A statistical evaluation of water quality trends in selected water bodies of Newfoundland and Labrador

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Abstract: Using water quality data collected since 1986, as part of the Canada–Newfoundland Water Quality Monitoring Agreement, 36 different water quality variables from 65 different water quality monitoring sites were examined for change over time. Moving averages, the Student's *t* test statistic, and Spearman's rank correlation coefficient were used. Throughout the province, turbidity and colour were generally displaying deteriorating trends, while conductivity, copper, lead, and mercury were consistently displaying improving trends. There was a notable deteriorating trend in nitrate and nitrite and nitrogen in select river basins, and an improving trend in phosphorous in more developed basins. Even in pristine watersheds, change was often observed in metals, major ions, turbidity, and colour. An examination of land and water use activities ongoing in each watershed allowed identification of likely localized causes and (or) factors contributing to observed water quality trends. In many cases trend-causing factors appeared to be more global in nature and most trends could be explained by an upward trend in river flows during the period analyzed.

Key words: water quality, Newfoundland, Labrador, trends, Spearman, land use, statistics, streamflow.

Résumé : Grâce à l'utilisation des données sur la qualité de l'eau colligées depuis 1986 dans le cadre de l'Accord Canada-Terre-Neuve visant le monitorage de la qualité des eaux (T), 36 différentes variables sur la qualité de l'eau provenant de 65 différents sites de surveillance de la qualité de l'eau ont été examinées afin de détecter tout changement dans le temps. Les moyennes mobiles, les statistiques du test de Student, et le coefficient de corrélation des rangs de Spearman (T) ont été utilisés. Dans toute la province, la turbidité et la couleur affichaient généralement des tendances à la détérioration alors que la conductivité, le contenu en cuivre, en plomb et en mercure présentaient des tendances constantes à l'amélioration. Il y avait une tendance nette à la détérioration pour les nitrates/nitrites et l'azote dans des bassins hydrographiques choisis, ainsi qu'une tendance à l'amélioration pour le phosphore dans des bassins plus développés. Même dans les bassins hydrographiques vierges, un changement a été souvent observé dans les métaux, les ions majeurs, la turbidité et la couleur. Une étude des activités d'utilisation des sols et des eaux en cours dans chaque bassin hydrographique a permis d'identifier des causes probables localisées et/ou des facteurs contributifs aux tendances observées dans la qualité de l'eau. Dans plusieurs cas, les facteurs causant des tendances semblaient être de nature plus globale et la plupart des tendances peuvent être expliquées par une tendance à la hausse des débits de cours d'eau durant la période d'analyse.

Mots clés : qualité de l'eau, Terre-Neuve, Labrador, tendances, Spearman, utilisation du sol, statistiques, débit d'eau.

[Traduit par la Rédaction]

Introduction

Newfoundland and Labrador is the easternmost province of Canada and consists of the Island of Newfoundland (111 390 km^2), situated in the Gulf of St. Lawrence, and Labrador (294 330 km^2) on the northeastern Canadian mainland (Water Resources Division 1992). Mountain ranges are found on the west coast of the Island and in northern Labrador. Lakes and ponds are common features of the landscape. Vegetation in the province varies from tundra in northern Labrador to mixed deciduous and coniferous forests in the southwest to barrens on the Avalon Peninsula in the southeast. Peatlands are concentrated along the coastal lowlands and on the interior high plateaus. The province has approximately half a million residents. Much of the province's economic development is derived from resources such as fish, forests, water, offshore oil, and minerals.

Environment Canada and the Newfoundland and Labrador Department of Environment and Conservation have been monitoring surface water quality of selected water bodies in the province since 1986. The main monitoring objectives of the Canada–Newfoundland Water Quality Agreement are to (*i*) determine if there are trends in water quality variables, (*ii*) determine how natural features and human activities are affecting water quality, and (*iii*) determine the status of the province's surface water quality. There has been increasing public interest and demand for such information on provincial surface water quality.

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The gradual accumulation of reliable and long-term water quality records is required for the statistical analysis of long-term trends. Trend can be tested for existence, significance, and magnitude. Because of the large number of monitored water quality sites (65) and variables (36) involved in this study, trends were only evaluated for existence and significance. Water quality is summarized as displaying improving, deteriorating or no trend.

A detailed catalogue of watershed characteristics and activities exists for each monitoring site. Many of the causes of water pollution and their associated effects on water quality are well known and documented. From observed water quality trends and known environmental and anthropogenic factors affecting each basin, possible causes of observed water quality trends were then determined.

Methodology

Considerable attention has been given to the testing of water quality for trend in recent years, as only recently has there been enough data available to make such analysis feasible (Sanders et al. 1983). Growing concern for the environment has led to an intrinsic interest in the question of changing water quality and the effect of anthropogenic activity on water quality.

Data collection

Water quality sampling stations are located throughout the province to provide geographic representation as shown in Fig. 1. Waterbodies of interest are divided into four regions — Eastern, Central, Western, and Labrador. Depending on the station, sampling has been carried out on a monthly, bi-monthly, or quarterly basis. Monitored water quality parameters can be divided into four major groupings: physical and major chemical parameters, major ions, nutrients, and metals.

Trend analysis

Trend analysis determines whether the measured values of a water quality parameter increase or decrease over the period of record. There are different statistical techniques suitable for trend analysis depending on the data set characteristics. Because of the volume of data to be analyzed, and the various characteristics of the data (distribution, seasonality, missing observations, outliers, censored data, serial dependence), many trend analysis techniques were either unsuitable or too time consuming to perform (Hirsch and Slack 1984).

The majority of water quality parameters being monitored displayed a lack of normally distributed data, which made parametric statistical methods unsuitable. An examination of the skewness of the distributions, the majority of which were positive or right skewed, further reinforced this finding. Standard practice for this monitoring program is that for values less than the detection limit, a value of half the detection limit is taken. The probability plot test for normality revealed that data for some parameters is censored by being grouped at certain values, particularly for fluoride, beryllium, cadmium, and molybdenum. Less reliance was placed on any trend detected from heavily censored data. Outliers, or observations considerably higher or lower than most of the data, were left in the data sets as they can indicate important phenomena, not necessarily erroneous data. For this analysis, outliers were demonstrated using time series plots. Serial dependence occurs when consecutive observations are correlated. From autocorrelation plots, it was evident the data showed an annual trend, which was dealt with by grouping the data into monthly time periods and then performing statistical analysis (Helsel and Hirsch 2002). The presence of non-normal distributions, censored data, outliers, and serial dependence made more robust statistical techniques necessary.

In the end, a combination of time series plots, moving averages, and use of the nonparametric Spearman's rank correlation coefficient were decided on to test for trend. The Spearman coefficient is more robust, has a higher power, and performs well in comparison to other statistical methods in testing for trend (Forester 2000). Calculation of the Spearman coefficient was made using the statistical software application SYSTAT 7.0.

In the first test for trend, time series plots of all parameter at each site were produced including 12-month moving averages. These plots provided a general indication of trend and supported observations made later in the statistical trend analysis.

For the second test for trend, the entire data series for each parameter, paired with cumulative month, was analyzed using the nonparametric Spearman's criterion to detect the existence of trend. The existence of a trend is checked using the test statistic t_t and is checked for significance at the level of 5% from statistical tables of the Student's t-distribution (Antonopoulous et al. 1998). The Spearman rank-correlation coefficient (R_{SP}) is described as

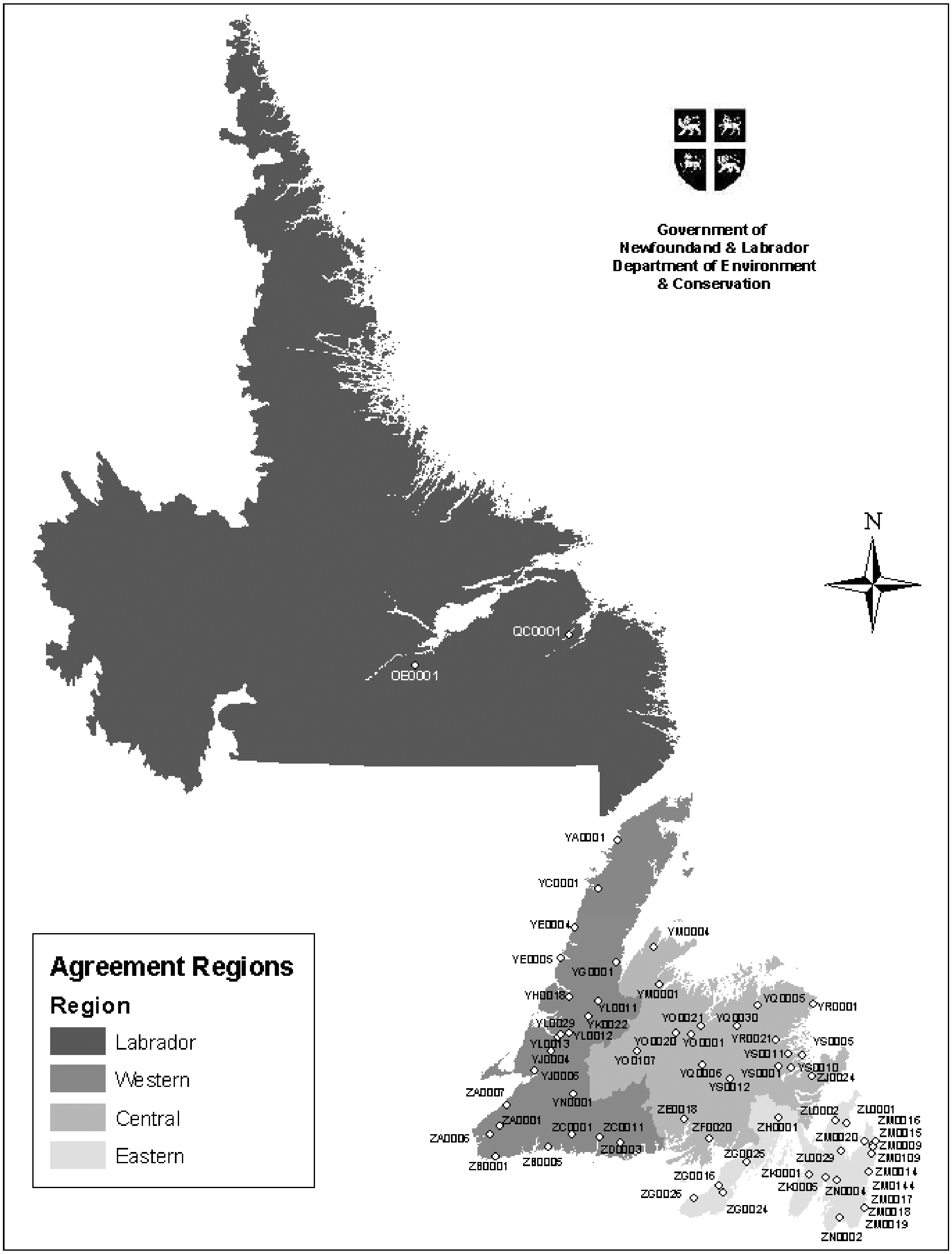
$$[1] \qquad R_{SP} = 1 - \frac{6 \sum_{i=1}^{n} (D_i D_i)}{n\left(n^2 - 1\right)}$$

where n is the total number of values in each time series, D is the difference, and i is the chronological order number. The difference between rankings is computed as $D_i = K_{xi} - K_{yi}$, where K_{xi} is the rank of a measured variable in chronological order and K_{yi} is the series of measurements transformed to its rank equivalent, by assigning the chronological order number of the measurement in the original series to the corresponding order number in the ranked series, y. The null hypothesis, $H_0 : R_{SP} = 0$ (there is no trend) against the alternate hypothesis, $H_1 : R_{SP} <$ or > 0 (there is a trend), is checked with the test statistic

$$[2] \qquad t_t = R_{SP} \left[\frac{n-2}{1-R_{SP}^2} \right]^{0.5}$$

where t_t has Student's t-distribution, with $\nu = n - 2$ degrees of freedom. At a significant level of 5%, the time series has no

Fig. 1. Sampling sites and regions of the Canada–Newfoundland water quality monitoring agreement. Reprinted with minor alterations from the Government of Newfoundland and Labrador, Department of Environment and Conservation.



trend if $t\{\nu, 2.5\%\} < t_t < t\{\nu, 97.5\%\}$ (Antonopoulous et al. 1998).

The third test for trend uses Spearman's rank correlation coefficient on the monthly values for each year, one month at a time, and provides a test for upward or downward trend over the years of record (El-Shaarawi et al. 1983). The exact distribution of R_{SP} can be obtained for $n > 6$, from statistical tables of critical values of the Spearman rank correlation coefficient (Johnson 1994).

The matrix produced was then evaluated for significant val-

Table 1. Potential factors affecting water quality.

Cause	Explanation	Parameters affected
Abatement	Through greater awareness people are: using less harmful household products and disposing of them safely, using phosphate-free soaps and detergents, reducing or eliminating use of fertilizers and pesticides on lawn and garden, checking and repairing fluid leaks from vehicles, not putting toxic chemicals down the drain, forming community stewardship groups to care for local waterbodies and provide stream enhancement, etc.; Phosphorous Control Act; move to unleaded gasoline; buffer zone regulations; using silt screens on construction sites.	Metals, nutrients, major ions, turbidity, pH, dissolved oxygen, conductivity
Atmospheric deposition	Long range transport of atmospheric pollutants and deposition on land and water surfaces; acid rain; also reduction in atmospheric pollutants through international initiatives such as the ban on leaded gasoline.	Nutrients, metals, pH, major ions
Climate change	Streamflow has an important effect on the level of many water quality indicators. Peak flows have increased levels of suspended solids and related indicators, while low flows are associated with increased levels of dissolved ions.	Turbidity, major ions, conductivity
Farming	Runoff from farms treated with manure, fertilizer, lime, pesticides, herbicides, etc.; farming practices such as land clearing, tillage, ploughing, irrigation, grazing, feedlots and animal corrals; aquaculture.	Nutrients, metals, pH, turbidity, major ions, dissolved oxygen
Forestry	Increased runoff from disturbed land, removal of vegetation, road construction and use, timber harvesting, etc.; silviculture practices.	Turbidity, colour
Industry	Wastes and sludge from industries such as pulp and paper mills, saw mills, smelting, metal production or plating, etc.	Metals, colour, dissolved oxygen
Landfill	Seepage from landfills and hazardous waste facilities. Deposition from incinerators.	Nutrients, metals, pH, dissolved oxygen
Mining	Runoff from mines and mine wastes, quarries and test well sites; residuals from nitrogen-based explosives; acid mine drainage.	Turbidity, pH, metals, major ions, dissolved oxygen
Natural sources	Local waterfowl populations; local geology; soil chemistry; forest fires; synergistic effects; flow conditions.	Major ions, nutrients, metals, dissolved oxygen, pH, conductivity
Recreation	Large variety of recreational land uses including ski resorts, boating and marinas, campgrounds, parks, tourist chalets, golf courses, hunting, cabin development, ATV and snowmobile trails, etc.	Nutrients, turbidity, metals
Rural sewage systems	Overloading and malfunction of septic systems from rural housing or cabin developments.	Nutrients
Sewage	Disposal of liquid wastes from municipal wastewater effluents, sewage sludge, industrial effluents and sludge, wastewater from home septic systems, cross-connections; legal and illegal dumping in water courses.	Nutrients, metals, turbidity, dissolved oxygen
Stream modification	Stream alterations such as dams, weirs, bridges, culverts, armoring, fish ladders, dredging, channelization; nutrients settle with suspended sediments in reservoirs while scouring occurs downstream of dams, flowing streams slow to form slack water pools.	Metals, dissolved oxygen, nutrients, turbidity
Transportation	Roads, railways, pipelines, hydro-electric corridors, bridges, etc.; chemicals from motor vehicles.	Nutrients, turbidity, metals
Urban development	Urban runoff from roofs, streets, parking lots, etc. carries by-products of human activity into receiving waters; overflow, cross-connections and leakage from sewer mains; corrosion of water pipes; local industries and businesses may discharge wastes to street gutters and storm drains; street cleaning; road salting; land clearing for new development and construction; water withdrawals; lawn care.	Nutrients, metals, turbidity, major ions, pH

ues using the table of critical values of the Spearman rank correlation coefficient. A significant positive value of R_{SP} indicates an increasing trend while a significant negative value indicates a decreasing trend for that month. Significance was determined at four different levels: 5%, 2%, 1%, and 0.5%. A majority of months with either negative or positive values indicates trend for that individual water quality parameter (El-Shaarawi et al. 1983).

To determine whether water quality parameter values had increased or decreased over the period of record a summary

Fig. 2. Time series plots including 12-month moving averages.

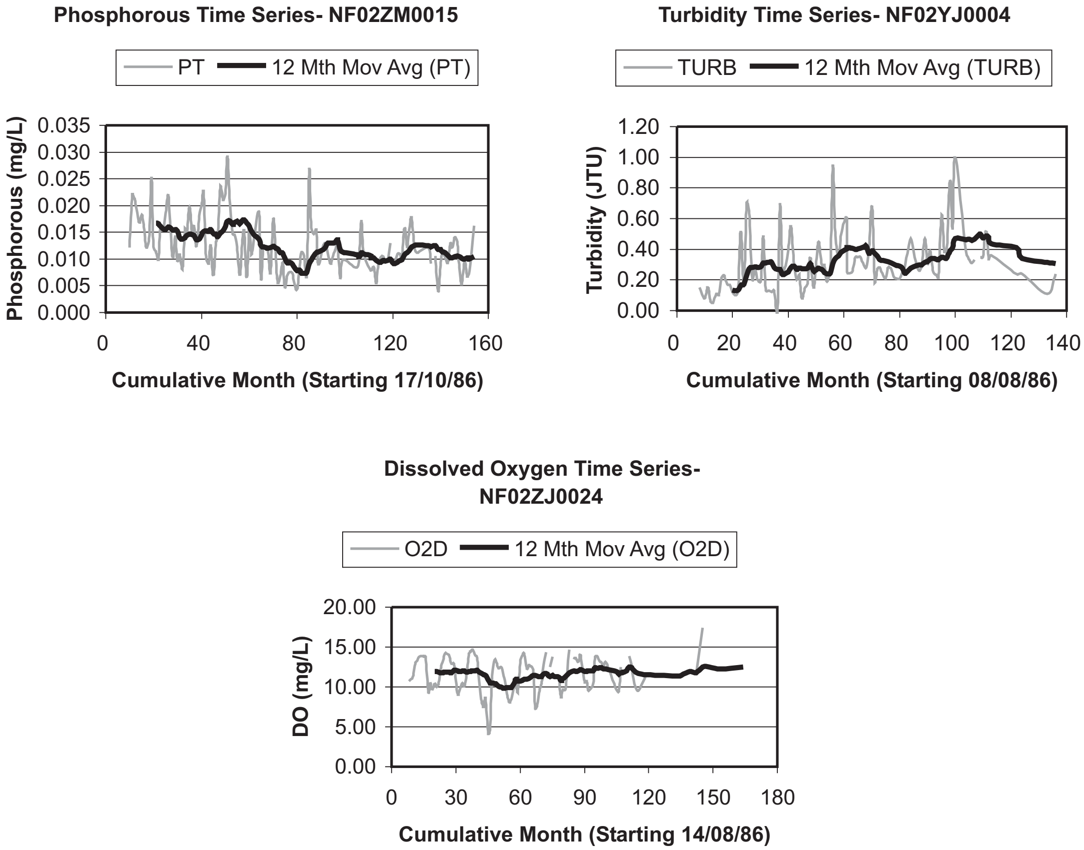


Table 2. Spearman trend analysis results of entire period of record.

Station	Variable	Spearman's Coef. (R_{SP})	Number of observations (n)	Test Statistic (t_t)	Trend
NF02ZM0015	Phosphorous	−0.422	130	−5.266	Down
NF02YJ0004	Turbidity	0.444	104	5.005	Up
NF02ZJ0024	Dissolved oxygen	0.004	97	0.039	No

matrix was produced for each site comparing the total Spearman trend, the monthly Spearman trend, and the 12-month moving average trend. A majority of indicators of trend was used to determine the overall trend for each individual parameter.

Factors affecting water quality

To identify possible factors contributing to the observed water quality trends in the province, Table 1 was generated, indicating known causes and impacts on water quality from documented studies on water quality in other jurisdictions (Schreier et al. 1997). A catalogue of natural characteristics and watershed activities for each monitoring site (Canada–Newfoundland Water Quality Monitoring Agreement 2003) was then used to make the link between observed water quality trends and possible causes. The assumption of causes made is reasonable, based on similar observances and known characteristics and activity in the watershed.

Results and discussion

The procedures of the previous sections were applied to each of the 65 data sets available to determine whether or not trends were present. Parameters with the most frequent occurrence of outliers included copper, zinc, turbidity, chromium, phosphorous, and nitrate and nitrite. Parameters with the highest occurrence of censored data included beryllium, cadmium, and molybdenum.

Trend analysis

To demonstrate the procedure used in determining the existence of trend, three parameters out of over 2000 analyzed will be examined in more detail. Figure 2 shows time series plots of decreasing phosphorous in Quidi Vidi Lake (station NF02ZM0015), increasing turbidity in Pinchgut Brook (station NF02YJ0004), and no change in dissolved oxygen (DO) in Southern Bay River (station NF02ZJ0024).

Spearman trend analysis of the entire data series for each of the above three parameters is given in Table 2. For data sets of $n > 29$, values of the test statistic (t_t) between 0.196 and −0.196 are not significant, indicating no trend. Values of t_t greater than 0.196, or less than −0.196, indicate changes in that specific variable over time at a certain rate.

Parameters with highly significant test statistics values ($t_t < -3.5$ or $t_t > 3.5$) were observed in all regions except Labrador. Many parameters in the Eastern Region had three or more highly significant test statistics values, most notably nitrogen with seven, turbidity with nine, and molybdenum with ten. The highest test statistic value in the Eastern Region was for potassium (−9.771) at Tides Brook. Many variables in the Central Region had at least one highly significant test statistic value. Conductivity had the most at eight, followed by sodium at seven. The sampling site at Exploits River below Millertown Dam had very high test statistic values, with the highest for the region being for zinc (−20.394). Three parameters in particular dominated the Western Region for highly significant test statistic values — sodium with seven, turbidity with ten, and mercury with fourteen. The highest test statistic value in the Western Region was for sodium (−10.329) at Portland Creek.

A matrix of monthly Spearman correlation coefficients for each of the above three parameters is given in Table 3. The monthly Spearman correlation coefficient values are marked by stars (*) to indicate their level of significance. One star (*) indicates significance at a level of 5%. Parameters such as conductivity, colour, turbidity, sodium, and mercury frequently displayed the highest number of significant values.

The overall trend, demonstrated by the above three methods is then summarized in Table 4. The three methods used reinforce each other by either showing a consistent downward trend, upward trend, or no discernable trend at all. No opposite trends were ever indicated in the analysis. Generally, the more significant the Spearman trend analysis of the entire data series, the higher the probability all three analysis methods agreed.

Table 5 provides a complete overview of observed trends in 36 water quality variables from all 65 monitoring sites throughout the province. In this table, the designation of trend is related to water quality, so for example, if dissolved oxygen concentrations were found to be decreasing over time this would be a deteriorating trend in water quality, while if lead concentrations were found to be decreasing over time this would be an improving trend in water quality.

Amongst the different parameters and parameter groupings, several overall or universal trends were detected including

- A decrease (or improving trend) in **conductivity** and by extension, major ion concentration (**calcium**, **sodium**, **magnesium**, **potassium**, **sulphate**, **chloride**) throughout the province.
- An increase (or deteriorating trend) in **colour** throughout the province.
- An increase (or deteriorating trend) in **turbidity** throughout the province.

Table 3. Spearman trend analysis results of collapsed monthly data.

Station Variable	NF02ZM0015 Phosphorous	NF02YJ0004 Turbidity	NF02ZJ0024 Dissolved oxygen
Jan.	−0.455	−0.073	0.000
Feb.	−0.527	0.251	−0.561
Mar.	−0.573	0.717*	−0.186
Apr.	−0.645*	−0.014	−0.262
May	−0.468	0.524	0.357
June	−0.273	0.655	0.288
July	−0.418	0.357	0.143
Aug.	−0.036	0.683	−0.599
Sept.	−0.118	0.524	−0.595
Oct.	−0.182	0.728*	0.133
Nov.	−0.524	0.433	0.115
Dec.	−0.636	0.821*	0.667
Positive	0	10	7
Negative	12	2	5
Trend	Negative trend	Positive trend	No trend

*Significant at 0.05 level.

- An increase (or deteriorating trend) in **nitrate** and **nitrite** and **nitrogen** throughout the province.
- A decrease (or improving trend) in **arsenic** throughout the province, more significantly in South Coast Rivers including the Avalon.
- A decrease (or improving trend) in **barium** throughout the province.
- An increase (or deteriorating trend) in **beryllium**, **cadmium**, and **molybdenum** throughout the province. However, these three parameters had the highest occurrence of censored data that is believed to have had some influence on the trend analysis.
- A decrease (or improving trend) in **copper** throughout the province.
- A decrease (or improving trend) in **mercury** throughout the province.
- A decrease (or improving trend) in **lead** throughout the province.
- A decrease (or improving trend) in **phosphorous** in rivers of the Central and Easter Region.
- The occurrence of trend in **cobalt** and **manganese** (all showed a majority of improving trends) is most apparent in water quality stations from the Eastern Region.
- An increase (or deteriorating trend) in **nickel** in rivers in non-urban areas of the Avalon and eastern rivers of the Central Region.
- An increase (or deteriorating trend) in **sulphate** in urban rivers of St. John’s.

Table 4. Overall trend analysis results.

Station	Variable	Moving average trend	Entire Spearman trend	Monthly Spearman trend	Overall trend
NF02ZM0015	Phosphorous	Down	Down	Down	Down
NF02YJ0004	Turbidity	Up	Up	Up	Up
NF02ZJ0024	Dissolved oxygen	No	No	No	No

- Frequent improving trends in **zinc**, **strontium**, **lithium**, and **selenium** throughout the province.

General trends in the 36 water quality parameters are categorized by region in Table 6. The five categories are (*a*) parameters with increasing values in more than 50% of locations overall, (*b*) parameters with no change or increasing values at a majority of locations overall, (*c*) parameters showing no change at more than 66% of locations, (*d*) parameters with no change or decreasing values at a majority of locations, and (*e*) parameters with decreasing values in more than 50% of locations overall. This table helps to summarize the trends noted above.

Factors affecting water quality

To understand what could be causing observed trends in water quality variables watershed activities, natural characteristics, and levels of development for each river of interest were cross-referenced with known sources of water quality change. Several noticeable factors emerged from this analysis including

- Representative plots of precipitation and streamflow since 1986 were generated for each region of the province (see Figs. 3 and 4). For the analysis of trend in streamflow, five representative watersheds from each region were analyzed using mean monthly flowrate data converted to millimetre depth of runoff over the watershed area. The ratio of mean monthly to mean streamflow for the period 1986–2000 was calculated for each hydrometric station and averaged for each region. From each region there was a noticeable upward trend in precipitation since 1986. There was a distinct upward trend in streamflow observed in both the Central and Labrador Regions, a slight upward trend observed in the Western Region, and no discernable trend observed in the Eastern Region. In pristine watersheds where there was little development or activity, trends were frequently observed in major ions (and conductivity), turbidity, and colour. As these trends were observed in all regions of the province, their cause is most likely linked to climate change. Increased precipitation leads to increased runoff, which in turn leads to decreased concentrations of major ions (and conductivity) and increased sediment loads, affecting turbidity, colour, and nutrients.

- Monitoring in pristine Arctic environments has revealed the presence of contaminants far from their source as a result of atmospheric deposition. Recent observations have shown reductions in lead levels, linked to reduced global emissions of lead into the atmosphere from leaded gasoline, since the 1970s. It has also revealed declining trends in zinc, declining trends in copper since 1991, and declining trends in mercury since 1990 (Indian and Northern Affairs Canada 1997). These results were mirrored in many of the more pristine watersheds of Newfoundland. Copper, mercury, and lead (and to a lesser extent barium, zinc, selenium, and arsenic) frequently displayed improving trends in watersheds with little human activity or development. The cause of these trends is most likely linked to reductions in the levels of contaminants from atmospheric deposition, due to improved emissions from pollution sources — local, continental, and global.

- Phosphorous Control Acts were implemented in the mid 1970s and continued to reduce the amounts of phosphorous used in detergents throughout the 1980s (Schreier et al. 1997). The results of this abatement are most evident in more populated urban areas (particularly St. John's).

- There are several river stewardship programs or societies, which try to promote, encourage, and maximize the ecological value of different rivers in the province. Such rivers include Virginia River, Rennies River, Waterford River, Cordroy Brook, and Corner Brook. These river societies plan river enhancement activities, including river restoration to facilitate fish spawning, alleviation of pollution, and the development of appropriate public access to the system. In many rivers, such programs have led to improved water quality through increased public awareness of harmful activities.

- Deteriorating trends in nitrate and nitrite and nitrogen were observed in both developed and more pristine river basins — specifically, basins with growing numbers of cabins, agriculture, and around urban centers. The observed trend is due to a combination of sewage either from direct outfalls and leaking septic systems, and residential and agricultural fertilizer application. Increased precipitation, surface runoff, and percolation could also be causing increased leaching of nitrogen from organic material into surface waters.

- Several site-specific effects were observed, as in the Exploits River (Station NF02YO0107 and NF02YO0001), Wild Cove Brook (Station NF02YL0029), and Mundy Pond (Station NF02ZM0109). The Exploits River is the largest river on the Island, and the upper portion of the basin contained the now abandoned ASARCO zinc, copper, and leads mine. The mine phased out operations, beginning in 1979, and concluding when the mine finally closed in 1984 (Canada–Newfoundland Water Quality Monitoring Agreement 2003).

Table 5. Summary of observed trends in major chemical and physical variables, major ions, nutrients and metals on water quality.

Envirodat	Site name	Turbidity	Colour	DO	pH	Conductivity	Calcium	Sodium	Magnesium
NF02ZL0002	Heart's Content Brook	Det.	Det.	NC	NC	NC	NC	Imp.	NC
NF02ZL0001	Spout Cove Brook	Det.	Det.	NC	NC	Imp.	NC	Imp.	Imp.
NF02ZL0029	Goulds Brook	NC	Det.	NC	NC	Det.	NC	Det.	NC
NF02ZM0020	Broad Cove Brook	Det.	Det.	NC	NC	Det.	NC	Det.	NC
NF02ZM0014	Virginia River	Det.	Det.	NC	Imp.	NC	Imp.	NC	Imp.
NF02ZM0015	Quidi Vidi Lake	Det.	Det.	NC	Imp.	NC	NC	NC	Imp.
NF02ZM0016	Rennies River	Det.	Det.	NC	Imp.	NC	NC	NC	Imp.
NF02ZM0144	Kelly's Brook	NC	Imp.	NC	NC	Imp.	Imp.	NC	Imp.
NF02ZM0109	Mundy Pond	Imp.	Imp.	NC	NC	Imp.	NC	NC	Imp.
NF02ZM0009	Waterford River	Det.	Det.	NC	Imp.	NC	NC	NC	Imp.
NF02ZM0017	Raymond Brook	Det.	NC	NC	NC	NC	NC	NC	NC
NF02ZM0018	Mobile River	Det.	Det.	NC	NC	Imp.	NC	Imp.	NC
NF02ZM0019	Seal Cove River	Det.	Det.	NC	NC	NC	NC	NC	NC
NF02ZN0002	Northwest Brook	Det.	Det.	NC	NC	Imp.	NC	NC	NC
NF02ZN0004	Salmonier River	Det.	Det.	NC	Imp.	Imp.	NC	Imp.	NC
NF02ZK0001	Rocky River	Imp.	NC	Det.	NC	NC	NC	NC	NC
NF02ZK0005	Northeast River	NC	NC	NC	Imp.	NC	NC	NC	NC
NF02ZH0001	Pipers Hole River	NC	Det.	—	NC	Imp.	Imp.	NC	Imp.
NF02ZG0025	Rattle Brook	Det.	NC	NC	NC	NC	NC	NC	NC
NF02ZG0016	Garnish River	NC	NC	NC	NC	NC	NC	NC	NC
NF02ZG0024	Tides Brook	Det.	Det.	NC	NC	Imp.	NC	Imp.	NC
NF02ZG0026	Grand Bank Brook	NC	NC	NC	NC	Imp.	NC	Imp.	Imp.
NF02YM0001	Indian Brook	NC	Det.	NC	NC	Imp.	Imp.	Imp.	Imp.
NF02YM0004	South West Brook	Det.	NC	NC	NC	Imp.	Imp.	Imp.	Imp.
NF02YO0107	Exploits River	NC	NC	Imp.	Imp.	Imp.	Imp.	Imp.	Imp.
NF02YO0020	Exploits River	NC	Det.	NC	Imp.	Imp.	Imp.	Imp.	NC
NF02YO0001	Exploits River	Imp.	Det.	NC	Imp.	Imp.	Imp.	Imp.	Imp.
NF02YO0021	Exploits River	NC	Det.	NC	Imp.	Imp.	NC	NC	NC
NF02YQ0006	North West Gander River	NC	NC	NC	NC	NC	NC	NC	NC
NF02YQ0030	Gander River	NC	NC	NC	NC	Imp.	Imp.	NC	Imp.
NF02YQ0005	Gander River	Det.	NC	NC	NC	NC	NC	Imp.	Det.
NF02YR0001	Pound Cove Brook	Det.	Det.	NC	Det.	Imp.	Imp.	NC	NC
NF02YR0021	Middle Brook	Det.	NC	Imp.	Det.	Imp.	Imp.	Imp.	Imp.
NF02YS0012	Terra Nova River	Det.	NC	NC	NC	NC	NC	Imp.	Imp.
NF02YS0001	Terra Nova River	Det.	NC	NC	NC	NC	Det.	NC	NC
NF02YS0011	Terra Nova River	Det.	NC	NC	NC	NC	NC	NC	Imp.
NF02YS0005	South West Brook	Det.	Det.	NC	NC	Imp.	Imp.	Imp.	Imp.
NF02YS0010	Bread Cove Brook	Det.	Det.	NC	Det.	Imp.	Imp.	Imp.	Imp.
NF02ZJ0024	Southern Bay River	Det.	Det.	NC	NC	Imp.	NC	Imp.	NC
NF02ZF0020	Bay du Nord River	NC	NC	NC	NC	NC	Imp.	Imp.	NC
NF02ZE0018	Jeddore Lake	NC	NC	NC	NC	Imp.	Imp.	Imp.	Imp.
NF02YA0001	Ste. Genevieve River	NC	NC	NC	NC	NC	NC	Imp.	NC
NF02YC0001	Torrent River	Imp.	Det.	NC	NC	Imp.	NC	Imp.	NC
NF02YE0004	Portland Creek	Det.	Det.	NC	Imp.	Imp.	Det.	Imp.	NC
NF02YE0005	Western Brook	Det.	Det.	NC	Imp.	Imp.	NC	Imp.	NC
NF02YG0001	Main River	Det.	Det.	NC	NC	Imp.	NC	Imp.	NC
NF02YH0018	Lomond River	Det.	Det.	NC	Det.	NC	NC	Imp.	NC
NF02YL0011	Humber River	Det.	Det.	NC	NC	NC	NC	Imp.	NC
NF02YK0022	Humber Canal	Det.	NC	Det.	Imp.	NC	NC	Imp.	NC
NF02YL0012	Humber River	Det.	Det.	Det.	Imp.	NC	Det.	Imp.	NC
NF02YL0013	Corner Brook	Det.	Det.	NC	NC	NC	NC	NC	NC
NF02YL0029	Wild Cove Brook	Det.	NC	Det.	Det.	NC	NC	NC	NC
NF02YJ0004	Pinchgut Brook	Det.	Det.	Det.	Det.	NC	NC	Imp.	NC
NF02YJ0006	Harry's River	NC	Det.	Imp.	NC	Imp.	NC	Imp.	Imp.
NF02ZA0007	Crabbe's River	Det.	NC	NC	Imp.	NC	NC	NC	NC
NF02YN0001	Lloyd's River	Det.	NC	Det.	NC	NC	NC	Imp.	NC
NF02ZA0001	South Branch River	Det.	NC	NC	NC	Imp.	Imp.	Imp.	NC
NF02ZA0006	Grand Codroy River	Det.	NC	NC	NC	Imp.	Imp.	Imp.	Imp.
NF02ZB0001	Isle aux Mort River	Imp.	NC	—	NC	Imp.	Imp.	NC	Imp.
NF02ZB0005	Cinq Cerf Brook	Det.	NC	Det.	NC	NC	NC	NC	NC
NF02ZC0001	Grandy's Brook	NC	Det.	NC	NC	Imp.	NC	NC	Imp.
NF02ZC0011	White Bear River	Det.	NC	Det.	NC	NC	NC	NC	NC
NF02ZD0003	Grey River	NC	Det.	—	NC	Imp.	NC	Imp.	Imp.
NF03OE0001	Churchill River	NC	Det.	—	NC	NC	NC	NC	NC
NF03QC0001	Eagle River	Imp.	NC	—	NC	NC	NC	NC	NC

Table 5. *Continued.*

Envirodat	Site name	Potassium	Sulphate	Chloride	Floride	Nitrogen	Nitrate/Nitrite	Phosphorous
NF02ZL0002	Heart's Content Brook	NC	NC	NC	NC	NC	NC	Imp.
NF02ZL0001	Spout Cove Brook	NC	NC	Imp.	NC	NC	NC	Imp.
NF02ZL0029	Goulds Brook	Imp.	Det.	Det.	NC	Imp.	Imp.	Imp.
NF02ZM0020	Broad Cove Brook	NC	NC	Det.	NC	Det.	NC	NC
NF02ZM0014	Virginia River	NC	Det.	NC	NC	Det.	Det.	Imp.
NF02ZM0015	Quidi Vidi Lake	NC	NC	NC	NC	Det.	Det.	Imp.
NF02ZM0016	Rennies River	NC	Det.	NC	NC	Det.	Det.	Imp.
NF02ZM0144	Kelly's Brook	Imp.	Imp.	Imp.	NC	Imp.	NC	Det.
NF02ZM0109	Mundy Pond	Imp.	NC	NC	NC	Imp.	NC	NC
NF02ZM0009	Waterford River	NC	Det.	NC	NC	Det.	Det.	Imp.
NF02ZM0017	Raymond Brook	Imp.	NC	Det.	NC	NC	NC	NC
NF02ZM0018	Mobile River	Imp.	NC	Imp.	NC	NC	NC	NC
NF02ZM0019	Seal Cove River	NC	NC	NC	NC	NC	NC	Imp.
NF02ZN0002	Northwest Brook	Imp.	NC	NC	NC	Det.	NC	NC
NF02ZN0004	Salmonier River	Imp.	NC	Imp.	NC	Det.	NC	Imp.
NF02ZK0001	Rocky River	NC	NC	NC	NC	Det.	Det.	NC
NF02ZK0005	Northeast River	NC	NC	Det.	NC	Det.	NC	Imp.
NF02ZH0001	Pipers Hole River	NC	Imp.	Imp.	NC	Det.	NC	NC
NF02ZG0025	Rattle Brook	Imp.	NC	NC	NC	NC	NC	Imp.
NF02ZG0016	Garnish River	NC	NC	NC	NC	NC	NC	NC
NF02ZG0024	Tides Brook	Imp.	NC	NC	NC	Det.	Imp.	NC
NF02ZG0026	Grand Bank Brook	Imp.	NC	NC	NC	NC	Imp.	NC
NF02YM0001	Indian Brook	NC	Imp.	Imp.	NC	NC	NC	Det.
NF02YM0004	South West Brook	Imp.	Imp.	Imp.	NC	Det.	NC	Imp.
NF02YO0107	Exploits River	Imp.	Imp.	Imp.	NC	Imp.	NC	Imp.
NF02YO0020	Exploits River	Imp.	Imp.	Imp.	NC	NC	NC	Imp.
NF02YO0001	Exploits River	NC	Imp.	Imp.	NC	Det.	Det.	NC
NF02YO0021	Exploits River	NC	Imp.	NC	NC	NC	Det.	Imp.
NF02YQ0006	North West Gander River	Imp.	Imp.	NC	NC	NC	NC	Imp.
NF02YQ0030	Gander River	Imp.	NC	NC	NC	NC	NC	NC
NF02YQ0005	Gander River	Imp.	NC	NC	NC	Det.	NC	NC
NF02YR0001	Pound Cove Brook	NC	Imp.	NC	NC	Det.	NC	Imp.
NF02YR0021	Middle Brook	Imp.	Imp.	NC	NC	NC	NC	NC
NF02YS0012	Terra Nova River	Imp.	NC	NC	NC	NC	NC	NC
NF02YS0001	Terra Nova River	Det.	NC	Det.	NC	Det.	Det.	NC
NF02YS0011	Terra Nova River	NC	NC	NC	NC	NC	NC	NC
NF02YS0005	South West Brook	Imp.	Imp.	NC	NC	NC	NC	Imp.
NF02YS0010	Bread Cove Brook	Imp.	Imp.	NC	NC	NC	NC	NC
NF02ZJ0024	Southern Bay River	NC	NC	Imp.	NC	NC	NC	Imp.
NF02ZF0020	Bay du Nord River	Imp.	NC	NC	NC	NC	NC	NC
NF02ZE0018	Jeddore Lake	Imp.	NC	NC	NC	NC	NC	NC
NF02YA0001	Ste. Genevieve River	Det.	Imp.	Imp.	NC	Det.	Det.	NC
NF02YC0001	Torrent River	NC	Imp.	Imp.	NC	Det.	NC	NC
NF02YE0004	Portland Creek	Imp.	Imp.	Imp.	NC	Det.	Det.	NC
NF02YE0005	Western Brook	NC	NC	Imp.	NC	Det.	Det.	NC
NF02YG0001	Main River	Imp.	Imp.	Imp.	NC	NC	NC	NC
NF02YH0018	Lomond River	Imp.	NC	Imp.	NC	Det.	Det.	NC
NF02YL0011	Humber River	NC	Imp.	NC	NC	NC	NC	NC
NF02YK0022	Humber Canal	NC	NC	Det.	NC	NC	Det.	NC
NF02YL0012	Humber River	Imp.	NC	NC	NC	Det.	Det.	NC
NF02YL0013	Corner Brook	NC	NC	NC	NC	Det.	Det.	NC
NF02YL0029	Wild Cove Brook	Det.	NC	NC	NC	Det.	Det.	NC
NF02YJ0004	Pinchgut Brook	Imp.	Imp.	Imp.	NC	NC	Det.	NC
NF02YJ0006	Harry's River	NC	Imp.	Imp.	NC	NC	Imp.	Det.
NF02ZA0007	Crabbe's River	NC	NC	NC	NC	NC	NC	NC
NF02YN0001	Lloyd's River	Imp.	NC	NC	NC	NC	Det.	NC
NF02ZA0001	South Branch River	Imp.	NC	NC	NC	NC	NC	NC
NF02ZA0006	Grand Codroy River	Imp.	Imp.	Imp.	NC	NC	NC	NC
NF02ZB0001	Isle aux Mort River	NC	NC	NC	NC	NC	NC	Det.
NF02ZB0005	Cinq Cerf Brook	Imp.	NC	NC	NC	NC	NC	Det.
NF02ZC0001	Grandy's Brook	NC	NC	NC	Imp.	NC	NC	NC
NF02ZC0011	White Bear River	Imp.	NC	NC	NC	NC	Imp.	NC
NF02ZD0003	Grey River	Imp.	NC	Imp.	NC	NC	NC	NC
NF03OE0001	Churchill River	Det.	Imp.	NC	NC	Det.	NC	NC
NF03QC0001	Eagle River	NC	Imp.	Imp.	NC	Det.	Det.	NC

Table 5. *Continued.*

Envirodat	Site name	Silica	DOC	Aluminium	Arsenic	Barium	Beryllium	Cadmium
NF02ZL0002	Heart's Content Brook	NC	Det.	NC	NC	Imp.	Det.	Det.
NF02ZL0001	Spout Cove Brook	NC	Det.	NC	Imp.	Imp.	NC	NC
NF02ZL0029	Goulds Brook	NC	NC	Imp.	NC	NC	Det.	Det.
NF02ZM0020	Broad Cove Brook	NC	NC	NC	NC	Det.	Det.	Det.
NF02ZM0014	Virginia River	NC	NC	NC	NC	Imp.	Imp.	NC
NF02ZM0015	Quidi Vidi Lake	NC	Det.	NC	NC	Imp.	NC	NC
NF02ZM0016	Rennies River	NC	Det.	NC	NC	Imp.	NC	Imp.
NF02ZM0144	Kelly's Brook	NC	NC	NC	NC	Imp.	Imp.	Imp.
NF02ZM0109	Mundy Pond	NC	Det.	NC	NC	Imp.	Imp.	Imp.
NF02ZM0009	Waterford River	Det.	Det.	NC	NC	NC	Det.	NC
NF02ZM0017	Raymond Brook	NC	NC	Imp.	Imp.	Imp.	Det.	Det.
NF02ZM0018	Mobile River	Det.	NC	NC	NC	NC	NC	NC
NF02ZM0019	Seal Cove River	NC	NC	NC	NC	NC	NC	NC
NF02ZN0002	Northwest Brook	NC	NC	NC	NC	Imp.	Det.	Det.
NF02ZN0004	Salmonier River	NC	NC	Imp.	Det.	Imp.	Det.	Det.
NF02ZK0001	Rocky River	NC	NC	NC	Imp.	NC	NC	Det.
NF02ZK0005	Northeast River	NC	NC	NC	NC	NC	Det.	Det.
NF02ZH0001	Pipers Hole River	NC	Det.	—	Imp.	—	—	—
NF02ZG0025	Rattle Brook	NC	NC	NC	Imp.	NC	NC	NC
NF02ZG0016	Garnish River	NC	NC	NC	Imp.	NC	Det.	NC
NF02ZG0024	Tides Brook	NC	NC	NC	NC	Imp.	NC	NC
NF02ZG0026	Grand Bank Brook	NC	NC	NC	NC	Imp.	NC	NC
NF02YM0001	Indian Brook	NC	NC	—	NC	—	—	—
NF02YM0004	South West Brook	NC	NC	NC	NC	Imp.	Det.	NC
NF02YO0107	Exploits River	Imp.	NC	Imp.	Imp.	Imp.	Det.	Imp.
NF02YO0020	Exploits River	NC	NC	NC	Imp.	Imp.	NC	NC
NF02YO0001	Exploits River	NC	NC	—	Imp.	—	—	—
NF02YO0021	Exploits River	NC	NC	NC	Imp.	Imp.	Det.	NC
NF02YQ0006	North West Gander River	NC	NC	Imp.	Imp.	Imp.	Det.	Det.
NF02YQ0030	Gander River	NC	NC	Imp.	Imp.	Imp.	Det.	Det.
NF02YQ0005	Gander River	NC	Det.	NC	NC	NC	NC	Imp.
NF02YR0001	Pound Cove Brook	NC	NC	NC	NC	NC	NC	Det.
NF02YR0021	Middle Brook	Imp.	NC	NC	NC	NC	Det.	Det.
NF02YS0012	Terra Nova River	NC	Imp.	NC	NC	NC	NC	Det.
NF02YS0001	Terra Nova River	Det.	NC	NC	NC	NC	Det.	Det.
NF02YS0011	Terra Nova River	NC	NC	NC	NC	NC	Det.	Det.
NF02YS0005	South West Brook	NC	NC	NC	NC	Imp.	Det.	Imp.
NF02YS0010	Bread Cove Brook	NC	NC	Det.	NC	NC	NC	NC
NF02ZJ0024	Southern Bay River	NC	NC	NC	NC	NC	Det.	Det.
NF02ZF0020	Bay du Nord River	NC	Imp.	NC	NC	NC	NC	NC
NF02ZE0018	Jeddore Lake	Det.	NC	NC	NC	NC	NC	NC
NF02YA0001	Ste. Genevieve River	NC	NC	Imp.	NC	NC	Det.	Det.
NF02YC0001	Torrent River	NC	NC	—	Imp.	—	—	—
NF02YE0004	Portland Creek	NC	Det.	Det.	NC	Imp.	Det.	Det.
NF02YE0005	Western Brook	Det.	Det.	Det.	Det.	NC	Det.	Det.
NF02YG0001	Main River	NC	NC	NC	NC	NC	Det.	NC
NF02YH0018	Lomond River	Det.	Det.	NC	NC	Imp.	Det.	Det.
NF02YL0011	Humber River	NC	NC	NC	NC	NC	Det.	Det.
NF02YK0022	Humber Canal	NC	NC	NC	Imp.	NC	NC	NC
NF02YL0012	Humber River	Det.	NC	NC	NC	Imp.	NC	NC
NF02YL0013	Corner Brook	NC	Det.	Det.	NC	NC	NC	NC
NF02YL0029	Wild Cove Brook	NC	Det.	Det.	Imp.	Det.	NC	NC
NF02YJ0004	Pinchgut Brook	Det.	Det.	NC	NC	Imp.	Det.	Det.
NF02YJ0006	Harry's River	NC	NC	NC	Imp.	NC	Det.	Det.
NF02ZA0007	Crabbe's River	NC	Imp.	NC	NC	NC	Det.	NC
NF02YN0001	Lloyd's River	NC	NC	NC	NC	NC	Det.	Det.
NF02ZA0001	South Branch River	NC	NC	NC	NC	NC	Det.	NC
NF02ZA0006	Grand Codroy River	Det.	NC	NC	Imp.	Imp.	NC	NC
NF02ZB0001	Isle aux Mort River	NC	NC	—	—	—	—	—
NF02ZB0005	Cinq Cerf Brook	NC	NC	NC	Imp.	NC	NC	NC
NF02ZC0001	Grandy's Brook	NC	NC	NC	Imp.	Imp.	Det.	Det.
NF02ZC0011	White Bear River	NC	NC	NC	Imp.	NC	NC	NC
NF02ZD0003	Grey River	NC	NC	—	Imp.	—	—	—
NF03OE0001	Churchill River	NC	NC	—	—	—	—	—
NF03QC0001	Eagle River	NC	NC	—	NC	—	—	—

Table 5. *Continued.*

Envirodat	Site name	Cobalt	Chromium	Copper	Iron	Lead	Lithium	Manganese
NF02ZL0002	Heart's Content Brook	NC	NC	Imp.	NC	Imp.	NC	NC
NF02ZL0001	Spout Cove Brook	NC	NC	Imp.	Det.	Imp.	NC	Det.
NF02ZL0029	Goulds Brook	Imp.	Det.	NC	NC	NC	NC	Imp.
NF02ZM0020	Broad Cove Brook	NC	NC	Imp.	NC	NC	Det.	NC
NF02ZM0014	Virginia River	Imp.	NC	NC	NC	NC	NC	NC
NF02ZM0015	Quidi Vidi Lake	Imp.	NC	NC	Imp.	Imp.	NC	Imp.
NF02ZM0016	Rennies River	Imp.	NC	NC	Imp.	Imp.	Det.	Imp.
NF02ZM0144	Kelly's Brook	Imp.	NC	Imp.	Imp.	NC	Imp.	Imp.
NF02ZM0109	Mundy Pond	Imp.	NC	NC	Imp.	NC	Imp.	Imp.
NF02ZM0009	Waterford River	Imp.	NC	NC	NC	NC	Det.	Imp.
NF02ZM0017	Raymond Brook	Imp.	NC	NC	NC	NC	NC	Imp.
NF02ZM0018	Mobile River	Imp.	NC	NC	NC	Imp.	NC	Imp.
NF02ZM0019	Seal Cove River	Det.	Imp.	Imp.	NC	Imp.	NC	NC
NF02ZN0002	Northwest Brook	NC	NC	Imp.	NC	NC	Imp.	NC
NF02ZN0004	Salmonier River	NC	Det.	NC	Imp.	NC	Imp.	NC
NF02ZK0001	Rocky River	NC	Det.	Det.	NC	NC	NC	NC
NF02ZK0005	Northeast River	NC	NC	NC	NC	Imp.	Imp.	NC
NF02ZH0001	Pipers Hole River	—	—	—	—	—	—	—
NF02ZG0025	Rattle Brook	NC	Imp.	Imp.	NC	Imp.	NC	NC
NF02ZG0016	Garnish River	NC	NC	Det.	NC	Imp.	NC	NC
NF02ZG0024	Tides Brook	Det.	NC	Imp.	Det.	Imp.	NC	NC
NF02ZG0026	Grand Bank Brook	NC	NC	NC	NC	NC	NC	NC
NF02YM0001	Indian Brook	—	—	—	—	—	—	—
NF02YM0004	South West Brook	NC	NC	NC	NC	Imp.	Imp.	NC
NF02YO0107	Exploits River	NC	Det.	Imp.	NC	Imp.	NC	Imp.
NF02YO0020	Exploits River	NC	NC	Imp.	NC	Imp.	Imp.	Imp.
NF02YO0001	Exploits River	—	—	—	—	—	—	—
NF02YO0021	Exploits River	NC	NC	Imp.	NC	Imp.	Imp.	NC
NF02YQ0006	North West Gander River	NC	NC	Imp.	NC	NC	Imp.	NC
NF02YQ0030	Gander River	NC	NC	NC	Imp.	NC	Imp.	NC
NF02YQ0005	Gander River	NC	NC	NC	Det.	NC	NC	NC
NF02YR0001	Pound Cove Brook	NC	NC	Imp.	NC	Imp.	Imp.	NC
NF02YR0021	Middle Brook	NC	NC	NC	NC	Imp.	Imp.	NC
NF02YS0012	Terra Nova River	NC	NC	NC	NC	Imp.	NC	NC
NF02YS0001	Terra Nova River	NC	NC	NC	NC	NC	NC	NC
NF02YS0011	Terra Nova River	Det.	NC	NC	Det.	Imp.	NC	NC
NF02YS0005	South West Brook	Imp.	Imp.	NC	NC	Imp.	Imp.	NC
NF02YS0010	Bread Cove Brook	NC	NC	Imp.	NC	Imp.	Imp.	NC
NF02ZJ0024	Southern Bay River	NC	NC	Imp.	NC	Imp.	NC	NC
NF02ZF0020	Bay du Nord River	NC	NC	NC	NC	Imp.	Imp.	NC
NF02ZE0018	Jeddore Lake	NC	NC	NC	NC	NC	Imp.	NC
NF02YA0001	Ste. Genevieve River	Det.	Det.	NC	NC	Det.	NC	NC
NF02YC0001	Torrent River	—	—	—	—	—	—	—
NF02YE0004	Portland Creek	Det.	NC	Imp.	Det.	Imp.	NC	Det.
NF02YE0005	Western Brook	Det.	NC	Imp.	NC	NC	NC	NC
NF02YG0001	Main River	NC	NC	Imp.	NC	Imp.	NC	NC
NF02YH0018	Lomond River	NC	NC	Imp.	NC	NC	NC	NC
NF02YL0011	Humber River	NC	NC	NC	NC	NC	NC	NC
NF02YK0022	Humber Canal	NC	NC	NC	NC	NC	NC	NC
NF02YL0012	Humber River	NC	NC	NC	Det.	Imp.	NC	NC
NF02YL0013	Corner Brook	NC	NC	Imp.	Det.	Imp.	NC	NC
NF02YL0029	Wild Cove Brook	NC	NC	NC	Det.	NC	Det.	NC
NF02YJ0004	Pinchgut Brook	NC	NC	Imp.	NC	Imp.	NC	NC
NF02YJ0006	Harry's River	NC	NC	NC	NC	NC	NC	NC
NF02ZA0007	Crabbe's River	NC	NC	Imp.	NC	NC	NC	Det.
NF02YN0001	Lloyd's River	Det.	NC	Imp.	NC	NC	NC	NC
NF02ZA0001	South Branch River	NC	NC	NC	NC	Imp.	NC	Det.
NF02ZA0006	Grand Codroy River	NC	NC	Imp.	NC	Imp.	NC	NC
NF02ZB0001	Isle aux Mort River	—	—	—	—	—	—	—
NF02ZB0005	Cinq Cerf Brook	NC	NC	NC	NC	NC	NC	Det.
NF02ZC0001	Grandy's Brook	NC	NC	NC	NC	NC	NC	NC
NF02ZC0011	White Bear River	Det.	Det.	NC	Imp.	NC	NC	NC
NF02ZD0003	Grey River	—	—	—	—	—	—	—
NF03OE0001	Churchill River	—	—	—	—	—	—	—
NF03QC0001	Eagle River	—	—	—	—	—	—	—

Table 5. *Concluded.*

ENVIRODAT	Site name	Mercury	Molybdenum	Nickel	Selenium	Strontium	Zinc	Vanadium
NF02ZL0002	Heart's Content Brook	Imp.	Det.	NC	Imp.	NC	NC	NC
NF02ZL0001	Spout Cove Brook	Imp.	Imp.	NC	Imp.	Imp.	NC	Imp.
NF02ZL0029	Goulds Brook	NC	Det.	Det.	NC	Det.	Det.	NC
NF02ZM0020	Broad Cove Brook	Imp.	Det.	Det.	NC	NC	Det.	NC
NF02ZM0014	Virginia River	NC	Det.	NC	Imp.	Imp.	Imp.	NC
NF02ZM0015	Quidi Vidi Lake	NC	Det.	NC	NC	Imp.	NC	NC
NF02ZM0016	Rennies River	NC	Det.	NC	NC	Imp.	NC	NC
NF02ZM0144	Kelly's Brook	Imp.	NC	NC	NC	Imp.	NC	NC
NF02ZM0109	Mundy Pond	NC	NC	NC	NC	Imp.	Imp.	NC
NF02ZM0009	Waterford River	Imp.	Det.	NC	NC	Imp.	NC	NC
NF02ZM0017	Raymond Brook	Imp.	Det.	Det.	NC	NC	Imp.	NC
NF02ZM0018	Mobile River	Imp.	NC	NC	NC	NC	NC	NC
NF02ZM0019	Seal Cove River	Imp.	NC	NC	NC	NC	NC	NC
NF02ZN0002	Northwest Brook	Imp.	Det.	Det.	NC	NC	NC	Det.
NF02ZN0004	Salmonier River	Imp.	Det.	Det.	NC	Imp.	NC	Imp.
NF02ZK0001	Rocky River	—	NC	NC	—	NC	NC	NC
NF02ZK0005	Northeast River	NC	Det.	Det.	NC	Imp.	NC	NC
NF02ZH0001	Pipers Hole River	—	—	—	—	—	—	—
NF02ZG0025	Rattle Brook	Imp.	NC	NC	NC	NC	Imp.	NC
NF02ZG0016	Garnish River	NC	Det.	NC	—	NC	NC	NC
NF02ZG0024	Tides Brook	Imp.	Det.	NC	NC	Imp.	Imp.	NC
NF02ZG0026	Grand Bank Brook	Imp.	NC	NC	NC	NC	NC	NC
NF02YM0001	Indian Brook	—	—	—	—	—	—	—
NF02YM0004	South West Brook	Imp.	Imp.	NC	NC	Imp.	NC	NC
NF02YO0107	Exploits River	Imp.	NC	NC	NC	Imp.	Imp.	NC
NF02YO0020	Exploits River	Imp.	NC	NC	NC	Imp.	Imp.	NC
NF02YO0001	Exploits River	—	—	—	—	—	—	—
NF02YO0021	Exploits River	NC	NC	NC	—	Imp.	Imp.	Imp.
NF02YQ0006	North West Gander River	Imp.	NC	NC	NC	NC	NC	Imp.
NF02YQ0030	Gander River	NC	Det.	NC	NC	Imp.	NC	Det.
NF02YQ0005	Gander River	NC	NC	Det.	NC	NC	NC	NC
NF02YR0001	Pound Cove Brook	NC	NC	Imp.	Imp.	NC	NC	NC
NF02YR0021	Middle Brook	Imp.	NC	Det.	NC	Imp.	Det.	Imp.
NF02YS0012	Terra Nova River	Imp.	NC	NC	NC	Imp.	NC	NC
NF02YS0001	Terra Nova River	Imp.	NC	NC	Imp.	NC	NC	NC
NF02YS0011	Terra Nova River	Imp.	NC	NC	NC	NC	NC	NC
NF02YS0005	South West Brook	NC	Det.	NC	NC	Imp.	NC	Imp.
NF02YS0010	Bread Cove Brook	Imp.	NC	NC	NC	Imp.	Imp.	NC
NF02ZJ0024	Southern Bay River	Imp.	Det.	Det.	NC	NC	NC	NC
NF02ZF0020	Bay du Nord River	Imp.	NC	NC	Imp.	Imp.	NC	NC
NF02ZE0018	Jeddore Lake	Imp.	NC	NC	NC	Imp.	Det.	NC
NF02YA0001	Ste. Genevieve River	NC	Det.	Det.	NC	NC	Det.	Det.
NF02YC0001	Torrent River	—	—	—	—	—	—	—
NF02YE0004	Portland Creek	Imp.	Det.	Det.	Imp.	NC	NC	NC
NF02YE0005	Western Brook	Imp.	Det.	NC	NC	Imp.	NC	NC
NF02YG0001	Main River	Imp.	NC	NC	NC	NC	NC	NC
NF02YH0018	Lomond River	Imp.	Det.	NC	NC	NC	NC	NC
NF02YL0011	Humber River	Imp.	Det.	NC	NC	NC	NC	NC
NF02YK0022	Humber Canal	Imp.	NC	NC	NC	NC	NC	NC
NF02YL0012	Humber River	Imp.	NC	NC	NC	NC	NC	NC
NF02YL0013	Corner Brook	Imp.	NC	NC	NC	NC	NC	NC
NF02YL0029	Wild Cove Brook	Imp.	NC	Det.	NC	NC	Det.	NC
NF02YJ0004	Pinchgut Brook	Imp.	Det.	NC	NC	NC	Imp.	NC
NF02YJ0006	Harry's River	NC	NC	NC	—	NC	NC	NC
NF02ZA0007	Crabbe's River	NC	Det.	NC	Imp.	NC	NC	NC
NF02YN0001	Lloyd's River	Imp.	NC	NC	NC	NC	NC	Det.
NF02ZA0001	South Branch River	Imp.	NC	NC	NC	NC	NC	NC
NF02ZA0006	Grand Codroy River	NC	Det.	Det.	NC	Imp.	NC	NC
NF02ZB0001	Isle aux Mort River	—	—	—	—	—	—	—
NF02ZB0005	Cinq Cerf Brook	Imp.	NC	NC	NC	NC	NC	NC
NF02ZC0001	Grandy's Brook	—	NC	NC	NC	NC	NC	NC
NF02ZC0011	White Bear River	Imp.	Det.	NC	Imp.	NC	NC	NC
NF02ZD0003	Grey River	—	—	—	—	—	—	—
NF03OE0001	Churchill River	—	—	—	—	—	—	—
NF03QC0001	Eagle River	—	—	—	—	—	—	—

Note: DO, dissolved oxygen; —, no data; Det., deteriorating; Imp., Improving; NC, No change.

Table 6. Categorization of variables based on percentage change across island regions.

	Eastern Region	Central Region	Western Region	Newfoundland
Increasing Values				
Turbidity	64	53	73	63
Colour	64	42	55	54
Beryllium	43	59	63	54
No change or increased values				
Nitrogen	86	95	100	94
Nitrate & Nitrite	86	100	91	92
Cadmium	86	82	100	89
Molybdenum	95	94	100	96
No change				
DO	95	89	60	82
pH	73	63	64	67
Flouride	100	100	100	100
Silica	91	79	77	83
DOC	68	84	68	73
Aluminum	86	76	74	79
Cobalt	48	88	74	68
Chromium	76	88	89	84
Iron	67	82	74	74
Manganese	57	88	79	74
Nickel	71	76	79	75
Selenium	84	81	83	83
Zinc	67	65	84	72
Vanadium	86	71	89	82
No change or decreased values				
Calcium	100	95	91	95
Magnesium	100	95	100	98
Sulphate	82	100	100	94
Chloride	82	95	95	90
Phosphorous	95	95	96	96
Arsenic	95	100	95	97
Barium	95	100	95	96
Copper	90	100	100	96
Lithium	86	100	95	93
Strontium	95	100	100	98
Decreasing values				
Conductivity	41	68	45	51
Sodium	27	68	68	54
Potassium	45	63	50	52
Lead	48	71	37	51
Mercury	65	71	78	71

Note: DO, dissolved oxygen; DOC, dissolved organic carbon.

Over time, effects of acid mine leachate from the mine have lessened, reducing metal and sulphate levels while moderating pH. The Abitibi Consolidated pulp and paper mill, located in Grand Falls, discharges effluent into the Exploits River, a factor in the deteriorating trend observed in colour. Wild Cove Brook is located next to the City of Corner Brook's landfill. Leachate from this landfill and the bark pile located nearby has caused deteriorating trends in metals, pH, and dissolved oxygen. Mundy Pond is a highly polluted urban waterbody that has seen improvements in nearly all water quality variables as a result of improved environmental practices by the population of the City of St. John's.

The decreasing trend in phosphorous in Quidi Vidi Lake (Station NF02ZM0015) can be attributed to phosphorous control measures reducing the amount of phosphorous in soaps and detergents first started in the 1970s. River conservation societies in this urban watershed have also done much to promote the cleanup of this river system, promoting river enhancement and abatement of pollution causing practices.

Fig. 3. Precipitation trends throughout province since 1986.

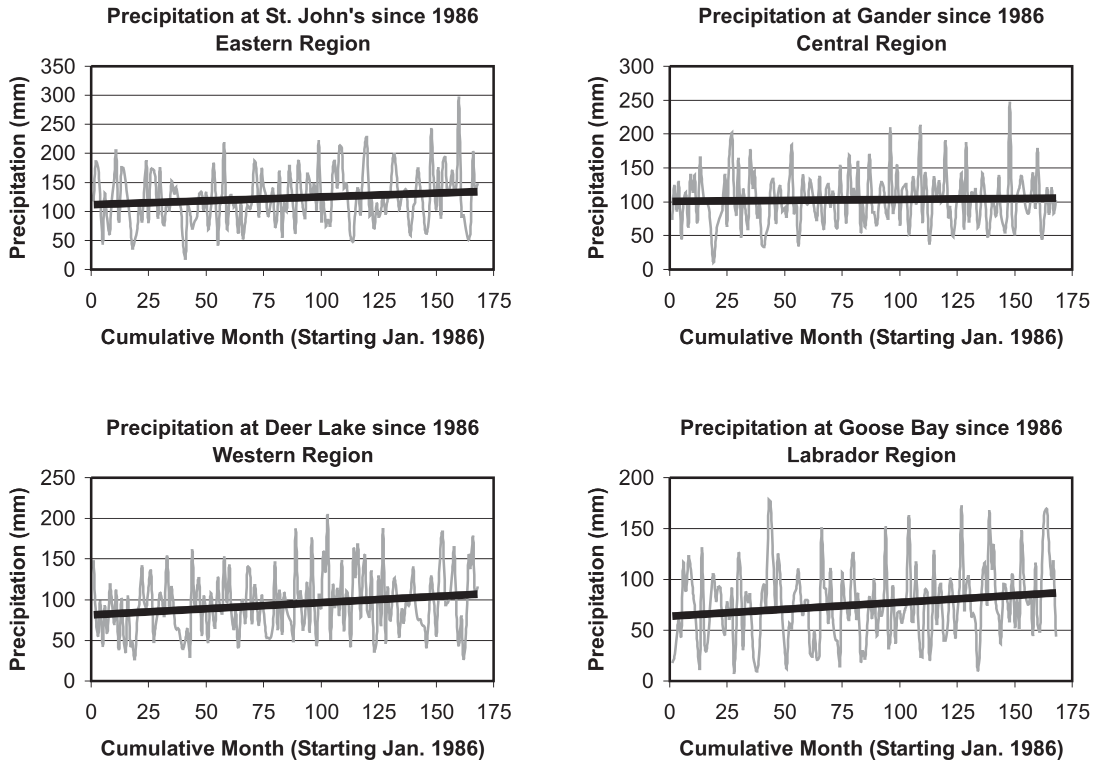
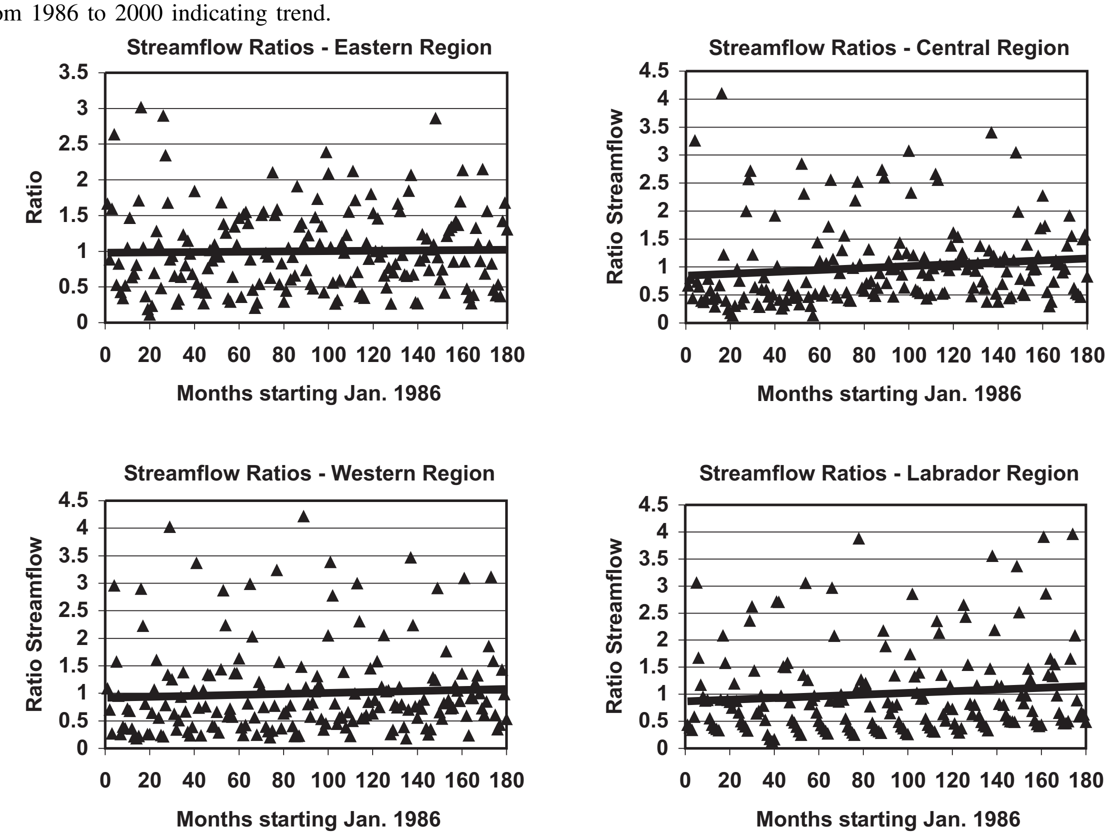


Fig. 4. Average ratio of mean monthly to mean streamflow for five representative watersheds per region throughout Newfoundland and Labrador from 1986 to 2000 indicating trend.



The increasing trend in turbidity in Pinchgut Brook (Station NF02YJ0004) can be linked to a number of different factors. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and increasing turbidity. Forestry practices in the watershed and cabin development along Pinchgut Lake have also influenced turbidity levels.

Conclusion

The results of this study indicate that there have been changes in many water quality variables throughout the rivers monitored as part of the Canada–Newfoundland Water Quality Monitoring Agreement since 1986. Changes have resulted in both improvement and deterioration in some water quality parameters. In trying to link factors affecting these changes, it is obvious that local and global conditions both have an impact on this dynamic, for even in pristine watersheds, significant change was observed. The most significant causal factors affecting water quality in Newfoundland and Labrador is the change in precipitation and streamflow observed throughout most of the province. In a majority of instances the observed upward and downward trends in values of individual parameters is consistent with, and can reasonably be attributed to, the upward trend in precipitation and consequently streamflow.

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