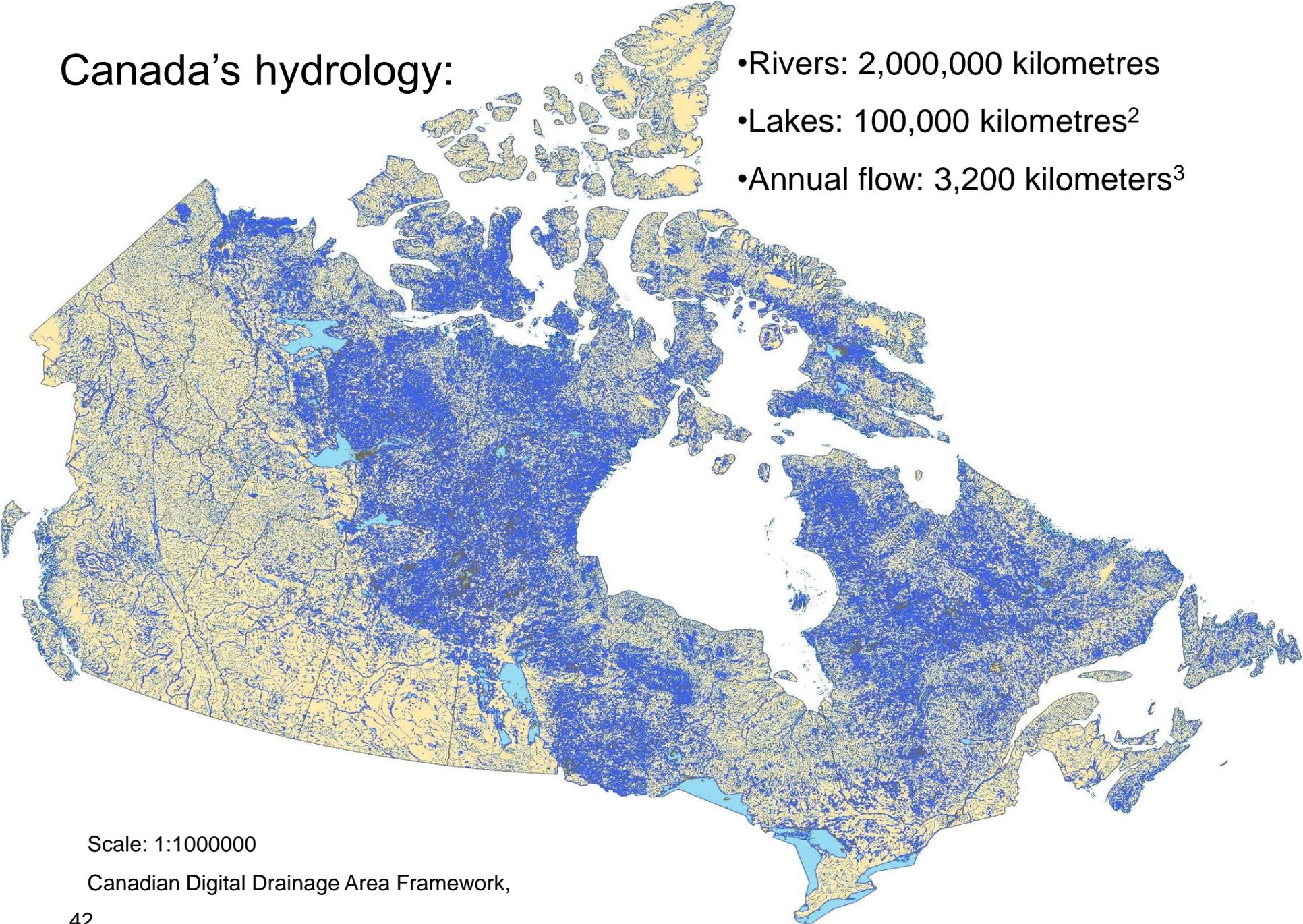
- Flood control
- Hydro-electric
- Irrigation
- Recreational
- Water supply
- Tailings
- Multipurpose / other



[Back](#)

Canada's hydrology:

- Rivers: 2,000,000 kilometres
- Lakes: 100,000 kilometres²
- Annual flow: 3,200 kilometers³



Scale: 1:1000000

Canadian Digital Drainage Area Framework,



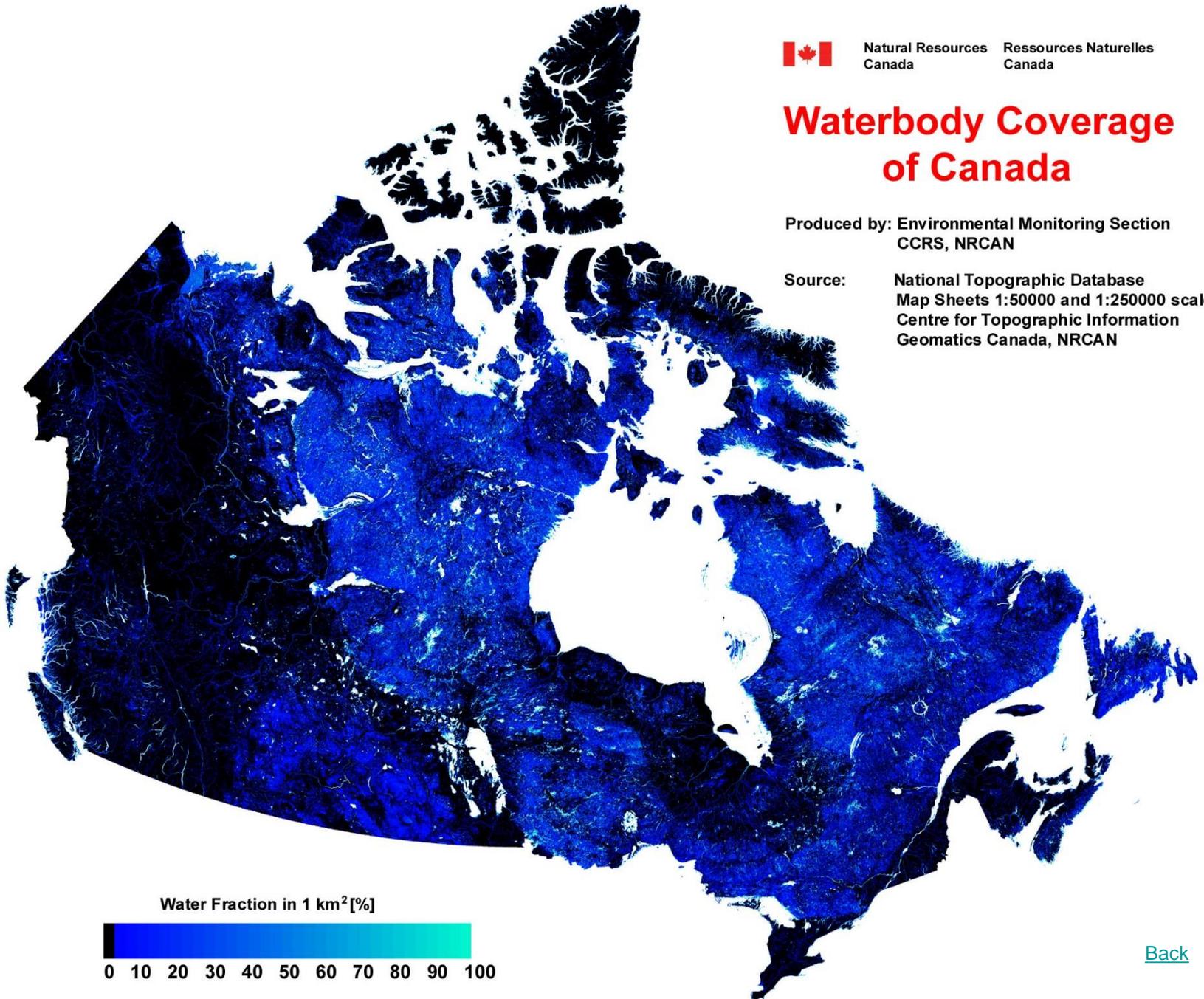
Natural Resources
Canada

Ressources Naturelles
Canada

Waterbody Coverage of Canada

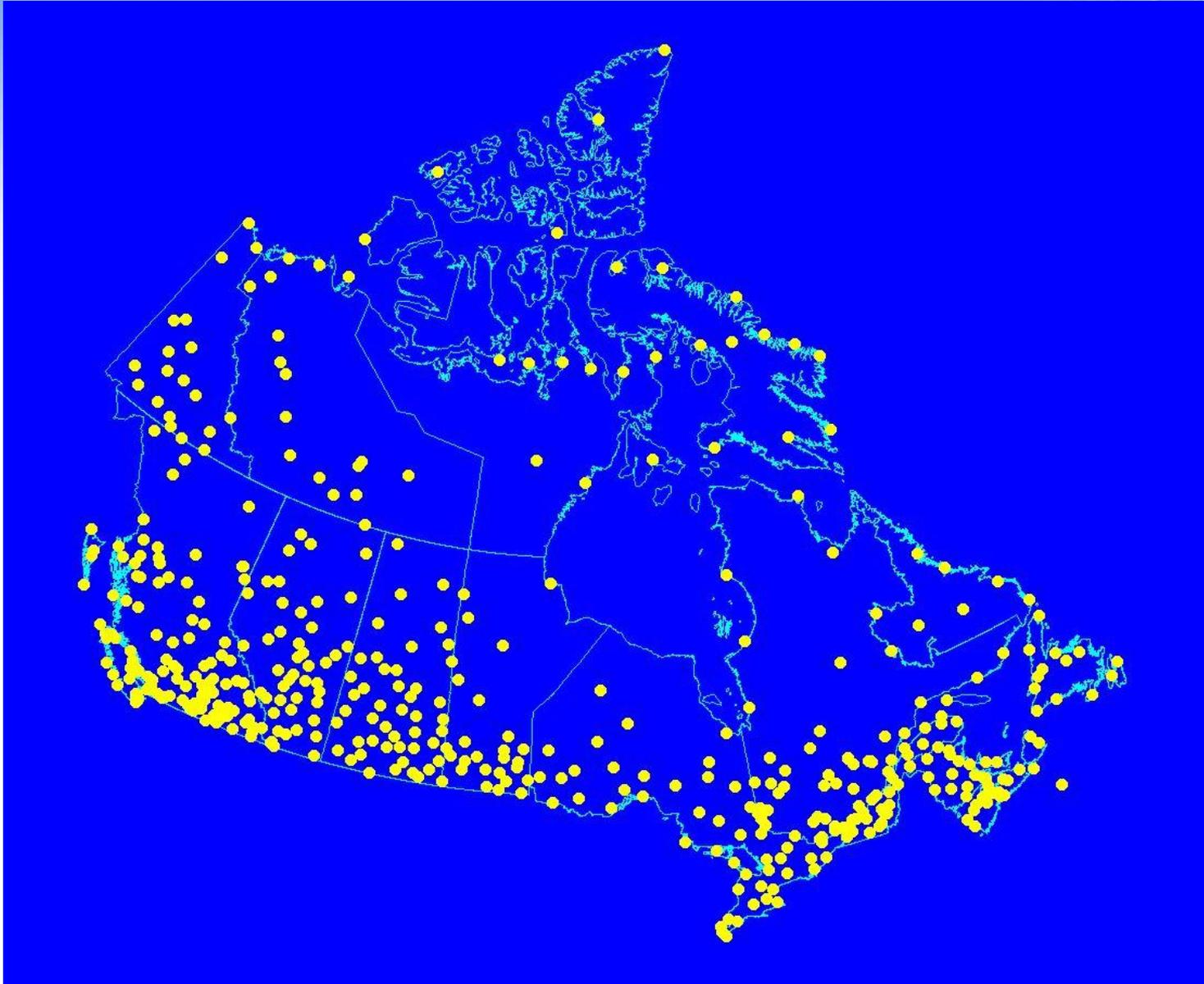
Produced by: Environmental Monitoring Section
CCRS, NRCAN

Source: National Topographic Database
Map Sheets 1:50000 and 1:250000 scale
Centre for Topographic Information
Geomatics Canada, NRCAN



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Canadian Climate Database

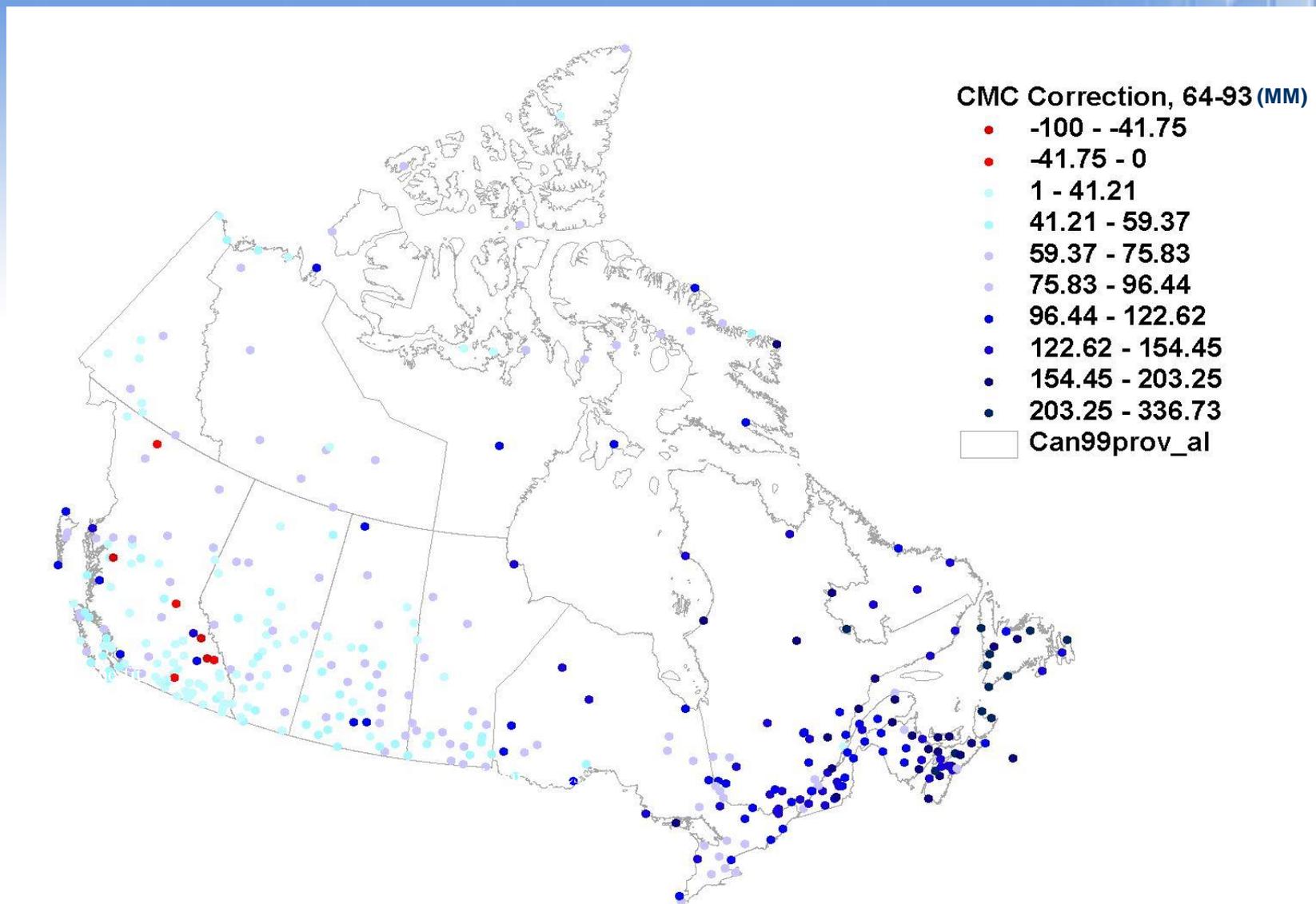


Main Issues with Precipitation Data

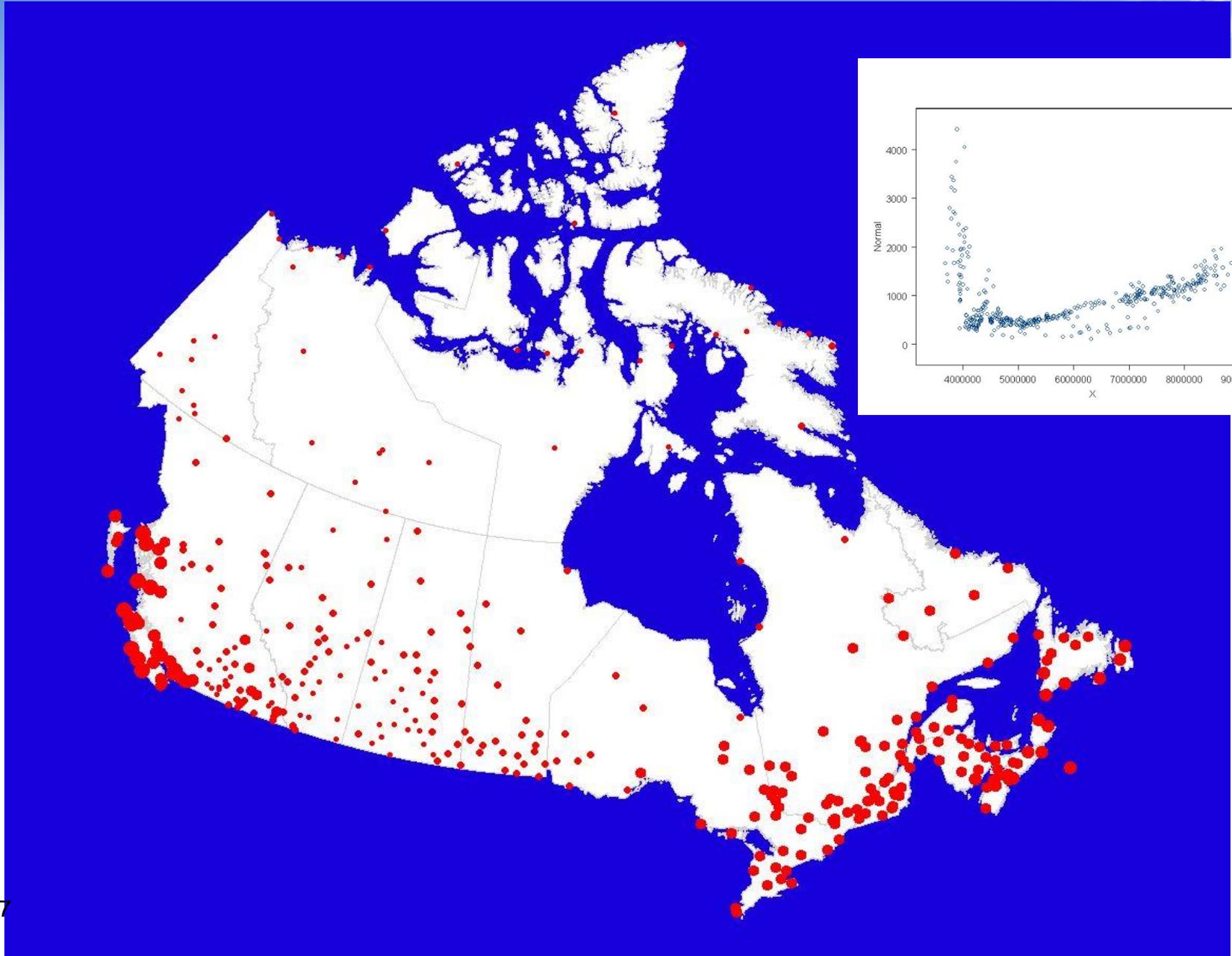


- Known inhomogeneities
 - Change of site location
 - Change of observing procedure
 - Instrument deficiencies
- Measurement errors
 - Trace elements (ex.: dew)
 - Undercatch (ex.: wind)
 - Viscosity (ex.: emptying rain gauge)
 - Precipitation density (ex.: snow measurement)
- Varying density of station network

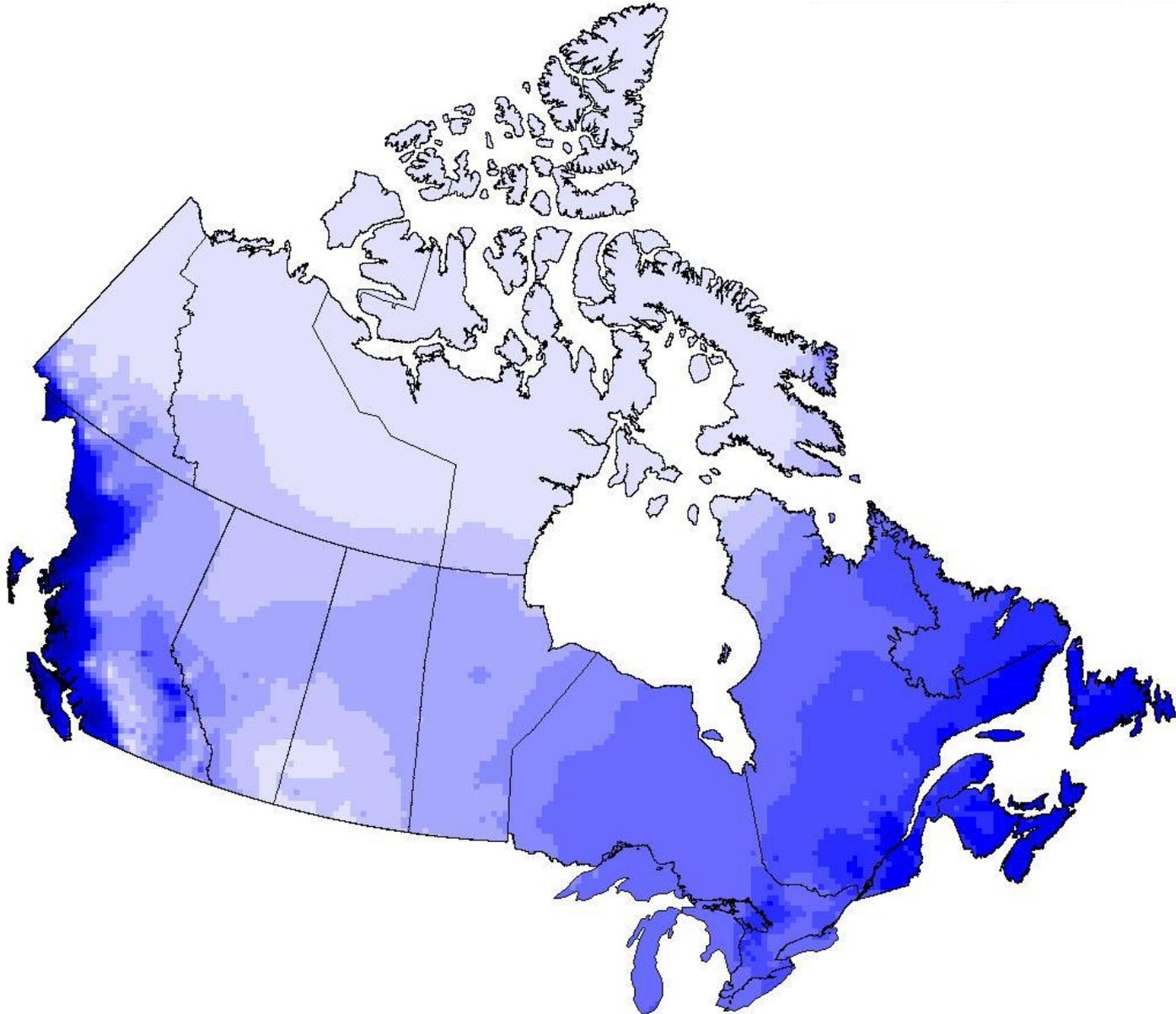
Correction to original data



1961-1990 Normal precipitation points

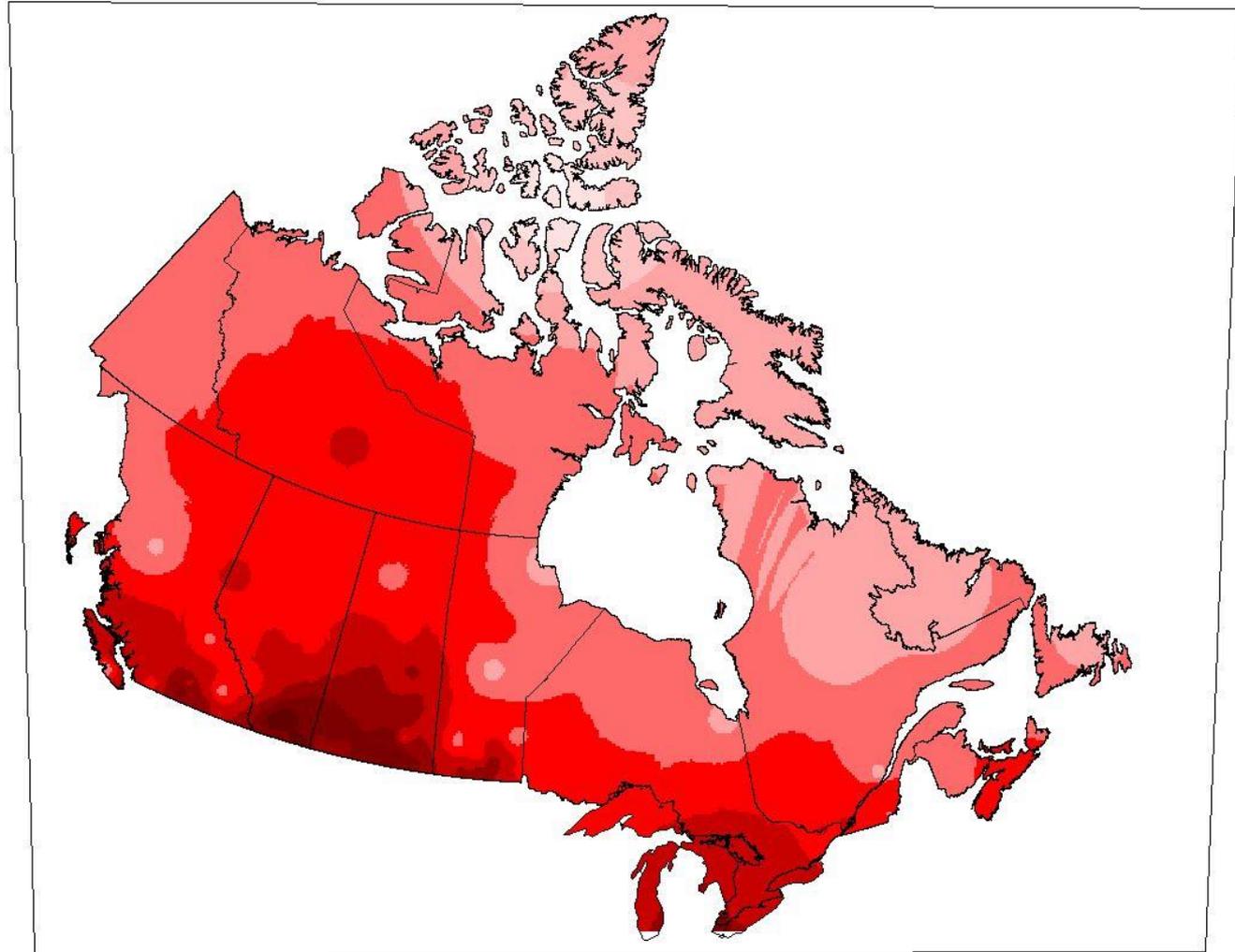


1961-1990 Normal precipitation surface

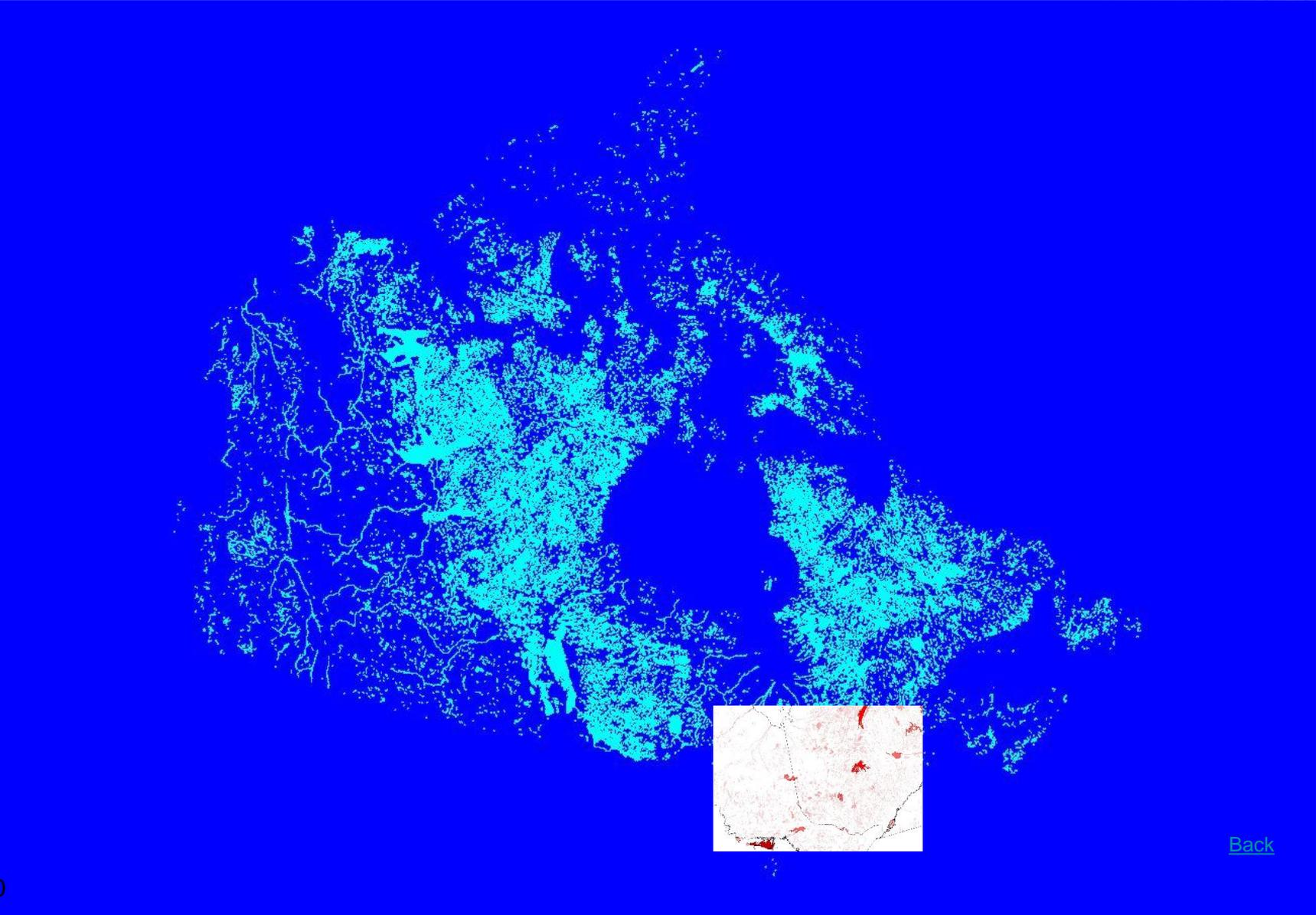


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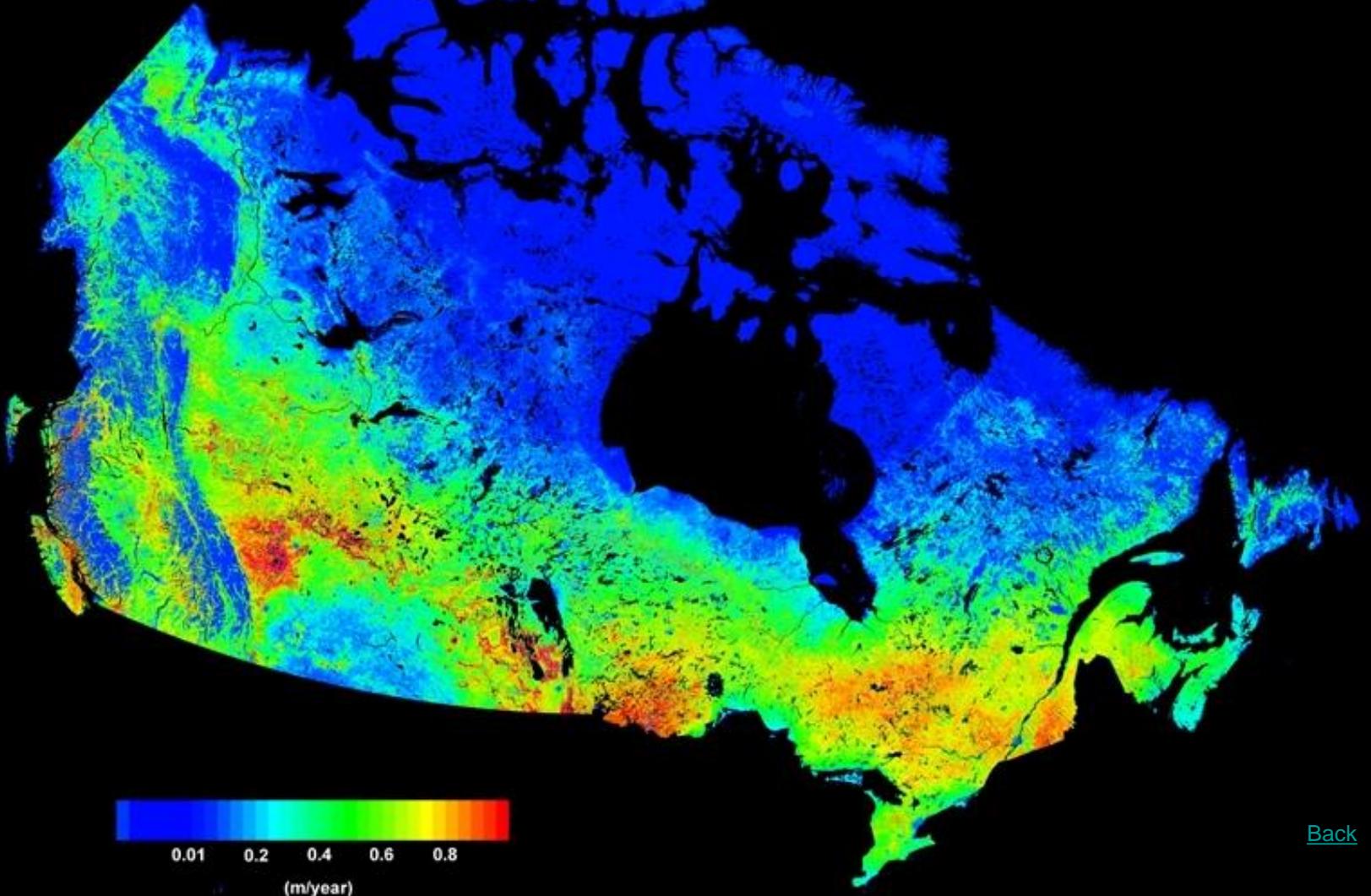
Estimating Evaporation



Lake evaporation



Evapotranspiration
Évapotranspiration
1994



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Table 153-0116 [1](#), [2](#), [3](#), [4](#), [6](#), [7](#), [8](#), [9](#), [10](#), [11](#), [12](#)[Back](#)**Physical flow account for water use
every 2 years (cubic metres x 1,000)**

[Data table](#) [Add/Remove data](#) [Manipulate](#) [Download](#) [Related information](#) [Help](#)

The data below is a part of CANSIM table 153-0116. Use the [Add/Remove data](#) tab to customize your table.

Selected items [\[Add/Remove data\]](#)

Geography = Canada

Sector	2009	2011	2013
Total, industries and households	38,788,670	35,517,933	37,910,769
Total, industries	35,200,016	32,011,699	34,671,607
Crop production [BS111]	1,266,057	942,159	1,069,461
Animal production [BS112]	1,100,057	866,357	937,352
Forestry and logging [BS11300]	346	585	647
Fishing, hunting and trapping [BS11400]	..	..	..
Support activities for agriculture and forestry [BS11500]	..	..	..
Oil and gas extraction [BS21100]	292,562	348,648	401,725
Coal mining [BS21210]	20,966	33,632	91,903
Metal ore mining [BS21220]	319,054	260,066	373,172
Non-metallic mineral mining and quarrying [BS21230]	103,073	123,732	134,303
Support activities for mining and oil and gas extraction [BS21300]	9	26	34
Electric power generation, transmission and distribution [BS22110]	26,213,561	23,715,875	25,635,244
Natural gas distribution, water, sewage and other systems [BS221A0]	968,870	925,044	884,849
Residential building construction [BS23A00]	4,929	5,296	6,795
52 Non-residential building construction [BS23B00]	2 092	2 300	2 874

Ocean drainage areas and drainage regions

This map outlines the boundaries of the 5 ocean drainage areas and the 25 drainage regions in Canada. These drainage regions include the interior freshwater lakes of Canada.



Source(s): Pearse, P.H., F. Bertrand and J.W. MacLaren, 1985, *Currents of Change: Final Report of the Inquiry on Federal Water Policy*, Environment Canada, Ottawa. Statistics Canada, Environment Accounts and Statistics Division.