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PRAIRIE PROVINCES WATER BOARD

Report #174

Review of the 1992 Interprovincial Water Quality Objectives and Recommendations for Change

Prepared for the Prairie Provinces Water Board
By the Committee on Water Quality

November 2015

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Executive Summary

In 1969 the governments of Alberta, Saskatchewan, Manitoba and Canada signed the Master Agreement on Apportionment (MAA). The agreement provided for equitable sharing of water in eastward flowing streams across interprovincial boundaries. The Prairie Provinces Water Board (PPWB) is accountable for the administration of the agreement and reporting achievements to the governments. In 1992 the agreement was amended to include the Agreement on Water Quality (Schedule E). This agreement defines the mandate of the Prairie Provinces Water Board in interprovincial water quality management and the duties of the Board in carrying out that mandate. As part of Schedule E, Water Quality Objectives (WQOs) were established for 11 transboundary river reaches crossing the Alberta-Saskatchewan and Saskatchewan-Manitoba borders.

The interprovincial water quality objectives are descriptions of water quality conditions that are known to protect specific water uses (as below) and are acceptable to upstream and downstream provinces. The provincial governments agree to endeavour to meet these objectives. The governments also agree that if the quality of the water in a transboundary river reach is better than the interprovincial water quality objectives, all reasonable and practical measures will be taken to maintain the existing water quality. The PPWB has developed an active water quality program to assess whether interprovincial objectives are being met. The program includes water quality monitoring at 12 transboundary river reaches by Environment Canada (Schedule E does not include WQOs for the Cold River downstream of Cold Lake).

Schedule E also directs the PPWB to review the interprovincial water quality objectives for each transboundary river reach on a periodic basis of at least every five years. Updates to the water quality objectives should reflect changes in water uses, management approaches and new scientific information. This document describes the process the Committee on Water Quality (COWQ), a permanent committee of the PPWB, undertook to review and provide recommendations on the update of the interprovincial WQOs that were set in 1992.

During this review of interprovincial WQOs, the COWQ took a consistent approach to setting water quality objectives across all transboundary river reaches that also considered site specific characteristics and conditions. The method used to review the WQOs was a four step process that included:

- assessment of water uses for the 12 transboundary river reaches;
- identification of water quality parameters to evaluate and assess ambient conditions;
- comparison of existing WQOs for different water uses from five jurisdictions (Alberta, Saskatchewan, Manitoba, Canada and the United States) and

- assessment of historic water quality data at each of the transboundary river reaches for which interprovincial WQO are being established.

The water uses considered in this review of interprovincial WQOs are the protection of aquatic life, agriculture uses (irrigation and livestock), recreation and aesthetics, treatability for use as a drinking water source, and fish tissue consumption (for human and aquatic biota consumers).

The COWQ in consultation with the Board recommended that all water uses be protected for all the transboundary river reaches. In 1992, specific uses were described for each site and not all water uses were protected for each transboundary river reach.

The COWQ selected the most protective water use guideline/objective available for each parameter of interest at each transboundary river reach. The objectives were either provincial guidelines/objectives used within the jurisdictions party to the Master Agreement or national generic guidelines developed by the Canadian Council of Ministers of the Environment (CCME), Health Canada, or the US Environmental Protection Agency (USEPA).

When existing water quality exceeded the current/proposed interprovincial WQO and the causes of the exceedances were suspected to be largely natural or in some cases where there was no appropriate water quality guideline, a background water quality objective was developed. Background WQOs were based on the 90th percentile of the historical ambient data. Where water quality parameters exhibited seasonal differences, 90th percentiles were calculated for both the open-water and ice covered periods. For nutrients, a tiered objective approach was adopted depending on the presence of a statistically significant monotonic trend. When a trend was present, the 90th percentile of the full data record was used as the upper limit water quality objective. A lower limit was calculated with the lowest running 10 year 90th percentiles.

Site specific background objectives were developed for nutrients (total phosphorus, total dissolved phosphorus, and total nitrogen), total suspended solids, fluoride, and major ions for some rivers.

Overall, 71 interprovincial WQOs for different water quality parameters are recommended for the transboundary river reaches. Objectives were included for nutrients, metals, major ions, physical characteristics, pesticides and radioisotopes. The same list of parameters is recommended for both the Alberta/Saskatchewan and the Saskatchewan/Manitoba boundaries. However in some cases, interprovincial WQOs may differ between individual transboundary river reaches, particularly those developed with the background approach.

In comparison to the 1992 interprovincial WQOs, the COWQ is recommending:

- Alberta/Saskatchewan border: 41 new water quality objectives, 15 objectives to remain the same, 15 objectives to be updated and 7 objectives to be removed; and
- Manitoba/Saskatchewan border: 40 new objectives, 9 objectives to remain the same, 22 objectives to be updated and 6 objectives to be removed.

The purpose of this review is to provide recommendations to the PPWB on appropriate interprovincial water quality objectives for a complete suite of parameters that would protect desired water uses on all transboundary river reaches. The PPWB will consider these recommendations, decide how these recommendations will be incorporated into the administration of the Master Agreement on Apportionment and submit its recommendations to Ministers of each government for consideration and approval.

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1. Introduction and Background

1.1 PPWB Water Quality Agreement

In October 1969, the governments of Alberta, Saskatchewan, Manitoba and Canada signed the Master Agreement on Apportionment (MAA). The MAA provided for the apportionment of water for eastward flowing interprovincial streams, and stated that interprovincial water quality problems are to be referred to the Board for consideration. The agreement established the Prairie Provinces Water Board to administer the Agreement.

In 1992, the MAA was amended to include the Agreement on Water Quality (Schedule E) [Appendix 1]. This agreement defines the mandate of the PPWB in interprovincial water quality management and the duties of the Board in carrying out that mandate. As part of schedule E, Interprovincial Water Quality Objectives (WQOs) were established for 11 transboundary river reaches (Attachment A to Schedule E) [Appendix 1].

The water quality objectives include chemical, physical and biological parameters. The objectives are descriptions of water quality conditions that are known to protect water uses and are acceptable to upstream and downstream provinces. The provincial governments have agreed to endeavour to meet these objectives. The governments also agreed that if the quality of the water in a transboundary river reach is better than the water quality objectives, all reasonable and practical measures will be taken to maintain the existing water quality.

The 11 transboundary river reaches included in schedule E are: Beaver River, North Saskatchewan River, Battle River, Red Deer River near Bindloss, and South Saskatchewan River on the Alberta/Saskatchewan border and Churchill River, Saskatchewan River, Carrot River, Red Deer River near Erwood, Assiniboine River and Qu'Appelle River on the Saskatchewan/Manitoba Border. Interprovincial WQOs were not established for the Cold River on the Alberta/Saskatchewan border in Schedule E in 1992 (Figure 1). However the Cold River has been included in the PPWB monitoring since 1993 to provide the water quality understanding necessary for establishing interprovincial water quality objectives.

The 1992 Agreement on Water Quality also states that "The objectives for each river reach should be reviewed on a periodic basis of at least every five years". This current review represents the most comprehensive review of the water quality objectives since the signing of Schedule E in 1992.

2. Water Quality Agreement (Schedule E)

The mandate of the Board as stated in Schedule E is to "foster and facilitate interprovincial water quality management among the parties that encourages the protection and restoration of the aquatic environment".

Under the MAA, through Schedule E (Appendix 1), the duties of the PPWB with regard to water quality are to:

- Monitor water quality in the 11 river reaches and make comparisons to the established objectives;
- Provide a written report to the parties at least annually, and from time to time as the Board considers necessary;
- Review the appropriateness of the objectives and make recommendations to the parties based on water quality data and scientific information;
- Promote compatible water quality objectives in the Provinces of Alberta, Saskatchewan, and Manitoba;
- Promote a preventative and proactive ecosystem approach to inter-provincial water quality management; and
- Promote recognition of the interdependence of quality and quantity of water in the management of the watercourses.

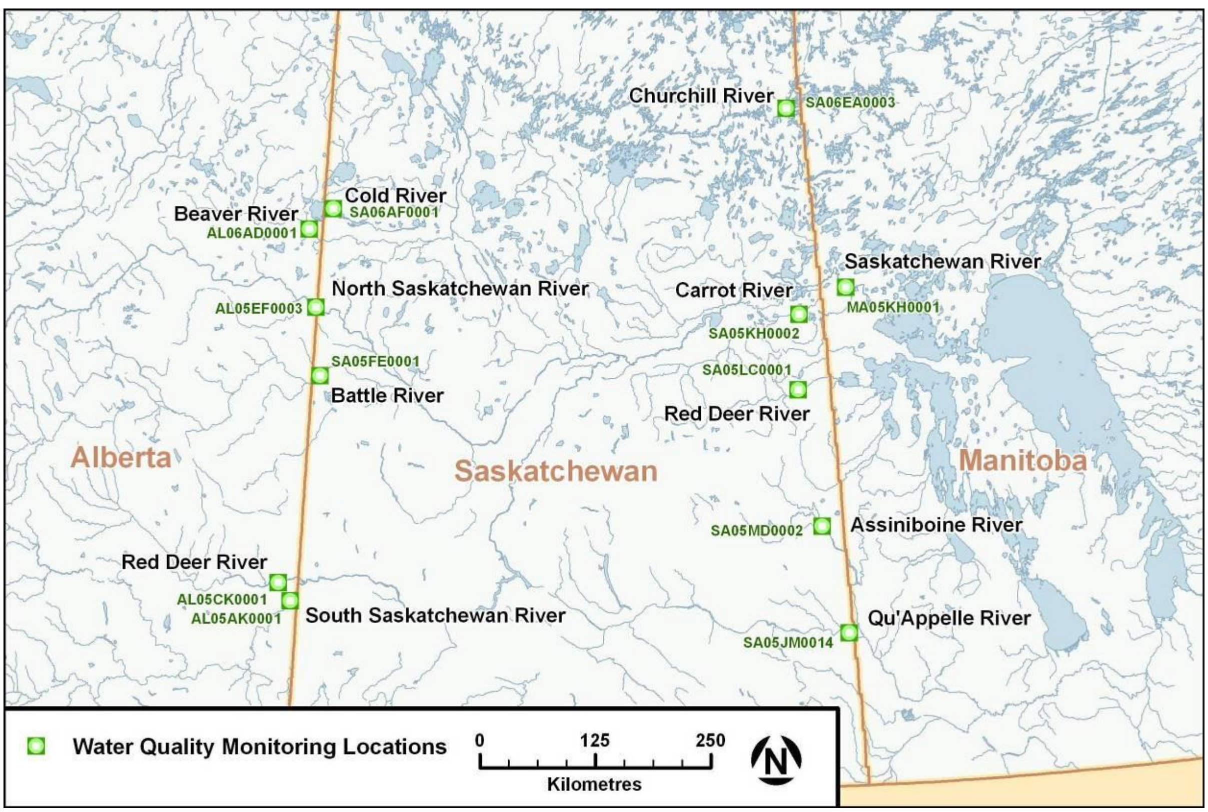


Figure 1 Water Quality Monitoring Locations

2.1 Water Quality Goals and Strategies

In 2012, the PPWB updated its Strategic Plan to identify the priorities of the Board and how they would be achieved.

- Goal 3 of the PPWB Strategic Plan relates to water quality objectives*, i.e.*: "*agreed Interprovincial water quality objectives are achieved.*" The strategies by which the PPWB is to achieve Goal 3 are:

  3-a Environment Canada monitors water quality and provides quality-controlled data to PPWB.
  3-b PPWB compares water quality data to *MAA* objectives, and annually identifies excursions and periodically assesses trends.
  3-c PPWB reports identified excursions and trends to Governments.
  3-d Governments undertake measures to protect and restore the quality of transboundary streams if objectives are not met.
  3-e PPWB assesses the adequacy of water quality monitoring for *MAA* purposes.
  3-f PPWB assesses and improves *MAA* water quality objectives as required.

- Goal 4 of the PPWB Strategic Plan relates to emergency and unusual water quality conditions, i.e. "*Governments are informed about emergency and unusual water conditions*." The strategies by which PPWB is to achieve Goal 4 are:

  4-a Governments report emergency and unusual surface and groundwater quantity and quality conditions to other Governments as outlined in the Event Contingency Plan.
  4-b Governments monitor water at boundary reaches to identify impacts of unusual events
  4-c Governments in which the event occurred prepare an evaluation report.
  4-d PPWB refines the Event Contingency Plan to define what constitutes an emergency.

3. Approach Used to Update Interprovincial Water Quality Objectives

Water quality standards, guidelines and objectives are used by jurisdictions in Canada and internationally to define and assess acceptable water quality. Water quality standards, guidelines or objectives are frequently developed to protect specific water uses. In Canada, national guidelines have been developed by the Canadian Council of Ministers of the Environment (CCME) for the protection of various water uses including the protection of aquatic life (PAL), agricultural uses (livestock and irrigation), and fish consumption for birds and wildlife (CCREM

1987, CCME 1991, 2007). Health Canada has published drinking water quality guidelines and recreational guidelines (Health Canada 1996; 2010) and fish consumption guidelines to protect human health. In some cases national guidelines have been adopted or modified by provincial jurisdictions to meet specific regional conditions and needs.

3.1 History of PPWB Interprovincial Water Quality Objectives

The first water quality objectives were adopted by the PPWB for eastward flowing interprovincial streams in March 1973. These objectives were jointly developed by the Provinces of Alberta, Saskatchewan and Manitoba and Canada and recommended by the Task Force on Water Quality. The 1973 objectives were based on a consistent approach to setting objectives and did not take into account water quality characteristic or conditions within each individual transboundary river reach.

In 1986, the Committee on Water Quality recommended site specific water quality objectives for the transboundary river reaches. The Committee recommended an assessment of water quality characteristics at each river and consideration of uses of the water in each river. In 1989, the Board decided not to use the site specific water quality objectives and directed the development of new water quality objectives that would be compatible with provincial water quality guidelines/objectives (PPWB 1991).

In 1990, the COWQ developed new water quality objectives to be applied at the interprovincial boundaries. These objectives were developed using provincial objectives or basin specific objectives. When provincial or basin specific objectives were not available then CCME Water Quality Guidelines were used (CCREM 1987). The objectives for each transboundary river reach were based on water quality requirements and upstream and downstream water uses. The objectives were approved by the Board in 1990 and incorporated into the Master Agreement on Apportionment as Schedule E which was signed by governments on April 2nd, 1992.

3.2 Water Quality Objectives Review

In the late 1990s, the PPWB discussed the development of nutrient objectives for the tranboundary river reaches. While nutrient objectives development remained a priority, in 2005 the objectives review was expanded to incorporate a complete review of the 1992 interprovincial water quality objectives. In Schedule E of the MAA, interprovincial WQOs were established for 11 transboundary river reaches. The Cold River downstream of Cold Lake was not included in Schedule E and does not have WQOs. However, monitoring has been conducted on this river since 1993. As part of the current objectives review and update, objectives are now recommended for the Cold River.

During the current objectives review, the COWQ took a consistent approach that considered site specific characteristics and conditions when reviewing water quality objectives across all transboundary river reaches. The COWQ developed a four step process for the review of the interprovincial water quality objectives (Figure 2). This process included:

- Assessment of water uses for the 12 transboundary river reaches;
- Identification of parameters to evaluate and assess water quality;
- Comparison of existing WQOs for different water uses from five jurisdictions (Alberta, Saskatchewan, Manitoba, Canada and United States) and
- Assessment of historic water quality data at each of the transboundary river reaches for which interprovincial WQOs are being established.

In Step 1, the COWQ reviewed the water uses for each transboundary river and with support of the Board, chose to protect all uses for each transboundary river reach. This differs from the 1992 approach where specific uses were identified for each reach and not all water uses were protected for each transboundary river reach. For example, in 1992 irrigation objectives were included for some rivers such as the South Saskatchewan River but not for the Assiniboine River, which was not used for irrigation nor anticipated at that time to be used for irrigation. However, during this review it was recognized that water uses may evolve over time and therefore, all water uses need to be protected. Water uses protected included:

- Protection of aquatic life
- Agriculture uses including irrigation and livestock
- Recreation and aesthetics
- Treatability for use as a drinking water source, and
- Fish tissue consumption (for human and aquatic biota consumers).

In Step 2, the COWQ considered which parameters should be incorporated to assess and protect water quality for the various water uses. The COWQ established a list of parameters for which interprovincial water quality objectives should be established including major ions, metals, nutrients, physical characteristics, bacteriological parameters, and pesticides (Table 1). In this step, the COWQ considered the existing water quality parameters with objectives for the transboundary river reaches, other parameters currently being monitored by Environment Canada and parameters of interest/concern at the transboundary river reaches.

The COWQ also considered new and emerging water quality issues such as pharmaceuticals, personal care products, flame retardants, *etc*. However, there is a general lack of water quality guidelines for these new and emerging contaminants and it is beyond the scope of the PPWB to conduct the toxicological research to develop scientifically defensible objectives for these contaminants. The Committee concluded that in subsequent reviews, objectives for new and emerging contaminants will be considered as more information becomes available.

In Step 3, an assessment of existing water use/toxicology water quality objectives was completed. The COWQ reviewed water use objectives from five different jurisdictions: Canada (national guidelines developed by CCME and Health Canada), Alberta, Saskatchewan, Manitoba and the United States. The COWQ then generally selected the most protective guideline/objective to protect all water uses on each transboundary rivers.

In the final step of the review (Step 4), ambient water quality data from the PPWB monitoring sites were reviewed and compared to the most protective water use objectives. When ambient water quality exceeded the most protective water quality guideline/objective on a regular and frequent basis (~ ≥ 10%), and when there was an assumption that the exceedance was primarily affected by natural conditions in the river a background objective was developed. A background approach was also considered for compounds for which toxicology objectives do not exist or if they do exist are not appropriate for these prairie rivers including nutrients (*i.e.* total phosphorus (TP), total dissolved phosphorus (TDP) and total nitrogen (TN)).

In summary, two main approaches were used to revise and develop new water interprovincial water quality objectives:

- Adopt the most protective and appropriate water quality guidelines (WQG) that have been developed for the site/basin, province, country or North America.
- Develop a background approach (based on ambient data), where there was no appropriate guideline.

Approach to Water Quality Objectives Review

Step 1: Assessment of Water Uses

- **Assessment of Uses is to be performed on a Site Specific Basis**
- **Uses are to include; Aquatic Life, Agricultural (Irrigation/Livestock watering), Recreational/Aesthetic, Fish Consumption, Source Water for Treatment (treatability)**

Steps for this exercise are outlined as:

A) All agencies review water uses listed above for upstream and downstream river reaches and determine which uses are not appropriate.
B) Tabulate current uses identified for each site (EC)
C) Agencies confer for each site on short list of uses; remove those uses all agencies have identified as not appropriate (step A above)
D) Prepare list of water uses to protect for each transboundary river reach.

Step 2: Assessment of Parameters

- **For each water use identified in Step 1, determine appropriate parameters for which an interprovincial water quality objective should be established**

Steps for this exercise are outlined as:

A) Tabulate current parameters used to assess each existing use (EC)
B) All agencies assess existing parameters – are they still relevant?
C) All agencies identify potential new parameters not currently contained in Schedule E of the MAA including;
- ❑ **new or emerging parameters of concern or**
- ❑ **parameters for which there are currently no toxicologically based objectives (*e.g.*, dissolved phosphorus)**

D) Consensus building exercise to determine revised list of parameters
E) Prioritize parameters on final list of parameters to assess

Step 3: Assessment of Objectives for each Parameter

- **For each parameter an assessment of the numerical objective is initiated by comparison with current, new or other existing objectives. If there is not an existing objective for the parameter in question go to Step 4.**

Steps for this exercise are outlined as:

A) Compare existing interprovincial water quality objectives to other existing site specific, provincial, CCME, or other available objectives as appropriate for each relevant use.
B) This exercise, for a limited set of parameters identified by the agencies, can include an examination of how the numerical objective is applied to assess water quality results. For example, dissolved oxygen objectives can be used assess acute (spot measurements) or chronic (7 day objective) conditions.
C) Select the numerical objective for evaluation in the following hierarchical priority; site-specific provincially adopted, overall provincial, CCME, other. Note that this hierarchical concept assumes that the most relevant objective is one developed and applicable at a site specific level, thus moving from a local to provincial, to national scale.
D) Repeat for each use
E) For each parameter tabulate the list of numerical objectives for each use at each transboundary river reach
F) Select the most sensitive / protective value from all the uses identified for the parameter at each transboundary river reach.
G) Go to flow diagram (Step 4) for each parameter

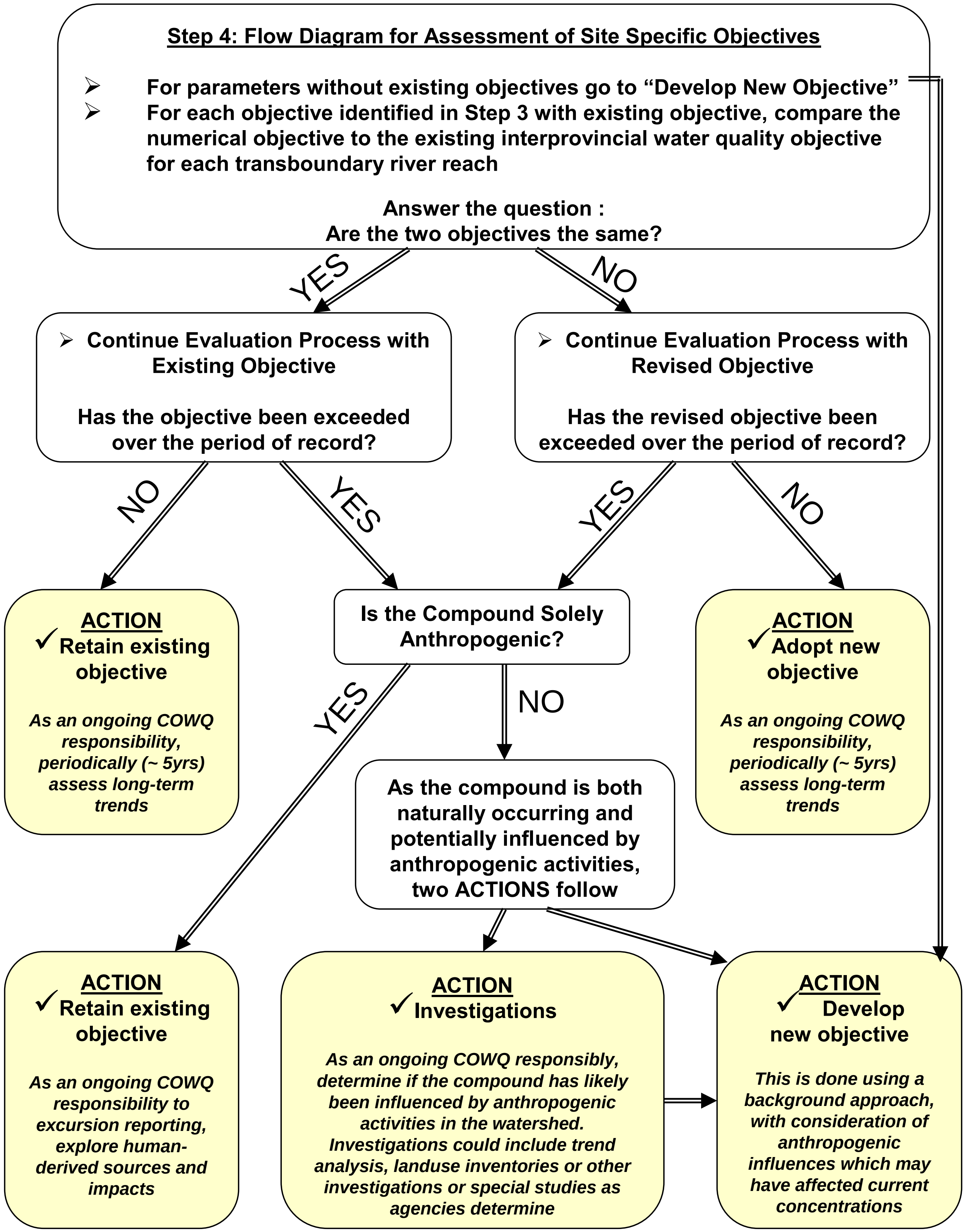


Figure 2 Approaches to the Water Quality Objectives Review

Table 1 Parameters Considered for the Establishment of an Interprovincial Water Quality Objective for the Transboundary River Reaches (Step 1).

Parameter			
Nutrients	**Pesticides**	**Metals**	**Fish Tissue**
Nitrate	*Acid Herbicides*	Aluminum	Human Consumption:
Ammonia	2,4-D	Antimony	Mercury in fish (muscle tissue)
Total Nitrogen	Bromoxynil	Arsenic	PCB in fish (muscle tissue)
Total Phosphorus	Dicamba	Barium	Arsenic in fish (muscle tissue)
Total Dissolved Phosphorus	MCPA	Beryllium	Lead In fish (muscle tissue)
Major Ions	Picloram	Boron	DDT (total) in fish (muscle tissue)
Total Dissolved Solids	Silvex	Cadmium	**Aquatic Biota Consumption**
Sulphate Dissolved	*Organochlorine Pesticides*	Chromium	PCB in fish (muscle tissue) for mammals
Sodium Dissolved	Endosulfan	Cobalt	PCB in fish (muscle tissue) for birds
Fluoride Dissolved	Hexachlorocyclohexane (gamma-HCH) (Lindane)	Copper	DDT in fish (total) (muscle tissue)
Chloride Dissolved	Hexachlorobenzene	Iron	Toxaphene in fish (muscle tissue)
Physicals and Other	Pentachlorophenol (PCP)	Lead	**Radionuclides**
pH	*Neutral Herbicides*	Lithium	Cesium-137
Oxygen Dissolved	Atrazine	Manganese	Iodine-131
Sodium Adsorption Ratio	Diclofopmethyl (Hoegrass)*	Mercury	Lead-210
Total Suspended Solids	Metolachlor	Molybdenum	Radium-226
Reactive Chlorine Species	Metribuzin	Nickel	Strontium-90
Cyanide (free)	Simazine	Selenium	Tritium
Biota	Triallate	Silver	
Escherichia Coli	Trifluralin	Thallium	
Coliforms Fecal	*Other*	Uranium	
	Glyphosate	Vanadium	
		Zinc	

4. Data Handling and Preparation

4.1 Monitoring Stations

Environment Canada currently monitors water quantity and quality for the transboundary river reaches as part of the administration of the Master Agreement on Apportionment. This includes a network of hydrometric stations and 12 water quality stations. With the exception of the Cold River and the North Saskatchewan River, water quality has been monitored at the same transboundary river locations since the late 1960s or early 1970s. While monitoring of the transboundary river reaches started in the late 1960s, the water quality monitoring program was not conducted on a regular and consistent schedule until 1974. Except for the trend analyses where all available data were used, data collected prior to 1974 were not included in these data analyses.

Similarly, since the data analysis component began in 2009, only data up to and including 2008 were used in this review.

Monitoring on the Cold River was initiated in 1993 (Table 2) and therefore, any data analyses were conducted for the period 1993 through 2008. Monitoring on the North Saskatchewan River began in the late 1960s, but the water quality station was moved three times with the most recent move in 1988. During this review only data from the current station (1988 onwards) were included in any data analyses.

The frequency of the water quality sampling has varied since inception of the program. In general, monitoring at the transboundary river reaches has been conducted monthly with the exception of the Cold River, Churchill River and Red Deer River at Erwood. The Cold River and the Churchill River have been monitored quarterly and the Red Deer River at Erwood was monitored six times per year. Water quality parameters incorporated in the PPWB monitoring program include nutrients, major ions, metals, bacteriological parameters, physical characteristics and pesticides.

Table 2 PPWB Water Quality Monitoring Stations

Station Name	Border	Station Number	Year Monitoring Started
Battle River near Unwin, Saskatchewan	A/S	SA05FE0001	1966
Beaver River at Beaver Crossing	A/S	AL06AD0001	1966
Cold River at Outlet of Cold Lake	A/S	SA06AF0001	1993
North Saskatchewan River at Highway #17 Bridge	A/S	AL05EF0003	1988
Red Deer River near Bindloss, Alberta	A/S	AL05CK0001	1967
South Saskatchewan River at Hwy 41	A/S	AL05AK0001	1970
Assiniboine River at Hwy 8 Bridge	S/M	SA05MD0002	1968
Carrot River near Turnberry	S/M	SA05KH0002	1974
Churchill River Below Wasawakasik	S/M	SA06EA0003	1974
Qu'Appelle River	S/M	SA05JM0014	1975
Red Deer River at Erwood	S/M	SA05LC0001	1967
Saskatchewan River Above Carrot River	S/M	MA05KH0001	1974

A/S = Alberta Saskatchewan Border; S/M = Saskatchewan/Manitoba Border

Streamflow data were used in the analysis of water quality trends. Streamflow data for the water quality monitoring stations were obtained as mean daily flow from the nearest Water Survey of Canada hydrometric station (Table 3). The hydrometric and water quality stations are generally located at the same site or are in close proximity. However for the South Saskatchewan River and the Saskatchewan River, flow data were not available from a nearby hydrometric station and therefore, flows were estimated for these water quality stations. For the water quality station on the South Saskatchewan River at Hwy 41, flow data from the hydrometric station at Medicine Hat were added to flows from two small tributaries (Seven Person Creek and Ross Creek). Total flows were lagged by two days (Brain Yee, personnel comm.) to estimate mean daily flows on the South Saskatchewan River at Hwy 41. For the Saskatchewan River at the Saskatchewan-Manitoba border, mean daily flows at the water quality site were calculated by subtracting mean daily flow at the Carrot River near Turnberry from flows on the Saskatchewan River at The Pas.

Table 3 PPWB Hydrometric Stations

Station Name	Border	Station Number	Year Monitoring Started	Flow
Battle River near the Saskatchewan Boundary	A/S	05FE004	1978	Mean Daily
Beaver River at Cold Lake Reserve	A/S	06AD006	1955	Mean Daily
Cold River at Outlet of Cold Lake	A/S	06AF001	1952	Mean Daily
North Saskatchewan River Near Deer Creek	A/S	05EF001	1917	Mean Daily
Red Deer River near Bindloss	A/S	05CK004	1960	Mean Daily
South Saskatchewan River at Medicine Hat	A/S	05AJ001	1911	Mean Daily
Seven Person Creek at Medicine Hat	A/S	05AH005	1910	Mean Daily
Ross Creek near Irvine	A/S	05AH003,	1909	Mean Daily
Ross Creek Highway 41	A/S	05AH052	2000	Mean Daily
Assiniboine River at Kamsack	S/M	05MD004	1944	Mean Daily
Churchill River at Sandy Bay	S/M	06EA002	1928	Mean Daily
Carrot River Near Turnberry	S/M	05KH007	1966	Mean Daily
Qu'Appelle River Near Welby	S/M	05JM001	1915	Mean Daily
Saskatchewan River at the Pas	S/M	05KJ001	1913	Mean Daily
Red Deer River near Erwood	S/M	05LC001	1914	Mean Daily

A/S = Alberta Saskatchewan Border; S/M = Saskatchewan/Manitoba Border

4.2 Data Preparation

Water quality data were initially reviewed for censored data, missing data, outliers, and anomalies in individual data points. For data reported as less than the method detection limits (MDL; referred to as censored data), values were estimated as half the detection limit. While statistical outliers were not removed, any erroneous data or obvious anomalies were removed from the dataset. Erroneous data were not common and were typically related to issues with the database or the laboratory/field analysis and were traceable to a particular issue.

For dissolved nitrogen (DN) and total nitrogen (TN), a change in the laboratory analytical method from a UV digestion to an alkaline-persulphate digestion in October 1993 resulted in a more efficient extraction procedure. However, since the method change produced a step in these data between the pre and post method change (Glozier *et al*, 2004), the pre and post 1993 data are not comparable. Therefore as recommended by Environment Canada, only nitrogen data after October 1993 were included in the objectives review and data analyses.

4.3 Analysis – Seasonality

Water quality parameters frequently exhibit seasonal patterns. Changes in water chemistry often follow changes in hydrologic patterns. For some water quality parameters including nutrients, new interprovincial water quality objectives (WQOs) were developed on a site specific basis using a background approach. Since concentrations of some water quality parameters change considerably but relatively predictably during the year, it was desirable to develop seasonal interprovincial WQOs that reflected the influence of flow on water quality. For example, suspended sediment concentrations are often at peak levels during spring freshet and decline predictably during low flow periods.

The COWQ agreed that two periods (hereon referred to as seasons) would be used at each transboundary river for the development of background nutrient objectives and for trend analysis. The use of more than two seasons was considered. However, the Committee hoped to consistently define the same seasons for all parameters for each transboundary river reach and this was more difficult if more than two seasons were identified. In addition, the number of samples per season declines with an increasing number of seasons. Seasons were defined to be five, six or seven months long. Determination of seasons was based on a number of scientific and practical considerations. The two seasons are based on major ecological periods incorporating:

- ice cover *versus* open water;
- more stable *versus* highly variable flows; and
- Low/stable water temperatures in fall/winter *versus* higher and more variable temperatures and biological growth during the open-water period.

For each transboundary river and each key water quality parameter (*i.e.* suspended sediment, nutrients and total dissolved solids) the Committee examined historic data to determine which months would fall within each season. Approximately thirty five years of PPWB water quality monitoring data were summarized graphically to show the annual distribution of these data (Figure 3). From a visual analysis of the graphs for each parameter of interest, these water quality data were divided into two seasons (Appendix 2).

Additional considerations that were used for determining the seasons included:

- Where possible, the two seasons were defined for the transboundary river rather than for individual parameters. This will aid the annual evaluation of exceedances and reporting.
- Where seasonal patterns in historical data for a specific water quality parameter were substantially different from the seasons set for a particular transboundary river reach, or a participating jurisdiction, a custom defined season was established for that specific parameter.

- Where possible, seasons were selected to be consistent with those established by jurisdictions participating in the Prairie Provinces Water

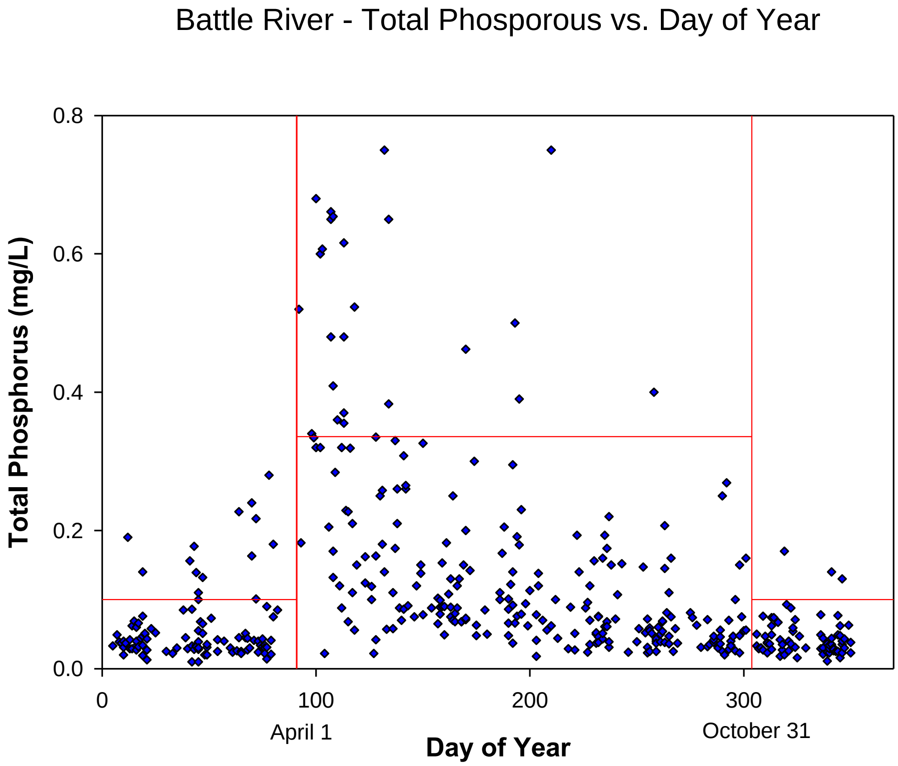


Figure 3 Day-of-Year Graph for Total Phosphorus on the Battle River
(The vertical lines indicate the start of season and the horizontal lines represent the 90th percentile for the season).

For example, seasons for the Alberta/Saskatchewan rivers were selected to be consistent with regional planning initiatives in Alberta. Seasons selected for Alberta/Saskatchewan rivers are April to October for the open water season and November to March for the ice covered season (Table 4). On the Saskatchewan/Manitoba border, the open water season begins in either April or May depending on the transboundary river and/or water quality parameter (Table 5).

4.4 Statistical Trend Analysis

Trend analysis was used to determine statistically significant changes in water quality (*i.e.* no change, increase or decrease) over time. Several factors can influence the detection of water quality trends including occurrence of seasonality, serial correlation (or autocorrelation), missing values, outliers, and censored data. Depending on the statistical technique used for trend analyses, assumptions must be considered regarding data distribution and independence.

A non-parametric method was selected for the detection of trends for selected water quality parameters. The non-parametric Mann-Kendall/Seasonal Mann Kendall was selected in part because most water quality data are not normally distributed and a non-parametric method tends to be more robust when there are missing data, outliers and censored data. In addition, the Mann Kendall/Seasonal Mann Kendall non-parametric method is used by several jurisdictions involved in the PPWB. Furthermore, a comparison of parametric methods used elsewhere (such as WQTrend from Vecchia 2003) suggested that the ability to detect trends were generally the same when both methods were run on the same time series data.

However, one key assumption of the Season Mann-Kendall is that the data be independent (Mann, 1945; Kendall 1975; Hirsch *et al*. 1982; Hirsch and Slack, 1984). Most water quality data that are collected monthly are not independent and the presence of serial correlation can increase the chance of type I errors (detecting a trend when there is none). While there are techniques that can be used to correct for serial correlation, thereby reducing type I errors, this can lead to an increase in type II errors. Type II errors occur when it is incorrectly concluded that there is no significant trend when there is a trend. In this review, water quality data were not corrected for serial correlation.

Trend analysis was completed for nutrients, major ions and total suspended solids (TSS). With the exception of TSS data, the trend analysis included all of the PPWB monitoring data since the monitoring site inception until the end of 2008. For TSS, trend analysis was done for the open-water season only. Seasons for trend analysis were those previously defined (Tables 4 and 5) for nutrients, TDS and TSS. The seasons defined for TDS for each transboundary river reach were used for all the major ion parameters. Trend analyses were run where:

- at least ten years of water quality monitoring data were available
- there was less than 20 percent censored data (data below the method detection limit)
- changes in analytical methodologies did not result in substantial changes in method detection limits (MDLs) or result in steps in the dataset.

Seasonality was tested with the non-parametric Kruskal-Wallis test. Data were considered seasonal if the Kruskal-Wallis test was significant at a 95% significant level ($\alpha = \leq 0.05$). If the dataset showed seasonality then the Seasonal Mann-Kendall was used for the trend analysis. If the dataset was not seasonal then the Mann-Kendall/Sen Slope Estimator test was used to test for trend analysis.

Water chemistry can be affected by river discharge and so the detection of trends was adjusted for the influence of flow. Data were flow adjusted with a simple regression equation based on the flow *versus* concentration relationship:

Log [Concentration] = Log [flow] b+a

Where:
Concentration = Concentration of parameter

Flow = Flow of the River
b = slope
a = intercept

Trends on flow adjusted time series data were reported at the 95 % significance level ($\alpha = \leq 0.05$). All statistical analyses were conducted with WQStat Plus v.9 (Sanitas Technologies 2009).

Table 4 Seasons for the PPWB Water Quality Monitoring Sites on the Alberta Saskatchewan Border for Setting Background Objectives and Trend Analysis

Station Name	Parameter	Season	
		Summer	Winter
Beaver River at Beaver Crossing	TP, TDP, TN, TDS, TSS	Apr to Oct	Nov to Mar
North Saskatchewan River at Hwy 17 Bridge	TP, TDP, TN, TDS, TSS	Apr to Oct	Nov to Mar
Battle River near Unwin Saskatchewan	TP, TDP, TN, TDS, TSS	Apr to Oct	Nov to Mar
Red Deer Near Bindloss	TP, TDP, TN, TDS, TSS	Apr to Oct	Nov to Mar
South Saskatchewan River at Hwy 21	TP, TDP, TN, TDS, TSS	Apr to Oct	Nov to Mar
Cold River	TP, TDP, TN, TDS, TSS	Apr to Oct	Nov to Mar

Table 5 Seasons for the PPWB Water Quality Monitoring Sites on the Saskatchewan Manitoba Border for Setting Background Objectives and Trend Analysis

Station Name	Parameter	Season	
		Summer	Winter
Churchill River below Wasawakasik	TP, TDP, TN, TDS, TSS	May to Oct	Nov to Apr
Saskatchewan River above Carrot River	TP, TDP, TN, TDS, TSS	Apr to Oct	Nov to Mar
Carrot River near Turnberry	TP, TDP, TN, TDS	May to Oct	Nov to Apr
	TSS	Apr to Oct	Nov to Mar
Red Deer River at Erwood	TP, TDP, TN, TDS, TSS	May to Oct	Nov to Apr
Assiniboine River at Hwy 8 Bridge	TP, TDP, TN, TDS, TSS	Apr to Oct	Nov to Mar
Qu'Appelle River	TP, TDP, TN, TDS	May to Oct	Nov to Apr
	TSS	Apr to Oct	Nov to Mar

5. Water Quality Objectives Based on Existing Guidelines

In Canada, Water Quality Guidelines (WQGs) are derived to protect major water uses including:

- Protection of aquatic life
- Agricultural uses (irrigation and livestock)
- Recreational uses and aesthetics
- Fish consumption (for the protection of human and wildlife health)
- Treated drinking water

Science-based guidelines have been derived through nationally approved scientific protocols (CCREM 1987; CCME 1991; 1999, 2007, Health Canada 1996, 2010). The national generic water quality guidelines represent numerical or narrative statements and can be adopted directly or may be modified to be applicable to regional or site specific circumstances. Water quality standards, guidelines or objectives in Canada are set by the jurisdiction in which they are being applied such that the objectives are established by the provinces and territories, except on federal lands.

Similarly in the United States, the United States Environmental Protection Agency (USEPA) sets national water quality criteria (USEPA 1986). The USEPA national criteria include both numerical values and narrative statements for water quality parameters for the protection of a number of uses.

During the review of the interprovincial water quality objectives, guidelines derived by the CCME, Health Canada, USEPA and the three provincial jurisdictions (Alberta, Saskatchewan, and Manitoba), as well as the existing interprovincial water quality objectives were compared for each water use (listed above) (Appendix 3). Given the approach adopted by PPWB to protect all rivers for all water uses, the most protective guideline was then selected for further consideration (Appendix 4). Protection of aquatic life guidelines were generally the most stringent followed by protection of agricultural uses (in particular irrigation guidelines).

For some water uses (such as irrigation), some parameters had multiple guidelines that depend, for example, on crop type. The Committee selected the most stringent guideline for a particular use. Protection of aquatic life guidelines are based on the response of different organisms to exposure, with the guideline designed to protect the most sensitive species tested. Generally, drinking water guidelines are specifically derived for post-treatment potable water supplies. National guidelines for treatability for use as a drinking water source are not available. However, the adoption of drinking water guidelines as objectives for treatability of source water (as proposed for the transboundary river reaches) provides an indication of the suitability of the water supply for treatment. In addition, an increase in the number of exceedances of the proposed WQOs could increase drinking water treatment costs for downstream jurisdictions. For example, total barium, total chromium and dissolved sodium are not removed through conventional water treatment. Special treatment technologies (such as reverse osmosis) that involve considerable additional cost would be required to remove these contaminants to below drinking water guidelines. While total iron and total manganese can be removed with conventional treatment, both directly impact chlorine demand and thus the formation of disinfection-by-products such as trihalomethanes. Additional treatment costs associated with meeting trihalomethane drinking water standards are considerable and are an immediate concern for water treatment plants using surface water supplies. Therefore, there is also a need to manage total iron and total manganese to drinking water guidelines. Treatability objectives were therefore only considered for parameters where increases in concentrations could result in the need for additional and potentially expensive treatment technologies.

The most protective guideline for each water quality parameter was then compared to historical data for each transboundary river reach (Appendix 5, 6, 7). Where the most protective guideline was generally met at all times in the historical dataset the water quality guideline was recommended as the updated interprovincial water quality objective. Where some or many exceedances of the most protective water quality guideline occurred historically, further analysis of the guideline was undertaken including:

- Preliminary evaluation of whether the guideline may be exceeded due to natural causes and/or is influenced by anthropogenic activities;
- Assessing the long term trend in concentration;
- Reviewing the most protective guideline for suitability for the transboundary river reach in question.

In some cases where the water quality parameter occurs naturally, a background objective was developed (see section 6). In other cases, insufficient information was available to develop and recommend an objective at this time (see Section 7).

For metals, the COWQ considered both total and dissolved metal objectives. National water quality guidelines developed by CCME are based on the total metal concentration. Total metal objectives may not be appropriate in some prairie streams where a high sediment load is accompanied by naturally high metal concentrations that may exceed toxicity based objectives (see Section 6.1). In the United States, objectives have been developed for the dissolved metal fraction including; arsenic, cadmium, trivalent and hexavalent chromium, copper, lead, mercury, nickel, silver and zinc. Some dissolved metal objectives have also been adopted by Manitoba.

For metals, the COWQ followed the same general principle that was used for all the objectives and selected the most protective metal guideline/objective (either total or dissolved but not both). However, for arsenic a water quality objective of 5 µg/L (total) was adopted for all sites along the Alberta/Saskatchewan border to protect aquatic life, the most sensitive use. On the Manitoba/Saskatchewan border an arsenic objective of 5 µg/L (total) was used for all the transboundary river reaches with the exception of the Carrot and Qu'Appelle rivers. Background concentrations of total arsenic at the Carrot River and the Qu'Appelle River frequently exceeded 5 µg/L. The arsenic (total) guideline was therefore considered not to be appropriate for these two interprovincial rivers, so the 1992 PPWB water quality objective of 50 µg/L arsenic (dissolved) was retained at these two river reaches.

6. Water Quality Objectives Based on Background Water Quality

6.1 Definition of Background Water Quality Objectives

Rivers and streams can have naturally high concentrations of some water quality parameters including suspended sediments, nutrients, metals, and major ions. Therefore, toxicity and laboratory-based guidelines may not be appropriate in aquatic environments where species are adapted to naturally high background concentrations.

In addition, the development of water quality guidelines for nutrients such as total phosphorus and total nitrogen presents unique challenges because nutrients do not generally cause direct toxicity. However, aquatic ecosystems with different ranges in nutrient concentrations have profoundly different structure and function. Natural background concentrations and trophic states can vary among river systems making universal guidelines inappropriate. The protocol to develop Canadian Water Quality Guidelines for the protection of aquatic life (CCME 2007) is intended to deal specifically with toxic substances. Although elemental phosphorus can be toxic, this toxicity is rare in nature and therefore rarely of concern. Some fractions of nitrogen such as ammonia and nitrate can also be toxic (and appropriate water guidelines have been developed). However, excess nitrogen, like excess phosphorus, can contribute to eutrophication. Eutrophication effects often occur at concentrations well below toxic effect concentrations. Toxicity-based nutrient guidelines are not protective of eutrophication.

Various methods exist for setting nutrient guidelines for rivers and streams including reference condition approaches and the use of predictive modelling. A general lack of information on the impact of nutrients on aquatic ecosystems within the transboundary river reaches themselves and the lack of reference rivers or reaches for these large prairie rivers, limits the use of many of the possible methods available in the literature. Nutrient objectives may also be set to protect sensitive downstream receiving waters. For example, several of the transboundary rivers are part of the Lake Winnipeg watershed and therefore, contribute nutrients to Lake Winnipeg. Increased nutrient loading is a concern in Lake Winnipeg (Environment Canada and Manitoba Water Stewardship 2011) where excess nutrients have lead to an increase in the frequency and severity of algal blooms (Figure 4). However, since long-term ecologically relevant nutrient objectives have not yet been developed for Lake Winnipeg, a downstream receiving environment approach to developing objectives was not possible for this review. Over the long term, nutrient objectives for the transboundary rivers which are tributaries to Lake Winnipeg may need to reflect downstream loading targets for Lake Winnipeg. It is also noted that nutrient loading and algae blooms are an issue not only in Lake Winnipeg but in rivers, streams and lakes throughout the three Prairie Provinces.

Therefore, COWQ developed a background approach to setting objectives for nutrients (Figure 2) and several other water quality parameters for which appropriate water quality guidelines were not available. The background method developed for this objectives review is a reference condition approach where the long-term dataset is used to establish reference conditions that are then used to set the objective. The background concentrations are based on the 90th percentile of the historical ambient data. Where data exhibit strong seasonality (such as total dissolved solids for some transboundary river reaches), 90th percentiles were calculated separately for each of two seasons (previously defined seasons in Tables 4 and 5).

The 90th percentiles were calculated in SigmaPlot version 11.2 with the Cleveland method. The Cleveland method uses the formula $v = fxk + 1(1-f)xk$ where *k* is the largest integer less than or equal to $(N)*\frac{p}{100}$, and *f* is $(N)\frac{p}{100}+0.5-k$ (Systat Software Inc., 2009).

Figure 4 Algae Blooms on Lake Winnipeg

6.2 Nutrients

Background objectives were developed for total phosphorus (TP), total dissolved phosphorus (TDP) and total nitrogen (TN) following the process outlined in Figure 5. As described previously for total nitrogen (TN), a change in the laboratory analytical method in October 1993 resulted in an increase in the reporting concentration of these parameters. As there is a step in these data pre- and post- 1993 data are not comparable. Therefore, only TN data from post October 1993 were included in these data analyses.

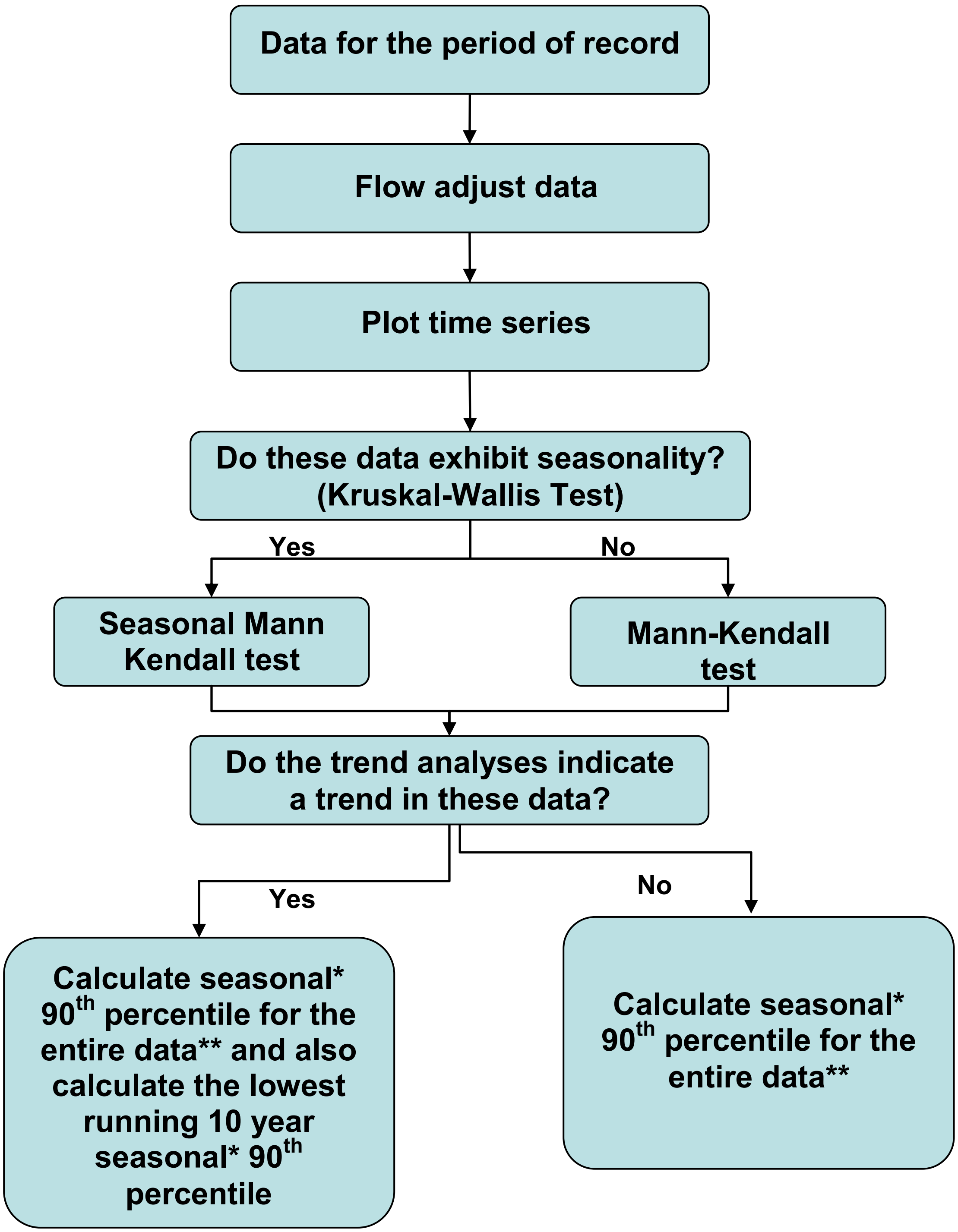
As previously described, two seasons were established representing the open water season and the ice covered season. Each dataset was tested for seasonality and the time series was plotted (Appendix 8a, and b respectively).

Trend analyses (Appendix 8c and Table 6) detected significant increasing trends of TP concentrations in the Battle River, Red Deer River near Erwood and Carrot River. Increasing trends of TDP concentration were also detected in the Carrot River and Red Deer River near Erwood. Increasing trends in TN concentration were detected in the Cold River, South Saskatchewan River and Carrot River.

Decreasing trends of TP concentrations were found in the North Saskatchewan River, Red Deer River near Blindloss, South Saskatchewan River, Qu'Appelle River, and Saskatchewan River. Total dissolved phosphorus concentrations declined in the Beaver River, North Saskatchewan River, and Red Deer River near Bindloss, South Saskatchewan River, Qu'Appelle River and the Saskatchewan River. Of all 12 rivers, only the North Saskatchewan River showed a decreasing trend in TN concentrations.

For transboundary rivers with significantly increasing or decreasing trends, the reference period was defined differently from those sites with no significant trend. When there were no long term trends in nutrient concentration then the numerical objective was based on the 90^{th} percentile of the full data record (Figure 5).

For transboundary rivers with significant trends two objectives were developed for nutrients: the 90^{th} percentile of the full record (1974 to 2008) (Table 7) and the lowest running10-year 90^{th} percentile. The lowest 10-year 90^{th} percentiles were calculated by dividing the dataset into ten year increments (1974-1983, 1975-1984, *etc.*) and calculating the 90^{th} percentiles for each increment (Table 8). All nutrient background objectives had separate objectives for each of the open- and ice-covered seasons.



*90th percentiles only calculated for both seasons if data exhibit seasonality
**data used for calculating 90th percentiles were taken from 1974-2008 for TP and TDP, and 1993-2008 for TN

Figure 5 Flow Diagram for the Development of Background Nutrient Objectives

Where nutrient concentrations were increasing, the assumption was that the lowest running 10-year 90th percentile would be reflective of conditions prior to nutrient increases and that a return to these lower concentrations is desirable to reduce the negative impacts of excess nutrient loading. For sites with decreasing concentrations of nutrients, the lowest running 10 year 90th percentiles would be reflective of the lowest concentrations observed historically and that it is desirable to maintain these lower concentrations of nutrients.

The 90th percentiles of the entire dataset represented the higher water quality objective for these rives, while the lowest 90th percentile calculated from the running ten year increments were selected as the lower water quality objective (Appendix 8e). For administration of the agreement and reporting excursions, it is recommended that if a nutrient concentration exceeds the lower water quality objective then an excursion should be reported (Figure 6). If a nutrient concentration exceeds both objectives, then follow up assessments including for example, an updated assessment of trend analysis and an assessment of sources of nutrients in the watershed should be considered.

Several potential challenges with using the ten year lowest running average were identified including:

- that the lowest running average does not always occur at the start (for increasing trends) or end (for decreasing trends) of the trend analysis period;
- no differentiation was made regarding whether the trends occurred in the upper quartile or elsewhere in the data distribution, which could be more relevant to the 90th percentile;
- no investigation was conducted to separate possible natural fluctuations in concentration from human caused changes, meaning the variability observed could result from natural processes that include long-term variability of precipitation which affects the contributing areas of watersheds;
- the nature of detected trends are not always monotonic, that any future change in the status of a trend (*i.e.* if a significant trend no longer becomes significant) could result in a substantial change in the objective value for that site; and given the above
- the increased challenge of interpreting appropriate expected long-term excursion frequencies.

Despite these challenges, a two tiered nutrient objectives approach is recommended to reflect changes in nutrient concentrations that have occurred at these sites over the period of record (1970s to 2008).

Table 6 Trend Analysis Results for the 12 Transboundary River Reaches (The arrows represent the direction of the trend at the 95 % confidence level)

Alberta - Saskatchewan Rivers	Nutrients		
	Total Phosphorus	Total Dissolved Phosphorus	Total Nitrogen
Battle River near Unwin	↑	↔	↔
Beaver River at Beaver Crossing	↔	↓	↔
Cold River at Outlet of Cold Lake	↔	↔	↑
North Saskatchewan River at Highway 17	↓	↓	↓
Red Deer River near Bindloss	↓	↓	↔
South Saskatchewan River	↓	↓	↑

Saskatchewan - Manitoba Rivers	Nutrients		
	Total Phosphorus	Total Dissolved Phosphorus	Total Nitrogen
Assiniboine River at HWY 8 Bridge	↔	↔	↔
Carrot River near Turnberry	↑	↑	↑
Churchill River	↔	↔	↔
Qu'Appelle River	↓	↓	↔
Red Deer near Erwood	↑	↑	↔
Saskatchewan River above Carrot River	↓	↓	↔

Table 7 90th Percentile of the Data by Season for the Carrot River

		Total Phosphorus (mg/L)	Total Dissolved Phosphorus (mg/L)	Total Nitrogen (mg/L)
Carrot River	Summer	0.140	0.057	1.417
	Winter	0.266	0.059	2.052

Table 8 Lowest Running Ten Year 90th Percentiles by Season for the Carrot River

Carrot River - 90th Percentiles						
Date	Total Phosphorous (mg/L)		Total Dissolved Phosphorus (mg/L)		Total Nitrogen (mg/L)	
	Summer	Winter	Summer	Winter	Summer	Winter
1974-1983	0.100	0.284	0.036	0.038	~	~
1975-1984	0.110	0.279	0.040	0.038	~	~
1976-1985	0.108	0.269	0.039	0.038	~	~
1977-1986	0.108	0.259	0.036	0.038	~	~
1978-1987	0.108	0.249	0.036	0.033	~	~
1979-1988	0.108	0.237	0.035	0.031	~	~
1980-1989	0.099	0.228	0.032	0.038	~	~
1981-1990	0.101	0.231	0.029	0.037	~	~
1982-1991	0.104	0.239	0.031	0.037	~	~
1983-1992	0.103	0.235	0.027	0.035	~	~
1984-1993	0.114	0.234	0.031	0.038	~	~
1985-1994	0.112	0.239	0.028	0.038	~	~
1986-1995	0.130	0.234	0.031	0.040	~	~
1987-1996	0.135	0.234	0.043	0.040	~	~
1988-1987	0.136	0.234	0.044	0.041	~	~
1989-1998	0.136	0.234	0.044	0.041	~	~
1990-1999	0.144	0.236	0.044	0.034	~	~
1991-2000	0.141	0.230	0.045	0.034	~	~
1992-2001	0.146	0.170	0.044	0.031	~	~
1993-2002	0.146	0.170	0.044	0.039	1.223	1.814
1994-2003	0.133	0.182	0.038	0.042	1.176	2.016
1995-2004	0.128	0.180	0.038	0.040	1.087	2.008
1996-2005	0.140	0.231	0.047	0.055	1.151	2.045
1997-2006	0.171	0.242	0.074	0.064	1.320	2.048
1998-2007	0.197	0.294	0.102	0.074	1.429	2.050
1999-2008	0.197	0.314	0.106	0.074	1.429	2.088
MIN	**0.099**	**0.170**	**0.027**	**0.031**	**1.087**	**1.814**

6.3 **Major ions** (fluoride, sulphate, chloride, and total dissolved solids)

Background water quality objectives were developed for a number of major ions and TDS on the transboundary rivers (Table 9). Background concentrations of major ions and total dissolved solids may be naturally high on the prairies and therefore toxicity-based guidelines developed in the laboratory may not be reflective of the requirements of adapted flora and fauna. Trend analysis was completed for those major ions where appropriate established guidelines were not available (Appendix 9).

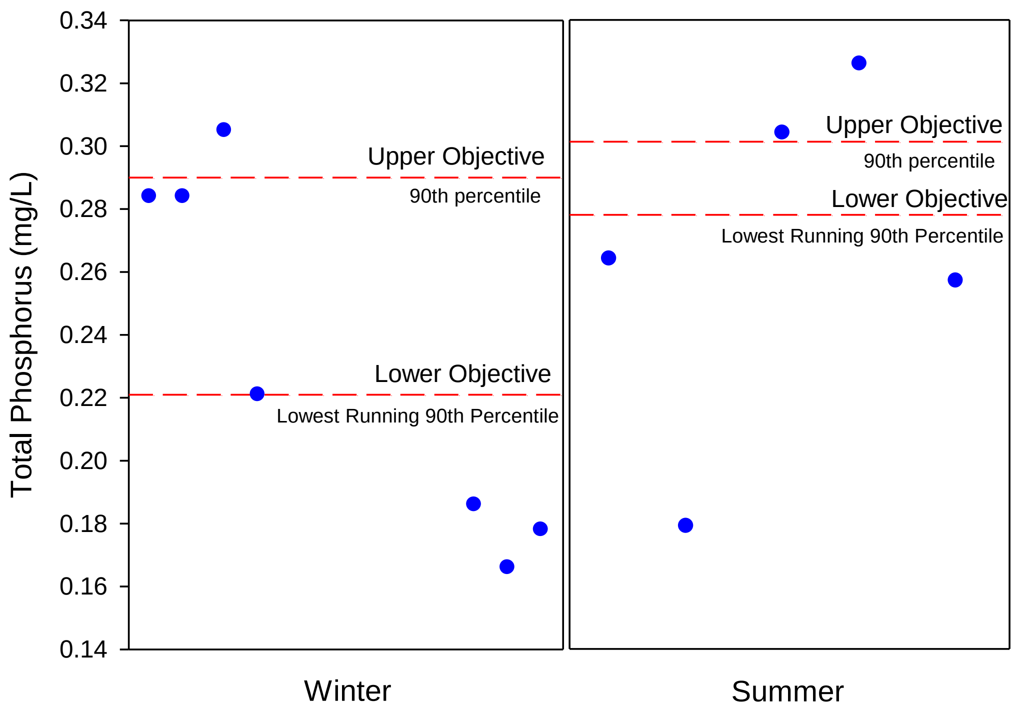


Figure 6 **Excursion Reporting using Tiered Objectives for Two Seasons Qu'Appelle River, 2010** **(Four excursions reported for the winter and 2 excursions for the summer)**

Table 9 **Parameters Where Background Concentration Exceeded Most Protective Toxicology-Based Objective, by River**

	River	**Parameters that Exceeded Lowest Water Use Objective**
Alberta/ Saskatchewan Border	Beaver	Fluoride
	Battle	Fluoride, TDS
	Red Deer	Fluoride
	Cold	Fluoride
	North Saskatchewan	Fluoride
	South Saskatchewan	Fluoride
Saskatchewan/ Manitoba Border	Assiniboine	Fluoride, TDS, Sulphate
	Carrot	Fluoride, TDS, Chloride, Sodium
	Churchill	Fluoride
	Qu'Appelle	Fluoride, TDS, Sulphate
	Red Deer	Fluoride
	Saskatchewan	Fluoride

6.3.1 Fluoride
A background objective was developed for fluoride for each transboundary river. Except for the Carrot River, the background objective for fluoride was the 90th percentile of all available data (Appendix 9). For the Carrot River, where seasonality in fluoride concentrations was observed, the background objective was calculated as the 90th percentile of the open and ice covered seasons.

6.3.2 Total Dissolved Solids (TDS)
The national CCME guideline for TDS was adopted at seven of the 12 transboundary rivers. A background objective was developed for total dissolved solids (TDS) at four of the twelve transboundary rivers including the Battle River, Assiniboine River, Carrot River and the Qu'Appelle River. Except for the Carrot River, the background objective for TDS was the 90th percentile of all available TDS data because of a lack of seasonality. For the Carrot River, the background objective was calculated as the 90th percentile of each of the open and ice covered seasons (Appendix 9).

6.3.3 Sulphate
The 1992 PPWB objective was adopted at 10 of the 12 transboundary rivers. Sulphate was established as a background objective on two rivers; the Assiniboine River and the Qu'Appelle River. For each river, the background objective was calculated as the 90th percentile of all available data. Seasonal objectives were not developed for sulphate (Appendix 9).

6.3.4 Sodium and Chloride
For the Carrot River, seasonal background objectives were developed for sodium and chloride. The background objectives were calculated as the 90th percentile of the open and ice covered season for all available Carrot River data (Appendix 9).

6.4 Total Suspended Solids (TSS)
Background objectives were developed for total suspended solids at all 12 transboundary rivers. The TSS background objectives included both an upper and lower limit to protect aquatic life and in particular to protect turbid water fish that are present in prairie river systems, notably in the Saskatchewan River system. Fish species present within the Saskatchewan River system include:

- Goldeye and mooneye which are obligate turbid water species. They have semi-buoyant eggs that are probably protected from predation in a turbid water environment.
- Shorthead redhorse, silver redhorse, and quillback have significant populations in turbid rivers, and are either absent or rare in other types of freshwater habitats (Nelson and Paetz 1992).

Given these unique fish populations and the naturally turbid nature of prairie river systems, an important factor structuring the ecosystem, the establishment of a

TSS objective for the transboundary rivers was considered important from a biodiversity perspective.

Total suspended solids background objectives were based on the open water season only as this is the most critical period for the protection of fish and early life stages. The upper TSS objective was the 90^{th} percentile of the open water season data while the lower objective below which the TSS should not fall was the 10^{th} percentile of data from the open water season (Appendix 10). Unlike the other background objectives based on the 90^{th} percentile approach that should (statistically) have a 10% excursion rate when there are no significant trends, the TSS objective could statistically be expected to have a 20% excursion rate (*i.e.* 10% above the upper limit plus 10% below the lower limit).

7. Exceptions - No Water Quality Objectives Established

Interprovincial water quality objectives were not established for dissolved oxygen, sodium adsorption ratio (SAR) and several metals (as noted below) for select transboundary river reaches. Objectives were not set at these sites because COWQ believes that toxicology-based objectives were not appropriate for these prairie rivers and/or insufficient information was available to support the development of a site-specific objective.

Dissolved oxygen objectives were not established on the Battle River, Beaver River and Carrot River during the ice covered season. These rivers exhibit low winter flows and often have low dissolved oxygen concentrations under ice. Insufficient information was available to develop a dissolved oxygen objective that reflected naturally low flow conditions in these rivers.

Sodium adsorption ratio (SAR) is a measurement used to determine the suitability of a water supply for agricultural irrigation. For the Battle, Carrot, and Qu'Appelle rivers, SAR values were above the recommended irrigation objective value of 3 (CCREM 1987). Therefore, the use of these river reaches for irrigation should be considered carefully depending on the crop to be irrigated and the soil water compatibility. Consultation with an agricultural irrigation specialist is recommended before using the Battle, Carrot or Qu'Appelle rivers for irrigation.

Metal concentrations can be high in prairie river systems especially during spring freshet when concentrations of total suspended sediments peak. A number of the transboundary rivers exhibit high metal concentrations with frequent excursions from the most protective water use objective. However, in some instances insufficient information was available to develop a background objective. No aluminum objective was established for any of the transboundary river reaches. Also, no objectives were developed for manganese (dissolved) on the Battle, Assiniboine, Carrot or Qu'Appelle rivers. Similarly, no objective was set for iron (dissolved) on the Carrot River. Finally, no objective was developed for cadmium (total) or copper (total) in the Red Deer River near Bindloss.

For those rivers where metal objectives could not be developed the COWQ recommends further investigations into metal concentrations, trends and toxicity. In particular, further understanding of the sources of these metals and the influence of natural *versus* anthropogenic factors would be helpful for future objective reviews.

8. Interprovincial Water Quality Objectives Retained but not Currently Monitored by Environment Canada

The COWQ recognizes that some of the objectives recommended in this review are not anticipated to be regularly monitored in the foreseeable future. These include reactive chlorine species, cyanide, mercury (in water) and radionuclides (Tables 12 and 13).

Cyanide and cyanide compounds are present in air, water, soil, and food due to both natural and anthropogenic sources. Compounds containing the cyanide group are used and readily formed in many industrial processes and can be found in a variety of effluents such as those from the steel, petroleum, plastics, synthetic fibres, metal plating, mining, and chemical industries. Cyanide is not currently part of the Prairie Provinces Water Board water quality monitoring program. However industrial processes, including those related to petroleum and mining can be found in the transboundary watersheds that are monitored as part of Board's activities and therefore, cyanide may be of interest for future monitoring programs.

Mercury occurs naturally but can enter ecosystems through anthropogenic emissions, re-emissions and discharges. Natural sources of mercury include geological mercury deposits, rock weathering, forest fires and other wood burning and hot springs. The primary anthropogenic sources of mercury include metal smelting, municipal waste incineration, sewage and hospital waste incineration, coal and other fossil fuel combustion, cement manufacturing, and mercury waste in landfills or storage. Newly created reservoirs can also temporarily increase the amount of methyl mercury in aquatic systems due to the accelerated microbial methylation of existing inorganic mercury forms caused by decomposing flooded vegetation. Collection and analysis of mercury in routine water quality monitoring programs is complicated by the unusually high risk of contamination during collection. Special monitoring techniques are required and therefore, mercury may not be included in routine monitoring programs but is typically sampled when there is a specific issue or concern.

The four main sources of reactive chlorine species to the environment are treated wastewater effluents, chlorinated cooling water effluents, spills due to breaks in the drinking water distribution system, and uncollected releases of drinking water. Chlorination of wastewater and/or cooling water occurs in meat processing plants, fish and poultry processing plants, natural gas plants, petroleum refineries, pulp and paper, and petrochemical industries, all potential sources that exist throughout the transboundary watersheds monitored by the Prairie

Provinces Water Board. The direct release of drinking water into the ambient environment through pipeline breaks in the drinking water distribution system or overflows from water storage reservoirs can release chlorinated or chloraminated water with concentrations of total residual chlorine above those that would be expected to cause considerable local effects.

Increased levels of radionuclides in surface waters may be linked to industrial processes, particularly uranium mining and milling operations, fallout from nuclear weapons testing (mostly before 1963), emissions from nuclear reactors, as well as cosmogenic and other artificial radionuclides. Although the establishment of drinking water guidelines for a contaminant usually takes into consideration the ability to measure the contaminant and remove it from drinking water, the Canadian Drinking Water Quality Guidelines proposed for adoption in Schedule E are based solely on health effects for radionuclides.

Given that cyanide, mercury, total residual chlorine and radionuclides may be released anthropogenically to the transboundary watersheds monitored by the Prairie Provinces Water Board, it is prudent to maintain water quality guidelines for the protection of aquatic life and treatability in the objectives established under Schedule E. Cyanide, mercury, total residual chlorine and radionuclides are included as existing objectives in Schedule E (1992) and have national guidelines as well as provincial objectives. Formally incorporating the objectives now, in the event of a future water quality issue or emergency, aids in the prevention and resolution of disputes, a key mission of the Board.

Compounds in fish tissue for consumption by humans and wildlife are not currently monitored as this sampling program is currently under review. However, after review of the historical sampling program, a fish tissue monitoring program may be reinstated and it would be valuable to maintain the existing interprovincial water quality objectives for fish tissue with relevant updates to reflect current science (Tables 12 and 13). Excluded at this time is the objective for methyl mercury for fish consumption by wildlife which requires further review of the historical sampling program results and potentially, an investigation of natural versus human sources of methyl mercury.

9. Water Quality Objectives Removed from the Interprovincial Water Quality Objectives

As part of the current interprovincial water quality objectives review the COWQ reviewed the interprovincial objectives established in 1992, and agreed that seven parameters should be removed from the updated objectives list. These included 2,4,5- TP, chlorophenols, PCB in fish muscle tissue, and several metals; aluminum (total), boron (dissolved), nickel (total), and selenium (dissolved).

The reasons the COWQ remove these objectives included:

- 2,4,5- TP is no longer approved for use in Canada (or the US) and is not expected to be an issue at the transboundary river reaches. The Canadian drinking water quality objective for 2,4,5-TP that was adopted in 1992 by the PPWB has been archived;
- A guideline is no longer available or supported for total chlorophenol. Instead, guidelines exist for individual compounds such as pentachlorophenol and these have been proposed for adoption where appropriate;
- The guideline for PCB in fish muscle tissue is no longer supported by Health Canada and is under review;
- For the metals aluminum, boron (dissolved), nickel (total), selenium (dissolved), the COWQ selected boron (total), nickel (dissolved), and selenium (total) as the interprovincial water quality objective and agreed to not include both a total and a dissolved metal objective.

10. Recommended Interprovincial Water Quality Objectives

The interprovincial water quality objectives recommended for the transboundary river reaches are predominantly based on the most protective water use guideline. The objectives are either provincial objectives used within the jurisdictions party to the MAA, or are national guidelines developed by CCME or Health Canada or the USEPA. The COWQ recommends that all transboundary rivers be protected for all water uses including the protection of aquatic life, agriculture uses (irrigation and livestock), recreation and aesthetics, treatability for use as a drinking water source, and fish tissue consumption by humans and wildlife.

Interprovincial water quality objectives are recommended for a number of parameters that can be toxic and those that influence ecosystem structure. Parameter groups for which objectives are recommended include nutrients, metals, major ions, physical characteristics, pesticides and radioisotopes.

Parameters with water quality objectives that are currently monitored at all 12 transboundary rivers are shown in Tables 10 and 11. Parameters with recommended interprovincial water quality objectives but are not currently monitored at the transboundary rivers are shown in Tables 12 and 13. Background nutrient objectives are also recommended for each of the 12 transboundary river reaches (Table 14).

The interprovincial water quality objectives recommended by the COWQ during this review represent revised and new WQOs as compared to the 1992 interprovincial water quality objectives. Some key differences include:

- the approach to protect all water uses for all rivers which was different from the 1992 approach
- the inclusion of site specific water quality objectives for selected parameters

- the establishment of objectives for 12 rivers *versus* 11 rivers in 1992. (new objectives are proposed for the Cold River).

The interprovincial water quality objectives recommended for the transboundary river reaches include 71 different water quality parameters. The recommended objectives represent acceptable water quality conditions for the transboundary rivers. In comparison, in 1992, interprovincial water quality objectives varied by river reach with between 28 to 38 water quality objectives at each river reach. A comparison between the currently recommended interprovincial water quality objectives and the 1992 interprovincial water quality objectives is shown in Appendix 11.

In summary, on the Alberta/Saskatchewan border, the COWQ recommends 41 new interprovincial water quality objectives, that 15 objectives remain the same as those established in 1992, that 15 objectives be updated, and that seven objectives be removed. On the Manitoba/Saskatchewan border, the COWQ recommends 40 new interprovincial water quality objectives be established, nine objectives remain the same, 22 objectives be updated and six objectives be removed.

11. Monitoring

Assessment of exceedances of the recommended water quality objectives can be supported with the existing water quality monitoring program. With the potential exception of the fish tissue sampling program, no changes to field sampling or analytical requirements are expected due to adoption of the recommended objectives.

The fish sampling program was suspended pending review of data previously collected and the program design. A new monitoring program is expected to be recommended once the review is completed.

12. Recommended Next Steps

The COWQ acknowledged a number of issues and challenges during the water quality objectives review and recommends that the following be studied in advance of the next objectives review:

- Methods for the development of site-specific objectives, including nutrient objectives, be reviewed for potential application to the transboundary river reaches. This work could include assessment of predictive modelling and downstream protection approaches as well as identification of data gaps.
- For those rivers where metal objectives could not be developed, the COWQ recommends further investigations into metal sources, trends and toxicity.

Table 10 Recommended Interprovincial Water Quality Objectives for the Transboundary River Reaches at the Alberta/Saskatchewan Border and Currently Monitored by Environment Canada

2012 Recommended Interprovincial Water Quality Objectives– AB/SK Border						
Parameter	**River**					
Nutrients	**Battle River**	**Beaver River**	**Cold River**	**North Saskatchewan River**	**Red Deer River (Bindloss)**	**South Saskatchewan River**
Nitrate as N (mg/L)	3	3	3	3	3	3
Ammonia Un-ionized (mg/L)	0.019 [a]	0.019 [a]	0.019 [a]	0.019 [a]	0.019 [a]	0.019 [a]
Major Ions						
Total Dissolved Solids (mg/L)	872	500	500	500	500	500
Sulphate Dissolved (mg/L)	250	250	250	250	250	250
Sodium Dissolved (mg/L)	200	200	200	200	200	200
Fluoride Dissolved (mg/L)	0.31	0.19	0.12	0.18	0.2	0.19
Chloride Dissolved (mg/L)	100	100	100	100	100	100
Physicals and Other						
pH Lab	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0
pH Field	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0	6.5-9.0
Oxygen Dissolved (mg/L)						
Open Season (>5°C)	5	5	5	5	5	5
Closed Season (<5°C)	Under Review	Under Review	3	3	3	3
Sodium Adsorption Ratio	Under Review	3	3	3	3	3
Total Suspended Solids (mg/L)	5.0 - 320.0	3.0 - 48.8	1.2 - 4.8	5.0 - 295.8	30.0 - 832.6	5.6 - 339.8
Biota						
E. Coli (No./100 mL)	200	200	200	200	200	200
Coliforms Fecal (No./100 mL)	100	100	100	100	100	100
Metals						
Arsenic Total (µg/L)	5	5	5	5	5	5
Arsenic Dissolved (µg/L)	No Objective	No Objective	No Objective	No Objective	No Objective	No Objective
Barium Total (µg/L)	1000	1000	1000	1000	1000	1000
Beryllium Total (µg/L)	100	100	100	100	100	100
Boron Total (µg/L)	500	500	500	500	500	500
Cadmium Total (µg/L)	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]	Under Review	Calculated[b]
Chromium Total (µg/L)	50	50	50	50	50	50
Cobalt Total (µg/L)	50	50	50	50	50	50
Copper Total (µg/L)	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]	Under Review	Calculated[b]
Iron Dissolved (µg/L)	300	300	300	300	300	300
Lead Total (µg/L)	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]
Lithium Total (µg/L)	2500	2500	2500	2500	2500	2500
Manganese Dissolved (µg/L)	Under Review	Under Review	50	50	50	50
Molybdenum Total (µg/L)	10	10	10	10	10	10
Nickel Dissolved (µg/L)	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]
Selenium Total (µg/L)	1	1	1	1	1	1
Silver Total (µg/L)	0.1	0.1	0.1	0.1	0.1	0.1
Thallium Total (µg/L)	0.8	0.8	0.8	0.8	0.8	0.8
Uranium Total (µg/L)	10	10	10	10	10	10
Vanadium Total (µg/L)	100	100	100	100	100	100
Zinc Total (µg/L)	30	30	30	30	30	30

2012 Recommended Water Quality Objectives – AB/SK Border						
Parameter	**River**					
Pesticides	**Battle River**	**Beaver River**	**Cold River**	**North Saskatchewan River**	**Red Deer River (Bindloss)**	**South Saskatchewan River**
Acid Herbicides						
2,4-D (µg/L)	4	4	4	4	4	4
Bromoxynil (µg/L)	0.33	0.33	0.33	0.33	0.33	0.33
Dicamba (µg/L)	0.006	0.006	0.006	0.006	0.006	0.006
MCPA (µg/L)	0.025	0.025	0.025	0.025	0.025	0.025
Picloram (µg/L)	29	29	29	29	29	29
Organochlorine Pesticides in Water						
Endosulfan (µg/L)	0.003	0.003	0.003	0.003	0.003	0.003
Hexachlorocyclohexane (gamma-HCH) (Lindane) (µg/L)	0.01	0.01	0.01	0.01	0.01	0.01
Hexachlorobenzene (µg/L)	0.52	0.52	0.52	0.52	0.52	0.52
Pentachlorophenol (PCP) (µg/L)	0.5	0.5	0.5	0.5	0.5	0.5
Neutral Herbicides in Water						
Atrazine (µg/L)	1.8	1.8	1.8	1.8	1.8	1.8
Diclofopmethyl (Hoegrass)* (µg/L)	0.18	0.18	0.18	0.18	0.18	0.18
Metolachlor (µg/L)	7.8	7.8	7.8	7.8	7.8	7.8
Metribuzin (µg/L)	0.5	0.5	0.5	0.5	0.5	0.5
Simazine (µg/L)	0.5	0.5	0.5	0.5	0.5	0.5
Triallate (µg/L)	0.24	0.24	0.24	0.24	0.24	0.24
Trifluralin (µg/L)	0.2	0.2	0.2	0.2	0.2	0.2
Other						
Glyphosate (µg/L)	Report Detections	Report Detections	Report Detections	Report Detections	Report Detections	Report Detections

Superscripts

a. Ammonia objective: Expressed as mg unionized ammonia/L. This would be equivalent to 0.0156 mg ammonia-nitrogen/L (0.019*14.0067/17.031).

b. The objective value in µg/L is a function of total hardness (CaCO3 mg/L) in the water column:

Cadmium Total is calculated using $10^{\{0.86[\log(hardness)]-3.2\}}$.

Copper Total's objective is 2 when total hardness is <82 or unknown, 4 when >180, and calculated using $0.2*e^{\{0.8545[\ln(hardness)]-1.465\}}$ when total hardness is ≥82 to ≤180.

Lead Total's objective is 1 when total hardness is ≤60 or unknown, 7 when >180, and calculated using $e^{\{1.273[\ln(hardness)]-4.705\}}$ when total hardness is >60 to ≤180.

Nickel Dissolved is calculated using $0.998*e^{\{0.8460[\ln(hardness)]+2.255\}}$.

Legend

Protection of Aquatic Life	Ag-Livestock	Ag-Irrigation	Recreation	Treatability	Ag-Irrigation + Treatability	Ag-Irrigation and Livestock	Fish Consumption

Table 11 Recommended Interprovincial Water Quality Objectives for the Transboundary River Reaches at the Saskatchewan/Manitoba Border and Monitored by Environment Canada

2012 Recommended Interprovincial Water Quality Objectives – SK/MB Border

Parameter	River						
	Assiniboine River	Carrot River		Churchill River	Qu'Appelle River	Red Deer River (Erwood)	Saskatchewan River
Nutrients		Open	Closed				
Nitrate as N (mg/L)	3	3		3	3	3	3
Ammonia Un-ionized (mg/L)	0.019 [a]	0.019 [a]		0.019 [a]	0.019 [a]	0.019 [a]	0.019 [a]
Major Ions							
Total Dissolved Solids (mg/L)	834	742	1672	500	1144	500	500
Sulphate Dissolved (mg/L)	299	250		250	486	250	250
Sodium Dissolved (mg/L)	200	164	442	200	200	200	200
Fluoride Dissolved (mg/L)	0.26	0.20	0.29	0.12	0.25	0.18	0.18
Chloride Dissolved (mg/L)	100	267	728	100	100	100	100
Physicals and Other							
pH Lab	6.5-9.0	6.5-9.0		6.5-9.0.	6.5-9.0	6.5-9.0	6.5-9.0
pH Field	6.5-9.0	6.5-9.0		6.5-9.0.	6.5-9.0	6.5-9.0	6.5-9.0
Oxygen Dissolved (mg/L)							
Open Season (>5°C)	5	5		5	5	5	5
Closed Season (<5°C)	3	Under Review		3	3	3	3
Sodium Adsorption Ratio	3	Under Review		3	Under Review	3	3
Total Suspended Solids (mg/L)	5.0 - 69.2	6.08 - 98.2		2.2 - 6.2	22.6 - 122.2	1.0 -19.7	27.0 - 125.0
Biota							
E. Coli (No./100 mL)	200	200		200	200	200	200
Coliforms Fecal (No./100 mL)	100	100		100	100	100	100
Metals							
Arsenic Total (µg/L)	5	No Objective		5	No Objective	5	5
Arsenic Dissolved (µg/L)	No Objective	50		No Objective	50	No Objective	No Objective
Barium Total (µg/L)	1000	1000		1000	1000	1000	1000
Beryllium Total (µg/L)	100	100		100	100	100	100
Boron Total (µg/L)	500	500		500	500[b]	500	500
Cadmium Total (µg/L)	Calculated[b]	Calculated[b]		Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]
Chromium Total (µg/L)	50	50		50	50	50	50
Cobalt Total (µg/L)	50	50		50	50	50	50
Copper Total (µg/L)	Calculated[b]	Calculated[b]		Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]
Iron Dissolved (µg/L)	300	Under Review		300	300	300	300
Lead Total (µg/L)	Calculated[b]	Calculated[b]		Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]
Lithium Total (µg/L)	2500	2500		2500	2500	2500	2500
Manganese Dissolved (µg/L)	Under Review	Under Review		50	Under Review	50	50
Molybdenum Total (µg/L)	10	10		10	10	10	10
Nickel Dissolved (µg/L)	Calculated[b]	Calculated[b]		Calculated[b]	Calculated[b]	Calculated[b]	Calculated[b]
Selenium Total (µg/L)	1	1		1	1	1	1
Silver Total (µg/L)	0.1	0.1		0.1	0.1	0.1	0.1
Thallium Total	0.8	0.8		0.8	0.8	0.8	0.8
Uranium Total (µg/L)	10	10		10	10	10	10
Vanadium Total (µg/L)	100	100		100	100	100	100
Zinc Total (µg/L)	30	30		30	30	30	30

2012 Recommended Water Quality Objectives– SK/MB Border							
Parameter	**River**						
Pesticides	**Assiniboine River**	**Carrot River** Open	**Carrot River** Closed	**Churchill River**	**Qu'Appelle River**	**Red Deer River (Erwood)**	**Saskatchewan River**
Acid Herbicides							
2,4-D (µg/L)	4	4		4	4	4	4
Bromoxynil (µg/L)	0.33	0.33		0.33	0.33	0.33	0.33
Dicamba (µg/L)	0.006	0.006		0.006	0.006	0.006	0.006
MCPA (µg/L)	0.025	0.025		0.025	0.025	0.025	0.025
Picloram (µg/L)	29	29		29	29	29	29
Organochlorine Pesticides in Water							
Endosulfan (µg/L)	0.003	0.003		0.003	0.003	0.003	0.003
Hexachlorocyclohexane (gamma-HCH) (Lindane) (µg/L)	0.01	0.01		0.01	0.01	0.01	0.01
Hexachlorobenzene (µg/L)	0.52	0.52		0.52	0.52	0.52	0.52
Pentachlorophenol (PCP) (µg/L)	0.5	0.5		0.5	0.5	0.5	0.5
Neutral Herbicides in Water							
Atrazine (µg/L)	1.8	1.8		1.8	1.8	1.8	1.8
Diclofopmethyl (Hoegrass)* (µg/L)	0.18	0.18		0.18	0.18	0.18	0.18
Metolachlor (µg/L)	7.8	7.8		7.8	7.8	7.8	7.8
Metribuzin (µg/L)	0.5	0.5		0.5	0.5	0.5	0.5
Simazine (µg/L)	0.5	0.5		0.5	0.5	0.5	0.5
Triallate (µg/L)	0.24	0.24		0.24	0.24	0.24	0.24
Trifluralin (µg/L)	0.2	0.2		0.2	0.2	0.2	0.2
Other							
Glyphosate (µg/L)	Report Detections	Report Detections		Report Detections	Report Detections	Report Detections	Report Detections

a. Ammonia objective: Expressed as mg unionized ammonia/L. This would be equivalent to 0.0156 mg ammonia-nitrogen/L (0.019*14.0067/17.031).
b. The objective value in µg/L is a function of total hardness (CaCO3 mg/L) in the water column:
Cadmium Total is calculated using $10^{\{0.86[\log(hardness)]-3.2\}}$.
Copper Total's objective is 2 when total hardness is <82 or unknown, 4 when >180, and calculated using $0.2*e^{\{0.8545[\ln(hardness)]-1.465\}}$ when total hardness is ≥82 to ≤180.
Lead Total's objective is 1 when total hardness is ≤60 or unknown, 7 when >180, and calculated using $e^{\{1.273[\ln(hardness)]-4.705\}}$ when total hardness is >60 to ≤180.
Nickel Dissolved is calculated using $0.998*e^{\{0.8460[\ln(hardness)]+2.255\}}$.

Legend

Protection of Aquatic Life	Ag-Livestock	Ag-Irrigation	Recreation	Treatability	Ag-Irrigation + Treatability	Ag-Irrigation and Livestock	Fish Consumption

Table 12 Recommended Interprovincial Water Quality Objectives for the Transboundary River Reaches at the Alberta/Saskatchewan Border, not Currently Monitored by Environment Canada.

2012 Recommended Water Quality Objectives – Alberta/Saskatchewan Border

Parameter	River					
	Battle River	Beaver River	Cold River	North Saskatchewan River	Red Deer River (Bindloss)	South Saskatchewan River
Physicals and Other						
Reactive Chlorine Species (mg/L)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Cyanide (free) (mg/L)	0.005	0.005	0.005	0.005	0.005	0.005
Metals						
Mercury (total) (µg/L)	0.026	0.026	0.026	0.026	0.026	0.026
Fish Tissue						
Mercury in Fish (muscle) (µg/kg)	200	200	200	200	200	200
Arsenic in fish (muscle) (µg/kg)	3500	3500	3500	3500	3500	3500
Lead In fish (muscle) (µg/kg)	500	500	500	500	500	500
DDT (total) in fish (muscle) (µg/kg)	5000	5000	5000	5000	5000	5000
Aquatic Biota Consumption						
PCB in fish (muscle) mammalian (µg TEQ/kg diet wet weight)	0.00079	0.00079	0.00079	0.00079	0.00079	0.00079
PCB in fish (muscle) avian (µg TEQ/kg diet wet weight)	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024
DDT total in fish (muscle) (µg/kg diet wet weight)	14	14	14	14	14	14
Toxaphene in fish (muscle) (µg/kg diet wet weight)	6.3	6.3	6.3	6.3	6.3	6.3
Radioactive						
Cesium-137 (Bq/L)	10	10	10	10	10	10
Iodine-131 (Bq/L)	6	6	6	6	6	6
Lead-210 (Bq/L)	0.2	0.2	0.2	0.2	0.2	0.2
Radium-226 (Bq/L)	0.5	0.5	0.5	0.5	0.5	0.5
Strontium-90 (Bq/L)	5	5	5	5	5	5
Tritium (Bq/L)	7000	7000	7000	7000	7000	7000

Legend

Protection of Aquatic Life	Treatability	Fish Consumption

Table 13 Recommended Interprovincial Water Quality Objectives for the Transboundary River Reaches at the Saskatchewan/Manitoba Border not Currently Monitored by Environment Canada.

2012 Recommended Water Quality Objectives– Saskatchewan/Manitoba Border							
Parameter	**River**						
	Assiniboine River	**Carrot River**		**Churchill River**	**Qu'Appelle River**	**Red Deer River (Erwood)**	**Saskatchewan River**
		Open	Closed				
Physicals and Other							
Reactive Chlorine Species (mg/L)	0.0005	0.0005		0.0005	0.0005	0.0005	0.0005
Cyanide (free) (mg/L)	0.005	0.005		0.005	0.005	0.005	0.005
Metals							
Mercury (total) (µg/L)	0.026	0.026		0.026	0.026	0.026	0.026
Fish Tissue							
Mercury in Fish (muscle) (µg/kg)	200	200		200	200	200	200
Arsenic in fish (muscle) (µg/kg)	3500	3500		3500	3500	3500	3500
Lead In fish (muscle) (µg/kg)	500	500		500	500	500	500
DDT (total) in fish (muscle) (µg/kg)	5000	5000		5000	5000	5000	5000
Aquatic Biota Consumption							
PCB in fish (muscle) mammalian (µg TEQ/kg diet wet weight)	0.00079	0.00079		0.00079	0.00079	0.00079	0.00079
PCB in fish (muscle) avian (µg TEQ/kg diet wet weight)	0.0024	0.0024		0.0024	0.0024	0.0024	0.0024
DDT total in fish (muscle) (µg/kg diet wet weight)	14	14		14	14	14	14
Toxaphene in fish (muscle) (µg/kg diet wet weight)	6.3	6.3		6.3	6.3	6.3	6.3
Radioactive							
Cesium-137 (Bq/L)	10	10		10	10	10	10
Iodine-131 (Bq/L)	6	6		6	6	6	6
Lead-210 (Bq/L)	0.2	0.2		0.2	0.2	0.2	0.2
Radium-226 (Bq/L)	0.5	0.5		0.5	0.5	0.5	0.5
Strontium-90 (Bq/L)	5	5		5	5	5	5
Tritium (Bq/L)	7000	7000		7000	7000	7000	7000

Legend

Protection of Aquatic Life	Treatability	Fish Consumption

Table 14 Recommended Nutrient Objectives for the Transboundary River Reaches Based on a Background Approach

Proposed Objectives for Nutrients		Total Phosphorus (mg/L)		Total Dissolved Phosphorus (mg/L)		Total Nitrogen (mg/L)	
Alberta - Saskatchewan Border							
Battle River Near Unwin	Summer	0.267	0.335	0.051		2.260	
	Winter	0.075	0.100	0.045		1.550	
Beaver River at Beaver Crossing	Summer	0.171		0.043	0.060	1.140	
	Winter	0.127		0.042	0.060	1.862	
Cold River at Outlet of Cold Lake	Summer	0.023		0.010		0.453	0.460
	Winter	0.024		0.017		0.452	0.467
North Saskatchewan River at Highway 17	Summer	0.253	0.278	0.026	0.046	1.169	1.230
	Winter	0.063	0.115	0.048	0.101	1.175	1.225
Red Deer River Near Bindloss	Summer	0.315	0.563	0.023	0.035	2.320	
	Winter	0.035	0.069	0.008	0.024	0.860	
South Saskatchewan River	Summer	0.159	0.246	0.014	0.018	1.073	1.114
	Winter	0.054	0.110	0.010	0.067	1.638	1.771

Proposed Objectives for Nutrients		Total Phosphorus (mg/L)		Total Dissolved Phosphorus (mg/L)		Total Nitrogen (mg/L)	
Saskatchewan - Manitoba Border							
Assiniboine River at Hwy 8 Bridge	Summer	0.311		0.186		1.801	
	Winter	0.180		0.115		2.252	
Carrot River near Turnberry	Summer	0.099	0.140	0.027	0.057	1.087	1.417
	Winter	0.170	0.266	0.031	0.059	1.814	2.052
Churchill River below Wasawakasik	Summer	0.025		0.010		0.484	
	Winter	0.021		0.010		0.411	
Qu'Appelle River	Summer	0.278	0.304	0.156	0.190	1.822	
	Winter	0.221	0.290	0.129	0.249	1.767	
Red Deer River at Erwood	Summer	0.052	0.066	0.021	0.029	1.195	
	Winter	0.074	0.161	0.025	0.055	1.998	
Saskatchewan River	Summer	0.088	0.124	0.014	0.018	0.838	
	Winter	0.028	0.034	0.011	0.017	0.761	

No Trend - 90th % of Database
90th % of Database
Decreasing Trend - Lowest 90th % of 10yr Running
Increasing Trend - Lowest 90th % of 10yr Running

13. Acknowledgements

This interprovincial water quality objectives update document was prepared by Dr. Joanne Sketchell of the PPWB Secretariat, with reviews and comments provided by the COWQ. Water quality data used in the objectives review were provided by Environment Canada, Water Quality Monitoring and Surveillance and water flow data were provided by Environment Canada, Water Survey of Canada through the MAA. Special thanks are provided to Nancy Glozier, Environment Canada for her work and contributions to the method development for the water quality objectives review while in the role of Secretary to the COWQ. Many thanks are also extended to the numerous students who worked with the PPWB Secretariat under the supervision of Dr. Joanne Sketchell on the trend analysis, statistical analysis and data calculations provided to the Committee on Water Quality throughout this water quality objectives review including Destiny Dewalt, Brent Giesbrecht, Ryan Husband, Jacklyn Kraiser, James Leach, Georgia Leslie, Kaitlyn Malowany, Alison Molaro, Jason Penner, Shannon Orloski, Echo Polivka, Conor Renouf, Andrew Robertson, Tyler Smith, Sean Tulloch and Kelly Weibe.

14. Committee on Water Quality Members

Mike Renouf, PPWB Executive Director (Chair)
Joanne Sketchell, Environment Canada (COWQ Secretary)
David Donald, Environment Canada
Bill Schutzman, Agriculture and Agri-Food Canada
Richard Casey, Alberta Environment and Sustainable Resource Development
John-Mark Davies, Saskatchewan Water Security Agency
Nicole Armstrong, Manitoba Conservation and Water Stewardship

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