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Canadian Environmental Sustainability Indicators: Freshwater Quality Indicator: Data Sources and Methods

2007

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Canadian Environmental Sustainability Indicators: Freshwater Quality Indicator: Data Sources and Methods

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. not available for any reference period
.. not available for a specific reference period
... not applicable
0 true zero or a value rounded to zero
0s value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
p preliminary
r revised
x suppressed to meet the confidentiality requirements of the *Statistics Act*
E use with caution
F too unreliable to be published

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1 Introduction

Canadians' health and their social and economic well-being are fundamentally linked to the quality of their environment. Recognizing this, in 2004, the Government of Canada committed to establishing national indicators of freshwater quality, air quality, and greenhouse gas emissions. The goal of these indicators is to provide Canadians with more regular and reliable information on the state of their environment and how it is linked with human activities. Environment Canada, Statistics Canada, and Health Canada are working together to develop and communicate these indicators. Reflecting the joint responsibility for environmental management in Canada, this effort has benefited from the cooperation and input of the provinces and territories.

This report is part of a suite of documents released under the Canadian Environmental Sustainability Indicators (CESI) initiative.[1] Each indicator reported in a given year under the CESI has an associated "data sources and methods" report to provide technical details and other background to facilitate interpretation of the indicator or allow others to build further analysis using the CESI data and methods as a starting point.

The information in this report should be used to ensure a clear understanding of the basic concepts that define the information provided in the freshwater quality indicator, of the underlying methodology, and of key aspects of the data quality. This information will provide users with a better understanding of the strengths and limitations of the data, and of how they can be effectively used and analysed. The information is of particular importance when making comparisons with data from other indicators, and in drawing conclusions regarding change over time.

This report deals with the underlying methods and data for the freshwater quality indicator as it was reported in 2007.

2 Description of the indicator

The freshwater quality indicator provides an overall measure of the suitability of water bodies to support aquatic life at selected monitoring sites in Canada. The indicator is based on applications of the Water Quality Index (WQI) endorsed by the Canadian Council of Ministers of the Environment (CCME) in 2001 (CCME, 2001). Given that aquatic life can be influenced by the presence of hundreds of both natural and anthropogenic substances in water, the WQI provides a useful tool that allows experts to translate vast amounts of water quality monitoring information into a simple overall rating.

In 2007, the freshwater quality indicator was presented as southern Canada and northern Canada histograms, and for major drainage areas, as histograms based on site specific calculations of the index for the 2003 to 2005 period. These histograms group WQI values into five categories: poor, marginal, fair, good, and excellent.

The WQI measures the frequency and extent to which selected parameters exceed water quality guidelines at individual monitoring sites. Water quality guidelines are numerical values for physical, chemical, radiological, or biological characteristics of water that indicate that adverse effects may be occurring when exceeded.[2] The water quality guidelines used in the calculations

1. http://www.environmentandresources.gc.ca and www.statcan.ca.
2. Guidelines are specific to particular water uses, such as protection of aquatic life, crop irrigation, livestock watering, drinking water, and recreation.

are those defined for the protection of aquatic life. They include national guidelines developed by the CCME, as well as provincial and site-specific guidelines developed by federal, provincial, and territorial partners. If a guideline value is exceeded at a given site, there is an increased probability of an adverse effect on aquatic life at that site.

The WQI reflects the potential for substances to impact aquatic life based on existing knowledge of toxicity and predicted fate and behaviour of chemical substances. It is not a direct measure of changes to aquatic communities, such as changes in the composition or abundance of benthic invertebrates or fish.

In aquatic ecosystems, water quality naturally varies seasonally and annually. For example fluctuations in weather, such as the timing and amount of precipitation, affects erosion in the drainage area and water levels and flows. Thus, the WQI is calculated for a period of three years (2002 to 2004) to dampen the effect of seasonal variability on the WQI score.

3 How the WQI for aquatic life is used

The Canadian Environmental Sustainability Indicators (CESI) 2007 report provides policy analysts, decision makers and the public with national and regional pictures of the status of water quality for the protection of aquatic life.

On a regional level, the CCME WQI has been used by many organizations and jurisdictions, such as watershed conservation groups, the media, and territorial, provincial, and federal government agencies, to inform the public, decision makers, and relevant stakeholders on the status and trends of local water bodies (British Columbia Ministry of Environment (BCMOE), 1996; Alberta Environment, 2002; Grand River Conservation Authority, 2004; Khan *et al*., 2004; CCME, 2005a; Environment Canada, 2005a; and Lumb *et al*., 2006, EC, BCMOE, YDOE 2007, Ottawa Citizen 2007). It has also been used to track the effectiveness of remedial measures on local water quality (Glozier *et al*., 2004 and Wright *et al*., 1999) and to report on the effectiveness of government programs and policies (Alberta Environment, 2002).

Although the CCME provides general guidance on using the index (www.ccme.ca), practitioners are responsible for deciding which parameters, guidelines, time periods, and number of samples to include in a given application of the index. As a result of this flexibility, different approaches have been used to apply the index to achieve different objectives. For example, the British Columbia Ministry of the Environment (1996) used site-specific guidelines to evaluate the suitability of water quality to support different beneficial uses, using the most recent three years of data. Glozier *et al*. (2004) applied the index using background concentration[3] values from reference sites[4] to assess change in status and trends for downstream sites. In this work, trends were calculated as rolling values based on blocks of five years of samples (for example, 1983 to 1987 and 1984 to 1988), while status was assessed for a 20-year period. In contrast, Wright *et al*. (1999) used background concentration values from a given time period (rather than reference sites) as benchmarks for the index to assess changes in water quality over time. Site-specific guidelines are developed because of the differences that exist between different aquatic ecosystems in terms of natural background, chemical interactions between water quality parameters, etc.

As a result of this flexibility in applying the index, a protocol for calculating the WQI ratings across Canada for this initiative was developed (Environment Canada, 2005b). For 2007, however, there remains variation in the applications of the WQI across Canada (see section 6).

3. The concentration of a naturally occurring water quality constituent, not influenced by human activity.
4. An area considered to be relatively unaffected by human activity.

4 How the indicator is calculated

The freshwater quality indicator is based on the application of the CCME WQI across Canada at 395 monitoring sites (streams, rivers, and lakes) using ambient water quality monitoring data for the 2003 to 2005 period, and relevant water quality guidelines for the protection of aquatic life. Of the 395 sites, 36 are located in northern Canada and 359 in southern Canada. The resulting ratings are each categorized as one of five categories (poor, marginal, fair, good, and excellent). These results are presented as histrograms: a national one for the South, one for the North, and one for each of the major drainage basins that had sufficient data.

4.1 Changes from previous period (2006 report)

A number of changes to the 2006 freshwater quality indicator were undertaken in 2007. The following list provides an overview of these changes, most of which are described in more detail in the subsequent sections:

- In total, there were 43 new sites added to the 2007 report, while 18 were not included due to reduced or discontinued monitoring. For the South, 37 new sites were added and 18 were not continued. In the North, there were 6 new sites added.
- An exception was made for including 10 sites (1 in New Brunswick and 9 in Manitoba) that had slightly fewer samples than the minimum criteria.
- Water quality results for the Great Lakes were not updated for the 2007 report as no new data were available at the time of preparation of the report.
- Presentation of the results by major drainage areas (where minimum data was sufficient).

4.2 Formulation of the CCME Water Quality Index

The CCME WQI relates water quality data to the various beneficial uses of water[5] using relevant water quality guidelines as benchmarks. Each index is calculated for an individual monitoring site during a chosen reference period. Water samples collected over this period of time are analyzed for a suite of water quality parameters. The measured values of each parameter are compared to the appropriate water quality guideline (Appendix 1). These are called tests. The percentage of parameters and tests that fail to meet the guidelines, as well as the deviation from the guideline for tests that do not meet guidelines, are captured in three factors used in the calculation of the index. These factors are scope (F_1), frequency (F_2), and amplitude (F_3). The index yields a number between 0 and 100. A higher number indicates better water quality.

CCME WQI formula

$$\text{CCME WQI} = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right)$$

5. These uses are: protection of aquatic life, drinking water, livestock watering, crop irrigation, and recreational use (CCME, 1999).

Scope (F_1)

The scope factor represents the percentage of the total number of parameters that fail to meet the water quality guidelines at any time during the reference period.

$$F_1 = \left(\frac{\text{number of failed parameters}}{\text{total number of parameters}} \right) \times 100$$

Frequency (F_2)

The frequency factor represents the percentage of individual tests that fail to meet the water quality guidelines.

$$F_2 = \left(\frac{\text{number of failed tests}}{\text{total number of tests}} \right) \times 100$$

A failed test occurs when an individual parameter value within a sample exceeds the guideline. The total number of failed tests represents the total number of failed parameter values in every sample during the reference period. The total number of tests for an individual site is calculated by multiplying the average number of parameters per sample by the total number of samples during the reference period.

Amplitude (F_3)

The amplitude factor represents the average deviation of failed test values from their respective guidelines. The relative deviation of a failed test from the guideline is termed an excursion and is calculated as follows:

I. When the test value must not exceed the guideline:

$$\text{excursion}_i = \left(\frac{\text{failed test value}_i}{\text{guideline value}_i} \right) - 1$$

II. When the test value must not fall below the guideline:

$$\text{excursion}_i = \left(\frac{\text{guideline value}_i}{\text{failed test value}_i} \right) - 1$$

The collective amount by which individual tests are out of compliance is calculated as follows:

$$\text{nse} = \frac{\sum_i \text{excursion}_i}{\text{total number of tests}}$$

where nse is the “normalized sum of the excursions” from the guidelines. The F_3 factor is then calculated by a formula that scales the nse to yield a range between 0 and 100.

$$F_3 = \frac{\text{nse}}{(0.01\text{nse} + 0.01)}$$

The rating system of index values

The WQI yields a number between 0 and 100 that is indicative of the overall water quality for a particular use (Text table 4.1).

Text table 4.1
The rating system of the CCME WQI values

Rating	Interpretation
Excellent (95.0 to 100.0)	Water quality measurements **never** or **very rarely** exceed water quality guidelines.
Good (80.0 to 94.9)	Water quality measurements **rarely** exceed water quality guidelines and, usually, by a narrow margin.
Fair (65.0 to 79.9)	Water quality measurements **sometimes** exceed water quality guidelines and, possibly, by a wide margin.
Marginal (45.0 to 64.9)	Water quality measurements **often** exceed water quality guidelines and/or by a considerable margin.
Poor (0 to 44.9)	Water quality measurements **usually** exceed water quality guidelines and/or by a considerable margin.

Note(s): These interpretations are adapted from those endorsed by the CCME (2001), based on the initial assessment of over 100 sites by several water quality experts in British Columbia (Rocchini and Swain, 1995).

4.3 Data preparation and presentation

The data used to calculate the freshwater quality indicator were derived from water samples collected at sites across the country from 2003 to 2005. Data were combined to calculate a single index value for each site using the equations described in section 4.2. The steps below, which are described in more detail in section 5, were followed in carrying out the calculations:

1. Selection step:
    a. Selection of sites
    b. Selection of parameters
    c. Selection of relevant national, regional, or site-specific guidelines
    d. Number of samples, timing, and collection period

2. Calculation step:
    a. Extraction of data
    b. Validation of data
    c. Calculation of index

The index values for each site were then classified into the five quality categories of the WQI (refer to Text table 4.1) and presented in a histogram as the freshwater quality indicator for northern Canada and southern Canada , separately. The line delineating the North is based on a series of climatic, biotic, and socio-economic aspects (McNiven and Puderer, 2000). A more detailed presentation of the results for sites in the North and the South is also made by the use of major drainage areas. These are based on the Major Drainage Areas, as defined by the Water Survey of Canada, except for the Newfoundland and Labrador Drainage Area which was modified to better reflect the natural flow of water to the Atlantic Ocean and be consistent with oceanic drainage basins. Histograms for each basin were further subdivided by sites located in the North and in the South. Only basins showing a minimal number of sites were considered.

5 Data sources – Review and selection

Water quality data used in the calculation of the freshwater quality indicator in the CESI 2007 report were obtained from a number of existing water quality monitoring programs across the country (Text table 5.1). These programs are managed by federal departments, provincial departments, and under federal-provincial agreements. They were originally established for many different reasons. Currently, there is no national network of water quality monitoring sites designed specifically for the purposes of reporting the state of Canada's water quality in a fully representative way at different geographic scales across Canada.

Text table 5.1
Monitoring programs that provided data on ambient water quality from 2003 to 2005

Province/territory	Monitoring program	Organization(s)
Alberta	Long-term River Network Monitoring Program	Alberta Environment
Alberta	Prairie Provinces Water Board	Environment Canada, Alberta Environment
British Columbia	Canada–British Columbia Water Quality Monitoring Agreement	British Columbia Ministry of Environment, Environment Canada
British Columbia and Yukon	Federal Water Quality Monitoring Program	Environment Canada
Manitoba	Prairie Provinces Water Board, Canada–Manitoba Water Quality Monitoring Agreement	Environment Canada, Manitoba Conservation
Manitoba	International Red River Pollution Board, Federal Water Quality Monitoring Program	International Red River Board, including Environment Canada and Manitoba Conservation
Manitoba	Ambient water quality monitoring network	Manitoba Conservation
New Brunswick	Canada–New Brunswick Water Quality Agreement	Environment Canada, New Brunswick Department of Environment and Local Government
New Brunswick	Long-range Transport of Atmospheric Pollutants	Environment Canada
New Brunswick	Surface water monitoring network, National Parks project	New Brunswick Department of Environment and Local Government
Newfoundland and Labrador	Canada–Newfoundland Water Quality Monitoring Agreement	Environment Canada, Newfoundland and Labrador Department of Environment and Conservation
Nova Scotia	Long-range Transport of Atmospheric Pollutants	Environment Canada

Text table 5.1 - suite
Monitoring programs that provided data on ambient water quality from 2003 to 2005

Province/territory	Monitoring program	Organization(s)
Nova Scotia	Pockwock–Bowater Watershed Study	Nova Scotia Department of Environment and Labour
Nova Scotia	Canadian Wildlife Service, park survey, Maritimes	Environment Canada
Ontario	Provincial Water Quality Monitoring Network	Ontario Ministry of the Environment
Ontario	Great Lakes Surveillance Program	Environment Canada
Prince Edward Island	Canada–Prince Edward Island Water Quality Agreement	Environment Canada, Prince Edward Island Department of Environment, Energy and Forestry
Quebec	Réseau-Rivières	Ministère du Développement durable, de l'Environnement et des Parcs du Québec
Quebec	The State of the St. Lawrence Monitoring Program	Environment Canada
Saskatchewan	Prairie Provinces Water Board	Environment Canada, Saskatchewan Environment
Saskatchewan	Souris River Bilateral Agreement, Federal Water Quality Monitoring Program	International Souris River Board, including Environment Canada and Manitoba Conservation
Northwest Territories and Nunavut	Northwest Territories-Nunavut extensive water quality monitoring network; Northern Energy MC aquatic quality network—Northwest Territories portion of Mackenzie River Basin; Alberta-Northwest Territories transboundary rivers water quality monitoring program; EC-Parks Canada Northern bioregion national parks programs (seven national parks in Northwest Territories-Nunavut-northern Yukon: Nahanni, Tuktut Nogait, Aulavik, Ivvavik, Quttinirpaaq, Auyuittuq, Ukkusiksalik); EC-Fisheries and Oceans Canada Lower Hornaday River water quality monitoring program. Indian and Northern Affairs Canada water quality programs in Northwest Territories basins with Northern Development (Coppermine, Yellowknife, Lockhart, Slave, Hay, Liard, Peel, Snare, Burnside River basins)	Environment Canada, Indian and Northern Affairs Canada, Parks Canada, Fisheries and Oceans Canada, Alberta Environment, Government of Northwest Territories (Environment and Natural Resources), Government of Nunavut (Department of Sustainable Development)
Nunavut	See above	See above

Each program monitors a specific array of parameters designed to suit the program's objectives and resource constraints. These monitoring programs track ambient concentrations[6] of major ions[7] (for example, chloride and sulphate), nutrients (for example, phosphorus and nitrogen), metals (for example, mercury), organic compounds (including pesticides and industrial chemicals), and other parameters (for example, dissolved oxygen, suspended solids and pH). Sampling frequencies also differ among networks, with program needs, resource constraints, and ease of access to sites being important determinants.

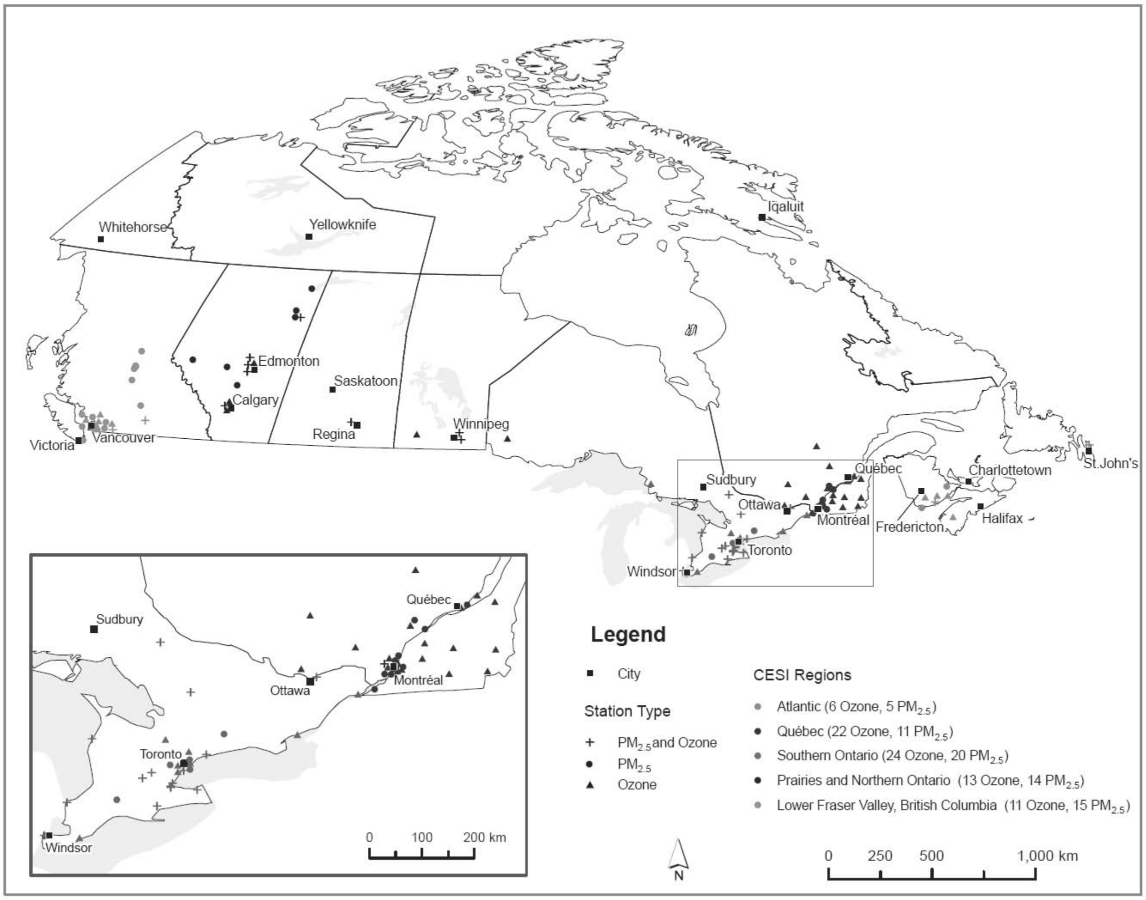
5.1 Site selection

For the freshwater quality indicator in the CESI 2007 report, data from 395 sites across all provinces and territories were selected from the available water quality monitoring sites that met the desired sampling frequency for the 2003 to 2005 period. Different sampling frequency criteria were applied to sites in the North and those in the South (section 5.4).

The 62 sites in the acid rain monitoring program in the Atlantic region were grouped into 7 clusters. This was done to reduce the influence on the national indicator of these numerous small and neighbouring sites, all subject to the same specific water quality concern. The sites were grouped into clusters based on their proximity. For the lakes in each cluster, the average WQI score, weighted by lake area, was calculated. The average lake area for each cluster was also calculated. The lake in each cluster with an area and WQI score closest to the average was selected to represent all sites in that cluster. Other sites in the cluster were then cut from the dataset. For those clusters with river sites, one river of average WQI score and flow was selected to represent the rivers of that cluster.

6. Concentration of substances in the aquatic environment, as opposed to effluent discharges.
7. Positively or negatively charged molecules that occur naturally in water as a result of geochemical weathering of rocks, surface runoff, and atmospheric deposition. The eight major ions—calcium, magnesium, sodium, potassium, bicarbonate, carbonate, sulphate, and chloride—account for most of the total dissolved solids in surface waters.

Figure 5.1
Locations of CESI 2007 water quality monitoring sites across Canada



Note(s): The "North line" is based on a statistical area classification of the North by Statistics Canada, reflecting a combination of 16 social, biotic, economic and climatic characteristics that delineate north from south in Canada (McNiven and Puderer 2000).

Source(s): Monitoring station information assembled by Environment Canada and Statistics Canada from federal, provincial and joint water quality monitoring programs.

5.2 Parameter selection

The parameters used in the WQI calculations can be linked to the main stressors on water quality across Canada, including urban development, agriculture, forestry, mining, smelting, pulp and paper mills and other industrial facilities, deposition of atmospheric pollutants, and dams (Environment Canada, 2001).

Decisions regarding parameters to use for national reporting of the WQI were made by provincial, territorial, and federal water quality experts. The decisions were based on local knowledge of stressors potentially affecting water quality in the region, or at each site, using available monitoring data for 2003 to 2005. Only parameters relevant to the protection of aquatic life were included. This excludes bacterial counts, for example, which are primarily of concern for human health. For all jurisdictions except British Columbia, a common suite of parameters was applied to all sites within the jurisdiction or monitoring program. Site-specific selections of parameters were made in British Columbia, with four parameters (dissolved oxygen, phosphorus, pH, water temperature) included at each site wherever available (refer to Text table 6.2 for details regarding the parameters used in each jurisdiction).

5.3 Guideline selection

Nationally, guidelines are developed according to the methodology outlined by the CCME science-based protocols for guideline derivation and endorsed by the CCME (CCME, 1991). Some provinces and territories have directly adopted the CCME guidelines for their needs, while others have developed their own guidelines using similar protocols to those of the CCME. Typically, water quality guidelines are based on laboratory toxicity studies showing effects on various aquatic life (fish, invertebrates, plants) from different concentrations of a constituent in the water.

For the CESI 2007 report, calculation of the freshwater quality indicator relied largely on the use of existing water quality guidelines for the protection of aquatic life. Most of the guidelines used are based on chronic exposure. In a few instances, guidelines were applied for short-term exposure[8]. Guidelines were selected on a site-specific or jurisdictional basis by teams of regional water quality experts from the suite of generic guidelines available from various sources[9] and from existing site-specific guidelines for the parameters of local interest (Appendix 1). The principle behind guideline selection is to choose those that are most "locally relevant", meaning appropriate to local aquatic life. Background levels of naturally occurring substances and other characteristics of water, such as hardness and temperature, can affect the toxicity of some of the substances of concern. It is recognised, however, that generic guidelines (that is, those not derived for a specific site) are often conservative to provide a high level of protection through the use of uncertainty factors, depending on the quality and availability of toxicological information for the substance. Thus, natural concentrations of some substances may exceed these guidelines.

Site-specific guidelines based on background concentration procedure (CCME, 2003) were used in the Northwest Territories and some Nunavut sites (that is, rivers). In these cases, the upper range of the local natural background level for selected parameters was statistically estimated and found to be greater than the recommended guideline. The CCME Canadian Water Quality Guidelines were found to be locally relevant and used at a few sites on watercourses near outlets of lakes (for example, Great Bear Lake, Lake Hazen).

The rapid assessment approach[10], another site-specific method for areas with high natural background levels (for example, turbidity), was used to generate a benchmark based on long-term monitoring data (not toxicity studies). This approach was carried out for many parameters for sites in British Columbia and may be done in future in other areas (for example, Northwest Territories).

5.4 Sample numbers, timing and collection period

Annual fluctuations in meteorology and hydrology can have a considerable impact on water quality and, consequently, on the resulting index ratings when applied for individual years. Thus, ratings were based on three years of data in order to dampen temporal variability and reflect a

8. In Quebec, the guideline used for turbidity is for short-term (acute) exposure.
9. Sources include Prairie Provinces Water Board (PPWB), 1992; Ontario Ministry of the Environment (OMOE), 1994; CCME, 1999; Alberta Environment, 1999; BCMOE, 2001; Le ministère du Développement durable, de l'Environnement et des Parcs (MDDEP) du Québec, 2006; Williamson, 2002; and United States Environmental Protection Agency (USEPA), 2005.
10. See Environment Canada, 2006. *Technical guidance document for Water Quality Index practitioners reporting under the Canadian Environmental Sustainability Indicators (CESI) initiative* – 2006 update. Ottawa. Available upon request.

more general state of water quality. The years 2003 to 2005 were the most recent available years across all monitoring programs.

Minimum sample numbers for the three-year reporting period were established for lake, river and northern sites (Text table 5.2). Sites that did not meet these minima were excluded from the national reporting of the indicator in the CESI 2007 report.

Text table 5.2
Sample frequency requirements for WQI application in the 2007 CESI report

Water body	Minimum requirements
Lakes	6 samples for the 2003 to 2005 period
Rivers	12 samples for the 2003 to 2005 period
Northern rivers	9 samples for the 2003 to 2005 period

In temperate lakes, the water column can become thermally stratified, or layered by temperature, during the summer and winter. Mixed conditions are typical during early spring and late fall. Chemical contaminants can also stratify in lakes, with their concentrations being determined in part by water density, which is in turn determined by water temperature. Lakes were sampled at least twice annually, once in the spring and once in the fall. If these spring and fall samples were not available, several samples were taken at various depths during another season. The results of these samples were weighted by the volume of water at the sampled depths and then averaged. Weighting by volume, however, was not always possible. As a final option, samples were taken at the surface of the lake.

In rivers and streams, surface sampling is generally considered to be representative of the water column, which is normally well mixed. However, sampling may need to be repeated more often throughout the year to better capture water quality variability. The CCME technical guidance document (CCME, 2001) recommended a minimum of four samples per year, accounting for seasonal or hydrological variability, based on the original testing of the index.

In northern and remote locations, routine water sampling can be costly and challenging, as it is sometimes dangerous and difficult to access sites, and weather conditions can be extreme. As a result, monitoring sites are often sampled less frequently. In addition, a sensitivity analysis conducted on several northern rivers revealed that having fewer samples (that is, 9) than the required minimum (12) in a three-year period did not produce WQI scores that were significantly different (Glozier *et al.*, pers. comm.). For these reasons, the minimum sampling frequency for rivers in the North was reduced from 12 (as used in southern Canada) to 9 for the 2003 to 2005 period and reported separately. These criteria apply to sites that fall north of a line delineated by McNiven and Puderer (2000).

5.5 Data management, calculation and verification

Water quality data from each of the monitoring programs are stored in provincial or federal databases, managed by the respective environment departments. Basic site information (for example, name and location) and water quality data were extracted from available databases, by regional and provincial data providers, and transferred to "WQI calculators" that is, spreadsheets programmed to calculate WQI ratings. These calculators allow users to select input parameters, guidelines, and sample periods (with options allowing guidelines to be modified by hardness, pH, or temperature, when appropriate).

Suspected outliers in the datasets were identified and validated by verifying field forms and books to check for accuracy of data entry, by ensuring that reported units were correct, by consulting stream flow and meteorological records, and/or by comparing with the levels of other parameters in the dataset (for example, turbidity, total suspended solids, major ions) that could explain the unusually high or low values of some parameters. Unless identified as likely erroneous, outliers were left in the dataset.

After validation of the dataset, calculations were verified and then peer reviewed. Environment Canada experts then transferred site information, WQI ratings and details on the application (that is, data source, parameters, guidelines, sample numbers and dates, and contact information) onto templates for incorporation into a central database. Statistics Canada experts reviewed site data to ensure that the number of samples, timing, and locations met the methodology requirements. This information was then used to generate the freshwater quality histograms and map of monitoring site locations by staff at Statistics Canada, the National Water Quality Monitoring Office, and the Strategic Information Integration Directorate of Environment Canada.

The ratings and calculation methods (that is, parameters included, guidelines used, site information) compiled into the national database were then verified for each site by each data provider to detect any errors introduced during the integration of this information.

6 Caveats and limitations of the indicator and data quality

6.1 Site selection

It is recognized that the current collection of monitoring networks was not designed to be representative of Canada and all its watersheds, but to respond to specific federal, provincial, or regional needs. Monitoring sites included in this analysis are almost all located in populated areas and other areas for which it is suspected that water quality is affected by surrounding land uses and other potential stressors, including acid rain deposition, dams, and industries (for example, pulp and paper and mines). Even so, sites do not comprehensively cover all geographic areas with potential water quality issues or problems across Canada.

From a coverage standpoint, it is unknown what percentage of Canadian lakes and rivers by geographic area or stream flow, is currently represented by the existing 395 monitoring sites. Additionally, each site was weighted equally and independently regardless of location. The only exception to this is the 62 clustered lakes in New Brunswick and Nova Scotia that were aggregated into 8 scores (2 in New Brunswick and 6 in Nova Scotia). One of the two New Brunswick lakes should not have been included in 2007 as they are both located in the same cluster, however this led no significant impact on the indicators results.

Text table 6.1
Number of sites in each jurisdiction in the freshwater quality indicator in 2007

	River sites		Lake sites	
	North	South	North	South
	number			
British Columbia	1	29	0	0
Alberta	5	24	0	0
Saskatchewan	1	3	0	0
Manitoba	2	32	6	0
Ontario	0	89	0	0
Quebec	0	120	0	0
New Brunswick	0	27	0	2
Nova Scotia	0	2	0	6
Prince Edward Island	0	8	0	0
Newfoundland and Labrador	6	15	0	2
Yukon	2	0	0	0
Northwest Territories	11	0	0	0
Nunavut	2	0	0	0
Total – Canada	**30**	**349**	**6**	**10**

Text table 6.2
Number of sites in each major drainage area in the freshwater quality indicator in 2007

	River sites		Lake sites	
	North	South	North	South
	number			
Maritime Provinces drainage area (01)		37		8
St. Lawrence drainage area (02)		209		
Nelson River drainage area (05)	3	52	5	
Western and Northern Hudson Bay	1	2	1	
Great Slave Lake drainage area (07)	10	5		
Pacific drainage area (08)	1	29		
Arctic drainage area (10)	9			
Newfoundland and Labrador drainage area	6	15		2
Total – Canada	**30**	**349**	**6**	**10**

6.2 Parameter selection

The type and number of parameters included in the WQI calculations differed across the water quality monitoring sites and/or jurisdictions. This flexibility allowed the specific local and regional water quality concerns and objectives of the monitoring programs to be reflected in the WQI scores. However, these differences in parameter selection among jurisdictions/sites make comparability of sites for national aggregation uncertain. It was recommended that between 4 and 15 parameters be measured for the WQI calculation, and this guidance was followed (Environment Canada, 2005b). A recent sensitivity analysis, however, shows that the use of approximately 10 parameters may yield the most stable WQI results (Painter and Waltho, 2005).

In addition, not all possible stressors were sampled everywhere, for several reasons: 1) the random nature of some releases (for example, unknown or accidental spills); 2) some substances are tracked in other media, such as sediment or fish tissue, that provide more reliable measures; and 3) the high cost of measuring on a routine basis (for example, for organic substances).

For the Pacific and Yukon Region, metals were removed from the WQI calculation when conditions at a given site were highly turbid. The rationale behind this is the expectation that the high concentrations of metals measured during such events are due to the suspended sediments. These metals are not generally available for biological uptake, and, as such, likely do not pose the same risk to aquatic life as dissolved metals.

Text table 6.3
Parameters used in each jurisdiction or program for the water quality index calculation in 2007

Parameter[1]	B.C.	Alta.	Sask.[3]	Man.	Ont.	Que.	N.B.	N.S.	P.E.I.	N.L.	Y.T.	N.W.T.	Nvt.
Alkalinity	B	…	…	…	…	…	…	…	…	…	…	…	…
Aluminum	…	B[2]	…	…	…	…	…	…	…	…	…		…
Ammonia	…	A	A	A	A	A	B	…	…	…	…	B	A
Antimony	B	…	…	…	…	…	…	…	…	…	…	…	…
Arsenic	B	B	A	A	…	…	B	…	…	A	…	B	…
Cadmium	B	B[2]	…	B[2]	…	…	…	…	…	…	B	…	…
Chloride	B	B[3]	A	B[3]	A	…	A	A	…	…	…	A	A
Chlorophyll	…	…	…	…	…	A	…	…	…	…	…	…	…
Chromium	B	…	…	…	A	…	…	…	…	A	B	B	…
Copper	B	A	A	A	…	…	A	A	…	A	A	A	A
Cyanide	B	…	…	…	…	…	…	…	…	…	…	…	…
Dissolved oxygen	B	A	A	A	…	…	B	…	A	…	…	B	…
Fluoride	B	…	…	…	…	…	…	…	…	…	…	…	…
Iron	B	B	…	B[2]	…	…	A	A	…	A	…	A	A
Lead	B	A	A	A	…	…	…	A	…	A	B	A	A
Manganese	B	…	…	…	…	…	…	…	…	…	…	…	…
Mercury	…	B[2]	…	…	…	…	…	…	…	…	…	…	…
Molybdenum	B	…	…	…	…	…	…	…	…	B	…	…	…
Nickel	B	B[3]	A	A	A	…	…	…	…	A	…	…	…
Nitrate	B	…	…	B[2]	A	…	A	A	A	…	A	…	…
Nitrite	B	…	…	…	…	…	…	…	…	…	A	B	…
Nitrate + Nitrite	B	B	…	…	…	A	…	…	…	…	…	B	A
Nitrogen	B	B	A	B[3]	…	…	…	…	…	…	…	…	…
Pesticide – 2,4-D	…	B	A	B	…	…	…	…	…	…	…	…	…
Pesticide – MCPA	…	B	A	B	…	…	…	…	…	…	…	…	…
pH	B	B[3]	A	A		A	A	A	A	A	A	A	A
Phosphorus	B	A	A	A	A	A	A	B	A	A	A	A	A
Selenium	B	B[2]	…	…	…	…	…	…	…	B	…	…	…
Silver	B	…	…	…	…	…	…	…	…	…	A	…	…
Sulphate	B	…	…	…	…	…	…	…	…	…	B	…	…
Suspended solids	…	…	…	B[2]	…	…	…	…	A	…	…	…	…
Temperature	A	…	…	…	…	…	…	…	…	…	A	…	…
Thallium	B	…	…	…	…	…	…	…	…	…	…	…	…
Turbidity	…	…	…	…	…	A	B	…	…	…	…	…	…
Zinc	B	A	A	A	A	…	B	A	…	A	A	A	..

1. Parameters marked with an 'A' were tested at all sites in the province or territory; those marked with 'B' were only tested at selected sites.
2. Tested only at sites from provincial monitoring programs.
3. Tested only at sites from federal monitoring programs.

6.3 Guideline selection

To some extent, exceedances from all parts of Canada for naturally occurring substances (for example, phosphorous, total suspended solids, and metals) can be due to naturally occurring phenomena, rather than human influence only (Appendix 1 provides a listing of water quality guidelines used in each jurisdiction).

In most cases, metal guidelines are based on measuring total (or extractable) rather than dissolved metals. This conservatively assumes that the full measured amount of the compound is available to be taken up by organisms. However, metals in unfiltered water may be bound to particulates or colloidal molecules and, depending on the chemical species in question, organic materials, making them less bio-available than suggested by a measure of total metals.

6.4 Sample timing and frequency

There is variation in timing and frequency of sampling among monitoring programs. Some programs are more intensive to capture the full range of variability/seasonality that is inherent to each site, while others are less intensive, more opportunistic, and/or random, due to resource constraints and the remote nature of some sites. It is not known currently if this poses a problem or creates a bias for the overall indicator. The three-year time period selected as the basis for the indicator accounts for some of this variation and helps to reduce the potential for some sites to “misrepresent” water quality on an annual basis.

A sensitivity analysis conducted on several northern rivers revealed that having fewer samples (that is, 9) than the required minimum (12) in a three-year period did not produce WQI scores that were significantly different (Glozier *et al*., pers. comm.).

A sensitivity analysis for southern Ontario streams suggests that more than 12 samples over three years could be required to produce more reliable calculations (Painter and Waltho, 2005).

Text table 6.4
Minimum and maximum number of samples for all sites by jurisdiction

	Samples			
	Lakes		Rivers	
	Minimum	Maximum	Minimum	Maximum
	number			
British Columbia	…	…	17	146
Alberta	…	…	13	37
Saskatchewan	…	…	12	36
Manitoba	8	9	9	36
Ontario (excluding the Great Lakes)	…	…	8	61
Quebec	…	…	20	41
New Brunswick	6	6	11	17
Nova Scotia	6	7	153	155
Prince Edward Island	…	…	23	26
Newfoundland and Labrador	12	16	9	25
Yukon	…	…	50	78
Northwest Territories	…	…	8[1]	32
Nunavut	…	…	7[1]	9
Canada	**6**	**16**	**7[1]**	**155**

1. Three sites in NT and NU are hybrid lotic-lentic sites located at the outflow of large lakes.

There were 11 exceptions made to the minimum 12 samples for the 2003 to 2005 period. Ten sites in Manitoba were sampled only three times per year due to limited accessibility. Local specialists were confident that the site scores were reliable because of the long monitoring history at these sites. Another exception was for a site in New Brunswick where only one sample was missed over the three-year reporting period. The other eleven samples were well distributed through the reporting period, and local specialists agreed that the site scores were reliable and the sites should be included. In a post-publication re-examination of the data, it was found that 1 site in Ontario was mistakenly included in the South and Major Drainage Histograms. It based only on 8 samples taken in 2003.

There were also three sites (one in the Northwest Territories and two in Nunavut) that were located at the outflow of large lakes. These sites exhibited behaviour more similar to lakes than flowing waters, that is, less variability in water quality throughout the year (D. Halliwell, pers. comm.). Thus, the minimum sampling frequency for lakes was adopted for these sites.

6.5 Data quality

Water quality data exist at three levels: individual samples taken at monitoring sites; the combination of individual samples to calculate a WQI value for a particular site; and the aggregated data set of all WQI values from the selected sites across the country (see 5.5).

It is inevitable that errors will sometimes occur in individual sample results. The most common are field errors (sample contamination, mislabeling), lab errors (misidentified samples, miscalculations, analytical mistakes) and data entry errors. Each monitoring program follows standardized methods for sample collection in the field to ensure reliability of measurements. Chemical analyses are undertaken in Canadian laboratories accredited by the Canadian Association for Environmental Analytical Laboratories, ensuring analytical methods are up to standard and proper quality assurance/quality control procedures are in place.

7 Future improvements

The freshwater quality indicator reported here will be improved in future reports. Work is being carried out on methods to improve the calculation and presentation of the current indicator, as there is a need to both compensate for the unbalanced geographical distribution of monitoring sites across Canada, and to present water quality trends over time.

In addition to improving the freshwater quality indicator for aquatic life, efforts are under way to develop measures that assess water quality for other important beneficial uses, including drinking water sources, agricultural uses and recreational uses. Surveys to better understand how water is used by the industrial and agricultural sectors are being conducted. A survey of public drinking water treatment plants is also being developed.

Protection of aquatic life

Environment Canada, in cooperation with the provinces and territories, will continue to work towards strengthening water quality monitoring networks, particularly in areas that have less representation (for example, Saskatchewan, Nova Scotia and the North). In partnership with provinces, territories and other federal departments and agencies (for example, Parks Canada, Fisheries and Oceans Canada, Agriculture and Agri-Food Canada), Environment Canada will continue to work on enhancing Canada's collective capacity to scientifically assess and report on water quality and aquatic ecosystem health through the application of physical, chemical and biological monitoring measures and approaches.

How well the WQI rates water quality depends on the use of appropriate water quality parameters and guidelines. Parameters and guidelines used in the WQI computation for the protection of aquatic life should be locally relevant, meaning appropriate to the local organisms and local water characteristics. Environment Canada, in consultation with the provinces and territories, is developing a consistent approach to site-specific guidelines across the country in order to better reflect local conditions. In particular, techniques are being evaluated to adjust current guidelines for substances that have naturally elevated concentrations. The water quality guidelines for key substances not yet included in the indicator are also under development.

Source and treated water quality

Source water is defined as “water in its natural or raw state, prior to being withdrawn for treatment and distribution as a drinking water supply.” From the source water to the consumer’s tap, barriers need to be put in place to reduce or prevent contamination to the drinking water supply, and therefore protect public health. Protecting source water quality is considered the first barrier in a multi-barrier approach to safe drinking water supply (Federal-Provincial-Territorial Committee on Drinking Water and CCME 2004).

Source water quality is considered an important asset for sustaining our health, environment and economy (NRTEE 2003). This was the basis for choosing to develop a source water quality indicator in Canada. However, source water quality is only indirectly linked to public health since almost all public water supplies treat the water before it is distributed for consumption. Therefore, to link water quality to human health, a treated water quality indicator will form another important component of this initiative.

The purpose of the source and treated water quality indicators is to provide an indication of the quality of source and treated water. These indicators will provide information for use in decision making to promote both source water protection and proper water treatment. Since 2006, work has been carried out on methodology development and two tools that will form part of the indicator calculation.

The first tool is a calculator that compares specific parameters of water quality (source and treated) to drinking water guidelines and calculates a score between 0 and 100, based on methodology developed for the CCME WQI. An additional tool, applicable to the source water quality indicator, provides an indication of the treatment required for specific parameters of water quality to meet drinking water guidelines, and assigns a treatability ranking based on the complexity of the identified treatment.

In order to support the production of these indicators, Statistics Canada has assembled an inventory of public drinking water treatment plants. This inventory will serve as a sampling base for a survey of source and treated water quality to be conducted in the spring of 2008.

Agricultural water

The development of an indicator to report on the suitability of water quality for agricultural uses such as crop irrigation and livestock watering will be investigated. The testing of the applicability of an indicator based on the WQI methodology will be done using a subset of relevant stations from the national indicator. A review of the current water quality guidelines for agricultural use is now under way. This analysis will help determine which guidelines need to be updated or developed for incorporation into the freshwater quality indicator for agricultural water use.

This work will be supported by a new survey: the **Agricultural Water Use Survey**, which was conducted early in 2008. Its objective is to collect nationally consistent data on water used for irrigation. Approximately 2000 farm operations were asked to provide information on the source and quantity of water used for irrigation by crop type, water management techniques, treatment required, equipment used, and crop production. The results are expected to be published in the summer of 2008.

Recreational water

A preliminary investigation has been conducted to develop an inventory of Canadian monitoring programs that collect water quality information relevant to recreational water uses. These are primarily related to swimming or bathing but can include other activities such as waterskiing, windsurfing, fishing and canoeing. Guidelines for Canadian Recreational Water Quality are developed by the Federal-Provincial-Territorial Working Group on Recreational Water Quality under the authority of the Federal-Provincial-Territorial Committee on Health and the Environment, and published by Health Canada.

Various divisions of government at all levels monitor water that is used for recreational purposes, as do certain private associations. Many of the programs reflect provincial, municipal or local needs and policies—and thus vary from jurisdiction to jurisdiction. Future work involves the examination of how the existing information may be best applied in the development of a national freshwater quality indicator for recreational water use.

Industrial water use

In 2007, results from the **Industrial Water Survey** provided information about the quantities of water consumed and costs, sources, treatments and discharge of water used by the primary, manufacturing and thermal-electric power industries in 2006. These results, however, did not include the oil and gas extraction sector. The next version of the survey, to be conducted in 2008, will attempt to address this data gap.

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Acronyms

BCMOE – British Columbia Ministry of Environment

CCME – Canadian Council of Ministers of the Environment

CESI – Canadian Environmental Sustainability Indicators

MDDEPQ – Ministère du Développement durable, de l'Environnement et des Parcs du Québec

OECD – Organisation for Economic Co-operation and Development

PPWB – Prairie Provinces Water Board

USEPA – United States Environmental Protection Agency

WQI – Water Quality Index

Appendix 1 – The water quality guidelines used in each jurisdiction

Table 1-A
Alberta

Parameter	Form	Guideline description[1]	Unit	Source
Aluminum[2]	Dissolved	5 at pH <6.5; 100 at pH >6.5	µg/L	CCME, 2005b
Ammonia	Un-ionized	0.019	mg/L	CCME, 2005b; Environment Canada, 2005c
Arsenic	Total	5	µg/L	CCME, 2005b
Cadmium[2]	Total	e^(1.0166*ln[hardness]– 3.924)	µg/L	USEPA, 2005
Chloride	Dissolved	150	mg/L	BCMOE, 2001; Environment Canada, 2005c
Copper[2]	Total	7	µg/L	Alberta Environment, 1999
Copper[3]	Total	2, for hardness 0–90 mg/L; e^(0.8545*ln[hardness)]– 1.465)* 0.2, for hardness >90 mg/L	µg/L	CCME, 2005b
Dissolved oxygen		6.5	mg/L	Alberta Environment, 1999
Lead	Total	e^(1.273*ln[hardness]– 4.705)	µg/L	CCME, 2005b; Environment Canada, 2005c
Mercury[2]	(Total) inorganic	0.026	µg/L	CCME, 2005b
Nickel	Total	e^(0.76[ln(hardness)]+1.06)	µg/L	CCME, 2005b
Nitrogen	Total	1	mg/L	Alberta Environment, 1999
Pesticides	2,4-D	4	µg/L	CCME, 2005b
Pesticides	MCPA	2.6	µg/L	CCME, 2005b
pH[3]		6.5–9.0	n/a	CCME, 2005b
Phosphorus	Total	0.05	mg/L	Alberta Environment, 1999
Selenium[2]	Total	2	µg/L	BCMOE, 2001; Environment Canada, 2005c
Zinc	Total	7.5, for hardness ≤90 mg/L; 7.5 + 0.75*(hardness– 90), for hardness >90 mg/L $CaCO_3$	µg/L	BCMOE, 2001; Environment Canada, 2005c

1. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).
2. Applies to sites monitored by provincial monitoring programs.
3. Applies to sites monitored under federal monitoring programs and the Prairie Provinces Water Board.

Table 1-B
British Columbia[1]

Parameter	Form	Guideline description[2]	Unit	Source
Alkalinity		20	mg/L ($CaCO_3$)	Nagpal et al., 2006
Antimony	Total	20	µg/L	Nagpal et al., 2006
Arsenic	Total	5	µg/L	CCME, 2005b
Cadmium	Total	□10^0.86[log(hardness)]– 3.2, when > 50mg/L $CaCO_3$; □0.019, when <50 mg/L $CaCO_3$, SSG	µg/L	CCME, 2005b; Environment Canada, 2005c; Environment Canada, 2005d
Cadmium	Extractable	SSG	µg/L	CCME, 2005b; Butcher, 1992
Chloride	Total or dissolved	SSG	mg/L	Nagpal, 2003
Chromium	Total	SSG	µg/L	Environment Canada, 2005c; Environment Canada, 2005e; Butcher, 1992; Environment Canada, 2005f; CCME, 2005b; Environment Canada, 2005g; Environment Canada, 2005h; Swain, 1990; EC, 2005i
Chromium	Extractable	SSG	ug/L	BCMOE, 1992
Copper	Total	SSG	µg/L	Environment Canada, 2005c; Singleton, 1987; BCMWLAP, 2004; Swain et al., 1997; Environment Canada, 2005i
Copper	Extractable	SSG	ug/L	Butcher, 1992; Singleton, 1987
Copper	Dissolved	SSG	ug/L	Swain, 1990
Cyanide	Total	SSG	µg/L	CCME, 2005b; Swain, 1990
Cyanide	Weak acid dissociable	5	µg/L	CCME, 2005b
Dissolved oxygen		SSG	mg/L	Environment Canada, 2005c; Environment Canada, 2005j; CCME, 2005b; Gwanikar et al., 1998; Swain and Girard, 1987
Fluoride	Total	0.30	mg/L	Warrington, 1995
Iron	Total	300	µg/L	CCME, 2005b
Lead	Total or extractable	SSG	µg/L	Nagpal, 1987; Environment Canada 2005c
Manganese	Total or dissolved	SSG	µg/L	Nagpal, 2001a; Swain, 1990; CCME 2005b
Molybdenum	Total	SSG	µg/L	CCME, 2005b; Swain, 1990
Nickel	Total	SSG	µg/L	Environment Canada; 2005c, Swain, 1990
Nitrate	Total dissolved as N	2.93	mg/L	CCME, 2005b
Nitrite	Total as N	0.02	mg/L	Nordin and Pommen, 1986
Nitrogen	Total or total dissolved	SSG	mg/L	CCME, 2005b; Environment Canada, 2005c
Nitrate and nitrite	Dissolved	2.93	mg/L	CCME, 2005b

Table 1-B - continued
British Columbia[1]

Parameter	Form	Guideline description[2]	Unit	Source
pH		SSG	n/a	CCME, 2005b; Swain, 1990; Butcher, 1992; Gwanikar et al., 1998
Phosphorus	Total or total dissolved	SSG	mg/L	Environment Canada, 2005c ; OMOE, 1994
Selenium	Total or dissolved	2	µg/L	Nagpal, 2001b
Silver	Total	SSG	µg/L	Environment Canada, 2005c
Sulphate	Dissolved	50	mg/L	Singleton, 2000
Temperature		SSG	°C	Fidler and Oliver, 2001; Environment Canada, 2005c; Gwanikar et al., 1998
Thallium	Total or extractable	0.8	µg/L	CCME, 2005b
Zinc	Total or extractable	SSG	µg/L	Nagpal, 1999; Environment Canada, 2005c; Swain, 1990; EC, 2005i; Butcher, 1992

1. British Columbia and Yukon parameter selections were site-specific.
2. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).

Table 1-C
Manitoba

Parameter	Form	Guideline description[1]	Unit	Source
Ammonia[2]	Total as nitrogen	Calculation based on pH and temperature	mg/L	USEPA, 2005
Ammonia[3]	Un-ionized	0.019	mg/L	CCME, 2005b
Arsenic[2]	Total or extractable	0.15	mg/L	USEPA, 2005
Arsenic[3]	Total	5	µg/L	CCME, 2005b
Cadmium[2]	Total or extractable	e^(0.7852*ln[hardness]– 2.715) where hardness = mg/L as $CaCO_3$	µg/L	USEPA, 2005
Chloride[3]	Dissolved	150	mg/L	BCMOE, 2001; Environment Canada, 2005c
Copper[2]	Total or extractable	e^(0.8545*ln[hardness]– 1.702) where hardness = mg/L as $CaCO_3$	µg/L	USEPA, 2005
Copper[3]	Total	2, for hardness 0–90 mg/L; e^(0.8545*ln[hardness]– 1.465)* 0.2, for hardness >90 mg/L	µg/L	CCME, 2005c; USEPA, 2005
Dissolved oxygen[2]		5	mg/L	USEPA, 2005
Dissolved oxygen[3]		6.5	mg/L	PPWB, 1992; Alberta Environment, 1999
Iron[2]	Total or extractable	0.3	µg/L	CCME, 2005b ; Environment Canada, 2005c
Lead	Total (or extractable)	e^(1.273*ln[hardness]– 4.705)	µg/L	CCME, 2005b ; Environment Canada, 2005c
Nickel[3]	Total	e^(0.76*ln[hardness]+1.06)	µg/L	CCME, 2005b ; Environment Canada, 2005c
Nickel[2]	Total or extractable	e^(0.8460*ln[hardness]+0.0584), where hardness = mg/L $CaCO_3$	µg/L	USEPA, 2005
Nitrate[2]	Total (as N)	2.9	mg/L	CCME, 2005b ; Environment Canada, 2005c
Nitrogen[3]	Total	1	mg/L	Alberta Environment, 1999

Table 1-C – continued
Manitoba

Parameter	Form	Guideline description[1]	Unit	Source
Pesticides	MCPA	2.6	µg/L	CCME, 2005b
Pesticides	2,4-D	4	µg/L	CCME, 2005b
pH		6.5–9.0	n/a	CCME, 2005b
Phosphorus	Total	0.05 (rivers); 0.25 (lakes)	mg/L	PPWB, 1992; Alberta Environment, 1999; Manitoba Conservation, 2002
Total suspended solids[2]		25	mg/L	Manitoba Conservation, 2002
Zinc[3]	Total	7.5, for hardness □90 mg/L; 7.5 + 0.75*(hardness– 90), for hardness >90 mg/L $CaCO_3$	µg/L	BCMOE, 2001; Environment Canada, 2005c
Zinc[2]	Total or extractable	e^(0.8473*ln[hardness]+0.884), where hardness = mg/L as $CaCO_3$	µg/L	USEPA, 2005

1. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).
2. Applies to sites monitored by provincial monitoring programs.
3. Applies to sites monitored under federal monitoring programs and the Prairie Provinces Water Board.

Table 1-D
New Brunswick

Parameter	Form	Guideline description[1]	Unit	Source
Ammonia	Un-ionized	0.019	mg/L	CCME, 2005b ; Environment Canada, 2005c
Chloride	Dissolved	150	mg/L	BCMOE, 2001; Environment Canada, 2005c
Copper	Total	2, for hardness <60 mg/L $CaCO_3$; e^(0.8545*ln[hardness]– 1.465)*0.2, for hardness >60 mg/L	µg/L	BCMOE, 2001
Iron	Dissolved	300	µg/L	CCME, 2005b ; Environment Canada, 2005c
Nickel	Total	e^(0.76*ln[hardness]+1.06)	µg/L	CCME, 2005b ; Environment Canada, 2005c
Nitrate	Total	2.9	mg/L	CCME, 2005b ; Environment Canada, 2005c
Oxygen	Dissolved	6.5	mg/L	CCME, 2005b ; Environment Canada, 2005c
pH		6.5–9.0	n/a	CCME, 2005b
Phosphorus	Total	0.03 (rivers); 0.02 (lakes)	mg/L	Dodds et al., 1998
Turbidity		10 (SSG)	NTU	Environment Canada, 2005c
Zinc	Total	7.5 for hardness <90 mg/L; 7.5 + 0.75*(hardness– 90) for hardness >90 mg/L	µg/L	BCMOE, 2001; Environment Canada, 2005c

1. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).

Table 1-E
Newfoundland and Labrador

Parameter	Form	Guideline description[1]	Unit	Source
Arsenic[2]	Total	5	µg/L	CCME, 2005b
Chromium[2]	Total	1	µg/L	CCME, 2005b
Copper[2]	Total	2, for $[CaCO_3]$ = 0– 120 mg/L 3, for $[CaCO_3]$ = 120– 180 mg/L 4, for $[CaCO_3]$ >180 mg/L	µg/L	CCME, 2005b
Iron[2]	Total	300	µg/L	CCME, 2005b ; Environment Canada, 2005c
Lead[2]	Total	1, for $[CaCO_3]$ = 0– 60 mg/L 2, for $[CaCO_3]$ = 60– 120 mg/L 4, for $[CaCO_3]$ = 120– 180 mg/L 7, for $[CaCO_3]$ >180 mg/L	µg/L	CCME, 2005b
Molybdenum[2]	Total	73	µg/L	CCME, 2005b
Nickel[2]	Total	25, for $[CaCO_3]$ = 0– 60 mg/L 65, for $[CaCO_3]$ = 60– 120 mg/L 110, for $[CaCO_3]$ = 120– 180 mg/L 150, for $[CaCO_3]$ = >180 mg/L	µg/L	CCME, 2005b
pH		6.5–9.0	n/a	CCME, 2005b
Phosphorus	Total	0.03 (rivers)	mg/L	Dodds et al., 1998
Selenium[2]	Total	1	µg/L	CCME, 2005b
Zinc[2]	Total	30	µg/L	CCME, 2005b

1. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).
2. Sites in Labrador had either total or extractable metals used in calculation of the WQI due to modification in sampling program.

Table 1-F
Northwest Territories and Nunavut

Parameter	Form	Guideline description[1]	Unit	Source
Ammonia	Dissolved	SSG for lotic sites (mean + 2SD) and 0.019 for lentic-lotic sites	mg/L	CCME, 2005b
Arsenic	Total	SSG (mean + 2 SD)	ug/L	DIAND
Chloride	Dissolved	SSG for lotic sites (mean + 2SD) and 150 for lentic-lotic sites	mg/L	CCME, 2005b
Chromium	Total	SSG (mean + 2 SD)	ug/L	DIAND
Copper	Total	SSG for lotic sites (mean + 2SD) and for lentic-lotic sites: 2, for $[CaCO_3]$ = 0– 120 mg/L 3, for $[CaCO_3]$ = 120– 180 mg/L 4, for $[CaCO_3]$ >180 mg/L	µg/L	CCME, 2005b
Iron	Total	SSG for lotic sites (mean + 2SD) and 300 for lentic-lotic sites	µg/L	CCME, 2005b
Lead	Total	SSG for lotic sites (mean + 2SD) and for lentic-lotic sites: 1, for $[CaCO_3]$ = 0– 60 mg/L 2, for $[CaCO_3]$ = 60– 120 mg/L 4, for $[CaCO_3]$ = 120– 180 mg/L 7, for $[CaCO_3]$ >180 mg/L	µg/L	CCME, 2005b
Nitrite	Dissolved	SSG (mean + 2 SD)	mg/L	DIAND

Table 1-F - continued
Northwest Territories and Nunavut

Parameter	Form	Guideline description[1]	Unit	Source
Nitrite-nitrate	Dissolved	SSG for lotic sites (mean + 2SD) and 2.93 (lentic-lotic sites)	mg/L	CCME, 2005b
Oxygen	Dissolved	5	mg/L	CCME, 2005b
pH		SSG for lotic sites (mean + 2SD) and 6.5–9.0 for lentic-lotic sites)	pH units	CCME, 2005b
Phosphorus	Total	SSG for lotic sites (mean + 2SD) and 0.03 (lentic-lotic sites)	mg/L	Dodds et al., 1998
Zinc	Total	SSG for lotic sites (mean + 2SD) and 30 for lentic-lotic sites	µg/L	CCME, 2005b

1. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).

Table 1-G
Nova Scotia

Parameter	Form	Guideline description[1]	Unit	Source
Chloride	Dissolved	150	mg/L	BCMOE, 2001; Environment Canada, 2005c
Copper	Total	2, for hardness <60 mg/L $CaCO_3$; e^(0.8545*ln[hardness]– 1.465)*0.2, for hardness >60 mg/L	µg/L	BCMOE, 2001; Environment Canada, 2005c
Iron	Dissolved	300	µg/L	CCME, 2005b; Environment Canada, 2005c
Lead	Total	e^(1.273*ln[hardness]– 4.705)	µg/L	CCME, 2005b; Environment Canada, 2005c
Nickel	Total	e^(0.76*ln[hardness]+1.06)	µg/L	CCME, 2005b; Environment Canada, 2005c
Nitrate	Total (as N)	2.9	mg/L	CCME, 2005b
pH		6.5–9.0	n/a	CCME, 2005b
Phosphorus	Total	0.03 (rivers); 0.02 (lakes)	mg/L	Dodds et al., 1998
Zinc	Total	7.5 for hardness <90 mg/L; 7.5 + 0.75*(hardness– 90) for hardness >90 mg/L	µg/L	BCMOE, 2001; Environment Canada, 2005c

1. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).

Table 1-H
Ontario

Parameter	Form	Guideline description[1]	Unit	Source
Ammonia	Un-ionized	0.019	mg/L	CCME, 2005b; Environment Canada, 2005c
Chloride	Dissolved	150	mg/L	BCMOE, 2001; Environment Canada, 2005c
Chromium	Total	2	µg/L	CCME, 2005b (guideline for Cr(VI) adjusted to total chromium)
Nickel	Total	e^(0.76*ln[hardness]+1.06)	µg/L	CCME, 2005b; Environment Canada, 2005c
Nitrate	Total (as N)	2.93	mg/L	CCME, 2005b
Phosphorus	Total	0.03	mg/L	OMOE, 1994
Zinc	Total	7.5, for hardness <90 mg/L; 7.5 + 0.75*(hardness– 90), for hardness >90 mg/L $CaCO_3$	µg/L	BCMOE, 2001; Environment Canada, 2005c

1. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).

Table 1-I
Prince Edward Island

Parameter	Form	Guideline description[1]	Unit	Source
Ammonia	Un-ionized	0.019	mg/L	CCME, 2005b; Environment Canada, 2005c
Nitrate	Dissolved (as N)	2.93	mg/L	CCME, 2005b; Environment Canada, 2005c
pH		6.5–9.0	n/a	CCME, 2005b
Phosphorus	Total	0.03	mg/L	Dodds et al., 1998
Suspended sediments	Total	29 (SSG)	mg/L	CCME, 2005b; Environment Canada, 2005c

1. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).

Table 1-J
Quebec

Parameter	Form	Guideline description[1]	Unit	Source
Ammonia	Total (as N)	0.05, at pH 8.2 and 20ºC	mg/L	MDDEP, 2006
Chlorophyll a		8	mg/m^3	OECD, 1982
Nitrite+nitrate	Total (as N)	2.93	mg/L	CCME, 2005b; Environment Canada, 2005c
pH		>6.5; <9.0	n/a	MDDEP, 2006
Phosphorus	Total	0.03	mg/L	MDDEP, 2006
Turbidity		10	NTU	MDDEP, 2006

1. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).

Table 1-K
Saskatchewan

Parameter	Form	Guideline description[1]	Unit	Source
Ammonia	Un-ionized	0.019	mg/L	CCME, 2005b; Environment Canada, 2005c
Arsenic	Total	5	µg/L	CCME, 2005b
Chloride	Dissolved	150	mg/L	BCMOE, 2001; Environment Canada, 2005c
Copper	Total	2, for hardness 0–90 mg/L; e^(0.8545*ln[hardness]– 1.465)* 0.2, for hardness >90 mg/L	µg/L	CCME, 2005b; Environment Canada, 2005c
Oxygen	Dissolved	6.5	mg/L	PPWB, 1992; Alberta Environment, 1999
Lead	Total	e^(1.273*ln[hardness]– 4.705)	µg/L	CCME, 2005b; Environment Canada, 2005c
Nickel	Total	e^(0.76*ln[hardness]+1.06)	µg/L	CCME, 2005b; Environment Canada, 2005c
Nitrogen	Total	1	mg/L	Alberta Environment, 1999
Pesticides	MCPA	2.6	µg/L	CCME, 2005b
Pesticides	2,4-D	4	µg/L	CCME, 2005b
pH		6.5–9.0	n/a	CCME, 2005b
Phosphorus	Total	0.05	mg/L	PPWB, 1992; Alberta Environment, 1999
Zinc	Total	7.5, for hardness □90 mg/L; 7.5 + 0.75*(hardness– 90), for hardness >90 mg/L $CaCO_3$	µg/L	BCMOE, 2001; Environment Canada, 2005c

1. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).

Table 1-L
Yukon Territory[1]

Parameter	Form	Guideline description[2]	Unit	Source
Arsenic	Total	5	µg/L	CCME, 2005b
Cadmium	Total	0.026	µg/L	BCMOE, 2001; CCME, 2005b; Environment Canada, 2005c
Chromium	Total	SSG	µg/L	BCMOE, 2001; Environment Canada, 2005c
Copper	Total	SSG	µg/L	Singleton, 1987
Lead	Total	e(1.273[ln*(hardness)]– 4.705)	µg/L	CCME, 2005b; Environment Canada, 2005c
Nitrate	Total as N	2.93	mg/L	CCME, 2005b; Environment Canada, 2005c
Nitrite	Not available	0.02	mg/L	Nordin and Pommen, 1986
pH		SSG		CCME, 2005b
Phosphorus	Total	0.03	mg/L	Dodds et al., 1998
Silver	Total	SSG	µg/L	Warrington, 1995; Environment Canada, 2005c
Sulphate	Dissolved	50	mg/L	
Temperature		SSG	˚ C	Fidler and Oliver, 2001
Zinc	Total	SSG	µg/L	BCMOE, 2001; Environment Canada, 2005c

1. British Columbia and YukonTerritory parameter selections were site-specific.
2. SSG means that different site-specific guidelines or formulas were used at different sites (specific site information available on request).