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Data Sources and Methods for the Phosphorus and Nitrogen Levels in the St. Lawrence River Indicator

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Aussi disponible en français

1 Introduction

The Phosphorus and Nitrogen Levels in the St. Lawrence River indicator (http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=F7F5426B-1) is part of the Canadian Environmental Sustainability Indicators (CESI) program (http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=47F48106-1), which provides data and information to track Canada's performance on key environmental sustainability issues. This indicator also measures progress towards the goals and targets of the Federal Sustainable Development Strategy (http://www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1).

2 Description and rationale of the Phosphorus and Nitrogen Levels in the St. Lawrence River indicator

2.1 Description

The Phosphorus and Nitrogen Levels in the St. Lawrence River indicator reports on the status of total phosphorus and total nitrogen concentrations along the St. Lawrence River for the 2010 to 2012 period. The indicator rates nitrogen and phosphorus status based on whether total phosphorus and total nitrogen concentrations exceed Quebec's total phosphorus water quality guideline for the protection of aquatic life, and its total nitrogen water quality guideline for the protection of aquatic life. When phosphorus and nitrogen concentrations exceed their respective water quality guidelines, this exceedance indicates that phosphorus and nitrogen pose a greater risk to the health of the St. Lawrence River aquatic ecosystem.

When fewer than 10% of water quality samples exceed the phosphorus or nitrogen water quality guideline, water quality at a monitoring station is considered to be minimally impacted by human development (green). When 10 to 50% of the samples exceed the phosphorus or nitrogen water quality guideline, the total phosphorus and total nitrogen concentrations are increasing, and the river is becoming more impaired by human activity (yellow). If more than 50% of the samples exceed the water quality guideline, total phosphorus and nitrogen concentrations are likely well above the water quality guideline and water quality is being impaired by human activity (red).

2.2 Rationale

The St. Lawrence River links the Great Lakes with the Atlantic Ocean and is among the world's most important commercial waterways. It is a complex ecosystem that includes lakes and freshwater reaches, a long estuary and a gulf with marine features. It features many different habitats, and is home to a diverse collection of plants, fish and animals.

Phosphorus and nitrogen are essential plant nutrients. However, when concentrations in the environment are too high or too low, they can cause harmful impacts on the ecosystem. Phosphorus enters the St. Lawrence River from many natural and human sources. Used in chemical fertilizers, phosphorus and nitrogen reach the river through erosion and leaching from urban areas and farmland runoff. Phosphorus and nitrogen also reach the St. Lawrence River in municipal and industrial wastewaters and air pollution. They can be found in aquatic ecosystems at levels that lead to eutrophication, a situation in which excess plant growth begins to change the structure of a river's ecosystem. Excess phosphorus and nitrogen in the river has the potential to alter the river's food web.

The indicator assumes that river water would rarely exceed phosphorus and nitrogen water quality guidelines in the absence of human development. Thus, the indicator shows how human activity

contributes to phosphorus and nitrogen levels in the St. Lawrence River. The more often the water quality guidelines are exceeded, the greater the risk phosphorus and nitrogen pose to the health of the St. Lawrence River. Continuing to monitor phosphorus and nitrogen concentrations allows governments and citizens to follow an important aspect of the environmental condition of the river.

2.3 Recent changes to the indicator

Total nitrogen guideline exceedances from 2010 to 2012 have been added to the indicator.

3 Data

3.1 Data source

Total phosphorus and total nitrogen data were provided by Environment Canada's Fresh Water Quality Monitoring and Surveillance program. The data can be found in Environment Canada's Fresh Water Quality Monitoring and Surveillance Web Mapping Application (http://www.ec.gc.ca/eaudouce-freshwater/default.asp?lang=En&n=EFDA57C6-1).

Quebec's provincial water quality guideline for total phosphorus is 0.03 milligrams of phosphorus per litre (mg P/L).[1]

Neither Quebec nor the Canadian Council of Ministers of the Environment (CCME) have a water quality guideline for total nitrogen. Accordingly, a total nitrogen guideline of 1 milligram of nitrogen per litre (mg N/L) was used to calculate the indicator. This guideline was selected based on the following criteria:

- this total nitrogen concentration is used to signal the transition between mesotrophic (medium-nutrient) and eutrophic (high-nutrient) conditions in lakes and rivers. Once the transition occurs, aquatic life has been impacted by eutrophication and is no longer protected;
- the United States Environmental Protection Agency's (U.S. EPA) recommended criteria for total nitrogen for rivers and streams in Nutrient Ecoregion VII is 0.54 mg N/L, with a range 0.46 – 1.88 mg N/L for Level III subregions.[2] The total nitrogen guideline of 1 mg N/L falls within the recommended range. Nutrient Ecoregion VII includes the St. Lawrence Lowlands ecozone;
- it is an internationally accepted water quality guideline adopted to prevent eutrophication. The United Nations Environment Programme's Global Environment Monitoring System/Water Programme's (UNEP GEMS/Water) Water Quality Index uses this criteria;[3] and

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[1] Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (2009) Critères de qualité de l'eau de surface : phosphore total (en P). Retrieved on 31 March, 2014. Available only in French from: http://www.mddelcc.gouv.qc.ca/eau/criteres_eau/index.asp.

[2] United States Environmental Protection Agency (2000) Ecoregional Nutrient Criteria Documents for Rivers and Streams: Ecoregion VII: Mostly Glaciated Dairy Region. EPA 822-B-00-018. Retrieved on 31 March, 2014. Available from: http://www2.epa.gov/nutrient-policy-data/ecoregional-nutrient-criteria-documents-rivers-and-streams.

[3] United Nations Environment Programme's Global Environment Monitoring System, GEMSTAT (2013) Water Quality Index by Country – Statistical help. Retrieved on 31 March, 2014. Available from: http://www.gemstat.org/StatsHelp/statshelp_WQI.aspx.

- in Canada, it is Alberta's total nitrogen guideline,[4] signifying that the value applies to the Canadian environment.

3.2 Spatial coverage

Data were obtained for nine water quality monitoring stations on the St. Lawrence River, ranging in location from the Quebec–Ontario border in the west to Quebec City in the east (Table 1). Three stations are located on the main stem of the St. Lawrence, while the other six are at or close to the mouths of the river's major tributaries.

Table 1. Water quality monitoring stations used for this indicator

Monitoring station	Station code	Station name	Longitude	Latitude
Carillon	QU02LB9001	Rivière des Outaouais, en aval du barrage de Carillon	-74.37987	45.56757
Lavaltrie	QU02OB9004	Fleuve Saint-Laurent, prise d'eau de l'usine de filtration de Lavaltrie	-73.280645	45.874418
Richelieu	QU02OJ0052	Rivière Richelieu, prise d'eau de l'usine de filtration de Sorel	-73.117582	46.033974
Yamaska	QU02OG3007	Rivière Yamaska, pont de la route 132	-72.910075	46.005059
Saint-François	QU02OF3004	Rivière Saint-François à Pierreville	-72.81218	46.066375
Nicolet	QU02OD3004	Rivière Nicolet à Nicolet	-72.651229	46.245373
Bécancour	QU02OD9009	Fleuve Saint-Laurent, prise d'eau de l'usine de filtration de Bécancour	-72.546012	46.311578
Saint-Maurice	QU02NG3013	Rivière Saint-Maurice, prise d'eau de l'usine de filtration de Trois-Rivières	-72.6105	46.382
Quebec City	QU02PH9024	Fleuve Saint-Laurent, prise d'eau de l'usine de filtration de Lévis	-71.190009	46.807123

3.3 Temporal coverage

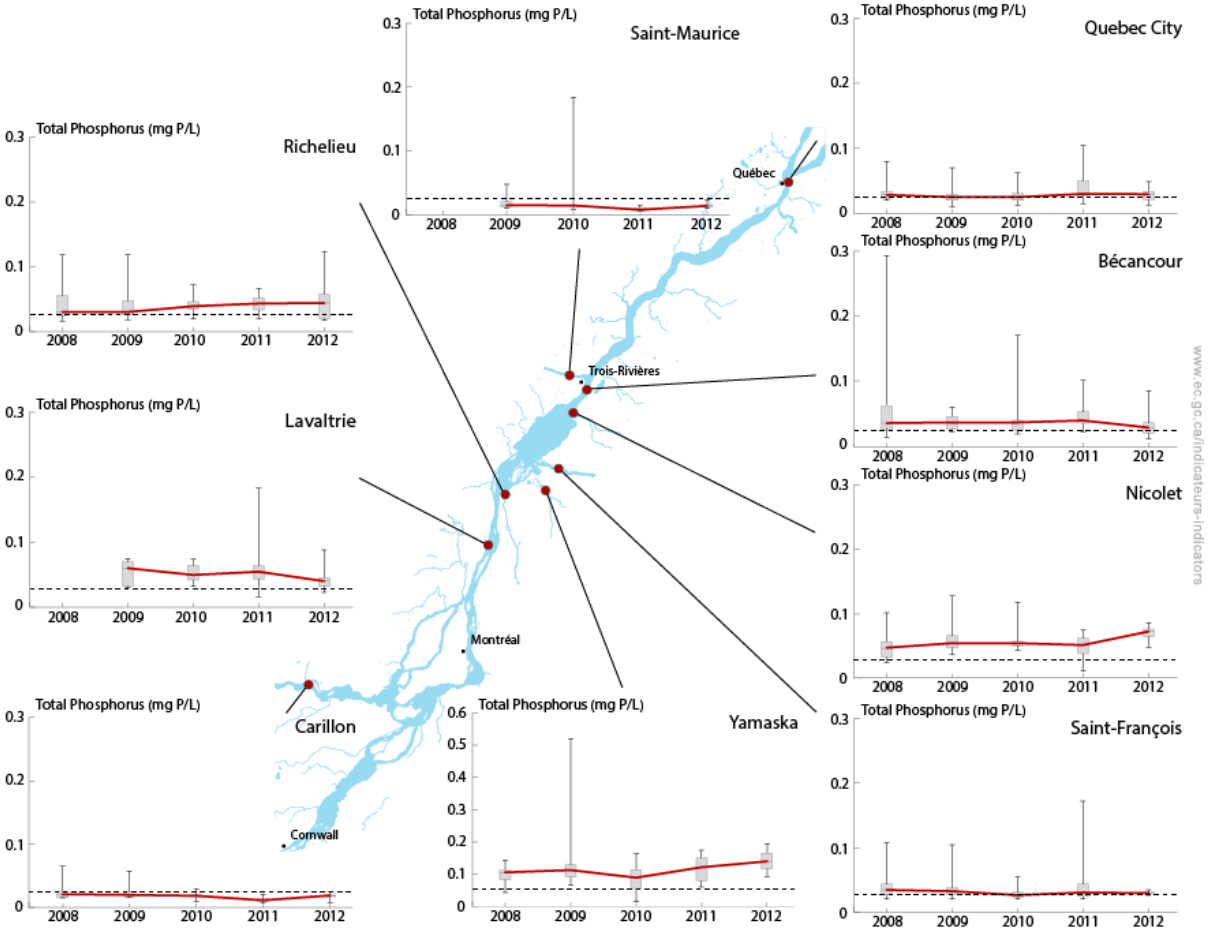
The total phosphorus ratings reported in the indicator are based on measurements from January 2010 to December 2012, the most recent data available. Similarly, the total nitrogen ratings are based on measurements from April 2010 to December 2012, the most recent data available. Data from 2008 for total phosphorus and 2009 for total nitrogen are included in Figures 1 and 2 to illustrate longer-term trends in the total phosphorus and total nitrogen concentrations in the river.

3.4 Data completeness

The sampling frequency at the water quality monitoring stations included in this indicator is not uniform. Sampling at Carillon, Lavaltrie, Bécancour, the mouth of the Saint-Maurice River and Quebec City is conducted monthly. Samples at monitoring stations at the mouths of the Nicolet, Saint-François and Yamaska rivers are collected biweekly from May until the end of September.

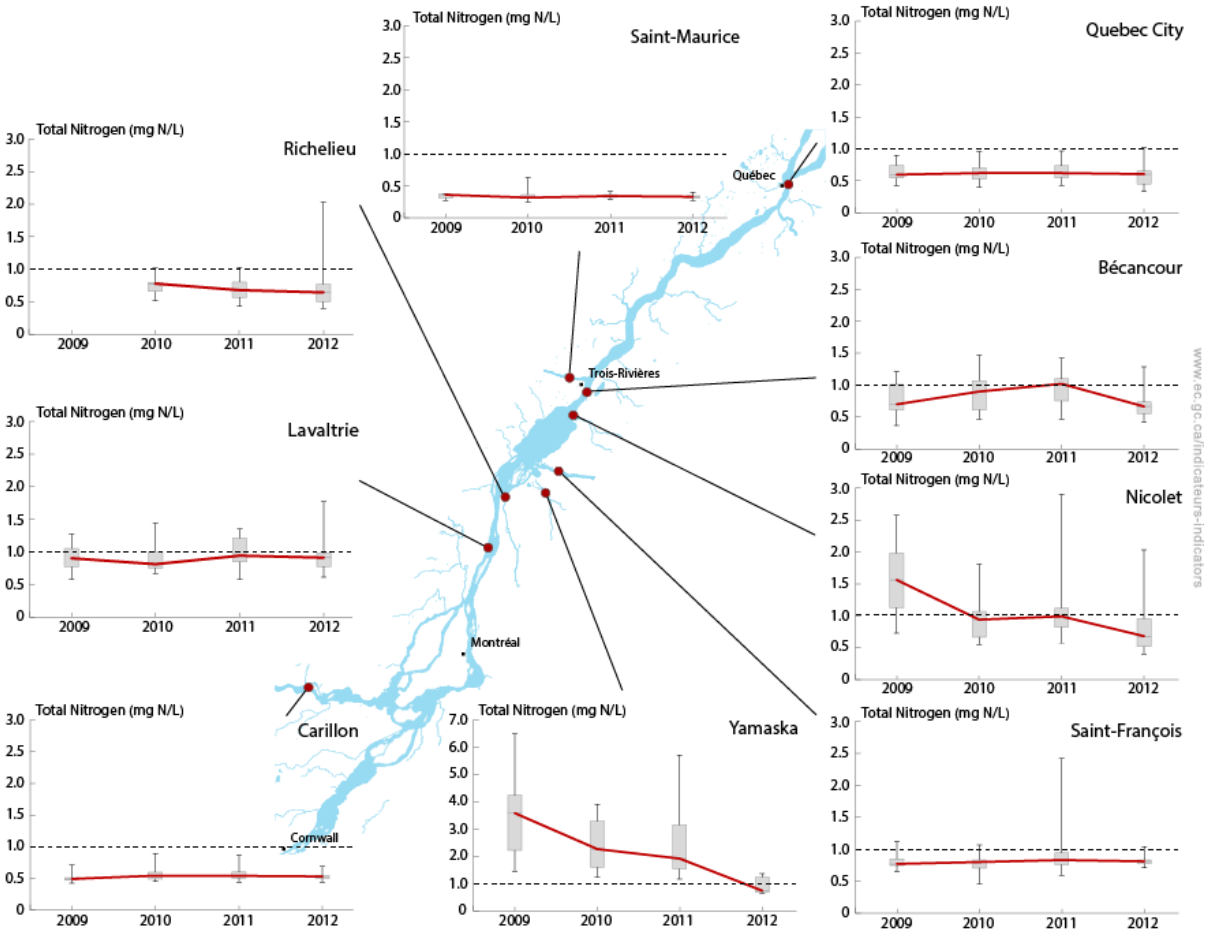
[4] Alberta Environment (1999) Surface water quality guidelines for use in Alberta. Retrieved on 31 March, 2014. Available from: http://environment.alberta.ca/01322.html.

Figure 1. Annual total phosphorus boxplots for nine water quality monitoring stations along the St. Lawrence River, 2008 to 2012



Note: The dotted line shows the guideline value of 0.03 mg P/L. The red line is drawn through the median to give a sense of trends in concentrations.

Figure 2. Annual total nitrogen boxplots for nine water quality monitoring stations along the St. Lawrence River, 2009 to 2012



Note: The dotted line shows the guideline value of 1 mg N/L. The red line is drawn through the median to give a sense of trends in concentrations.

3.5 Data timeliness

The indicator was calculated using data from 2010 to 2012, the most recent data available for all water quality monitoring stations included in this indicator. The lag time between 2012, the last year reported, and the publication of this indicator is due to several intertwining factors, including the time required to analyze the water samples; verify the raw data; compile the data; and analyze, review and report the data.

4 Methods

The phosphorus status for each of the nine water quality monitoring stations was determined by comparing total phosphorus concentrations with Quebec's water quality guideline of total

phosphorus for the protection of aquatic life of 0.03 mg P/L.[5] Data from 2008 for each station are summarized in the boxplots in Figure 1, along with the phosphorus water quality guideline. A line is drawn through the median to give a sense of trends in concentrations.

The nitrogen status for each water quality monitoring station was determined by comparing the total nitrogen concentrations at each station to the water quality guideline for the protection of aquatic life for total nitrogen of 1 mg N/L.[6] Data from 2009 for each station are summarized in the boxplots in Figure 2, along with the total nitrogen water quality guideline. A line is drawn through the median to give a sense of trends in concentrations.

To derive the indicator, the number of times total phosphorus and total nitrogen concentrations exceeded the guidelines were summed over the 3-year period from 2010 to 2012, and the results were divided by the total number of samples collected over the same period. The status of each station was determined by calculating the percentage of samples exceeding the guidelines. Stations with fewer than 10% of samples exceeding the guidelines are given a green water quality status. Stations with 10 to 50% exceedances are given a yellow water quality status because phosphorus or nitrogen may be becoming a problem in these areas. Stations with more than 50% of samples exceeding the guidelines are given a red water quality status.

In rivers, total phosphorus and total nitrogen concentrations will often exceed the guidelines when water levels are high, a situation that occurs most commonly when the snow cover melts in the spring. The 10% cutoff allows for one sample per year in general to exceed the guideline. Thus, a green designation means total phosphorus and nitrogen concentrations are minimally impacted by human development. In contrast, if more than 50% of the samples exceed the water quality guidelines, median total phosphorus and nitrogen concentrations are likely well above the water quality guideline and water quality is being impaired by human activity.

5 Caveats and limitations

The Phosphorus and Nitrogen Levels in the St. Lawrence River indicator reflects the state of water quality in the St. Lawrence River based on total phosphorus and total nitrogen concentrations. These concentrations do not show the effect of spills or other transient events unless these are frequent or long-lasting.

Comparing this indicator with similar indicators for lakes requires a degree of caution. In rivers, total phosphorus concentrations are influenced by suspended particles in the water that increase during high-flow events. High total nitrogen concentrations result from high runoff due to precipitation events, which washes nitrogen out of soils. This situation differs in lake ecosystems as suspended particles generally settle out. It is still reasonable to compare lake and river systems as long as the methods to determine the classifications are clear.

[5] Ministère du Développement durable, de l'Environnement et de la Lutte contre les changements climatiques (2009) Critères de qualité de l'eau de surface : phosphore total (en P). Retrieved on 31 March, 2014. Available only in French from: http://www.mddelcc.gouv.qc.ca/eau/criteres_eau/index.asp.

[6] United States Environmental Protection Agency (2000) Ecoregional Nutrient Criteria Documents for Rivers and Streams: Ecoregion VII: Mostly Glaciated Dairy Region. EPA 822-B-00-018. Retrieved on 31 March, 2014. Available from: http://www2.epa.gov/nutrient-policy-data/ecoregional-nutrient-criteria-documents-rivers-and-streams.

6 References and further reading

6.1 References

Alberta Environment (1999) Surface water quality guidelines for use in Alberta. Retrieved on 31 March, 2014. Available from: http://environment.alberta.ca/01322.html.

United States Environmental Protection Agency (2000) Ecoregional Nutrient Criteria Documents for Rivers and Streams: Ecoregion VII: Mostly Glaciated Dairy Region. EPA 822-B-00-018. Retrieved on 31 March, 2014. Available from: http://www2.epa.gov/nutrient-policy-data/ecoregional-nutrient-criteria-documents-rivers-and-streams.

United Nations Environment Programme's Global Environment Monitoring System, GEMSTAT (2013) Water Quality Index by Country – Statistical help. Retrieved on 31 March, 2014.
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Available only in French from: http://www.mddelcc.gouv.qc.ca/eau/criteres_eau/index.asp.

6.2 Further reading

Environment Canada (2011) Phosphorus at the Mouths of Lake Saint-Pierre Tributaries. Retrieved on 31 March, 2014. Available from: http://www.ec.gc.ca/stl/default.asp?lang=En&n=11281F1B-1.

Environment Canada (2011) Phosphorus in Canada's Aquatic Ecosystems. Retrieved on 31 March, 2014.
Available from: http://www.ec.gc.ca/eaudouce-freshwater/default.asp?lang=en&n=0A77A85E-1.

Governments of Canada and Quebec (2011) St. Lawrence Action Plan 2011–2026 Retrieved on 31 March, 2014. Available from: http://planstlaurent.qc.ca/en/home.html.

6 Annex

Annual total phosphorus boxplots for nine water quality monitoring stations along the St. Lawrence River, 2008 to 2012

Year	Median (mg P/L)	Min (mg P/L)	Max (mg P/L)	Number of samples
Carillon				
2008	0.021	0.015	0.065	14
2009	0.020	0.016	0.058	17
2010	0.019	0.009	0.030	14
2011	0.012	0.008	0.021	14
2012	0.019	0.008	0.025	14
Lavaltrie				
2009	0.060	0.03	0.075	9
2010	0.050	0.032	0.074	12
2011	0.055	0.016	0.183	12

2012	0.040	0.023	0.088	12
Richelieu				
2008	0.030	0.016	0.118	12
2009	0.039	0.018	0.118	10
2010	0.043	0.019	0.072	12
2011	0.044	0.02	0.066	12
2012	0.000	0.017	0.123	12
Yamaska				
2008	0.106	0.044	0.143	19
2009	0.113	0.066	0.520	17
2010	0.090	0.015	0.164	18
2011	0.122	0.060	0.175	14
2012	0.140	0.093	0.195	7
Saint-François				
2008	0.035	0.021	0.108	15
2009	0.033	0.021	0.105	15
2010	0.027	0.021	0.055	15
2011	0.031	0.021	0.172	14
2012	0.030	0.027	0.035	7
Nicolet				
2008	0.046	0.025	0.102	15
2009	0.053	0.036	0.126	15
2010	0.053	0.042	0.116	15
2011	0.050	0.010	0.073	14
2012	0.071	0.047	0.085	7
Saint-Maurice				
2009	0.015	0.01	0.048	10
2010	0.015	0.009	0.184	12
2011	0.008	0.005	0.015	13
2012	0.014	0.01	0.024	12
Bécancour				
2008	0.037	0.013	0.293	12
2009	0.038	0.024	0.062	12
2010	0.038	0.020	0.172	12
2011	0.041	0.024	0.103	12
2012	0.030	0.013	0.087	12
Quebec City				
2008	0.029	0.020	0.080	18
2009	0.025	0.008	0.070	17
2010	0.025	0.013	0.062	17
2011	0.030	0.015	0.104	17
2012	0.030	0.013	0.049	20

Note: Samples from the mouths of the Nicolet, Saint-François and Yamaska rivers are collected from May until the end of September only.

Annual total nitrogen boxplots for nine water quality monitoring stations along the St. Lawrence River, 2009 to 2012

Year	Median (mg N/L)	Min (mg N/L)	Max (mg N/L)	Number of samples
Carillon				
2009	0.492	0.426	0.713	11
2010	0.543	0.450	0.897	14
2011	0.540	0.440	0.870	14
2012	0.530	0.440	0.690	13
Lavaltrie				
2009	0.900	0.58	1.40	9
2010	0.810	0.67	1.44	21
2011	0.940	0.58	1.35	15
2012	0.910	0.61	1.77	12
Richelieu				
2010	0.780	0.520	1.02	17
2011	0.680	0.430	1.03	15
2012	0.645	0.400	2.03	12
Yamaska				
2009	3.58	1.46	6.48	15
2010	2.20	1.25	3.91	30
2011	1.90	1.17	5.70	14
2012	0.750	0.660	1.37	7
Saint-François				
2009	0.770	0.650	1.12	15
2010	0.800	0.460	1.07	30
2011	0.830	0.590	2.42	14
2012	0.810	0.710	1.04	7
Nicolet				
2009	1.560	0.730	2.57	15
2010	0.940	0.550	1.81	30
2011	0.990	0.570	2.90	14
2012	0.680	0.400	2.03	16
Saint-Maurice				
2009	0.360	0.270	0.380	9
2010	0.315	0.243	0.630	12
2011	0.340	0.290	0.417	13
2012	0.330	0.270	0.400	12
Bécancour				
2009	0.700	0.370	1.21	9
2010	0.900	0.470	1.47	21
2011	1.02	0.470	1.42	15
2012	0.665	0.420	1.29	12
Quebec City				
2009	0.595	0.420	0.900	14
2010	0.620	0.400	0.960	31
2011	0.620	0.430	0.970	20
2012	0.605	0.330	1.02	20

Note: Samples from the mouths of the Nicolet, Saint-François and Yamaska rivers are collected from May until the end of September only.

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