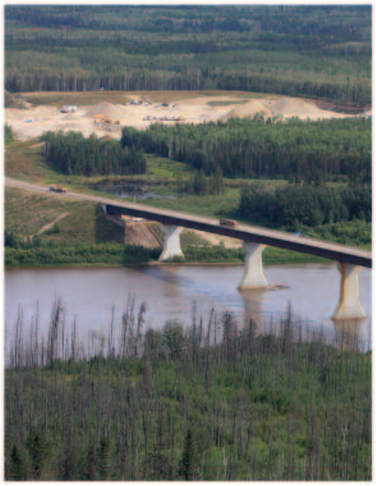
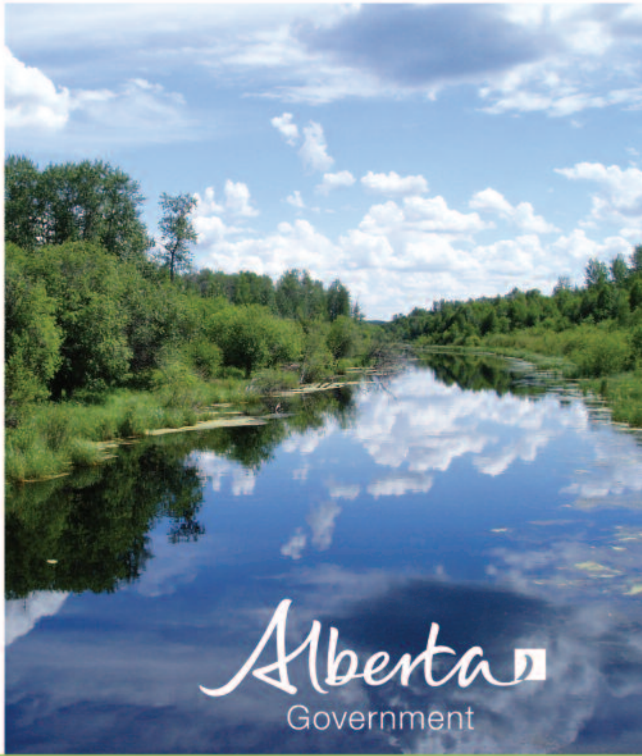
# Lower Athabasca Region

## Surface Water Quality Management Framework for the Lower Athabasca River

environmental • social • economic
LAND-USE FRAMEWORK





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# 1.0 Introduction

Alberta Environment and Sustainable Resource Development's three Lower Athabasca Region management frameworks were developed using input from different stakeholders within the Lower Athabasca Region including industry, First Nations and Métis peoples, and non-governmental organizations. As part of a series developed by the department for the Government of Alberta's *Lower Athabasca Regional Plan*, these frameworks are designed to maintain flexibility and to proactively manage cumulative effects to air quality, surface water quality and groundwater quality and quantity within the Lower Athabasca Region. The frameworks provide context for development and related regulatory processes and facilitate sustainable resource management. They are intended to add to and complement, not replace existing policies, legislation, regulations and management tools.

The frameworks are policy documents that will be implemented and given legal authority as specified in the regional plan, and through Alberta Environment and Sustainable Resource Development's and potentially other departments' mandates and legislation.

The **Air Quality Management Framework** provides an additional component for the region in the overall air quality management system. This includes the setting of ambient air quality triggers and limits for nitrogen dioxide ($NO_2$) and sulphur dioxide ($SO_2$) with guidance for long-term decision-making and management.

The **Surface Water Quality Management Framework** focuses on the lower Athabasca River downstream of the Grand Rapids to the Athabasca River Delta. It sets surface water quality triggers and limits for 38 indicators measured at the Old Fort monitoring station.

The goal of the **Groundwater Management Framework** is to enhance the existing system to manage non-saline groundwater resources across the Lower Athabasca Region including management of potential cumulative effects on these resources. It establishes indicators of groundwater quality and quantity and the method for developing triggers and limits. This document forms the basis for more technical, detailed documents that have been prepared for each of the groundwater management areas in the region. These are *Groundwater Management Framework* supporting documents for the:

- North Athabasca Oil Sands Area
- South Athabasca Oil Sands Area
- Cold Lake – Beaver River Area

*Please note that in May 2012, the Government of Alberta brought together the ministries of Environment and Water and Sustainable Resource Development to create one ministry called Alberta Environment and Sustainable Resource Development.*

# 2.0 Purpose

The framework described in this document is part of the shift to cumulative effects management. It seeks to balance anticipated development with environmental protection. The use of indicators of surface water quality and corresponding triggers and limits helps to clearly define the management of cumulative effects of development and contributes to the achievement of the desired regional objective for surface water quality.

This *Surface Water Quality Management Framework for the Lower Athabasca River* was prepared by Alberta Environment and Sustainable Resource Development for the *Lower Athabasca Regional Plan*, one of seven regional plans being advanced under the *Alberta Land Stewardship Act* and the *Land-use Framework*.

The Lower Athabasca Region is the focus of major industrial development that is driving Alberta's and Canada's economy. Increasing population and industrial expansion is expected to continue in the coming years making management frameworks important components of the regional plan.

This framework builds on, but does not replace, existing provincial legislation and policy on water quality, wastewater and the aquatic environment. It will not replace existing management systems such as spill reporting or drinking water surveillance. It will, however, fill a key gap by providing a framework in which to monitor and manage long-term, cumulative changes in water quality within the lower Athabasca River.

**Goals of the Surface Water Quality Management Framework**

- Identify ambient surface water quality triggers (WQTs) and ambient surface water quality limits (WQLs) to protect surface water quality, clarify Government of Alberta expectations, address cumulative effects, and support pollution prevention and proactive management strategies.
- Enhance transparency and assurance through regular monitoring, evaluation and reporting on ambient surface water quality conditions within the lower Athabasca River from downstream of the Grand Rapids to the Athabasca River Delta.

## 2.1 Regional Context

The Lower Athabasca Region spans the boundaries of three major river basins – the Athabasca River basin, the Beaver River basin and the Peace/Slave River basin. The region has extensive natural resource development potential in the oil sands, natural gas and forestry sectors. Residents have expressed concerns about development within the region and its impact on water quality, particularly within the Athabasca River downstream of the oil sands.

The Athabasca River flows northeast approximately 1,400 kilometres from the Athabasca Glacier in the Columbia Icefields to where it drains into the Athabasca River Delta near Lake Athabasca. From there, the water flows north as the Slave River into Great Slave Lake and ultimately drains into the Arctic Ocean, by way of the Mackenzie River.

This framework applies to the lower section of the Athabasca River from just downstream of the Grand Rapids (approximately 135 kilometres upstream of Fort McMurray) to the Athabasca River Delta (Figure 1).

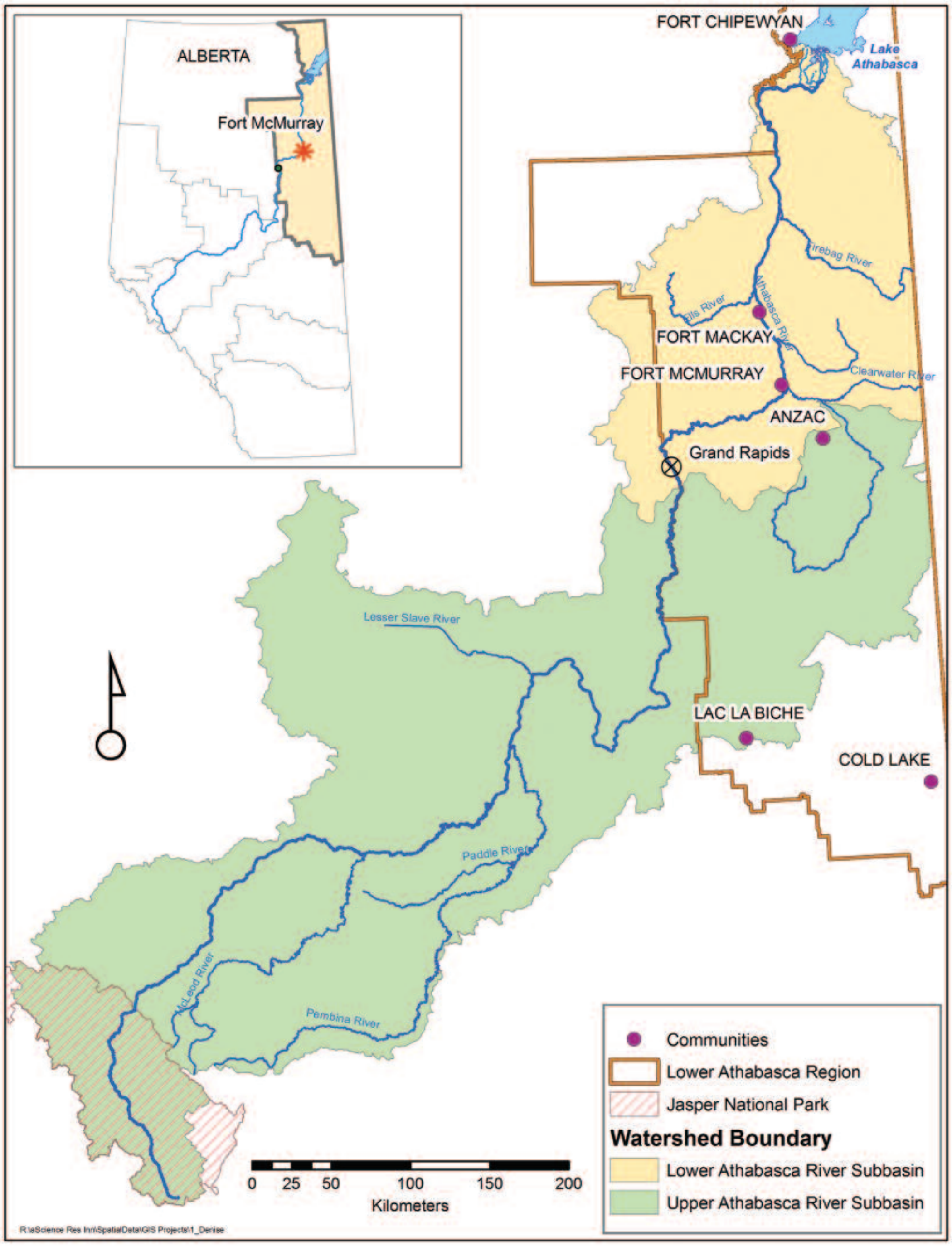


Figure 1

Map of the Athabasca River Basin and Boundary of the Lower Athabasca Region

Note: The *Surface Water Quality Management Framework* for Lower Athabasca Region focuses on the lower Athabasca River downstream of the Grand Rapids to the Athabasca River Delta.

## 2.2 Framework Development

The *Lower Athabasca Regional Plan* is one of seven regional plans being developed under the *Land-use Framework* (2008) to acknowledge the diversity of Alberta's regions, while coordinating provincial decisions about Crown lands and local land-use decisions.

In 2010, the Government of Alberta led a consultation process about the *Lower Athabasca Regional Plan* that involved gathering feedback on key aspects of advice provided by the Regional Advisory Council and on the management frameworks. To develop this framework as part of that regional planning process, work was gathered from the Cumulative Environmental Management Association's (CEMA) Surface Water Working Group (WRS 2003, Golder 2007). The initial drafting and detailed revision of this framework relied on technical and editorial input from federal regulators, industry, multi-stakeholder organizations, non-governmental groups and First Nations and Métis peoples. An engagement process led by Alberta Environment and Sustainable Resource Development (AESRD) involved targeted stakeholders as well as acceptance of written feedback about the framework.

All technical and editorial input from consultation and engagement was considered as the framework was developed. Overall, the comments received during the engagement and consultation processes supported the framework as a beneficial tool for environmental management within the Lower Athabasca Region.

# 3.0 Key Concepts and Principles

Two drivers have guided this framework. The first is the need to build on provincial environmental protection and management policies and principles. The second is the need to adopt a cumulative effects management system in the region.

## 3.1 Provincial Policy Direction

One of the purposes of regional plans is to translate provincial policy to the regional scale. The *Surface Water Quality Management Framework for the Lower Athabasca River* helps to do that.

By reflecting the ongoing desire to balance environmental, economic and social considerations, this framework aligns with the goals of Alberta's *Land-use Framework* and other key policies including *Water for Life* and the *Regional Sustainable Development Strategy for the Athabasca Oil Sands Area* (1999a).

In addition, the need for integration is central to the provincial *Strategy for the Protection of the Aquatic Environment* found in the *Framework for Water Management Planning*. Comprehensive management of the region's surface water resources will require careful and integrated management of three linked ecosystem components: water quality, water quantity and the aquatic environment. Although the current focus of the *Surface Water Quality Management Framework for the Lower Athabasca River* is on managing surface water quality within a specific reach of the Athabasca River, continuing work in the region will contribute to the direction for integration.

## 3.2 Cumulative Effects Management and Management Frameworks

The Government of Alberta has made a commitment to cumulative effects management that focuses on achievement of outcomes, understanding the effects of multiple development pressures (existing and new), assessing risk, collaborative work with shared responsibility for action, and improved integration of economic, environmental and social considerations. It also follows an adaptive management model; which means decision makers learn from experience and new information and adapt to changing social expectations and demands. Performance management is an essential element providing information on environmental conditions and identifying the need for any adjustments and changes on an ongoing basis. The development of management frameworks is an important approach being used to accomplish the shift to a cumulative effects management system. They will play an important role in long-term planning and decision-making in accordance with the outcomes defined in the regional plan.

The management framework approach is depicted in Figure 2.

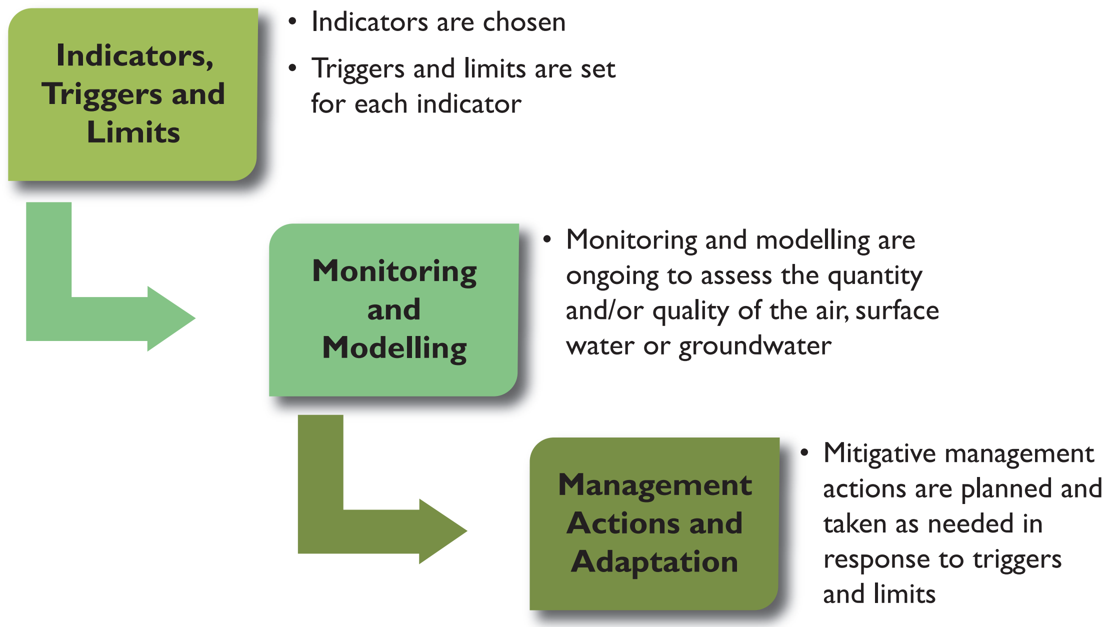


Figure 2
The Management Framework Approach

## 3.3 Key Principles

The following are key concepts and principles that form a foundation for the management framework.

### 3.3.1 Surface Water Quality Management

- New activities and pressures on the lower Athabasca River will be monitored and evaluated relative to a more conservative benchmark than before, namely historical conditions. That does not mean that departures from historical water quality conditions will not be allowed, but rather that the cumulative environmental risks of future departures need to be comprehensively assessed and mitigated before they will be allowed.
- Pollution prevention and continuous improvement as outlined in Alberta Environment's Industrial Release Limits Policy (2000) will remain key management principles, although departures from historical water quality conditions may be allowed.

### 3.3.2 Builds on Existing Legislation, Regulations and Policies

- The framework is intended to add to and complement, not replace, existing policies, legislation and regulations.
- The framework is consistent with provincial policies, strategies and frameworks, and with the stated desired outcomes for the region.

### 3.3.3 Applies a Regional Perspective

- The framework proactively manages water quality within the region with consideration of human population and ecosystem health.
- The framework assigns and applies ambient water quality triggers and limits to identified substances as measured at the Old Fort monitoring station.
- The framework addresses potential adverse impacts on ambient water quality from human activities along the lower Athabasca River.

### 3.3.4 Incorporates Flexibility and Adaptability

- A range of potential actions and tools are expected to be used, as required, to manage ambient water quality with respect to identified indicators.
- The framework recognizes that development plans, technology and scientific understanding may change over time, and flexibility is needed to ensure that the desired environmental outcomes continue to be achieved.
- Alberta Environment and Sustainable Resource Development will review and update the framework to reflect changes in information, knowledge and continuing work on water quality indicators.

### 3.3.5 Clearly Communicates

- The framework supports long-term certainty in Alberta's policy and regulatory process. It provides clarity for industry, early in the design cycle, about restrictions on wastewater releases that may be needed to avoid cumulative impacts on the receiving water environment.
- The system described in this framework and the expectations for surface water quality management are clearly defined and transparent.

### 3.3.6 Involves Partnerships

- Citizens, communities, industry and government must share the responsibility for water management. As with framework development, Alberta Environment and Sustainable Resource Development will continue to involve stakeholders, First Nations and Métis peoples, and working groups who live and work in the area as the framework is implemented.

# 4.0

# The Current Management System

## 4.1 Regulatory and Policy Context

A stringent regulatory system governs municipal and industrial releases into rivers in Alberta. At present, notable releases to the lower Athabasca River are limited to wastewater from the city of Fort McMurray and one industrial release from oil sands operations. Any proposed new municipal or industrial releases would require the proponent to assess the potential effects as part of environmental impact assessments and/or applications for operating approvals under the *Environmental Protection and Enhancement Act*. Water resources are also managed under the provincial *Water Act*. A licence under this act is needed to use water. Impacts to water quality can be considered when applications for licences are being reviewed. The *Water Act* also includes provisions to address activities that can affect watercourses.

There are also major policies that guide management and planning for the protection and maintenance of surface water quality. This includes *Water for Life* and the *Framework for Water Management Planning*. Additional policy context for the framework is provided by the *Regional Sustainable Development Strategy for the Athabasca Oil Sands Area* (1999a) and *Responsible Actions: A Plan for Alberta's Oil Sands* (2009). Table 1 summarizes the key legislation and policies, strategies and agreements currently governing surface water quality including transboundary considerations.

## 4.2 Transboundary Considerations

When rivers flow from one province or territory to the next, there are transboundary agreements in place to ensure that adequate water quality and quantity are maintained. The Athabasca River (along with the north-flowing waters of the Clearwater and Slave rivers) is part of the *Mackenzie River Basin Transboundary Waters Master Agreement*. This agreement has been in effect since 1997 when it was signed by the governments of Canada, British Columbia, Alberta, Saskatchewan, Northwest Territories and Yukon.

The agreement established common principles for cooperative water management and the Mackenzie River Basin Board to facilitate application of these principles. The *Master Agreement* also commits jurisdictions to the development of bilateral water management agreements that will establish specific water quality and quantity objectives. Alberta and the Northwest Territories have established a target of having a bilateral agreement in place by 2012. Both jurisdictions are actively collecting and sharing all relevant information that will inform the negotiations.

Table 1: Key Legislation and Policy for Managing Surface Water Quality in the Lower Athabasca Region

| Governance | Jurisdiction |
|---|---|
| **Provincial Acts, Regulations and Authorizations** | |
| *Alberta Land Stewardship Act* (ALSA) | Provincial / Regional |
| *Environmental Protection and Enhancement Act* (EPEA) | Alberta |
| *Water Act* | Alberta (*Water Act*) |
| Approvals, monitoring and reporting requirements | Alberta (EPEA) |
| Compliance and enforcement | Alberta (EPEA) |
| Licences, approvals, monitoring and reporting requirements | Alberta (*Water Act*) |
| Compliance and enforcement | Alberta (*Water Act*) |
| **Guidelines** | |
| *Surface Water Quality Guidelines for Use in Alberta* | Alberta |
| *Canadian Environmental Quality Guidelines* | Canadian Council of Ministers of the Environment (CCME) |
| *Guidelines for Canadian Drinking Water Quality* | Health Canada |
| *Guidelines for Canadian Recreational Water Quality* | Health Canada |
| **Policies** | |
| *Framework for Water Management Planning* | Alberta |
| *Industrial Release Limits Policy* | Alberta |
| *Water Quality Based Effluent Limits Procedures Manual* | Alberta |
| **Strategies** | |
| *Regional Sustainable Development Strategy for the Athabasca Oil Sands Area* | Alberta |
| *Responsible Actions: A Plan for Alberta's Oil Sands* | Alberta |
| *Strategy for the Protection of the Aquatic Environment* | Alberta |
| *Water for Life* | Alberta |
| *Land-use Framework* | Provincial / Regional |
| **Agreements** | |
| *Mackenzie River Basin Transboundary Waters Master Agreement* | Federal-Provincial-Territorial |
| **Federal Acts** | |
| *Canadian Environmental Protection Act* | Canada |
| *Fisheries Act* | Canada |

## 4.3 Characterization of Surface Water Quality within the Region

Water quality varies considerably along the length of the Athabasca River. It is influenced by natural factors (e.g., geology and soils), as well as point- and non-point source inputs from human development (e.g., industrial wastewater and urban runoff). The Athabasca River receives continuous releases from five pulp mills and four municipal wastewater treatment plants upstream of the Grand Rapids. As mentioned earlier, notable wastewater loadings to the lower Athabasca River are limited to treated municipal wastewater from the city of Fort McMurray and one industrial release from an oil sands operation.

Spring runoff naturally results in seasonal increases in total suspended solids (TSS) and turbidity within the Athabasca River. Both nutrients and total metals are associated with the particles suspended in the runoff, and these indicators also increase during high flows. As a result, seasonal exceedances of water quality guidelines are relatively common.

The water quality at the Long-term River Network (LTRN) monitoring sites upstream of Fort McMurray and at Old Fort have consistently demonstrated Alberta River Water Quality Index (ARWQI) ratings in the "good" to "excellent" range. Both sites have had occasional guideline exceedances for nutrients and metals. Pesticides such as 2,4-D and MCPA have also been detected at the Old Fort site, but at concentrations below guidelines. Section 4.4 expands on the descriptions of the LTRN and other monitoring programs.

Total phosphorus and other nutrients increase along the length of the Athabasca River. This spatial pattern is thought to be due to a combination of point sources (i.e., pulp mills and municipal wastewater) non-point sources (e.g., agriculture and road and pipeline networks) and tributary inputs (North-South 2007).

Several hydrocarbons (including total phenolics, naphthenic acids (NAs) and polycyclic aromatic hydrocarbons (PAHs) are present at low concentrations in the lower Athabasca River. This is thought to be largely due to the region's natural bitumen deposits (North-South 2007). However, industrial sources of these contaminants do exist, and have the potential to increase loading to aquatic systems within the region through a variety of pathways (Hatfield Consultants et. al. 2009) if not managed carefully.

Climatic conditions may also impact water quality in the lower Athabasca River. Significant increasing trends were found for several indicators sampled at the Old Fort station between 1987 and 2007 (Hebben 2009). These increasing trends include pH, turbidity and non-filterable residue, as well as several nutrients and metals. Although many of these variables can be closely related to sediment loads within a river, these trends could also be related to decreasing stream flows in the lower Athabasca River or other causes (Hebben 2009).

## 4.4 Current Surface Water Quality Monitoring in the Region

Alberta Environment and Sustainable Resource Development's monitoring, evaluating and reporting of surface water quality includes the Long-term River Network (LTRN), which supports the ARWQI and periodic trend assessments (e.g., Hebben 2009). The department also leads and supports various water quality research initiatives in the area including the comprehensive contaminant load study described below. Other water quality monitoring in the region includes the Regional Aquatics Monitoring Program (RAMP), facility-specific monitoring (industrial and municipal approval and licence holders), and various federal government monitoring and research initiatives. Please see Figure 3 for locations of select Alberta Environment and Sustainable Resource Development water quality monitoring stations.

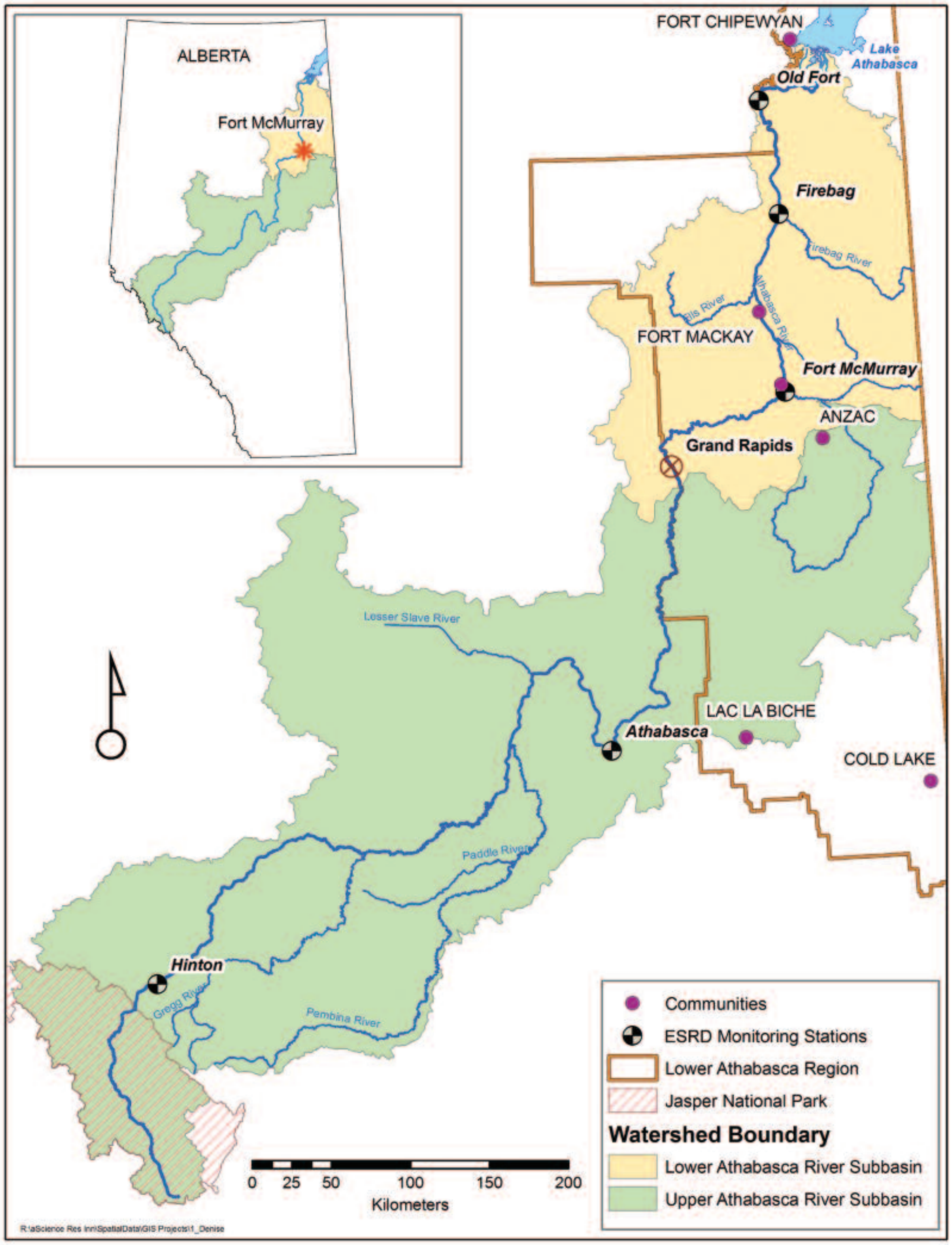


Figure 3
Map of the Athabasca River Basin Showing Select Alberta Environment and Sustainable Resource Development Surface Water Quality Monitoring Stations

### 4.4.1 Long-term River Network

The LTRN program focuses on known problem areas and sources of pollution within larger rivers. Existing network sites were selected because: (1) they are accessible; and (2) river waters are well-mixed with respect to tributary and point source inputs. Network sites are generally located upstream and downstream of municipal and industrial development, or otherwise spaced at important locations on river systems.

Alberta Environment and Sustainable Resource Development has four LTRN sites on the Athabasca River – two of which are on the lower Athabasca River: the Athabasca River upstream of Fort McMurray and the Athabasca River at Old Fort (Figure 3). A suite of water quality indicators are sampled at these sites on a regular basis. The Old Fort site has been monitored since 1977, while the site upstream of Fort McMurray has been in operation since 2002. The department has also been monitoring other sites in the area regularly since 2008, including one on the mainstem – the Athabasca River upstream of the Firebag River – and co-ordinates the monitoring of seven sites on the Muskeg River, a major tributary to the lower Athabasca River with significant oil sands activity within its basin.

### 4.4.2 Alberta River Water Quality Index

The ARWQI summarizes complex data into a simple descriptor of water quality and provides a snapshot of annual water quality conditions. Data is collected for 22 metals, 17 pesticides, six nutrients and two bacteria indicators through the province's LTRN. These data are then compared to water quality guidelines and calculated into an average index rating, as follows:

Excellent: Guidelines are almost always met. This is considered the "best" water quality.

Good: Guidelines are occasionally exceeded, but usually by small amounts. Threat to quality is minimal.

Fair: Guidelines are sometimes exceeded by moderate amounts. Quality occasionally departs from desirable levels.

Marginal: Guidelines are often exceeded, sometimes by large amounts. Quality is threatened and often departs from desirable levels.

Poor: Guidelines are almost always exceeded by large amounts. Quality is significantly impaired and is well below desirable levels. This is considered the "worst" water quality.

Water quality at the Old Fort site has been assessed annually since 1996 through the ARWQI. The ARWQI is included as a provincial performance indicator in the Alberta government's *Measuring Up Annual Report*. More information on the ARWQI is available through Alberta Environment and Sustainable Resource Development's website at www.environment.alberta.ca.

### 4.4.3 Comprehensive Contaminant Load Study

In 2009, the department initiated a comprehensive contaminant load study to assess contaminants in environmental media (e.g., water, air and soil) within the lower Athabasca River basin in the mineable oil sands region. The study is investigating metals including arsenic and mercury as well as hydrocarbons such as PAHs and NAs. The overall goal is to address a number of questions related to the potential impacts of oil sands operations on the transport and accumulation of contaminants along the Athabasca River into the Peace-Athabasca Delta and western Lake Athabasca, and the implications of this to ecosystem and human health.

The water quality component of the study consists of monthly bulk water sampling and the deployment of passive sampling devices (semi-permeable membrane devices for PAHs, polar organic chemical integrative samplers for NAs, and diffusive gradients in thin films for metals) at 11 sites within the region. Six of these sites are located on the lower Athabasca River main stem (two are LTRN sites) and five on larger tributaries. The study is expected to be completed in 2012.

### 4.4.4 Regional Aquatics Monitoring Program

The Regional Aquatics Monitoring Program (RAMP) is a multi-stakeholder aquatic monitoring program that "strives to achieve a holistic understanding of potential effects of oil sands development on aquatic systems, as well as address specific issues important to communities of the region" (Hatfield et. al. 2009). The program devotes effort to a broad geographic scale that includes the Athabasca River mainstem and tributaries, the Peace-Athabasca Delta and small lakes throughout the oil sands region. The program includes long-term monitoring of the physical, chemical and biological environment. The core elements of RAMP and the approach have remained relatively consistent over time, but the design of the program continues to be refined in response to new information, stakeholder input and technical peer reviews. Results of the RAMP program, including the complete database, are available to the public through a dedicated website at www.ramp-alberta.org/RAMP.aspx.

### 4.4.5 Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring

Under the joint implementation plan, the Governments of Alberta and Canada are working together to implement a world class monitoring program for the oil sands that integrates all environmental components—air quality, water quality, water quantity, aquatic ecosystems, terrestrial biodiversity and habitat. Implementation of the plan will result in improved knowledge of the state of the environment in the oil sands area and an enhanced understanding of cumulative effects. The expanded water monitoring program will increase the amount of site-specific, reach-specific and regional scale information, including spatial and temporal status and trends in contaminant loadings. More information on the joint monitoring plan for oil sands is available through Alberta Environment and Sustainable Resource Development's website at www.environment.alberta.ca.

# 5.0

# Regional Objective

In support of the outcomes of the *Lower Athabasca Regional Plan*, this management framework establishes the following regional objective for surface water quality:

>> Water quality in the lower Athabasca River is managed so current and future water uses are protected.

For the purposes of this framework, water uses include: protection of aquatic life, drinking water, recreation and aesthetics, agricultural and industrial. To better describe the water quality objective, indicators have been chosen and triggers and limits established for those indicators.

## 5.1 Indicators

Indicators provide information about whether or not a regional objective is being met.

Since long-term water quality data are available for the Old Fort monitoring station, and it is located downstream of oil sands development, indicators for the lower Athabasca River were chosen from among the parameters being measured at Old Fort. Ambient water quality triggers and water quality limits were then developed for those indicators. As soon as possible, triggers and limits will also be developed for Alberta Environment and Sustainable Resource Development's monitoring station on the Athabasca River upstream of the Firebag River, since that site is closer to current oil sands development.

Long-term data are used to establish historical conditions for the indicators included in this framework. In addition, the indicators chosen for the framework were selected because they:

- have known concentrations in existing or potential wastewater releases that exceed concentrations in the Athabasca River by two-fold or more.
- exhibit a downstream increase (and therefore loading) to the lower Athabasca River between the upstream of Fort McMurray and Old Fort LTRN monitoring stations.

Thirty-eight indicators met the selection criteria and were not overly affected by censored data (missing observations or values below method detection limits). The indicators selected include a variety of toxic and non-toxic water quality substances and of these, 11 are classified as general indicators and 27 as metal indicators.

- **11 General Indicators**: calcium, chloride, magnesium, potassium, sodium, sulphate, total dissolved phosphorus, total phosphorus, nitrate, total ammonia, total nitrogen.
- **27 Metal Indicators**: (total and dissolved except where noted) aluminum, antimony, arsenic, barium, beryllium (total only), bismuth (total only), boron, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury (total only), molybdenum, nickel, selenium, silver (total only), strontium, thallium, thorium, titanium, uranium, vanadium and zinc.

Polycyclic aromatic hydrocarbons and NAs are also important indicators of concern given their toxicity and potential for natural and industrial loading to the lower Athabasca River. Nevertheless, these substances are not currently on the indicator list, as important science gaps exist around the identification, quantification, and toxicity of NAs. Moreover, reliable approaches to quantify PAHs at the low concentrations found in water, as well as our understanding of their toxicity in aquatic environments, are still evolving. Challenges in identifying and measuring NAs and PAHs have limited the collection and availability of data for these indicators within the lower Athabasca River.

Despite these challenges, Alberta Environment and Sustainable Resource Development has begun monthly sampling for NAs using the best available methods, at all three AESRD stations on the lower Athabasca River. Moreover, monthly sampling for PAHs has also recently been implemented at all three stations, and complementary approaches such as the use of semi-permeable membrane devices are currently being explored to address the frequent non-detects for these indicators. Once a reliable dataset has been compiled for the Athabasca River stations at Old Fort and upstream of the Firebag, triggers will be developed. In the meantime, AESRD will continue to evaluate the incoming PAH and NA data and will work to fill the science and data gaps that currently limit the inclusion of these parameters in this framework.

The indicator list presented in this framework is expected to change over time in response to new information including additional monitoring data, new contaminants of concern, or as we gain a greater understanding of the behaviour and fate of contaminants within the lower Athabasca River. The department will continue to monitor and report on a variety of other water quality parameters not identified through this indicator selection process, through its monitoring and reporting on other stations on the lower Athabasca River.

## 5.2 Triggers and Limits

Ambient water quality triggers (WQT), calculated from historical monthly or quarterly samples from the Old Fort monitoring station, are an "early warning system" that signal potential change in ambient environmental conditions in the lower Athabasca River. They are set very conservatively at values that have historically been observed at the Old Fort monitoring station, therefore not all trigger exceedances signal real or meaningful change. Nevertheless, trigger exceedances provide an early opportunity to examine an indicator to determine whether or not change is occurring. Triggers are based on the premise that deviations from existing water quality are acceptable, provided they are closely monitored and managed.

Water quality limits (WQL) derived from provincially-accepted water quality guidelines represent conditions where the risk of adverse effects is heightened. Exceedance of the WQT indicates that a statistically significant change from historical conditions may have occurred, while exceedance of the WQL indicates that designated water uses may not be protected.

The steps involved in setting the WQTs and WQLs are linked to the selected water quality indicators, as depicted in Figure 4.

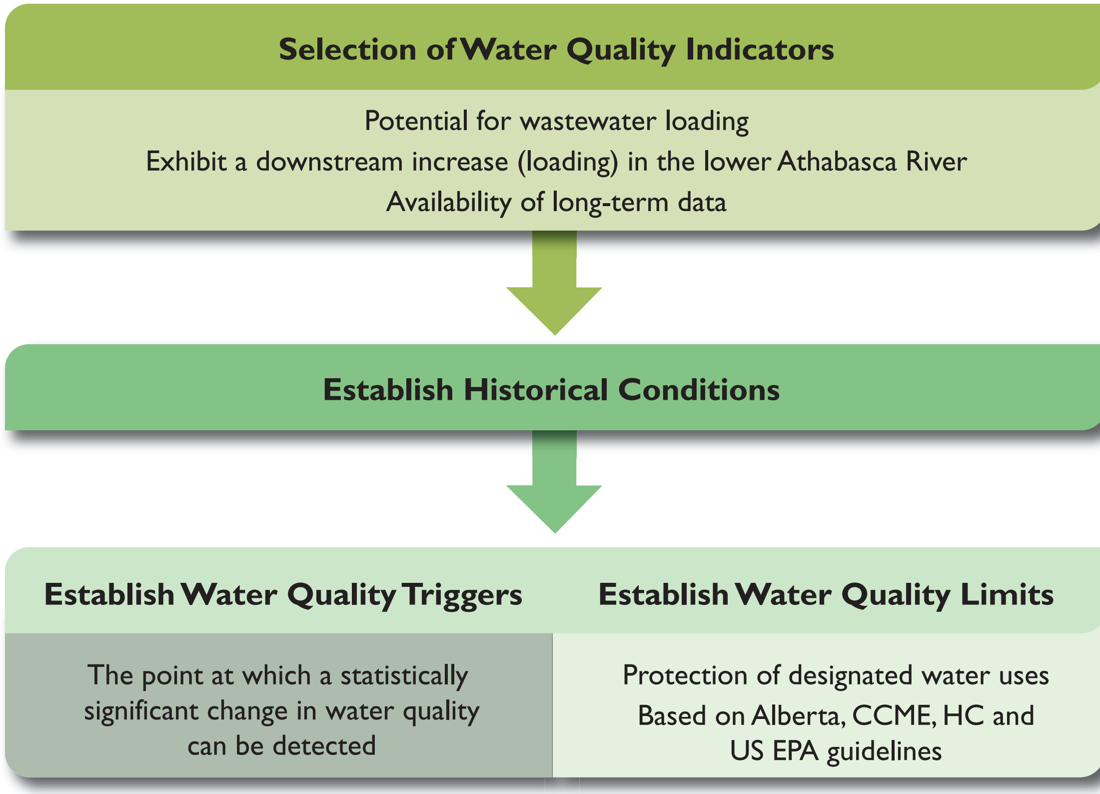


Figure 4
The Steps to Establish Surface Water Quality Triggers and Limits

## 5.3 Setting Water Quality Triggers (WQTs)

To determine the historical range of water quality within the lower Athabasca River, the available historical data were compiled for each indicator. Data collected at the Old Fort monitoring station from 1988 to 2009 were used to establish historical conditions for the general indicators. There were several reasons for limiting the dataset to these dates:

- Samples collected before 1988 were often analysed by different analytical techniques with less sensitive detection limits.
- Data collected before 1988 were often incomplete and did not have 12 full months represented. As several indicators exhibit significant seasonal differences, the missing samples, especially from the winter months, would bias the long-term statistical distribution of the indicator.
- In 1987, the monitoring sites were transferred from Environment Canada to Alberta Environment. Distinct differences (step trends) were evident in several indicators between those samples collected prior to and after 1988 (Hebben 2009). Potential biases in the long-term statistics were avoided by using the data collected after 1987.

The historical dataset for metals was further constrained to data collected from 1999 to 2009 for many metals because significantly lower detection limits were instituted in the department's monitoring at that time. For some metals, the dataset was largely restricted to data collected from 2003 to 2009, as additional improvements in analytical detection levels and better analytical methodologies were implemented, and therefore the number of observations above detection limits increased. It is also important to note that the historical data for metals is largely based on quarterly sampling, whereas current metal sampling is being carried out monthly. As noted above, these temporal differences may require special attention when interpreting differences between historical and current conditions.

The mean ambient WQTs were calculated as the arithmetic mean (i.e., sum of all the observations divided by the total number of observations taken from the historical datasets). Peak WQTs were also calculated for each indicator. These historical peaks were defined as the $95^{th}$ percentiles (i.e., captured 95 per cent of the historical dataset). Tables showing the summary statistics for the data used to generate general and metal indicator triggers are presented in Appendix A (Tables A1 and A2).

**Please note that** the WQTs included in this framework only apply to Alberta Environment and Sustainable Resource Development's monitoring station on the Athabasca River at Old Fort. These WQTs may change over time as the protocol for developing triggers is finalized or as new triggers are developed.

## 5.4 Setting Water Quality Limits (WQLs)

In addition to their current use in the regulatory system, water quality guidelines were used to define ambient WQLs for each surface water quality indicator in this framework. A surface water quality guideline, according to the Canadian Council of Ministers of the Environment (CCME), "is a numerical concentration or narrative statement recommended to support and maintain a designated use".

The guidelines chosen as WQLs for the Old Fort monitoring station followed an order of priority. Depending on availability, guidelines for each indicator were selected first from the Alberta Water Quality Guidelines for the Protection of Aquatic Life (AENV 1999) and then from the most stringent of the following guidelines:

- CCME Water Quality Guidelines for the Protection of Aquatic Life (www.st-ts.ccme.ca)
- CCME Water Quality Guidelines for the Protection of Agricultural Water Uses (www.st-ts.ccme.ca)
- Guidelines for Canadian Drinking Water Quality (Health Canada 2010)
- Guidelines for Canadian Recreational Water Quality (Health and Welfare Canada 1992)
- United States Environmental Protection Agency's (U.S. EPA) Aquatic Life Criteria (U.S. EPA 2009).

Only chronic guidelines were considered when examining protection of aquatic life guidelines.

Generic provincial guidelines were not used to set WQLs when the following situations applied:

- guidelines were lower than historical concentrations and/or WQTs
- no provincially acceptable guidelines were available.

Of the 38 water quality indicators currently included in this framework, 10 had guidelines that were lower than historical concentrations at the Athabasca River monitoring station at Old Fort, and seven did not have an existing guideline value.

The WQLs for the lower Athabasca River should be expected to change over time as existing guidelines are updated and new guidelines are developed.

**Please note that** the WQLs included in this framework only apply to Alberta Environment and Sustainable Resource Development's monitoring station on the Athabasca River at Old Fort.

### 5.4.1 Triggers and Limits for General Indicators

The general water quality indicators include several major ions and nutrients. These substances are ubiquitous in natural waters and can occur at concentrations that negatively impact the aquatic ecosystem and other water uses. Table 2 provides the WQTs and WQLs established for general water quality indicators within the lower Athabasca River as measured at the Old Fort monitoring station.

Table 2: Ambient Surface Water Quality Triggers and Limits for the Athabasca River at Old Fort – General Indicators

*Note: All values are in mg/L.*

| General Indicator | Surface Water Quality Triggers | | Surface Water Quality Limit |
|---|---|---|---|
| | **Mean** | **Peak** | |
| Calcium ($Ca^{2}+$) | 34.7 | 48.9 | 1,000[b] |
| Chloride ($Cl^{-}$) | 20.2 | 45.0 | 100[b] |
| Magnesium (Mg+) | 9.5 | 13.7 | - |
| Potassium ($K^{+}$) | 1.4 | 2.1 | - |
| Sodium ($Na^{+}$) | 21.5 | 43.7 | 200[c] |
| Sulphate ($SO_4^{-}$) | 26.7 | 41.4 | 500[c] |
| Total Dissolved Phosphorus (TDP) | 0.016 | 0.032 | - |
| Total Phosphorus (TP) | 0.074 | 0.261 | - |
| Nitrate ($NO_3$-N) | 0.092 | 0.264 | 2.935[a] |
| Total Ammonia ($NH_{3+4}$-N) | 0.05 | 0.12 | Varies with pH and temperature[d,1] |
| Total Nitrogen (TN) | 0.597 | 1.041 | - |

a CCME Guidelines for the Protection of Aquatic Life

b CCME Guidelines for the Protection of Agricultural Water Uses

c The Guidelines for Canadian Drinking Water Quality

d US EPA Aquatic Life Criteria

1 Fish early life stages present: chronic criterion = $((0.0577/(1 + 10^{7.688\text{-}pH})) + (2.487/(1 + 10^{pH\text{-}7.688}))) \times MIN(2.85, 1.45 \cdot 10^{0.028 \cdot (25\text{-}T)})$. See Table A3 for computed temperature and pH-dependent total ammonia values and Table A4 for temperature and pH values from the Old Fort monitoring station.

### 5.4.2 Triggers and Limits for Metal Indicators

The metal indicators in this framework include a wide variety of elements. Some are essential for aquatic life (e.g., zinc), but excessive or deficient concentrations can be problematic. Metals can enter surface waters through natural processes, but are also present in industrial and municipal wastewater releases. Table 3 provides the WQTs and WQLs established for metal indicators within the lower Athabasca River. Although triggers have been developed for both dissolved and total metals, WQLs only apply to the total metals.

Table 3: Ambient Surface Water Quality Triggers and Limits for the Athabasca River at Old Fort – Metal Indicators

*Note: All values are µg/L; D=dissolved, T=total.*

| Metal Indicator | Surface Water Quality Triggers | | Surface Water Quality Limit |
|---|---|---|---|
| | Mean | Peak | |
| Aluminum D | 16 | 49 | - |
| Aluminum T | 1533 | 6454 | - |
| Antimony D | 0.107 | 0.202 | - |
| Antimony T | 0.148 | 0.388 | 6[c,1,2] |
| Arsenic D | 0.5 | 0.7 | - |
| Arsenic T | 1.1 | 2.5 | 5[a] |
| Barium D | 52.6 | 73.7 | - |
| Barium T | 79.3 | 147.6 | 1,000[c] |
| Beryllium T | 0.077 | 0.269 | 100[b,3] |
| Bismuth T | 0.0172 | 0.0564 | - |
| Boron D | 26 | 40 | - |
| Boron T | 48 | 69 | 500[b] |
| Cadmium D | 0.0997 | 0.5150 | - |
| Cadmium T | 0.3 | 1.2 | - |
| Chromium D | 0.41 | 0.65 | - |
| Chromium T | 3 | 8 | 50[c] |
| Cobalt D | 0.07 | 0.11 | - |
| Cobalt T | 0.8 | 2.2 | 50[b] |
| Copper D | 1.6 | 3.6 | - |
| Copper T | 3.1 | 7.2 | - |
| Iron D | 185 | 372 | - |
| Iron T | 1899 | 5821 | - |
| Lead D | 0.56 | 0.56 | - |
| Lead T | 3.3 | 7.0 | - |
| Lithium D | 6 | 9 | - |

| Metal Indicator | Surface Water Quality Triggers | | Surface Water Quality Limit |
| --- | --- | --- | --- |
| | Mean | Peak | |
| Lithium T | 9 | 12 | 2,500[b] |
| Manganese D | 12 | 36 | - |
| Manganese T | 65 | 141 | - |
| Mercury T | 0.0051 | 0.0159 | - |
| Molybdenum D | 0.7 | 1.2 | - |
| Molybdenum T | 0.9 | 1.6 | 10[b] |
| Nickel D | 1.6 | 4.7 | - |
| Nickel T | 3.4 | 8.2 | Varies with hardness[d,4] |
| Selenium D | 0.229 | 0.409 | - |
| Selenium T | 0.333 | 0.581 | 1[a] |
| Silver T | 0.0243 | 0.0677 | 0.1[a] |
| Strontium D | 215 | 361 | - |
| Strontium T | 225 | 361 | - |
| Thallium D | 0.0238 | 0.1137 | - |
| Thallium T | 0.0546 | 0.1751 | 0.8[a] |
| Thorium D | 0.0284 | 0.0942 | - |
| Thorium T | 0.35 | 1.44 | - |
| Titanium D | 2 | 7 | - |
| Titanium T | 30 | 104 | - |
| Uranium D | 0.313 | 0.381 | - |
| Uranium T | 0.4 | 0.7 | 10[b,5] |
| Vanadium D | 0.450 | 0.698 | - |
| Vanadium T | 4 | 16 | 100[b] |
| Zinc D | 4.5 | 12.4 | - |
| Zinc T | 12.3 | 25.6 | - |

a CCME Guidelines for the Protection of Aquatic Life
b CCME Guidelines for the Protection of Agricultural Water Uses
c The Guidelines for Canadian Drinking Water Quality
d U.S. EPA Aquatic Life Criteria
1 Developed as an interim maximum acceptable concentration
2 Faucets should be thoroughly flushed before water is taken for consumption or analysis
3 Livestock watering guideline is interim
4 Total nickel CCC = $e^{0.846(\ln \text{hardness})+0.0584}$ µg/L, where hardness is measured in mg/L $CaCO_3$. See Table A4 for alkalinity ($CaCO_3$) values from the Old Fort monitoring station
5 Interim guideline

# 6.0

# The Management System

This framework brings the following new elements to the existing system:

- establishing a surface water quality objective for the lower Athabasca River
- identifying key indicators for that objective
- setting of triggers and/or limits for those indicators
- identifying the management response when triggers and limits are exceeded.

Within this framework, ambient surface water quality levels have been assigned to identify where ambient water quality conditions are in relation to the triggers and limits and to define the corresponding management response. When ambient surface water quality levels change, the main influences are identified, and the appropriate management actions can be applied if needed.

At present, surface water quality levels have been assigned to the Athabasca River at the Old Fort monitoring station. In the future, additional triggers and limits will be included in this management framework as the monitoring station upstream of the Firebag River and possibly other stations are added.

Alberta Environment and Sustainable Resource Development will use the ambient surface water quality levels to:

- describe ambient water quality conditions in the lower Athabasca River as measured at the Old Fort monitoring station
- initiate the management response outlined in this framework when monitoring indicates undesirable trends are developing or triggers and/or limits are being exceeded
- assess the impacts of water quantity management on water quality conditions
- in conjunction with water quantity and water quality models, evaluate water and reclamation policy options on the lower Athabasca River.

It is important to understand that this framework is intended to be used to monitor and manage long-term, cumulative changes in water quality in the lower Athabasca River, and not intended to replace existing management systems such as spill reporting, drinking water surveillance, or facility or activity-specific regulation.

Overall, this framework fits within, and supports, the broader provincial water legislation and policy framework that applies to the lower Athabasca River. The management approaches presented in this framework to manage ambient surface water quality are collective requirements that apply to all regulated water users or parties releasing substances to the lower Athabasca River. The framework requirements do not replace existing policies guiding development of individual facility approval and licence conditions; they are additional requirements that will formally be incorporated into new applications and into approval and licence amendments and renewals.

Elements from the framework will be included in the *Lower Athabasca Regional Plan* and will be implemented as part of that plan with legal force as provided by the *Alberta Land Stewardship Act*. The ambient WQTs and WQLs come into effect when the regional plan is approved.

## 6.1 Assignment of Surface Water Quality Levels

To help define where ambient water quality conditions sit relative to the triggers and limits, surface water quality levels are assigned for each indicator. Level 1 represents ambient conditions within the range of historically observed conditions; there are no trigger exceedances in Level 1. Level 2 indicates a shift away from historical conditions, where there is a trigger exceedance and the potential development of an undesirable trend. Level 3 indicates the exceedance of a water quality limit. The management focus also varies depending on the surface water quality level (Table 4).

The purpose of assigning the three levels is to identify where ambient conditions are in relation to the defined ambient surface WQTs and WQLs. Assignment of levels also provides a way to manage changes in surface water quality so that they do not compromise the protection of aquatic life and other water uses.

There are corresponding management intentions for each of the three ambient water quality levels. The idea is to prevent ambient surface water quality concentrations from approaching or reaching Level 3, as defined by the WQL, by proactively monitoring and managing water quality indicators in Level 2.

LEVEL 1

**Level 1**

Ambient water quality conditions are within mean and peak historical values. Approval and licence conditions are being implemented and water, wastewater and aquatic ecosystem policy is being applied.

**Level 2**

Ambient water quality conditions are shifting away from mean and/or peak historical conditions. Level 2 conditions are statistically defined and do not necessarily signal additional environmental risk. Confirming whether an undesirable trend is developing and evaluating the consequences of that trend is central to deciding on the need for action. The proximity of each indicator to its limit varies; consequently, a range of management actions may be used in Level 2 to address individual situations depending on urgency and potential risk. Level 2 conditions are defined by WQTs.

LEVEL 2

LEVEL 3

**Level 3**

Water quality conditions exceed the limit established to protect the most sensitive water use for a given indicator. Human contributions to the indicator are documented and suspected of posing additional, unacceptable risk to human or ecosystem health. Level 3 conditions will be avoided through careful management of activities influencing the indicator in Level 2 and good wasteload management. Level 3 conditions are defined by WQLs.

Table 4: Description of Ambient Surface Water Quality Levels

| Level | Description | Management Intent |
|---|---|---|
| 3 | Exceedance of water quality limits. | Improve ambient water quality to below limits. |
| | Limit | |
| 2 | Exceedance of water quality triggers. | Proactively maintain water quality below limits. Improve knowledge and understanding of trends. |
| | Trigger | |
| 1 | Mean and peak water quality conditions at or better than historical water quality conditions. | Apply standard regulatory and non-regulatory approaches to manage water quality. |

## 6.2 Working with the Current Data

There are two ions, four metals and one dissolved nutrient for which no guidelines exist, and therefore no limit was set in this framework. There are also some indicators with mean and/or peak historical values that are higher than provincially-accepted guidelines. These include two nutrients: total phosphorus and total nitrogen; and eight metals: total aluminum, total cadmium, total copper, total iron, total lead, total manganese, total mercury and total zinc (Table 5). In addition, several of the indicators have maximum observed historical values (Tables A1 and A2) that are close to, or exceed, the WQL. These indicators will need to be followed carefully as relatively small changes in contaminant loading (natural or anthropogenic) may lead to limit exceedances.

With the exception of total manganese, all of the indicators with historical exceedances were higher than chronic guidelines or chronic criteria for the protection of aquatic life. When guidelines are naturally exceeded within aquatic ecosystems, these indicators are typically present in forms that reduce their toxicity (CCME 1999). In the Athabasca River, this is thought to be associated with high concentrations of suspended particulate matter; however more work is needed to confirm this notion.

For indicators with historical exceedances of guidelines, Alberta Environment and Sustainable Resource Development will evaluate and prioritize the need for investigation and management of these exceedances. Investigation and/or the development of management options may require additional source characterization and water, sediment and biological monitoring to better define or evaluate the issue. If significant human influences are found and are suspected of posing additional, unacceptable risk, indicators with historical exceedances may be assigned to Level 3 and require mandatory management action.

For indicators where no guideline exists or indicators with historical exceedances of guidelines, Alberta Environment and Sustainable Resource Development will evaluate and prioritize the development of acceptable limits. The preferred method for defining acceptable risk is to develop a site-specific guideline using CCME protocols. It should be noted that limits will not be developed for dissolved metals at this time, but trigger exceedances will require follow-up.

A report summarizing conditions at the Old Fort monitoring station will be prepared once the Lower Athabasca Regional Plan is approved. This report will describe the status of each water quality indicator relative to the surface water quality levels described in Table 4.

Table 5: Surface Water Quality Indicators with Historical Conditions in the Athabasca River at the Old Fort Station that Exceed Water Quality Guidelines

*Note: Guidelines are total concentrations except copper.*

| Indicator | Unit | Water Quality Guideline |
|---|---|---|
| Aluminum | µg/L | 5 or 100[b,1] |
| Cadmium | µg/L | Varies with hardness[b,2] |
| Copper | µg/L | 7[a,3] |
| Iron | µg/L | 300[b] |
| Lead | µg/L | Varies with hardness[e,4] |
| Manganese | µg/L | 50[d] |
| Mercury | µg/L | 0.005[a,5] |
| Total Phosphorus | mg/L | 0.05[a] |
| Total Nitrogen | mg/L | 1.00[a] |
| Zinc | µg/L | 30[b] |

a Alberta Guidelines for the Protection of Freshwater Aquatic Life
b CCME Guidelines for the Protection of Aquatic Life
c CCME Guidelines for the Protection of Agricultural Water Uses
d The Guidelines for Canadian Drinking Water Quality
e US EPA Aquatic Life Criteria
1 5 µg/L if water pH < 6.5, 100 µg/L if water pH ≥ 6.5. See Table A4 for pH values from the Old Fort monitoring station
2 Total cadmium = $10^{0.86[\log 10(\text{hardness})]-3.2}$ µg/L, where hardness is measured in mg/L $CaCO_3$. See Table A4 for alkalinity ($CaCO_3$) values from the Old Fort monitoring station
3 The Alberta guideline is for acid extractable copper, however it is being applied to total recoverable copper (a more conservative application of the guideline)
4 Total lead CCC = $e^{1.273(\ln \text{hardness})-4.705}$ µg/L, where hardness is measured in mg/L $CaCO_3$ See Table A4 for alkalinity ($CaCO_3$) values from the Old Fort monitoring station
5 The Alberta guideline for total mercury is draft.

## 6.3 Management Response

The terms management response and management action have distinct meanings in the context of this management framework. The management response is a set of steps that will be undertaken (all or in part) if an ambient surface water quality trigger or limit is believed to have been exceeded. Part of the management response is determining the need for management actions.

The management response begins with verifying whether an ambient surface WQT or WQL has been exceeded. Depending on the findings of assessment and investigation, the contributing parties responsible for reaching the ambient surface WQT or WQL may be required to take mitigative management actions. Alberta Environment and Sustainable Resource Development will provide oversight of the management actions, evaluate the effects of implementation, and communicate progress toward meeting regional outcomes.

The framework addresses the cumulative effects of point sources and non-point sources on general and metal indicators. It enables the identification of local and regional contaminant sources that contribute to ambient concentrations reaching WQTs and WQLs, and ensures that appropriate actions are taken when the triggers and limits are exceeded. The intent is to use appropriate place-based measures to address specific circumstances.

It should be noted that this management response does not replace other responses that are taken as part of ensuring compliance under the environmental regulatory system.

Further description of the regional management response follows.


Figure 5
Management Response

### 6.3.1 Verification

The monitoring data used to assess ambient surface water quality conditions as part of this framework will be verified by Alberta Environment and Sustainable Resource Development. Verification involves ensuring the integrity of the data. This could include looking at sample collection, sample analysis, data validation, and data reporting and storage. Once the data have been verified, the water quality metrics that will be used to assess ambient conditions relative to triggers and limits will be calculated.

Alberta Environment and Sustainable Resource Development's current ambient surface water quality monitoring program will be augmented to implement this framework. Water quality indicators will be monitored monthly at all three AESRD monitoring stations on the lower Athabasca River: upstream of Fort McMurray, upstream of the Firebag River and at Old Fort. Until sufficient data are available to develop triggers and limits for AESRD's Firebag River monitoring station, reporting on the status of ambient surface water quality triggers and limits in the lower Athabasca River will be based on the water quality data collected from the department's Old Fort monitoring station.

The historical datasets for the general (1988-2009) and trace metals indicators (generally 1999-2009) will be compared against annual monitoring data from the Old Fort monitoring station to identify large-scale changes. Less frequent, longer-term analysis will monitor for subtle trends that may not be evident in a single year of data. Trends within and between levels will be identified and considered.

### 6.3.2 Preliminary Assessment

Once the ambient surface water quality monitoring data is verified, and indicator annual means, peaks and other metrics are calculated, the results will be assessed against ambient surface WQTs and WQLs (Appendix B). This preliminary assessment determines if a trigger or a limit has been exceeded and evaluates whether an investigation is warranted. Part of this assessment involves ensuring that rare events (e.g., spills) or natural circumstances that cannot be controlled through wastewater management (e.g., high river flows) are understood as part of the annual assessment. This will be accomplished by consulting upstream monitoring data and other supporting information (e.g., meteorological data) to check for potential causes.

Additionally, because WQTs are set very conservatively within historically observed values at the Old Fort monitoring station, false positives (i.e., a trigger is exceeded, but no change has occurred) should be expected. For this reason, Alberta Environment and Sustainable Resource Development may choose not to initiate an investigation until more evidence exists that an undesirable trend is developing.

### 6.3.3 Investigation

When a WQT or WQL is exceeded and the preliminary assessment confirms the need for an investigation, Alberta Environment and Sustainable Resource Development has a two-phased approach. Relevant stakeholders, First Nations and Métis peoples may be included in the investigation, and parties that are potentially contributing to the problem may be asked to conduct portions of the investigation.

In phase 1, gaps in knowledge and data are identified. Activities are conducted to define and characterize the problem. The results of this characterization are evaluated relative to regional conditions and desired outcomes. Alberta Environment and Sustainable Resource Development will decide whether a more comprehensive, phase 2 investigation is needed or what mitigation actions, if any, are required.

In phase 2, terms of reference are developed for a comprehensive evaluation of risks to human and aquatic ecosystem health. A comprehensive evaluation is conducted and its results are assessed. The investigation determines if mitigation is required.

A management plan and management actions will be required if the phase 2 investigation indicates mitigation is required to avoid an unacceptable risk to the aquatic environment or human health.

### 6.3.4 Mitigative Management Actions

Mitigation includes any action that is needed due to changes, or trends, in surface water quality conditions that are deemed unacceptable. Changes from existing conditions will be carefully monitored and impairment of water uses will be avoided by the use of WQTs (Level 2) and by managing indicators so that they do not reach the WQL and enter Level 3.

The intent of mitigative management action is to halt the problem, set a goal and manage the problem until that goal is met. Before determining whether mitigative management action is needed, Alberta Environment and Sustainable Resource Development will determine if other management frameworks have been triggered, or if other initiatives are taking steps to address the issue. Mitigative management actions may require amendments to existing approvals. These amendments would be made in accordance with existing authority under the *Environmental Protection and Enhancement Act* including Director-initiated amendments to monitoring or reporting requirements, or amendments arising from unforeseeable effects.

Alberta Environment and Sustainable Resource Development will determine which stakeholders will be involved in the mitigative actions and what aspects of the process they will be responsible for (e.g., monitoring, data analysis, modelling and/or technology assessment). Alberta Environment and Sustainable Resource Development will be responsible for all key decisions about mitigative management actions and will retain overall accountability for the effectiveness of the action.

#### 6.3.4.1 Level 1

When ambient water quality conditions are at Level 1, water quality is within historically observed conditions (i.e., mean and peak values at or better than the mean or peak historical conditions). There should be little to no risk of detectable impacts to water quality or the aquatic environment.

When water quality conditions are at Level 1, management for Alberta Environment and Sustainable Resource Development includes operation of the existing regulatory system and conducting ambient water quality monitoring and reporting. For regulated parties, the expectation is that they are operating within the terms of their approvals and licences, and are applying all existing water, wastewater and aquatic ecosystem policies. Regulated parties are expected to participate in regional monitoring and management activities.

#### 6.3.4.2 Level 2

When monitoring indicates that water quality is shifting away from mean and/or peak historical conditions, Level 2 is triggered. Level 2 conditions are statistically defined to act as early warning triggers and do not necessarily signal additional environmental risk, as they are not based on ecological risk criteria. Therefore, impacts to the aquatic environment are likely negligible to low.

WQTs are set very conservatively at historically observed values at the Old Fort monitoring station, therefore not all trigger exceedances signal real or meaningful change. Significant new changes to contaminant loading to the lower Athabasca River would be needed to trigger real changes in many of the water quality indicators at the Old Fort monitoring site. Exceptions to this rule include indicators that have maximum observed historical values (Tables A1 and A2) that are close to, or exceed, the WQL set out in this framework.

Level 2 management actions may be required when ambient water quality monitoring indicates WQTs have been exceeded and an undesirable trend is developing. Level 2 management actions may involve increased surveillance monitoring (of water, sediment and biota), additional modelling, and trend assessment. Where an undesirable trend in an indicator is predicted to continue rather than stabilize, management options will be reviewed to ensure limits are not used as "pollute up to" numbers.

Level 2 management actions may also be required when water quality modelling indicates WQTs will be exceeded. When Level 2 conditions are triggered in this context (e.g., based on information from environmental impact assessment or in support of an application to release substances to the lower Athabasca River), additional effort such as increased monitoring or toxicity evaluation may be required to reduce uncertainty in model outcomes and/or in assessing the cumulative environmental risk.

#### 6.3.4.3 Level 3

Level 3 conditions occur when an indicator exceeds a WQL at the Old Fort monitoring station and human sources are thought to pose additional, unacceptable risk to ecosystem or human uses. While it is expected that anthropogenic WQL exceedances will be avoided through the use of WQTs and good wasteload management, should an exceedance occur, mandatory management actions will be required.

WQL exceedances will most often require a phase 2 investigation and/or mitigation actions that may, for example, include wastewater loading restrictions and more stringent wastewater treatment or performance standards.

In addition to existing policy guiding regulatory decisions, if modelling through the environmental impact assessment process or in support of an application to release wastewater to the lower Athabasca River indicates that an ambient WQL will be exceeded at the Old Fort monitoring station, the proposed wastewater release will not be permitted without appropriate mitigation.

### 6.3.5 Evaluation and Communication

Alberta Environment and Sustainable Resource Development will use annual evaluations under this framework and other means to assess, over time, if required management actions are achieving the anticipated results.

In addition, the department will prepare an annual report that will summarize the status of ambient surface water quality conditions relative to both WQTs and WQLs and describe activities initiated as part of the management response. The report may also integrate relevant water quantity and groundwater monitoring results, identify gaps in data, knowledge and monitoring, report on progress in implementing the framework, and provide recommendations for improvements. This report will be posted on the Government of Alberta's website.

Public access to ambient water quality monitoring data is available through the Alberta Environment and Sustainable Resource Development website. The LTRN data is used to determine ambient surface water quality levels within the lower Athabasca River at Old Fort.

# 7.0 Implementation

Implementation details, including timelines and allocation of resources, will be determined when the *Lower Athabasca Regional Plan* has been approved by Cabinet and this framework is considered final.

Implementation planning will include the following:

- An inventory of tasks that must be done to meet the requirements of the framework for the lower Athabasca River including at a minimum: identification and development of system components such as monitoring, modelling, evaluation and reporting; a protocol for periodic trend assessment; management response expectations; reporting processes and communication plans for ambient water quality and management responses activated by the framework; evaluation and prioritization of management options for historical exceedances; and evaluation and prioritization of limit development for indicators without appropriate limits.
- Confirmation of roles and responsibilities of government and other parties for implementation of the framework and an assessment of resources needed to fulfill the tasks and commitments of the framework, including human resources and any missing data requirements.
- Ongoing evaluation of the framework's alignment with other policies and initiatives (e.g., other Lower Athabasca Region management frameworks, provincial policies) to ensure consistency of management intent and process.
- Ongoing evaluation of progress towards incorporating the Athabasca River upstream of the Firebag River monitoring station into the framework, as well as progress towards developing indicators for NAs and PAHs for both the Old Fort and upstream of the Firebag River monitoring stations.
- A timeline for implementation including key milestones and their target dates for completion.

## 7.1 Roles and Responsibilities

Alberta Environment and Sustainable Resource Development, environmental and community associations, and regulated parties (i.e., *Environmental Protection and Enhancement Act* and *Water Act* approval holders and licencees) all have responsibilities related to managing wastewater releases and ambient surface water quality. These roles and responsibilities are described only briefly in the context of the framework, so should not be regarded as an exhaustive list.

### 7.1.1 Alberta Environment and Sustainable Resource Development

Alberta Environment and Sustainable Resource Development is responsible for ensuring the framework is implemented, but engagement of stakeholders remains key to the overall management intent. The department also:

- is responsible for managing the data used in the annual ambient surface water quality assessment
- is responsible for the annual review and assessment of water quality data to determine ambient water quality levels at the Old Fort monitoring station
- is responsible for initiating a management response when required based on the assessment of data and other approaches such as forecasting future development (e.g., spatial, temporal)
- identifies stakeholders, First Nations and Métis peoples roles, and considers their inclusion in management planning and actions. If a multi-stakeholder process is desirable, the use of established multi-stakeholder groups (such as CEMA and WBEA) will be considered
- assesses management actions implemented through other frameworks or initiatives to determine impacts on ambient water quality
- defines timelines and selects or recommends management approaches and tools, if required, to manage ambient water quality
- communicates to stakeholders the implementation status and selected management actions.

### 7.1.2 Regulated Parties and Proponents

Regulated parties and project proponents include a variety of players including industry, municipalities and communities. As a result, there may be roles for all levels of government and government agencies within surface water quality management. Roles and responsibilities for regulated parties and proponents with respect to the framework include:

- participating in regional water quality and aquatic ecosystem monitoring (e.g., RAMP)
- providing wastewater characterization, storage and release information to the department when requested
- modelling and assessing how current and planned operations influence local and regional ambient water quality
- participating in ambient water quality management action, if identified (e.g., development of plans or implementation of reductions)
- reporting on progress of implementation of management actions, as required.

# 8.0 Integration

This management framework is part of a series of management frameworks developed by Alberta Environment and Sustainable Resource Development for the Government of Alberta's *Lower Athabasca Regional Plan*. As the regional plan is implemented, all of the outcomes and objectives in it, including those for air, surface water and groundwater, will be considered in planning and decision-making for the region by all provincial government departments and municipal governments. This will help to drive integration across environmental media.

**Surface Water Quality and Water Quantity**

As noted earlier, comprehensive management of the region's surface water resources will require the careful, integrated management of three linked ecosystem components: water quality, water quantity and the aquatic environment (species and habitat). In time, the intention is for management of all of these components to be integrated for the Lower Athabasca Region. Continuing work in the region will include a renewed surface water quantity management framework for the lower Athabasca River and the development of a management framework for biodiversity, including biodiversity of aquatic ecosystems. There are challenges to making integration happen; however, development of these additional management frameworks and advances in knowledge, understanding and analytical tools will support these efforts moving forward.

**Surface Water and Groundwater**

A second critical point of integration is between surface water management and groundwater management. Implementation of the *Groundwater Management Framework* and the *Surface Water Quality Management Framework* will support better understanding of these components of our environment and the interaction of impacts on both. Other frameworks will also contribute as they are completed. For this reason, integrating, as much as possible, all monitoring, evaluation and reporting for surface water with groundwater will help to address the challenges of managing the interaction between surface water and groundwater.

# 9.0 Terminology

## 9.1 Abbreviations and Acronyms

| Abbreviation/Acronym | Description |
|---|---|
| AESRD | Alberta Environment and Sustainable Resource Development |
| AENV | Alberta Environment |
| AEP | Alberta Environmental Protection |
| ARWQI | Alberta River Water Quality Index |
| CCME | Canadian Council of Ministers of the Environment |
| CEMA | Cumulative Environmental Management Association |
| HC | Health Canada |
| LTRN | Long-term River Network |
| NA | Naphthenic Acid |
| mg/L | Milligrams per Litre |
| PAH | Polycyclic Aromatic Hydrocarbon |
| RAMP | Regional Aquatics Monitoring Program |
| TSS | Total Suspended Solids |
| µg/L | Micrograms per Litre |
| U.S. EPA | United States Environmental Protection Agency |
| WQT | Water Quality Trigger |
| WQL | Water Quality Limit |

## 9.2 Glossary

**Aquatic Ecosystem** .................. For the purposes of this framework, "aquatic ecosystem" is synonymous with the definition of "aquatic environment" under the *Water Act*: "the components of the earth related to, living in or located in or on water or the beds or the shores of a water body, including but not limited to: 1. all organic and inorganic matter, and 2. living organisms and their habitat, including fish habitat, and their interacting natural systems". [a]

**Contaminant / Pollutant** ........ A substance in a concentration or amount that adversely alters the physical, chemical, or biological properties of the natural environment. [b] (adapted from)

**Ecosystem Health** ..................... A healthy aquatic ecosystem is an aquatic environment that sustains its ecological structure, processes, functions, and resilience within its range of natural variability. [c]

**Non-point Source Pollutant** .................... Pollution that enters a water body from diffuse or undefined sources and is usually carried by runoff. [b] (adapted from)

**Point Source Pollutant** ........... Pollution that originates from an identifiable cause or location, such as a sewage treatment plant. [d]

**Substance** .................................... For the purposes of this framework, a "substance" is defined as:
(i) any matter that:
(A) is capable of becoming dispersed in the environment, or
(B) is capable of becoming transformed in the environment into matter referred to in (A),
(ii) any sound, vibration, heat, radiation or other form of energy, and
(iii) any combination of things referred to in (i) and (ii).

**Toxicity** .......................................... The adverse effect on the growth, reproduction, or survival of an organism.

**Wastewater** ................................ The liquid waste generated through various industrial and municipal processes.

Sources:
a *Water Act* RSA 2000 cW-3.
b AENV (2008). Glossary of Terms Related to Water and Watershed Management in Alberta.
c Alberta Water Council: Healthy Aquatic Ecosystems Working Group.
d AENV (2003). *Water for Life: Alberta's Strategy for Sustainability.*

# 10.0

# References

*Please note that in May 2012, the Government of Alberta brought together the ministries of Environment and Water and Sustainable Resource Development to create one ministry called Alberta Environment and Sustainable Resource Development.*


Alberta Environment 1999a. *Regional Sustainable Development Strategy for the Athabasca Oil Sands Area*. Pub. No. I/754, Edmonton, Alberta. Alberta Environment.

———. 1999b. *Surface Water Quality Guidelines for Use in Alberta*. Pub. No. T/483. Edmonton, AB: Alberta Environment.

———. 2000. *Industrial Release Limits Policy*. Pub. No. T/569. Edmonton, AB: Alberta Environment.

Alberta Environmental Protection. 1995. *Water Quality Based Effluent Limits Procedures Manual*. Edmonton, AB: Standards and Guidelines Branch. Alberta Environmental Protection.

Canadian Council of Ministers of the Environment. 1999. *Canadian Environmental Quality Guidelines*. Hull, QC: Canadian Council of Ministers of the Environment. Environment Canada.

Golder Associates Ltd. 2007. *Reach-specific Water Quality Objectives for the lower Athabasca River*. Calgary, AB: Prepared for Cumulative Environmental Management Association Surface Water Working Group. Government of Alberta. 2008. *Land-use Framework*. Pub No. I/321. Edmonton, AB: Government of Alberta.

Government of Alberta. 2003. *Water for Life: Alberta's Strategy for Sustainability*. Pub. No. I/955. Edmonton, AB: Government of Alberta.

———. 2008. *Land-use Framework*. Pub No. I/321. Edmonton, AB: Government of Alberta.

———. 2009. *Responsible Actions: A Plan for Alberta's Oil Sands*. Edmonton, AB: Treasury Board.

Hebben, Thorsten. 2009. *Analysis of Water Quality Conditions and Trends for the Long-Term River Network: Athabasca River*, 1960-2007. Edmonton, AB: Alberta Environment.

Hatfield Consultants, Kilgour and Associates Ltd., Klohn-Crippen Berger Ltd. And Western Resource Solutions. 2009. *RAMP: Technical Design and Rationale*. Prepared for RAMP Steering Committee.

North-South Consultants Inc. (North-South) 2007 *Information Synthesis and Initial Assessment of the Status and Health of Aquatic Ecosystems in Alberta: Surface Water Quality, Sediment Quality and Non-Fish Biota*. Technical Report #278/279-01. Edmonton, AB: North/South Consultants Inc. in association with Clearwater Environmental Consultants Inc. And Patricia Mitchell Environmental Consulting

Western Resource Solutions (WRS). 2003. *Development of Reach Specific Water Quality Objectives for Variables of Concern in the lower Athabasca River: Identification of Variables of Concern and Assessment of the Adequacy of Available Guidelines*. Prepared for the Cumulative Environmental Management Association.

# 11.0 Appendices

## Appendix A

Table A1: Summary Statistics for Surface Water Quality Triggers for the Athabasca River at Old Fort – General Indicators

*Note: All values are in mg/L; n = sample size, P = percentile, SD = standard deviation.*

| General Indicator | n | Max | Min | Median | Mean | 99.9th P | 99th P | 95th P | Variance | SD |
|---|---|---|---|---|---|---|---|---|---|---|
| Calcium ($Ca^{2+}$) | 235 | 54.8 | 19.1 | 33.7 | 34.7 | 54.8 | 52.4 | 48.9 | 63.2 | 8.0 |
| Chloride (Cl-) | 235 | 64.2 | 1.2 | 17.1 | 20.2 | 63.9 | 61.0 | 45.0 | 195.6 | 14.0 |
| Magnesium (Mg+) | 235 | 15.7 | 4.59 | 9.6 | 9.5 | 15.6 | 14.3 | 13.7 | 5.7 | 2.4 |
| Potassium (K+) | 235 | 8.2 | 0.15 | 1.3 | 1.4 | 7.2 | 2.9 | 2.1 | 0.4 | 0.6 |
| Sodium (Na+) | 235 | 51.4 | 4.6 | 19.4 | 21.5 | 51.0 | 48.2 | 43.7 | 138.2 | 11.8 |
| Sulphate (SO4-) | 235 | 53.9 | 0.3 | 25.6 | 26.7 | 52.4 | 47.2 | 41.4 | 91.2 | 9.5 |
| Total Dissolved Phosphorous (TDP) | 228 | 0.096 | 0.002 | 0.013 | 0.016 | 0.091 | 0.067 | 0.032 | 0.000 | 0.012 |
| Total Phosphorous (TP) | 231 | 0.370 | 0.013 | 0.042 | 0.074 | 0.369 | 0.336 | 0.261 | 0.005 | 0.072 |
| Nitrate (NO3-N) | 118 | 0.630 | 0.002 | 0.052 | 0.092 | 0.597 | 0.340 | 0.264 | 0.011 | 0.105 |
| Total Ammonia (NH3+4-N) | 229 | 1.00 | 0.01 | 0.03 | 0.05 | 0.84 | 0.20 | 0.12 | 0.01 | 0.08 |
| Total Nitrogen (TN) | 231 | 1.931 | 0.034 | 0.568 | 0.597 | 1.785 | 1.207 | 1.041 | 0.060 | 0.246 |

Table A2: Summary Statistics for Surface Water Quality Triggers for the Athabasca River at Old Fort - Metals

*Note: All values are in µg/L.; T = total, D = dissolved; n = sample size, P = percentile, SD = standard deviation.*

| Metal Indicator | n | Max | Min | Median | Mean | 99.9th P | 99th P | 95th P | Variance | SD |
|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum D | 49 | 98 | 2 | 9 | 16 | 97 | 81 | 49 | 312 | 18 |
| Aluminum T | 54 | 8220 | 8 | 586 | 1533 | 8196 | 7976 | 6454 | 4507322 | 2123 |
| Antimony D | 34 | 0.459 | 0.007 | 0.092 | 0.107 | 0.451 | 0.376 | 0.202 | 0.006 | 0.078 |
| Antimony T | 39 | 0.725 | 0.050 | 0.100 | 0.148 | 0.715 | 0.626 | 0.388 | 0.019 | 0.137 |
| Arsenic D | 49 | 1.1 | 0.1 | 0.5 | 0.5 | 1.1 | 0.9 | 0.7 | 0 | 0.2 |
| Arsenic T | 52 | 5.0 | 0.1 | 0.8 | 1.1 | 4.9 | 3.8 | 2.5 | 0.7 | 0.9 |
| Barium D | 49 | 268.0 | 33.1 | 45.1 | 52.6 | 259.3 | 180.8 | 73.7 | 1103.1 | 33.2 |
| Barium T | 52 | 269.0 | 43.1 | 67.1 | 79.3 | 264.2 | 220.6 | 147.6 | 1521.4 | 39.0 |
| Beryllium T | 33 | 0.277 | 0.002 | 0.030 | 0.077 | 0.277 | 0.276 | 0.269 | 0.008 | 0.087 |
| Bismuth T | 35 | 0.0628 | 0.0005 | 0.0107 | 0.0172 | 0.0628 | 0.0628 | 0.0564 | 0.0003 | 0.0168 |
| Boron D | 49 | 60 | 5 | 25 | 26 | 59 | 50 | 40 | 93 | 10 |
| Boron T | 52 | 848 | 5 | 30 | 48 | 810 | 472 | 69 | 13045 | 114 |
| Cadmium D | 34 | 1.0200 | 0.0050 | 0.0269 | 0.0997 | 1.0188 | 1.0078 | 0.5150 | 0.0547 | 0.2339 |
| Cadmium T | 52 | 2.6 | 0.0 | 0.1 | 0.3 | 2.6 | 2.3 | 1.2 | 0.2 | 0.5 |
| Chromium D | 34 | 0.69 | 0.02 | 0.40 | 0.41 | 0.69 | 0.68 | 0.65 | 0.03 | 0.17 |
| Chromium T | 53 | 10 | 0 | 2 | 3 | 10 | 10 | 8 | 7 | 3 |
| Cobalt D | 34 | 0.11 | 0.02 | 0.07 | 0.07 | 0.11 | 0.11 | 0.11 | 0.00 | 0.02 |
| Cobalt T | 52 | 3.1 | 0.0 | 0.5 | 0.8 | 3.1 | 2.9 | 2.2 | 0.5 | 0.7 |
| Copper D | 48 | 5.8 | 0.1 | 1.3 | 1.6 | 5.8 | 5.6 | 3.6 | 1.4 | 1.2 |
| Copper T | 53 | 11.7 | 0.1 | 2.4 | 3.1 | 11.5 | 9.9 | 7.2 | 5 | 2.2 |
| Iron D | 120 | 1600 | 5 | 160 | 185 | 1500 | 724 | 372 | 30045 | 173 |
| Iron T | 54 | 9630 | 13 | 881 | 1899 | 9477 | 8104 | 5821 | 4018346 | 2005 |
| Lead D | 49 | 18.50 | 0.00 | 0.15 | 0.56 | 17.67 | 10.21 | 0.56 | 6.88 | 2.62 |
| Lead T | 54 | 71.0 | 0.1 | 1.1 | 3.3 | 68.6 | 47.3 | 7.0 | 102.3 | 10.1 |

| Metal Indicator | n | Max | Min | Median | Mean | 99.9th P | 99th P | 95th P | Variance | SD |
|---|---|---|---|---|---|---|---|---|---|---|
| Lithium D | 49 | 11 | 2 | 6 | 6 | 11 | 10 | 9 | 4 | 2 |
| Lithium T | 51 | 54 | 2 | 8 | 9 | 53 | 44 | 12 | 59 | 8 |
| Manganese D | 120 | 59 | 1 | 6 | 12 | 58 | 53 | 36 | 175 | 13 |
| Manganese T | 54 | 295 | 22 | 47 | 65 | 288 | 225 | 141 | 2134 | 46 |
| Mercury T | 34 | 0.0197 | 0.0003 | 0.0030 | 0.0051 | 0.0196 | 0.0191 | 0.0159 | 0.0000 | 0.0054 |
| Molybdenum D | 49 | 2.6 | 0.1 | 0.6 | 0.7 | 2.5 | 2.1 | 1.2 | 0.1 | 0.4 |
| Molybdenum T | 52 | 4.6 | 0.3 | 0.7 | 0.9 | 4.5 | 3.9 | 1.6 | 0.5 | 0.7 |
| Nickel D | 49 | 9.7 | 0.0 | 0.9 | 1.6 | 9.7 | 9.4 | 4.7 | 3.7 | 1.9 |
| Nickel T | 52 | 11.5 | 0.0 | 2.2 | 3.4 | 11.5 | 11 | 8.2 | 8.5 | 2.9 |
| Selenium D | 34 | 1.200 | 0.020 | 0.199 | 0.229 | 1.176 | 0.963 | 0.409 | 0.037 | 0.194 |
| Selenium T | 35 | 0.9 | 0.050 | 0.282 | 0.333 | 0.889 | 0.792 | 0.581 | 0.026 | 0.161 |
| Silver T | 35 | 0.1350 | 0.0003 | 0.0136 | 0.0243 | 0.1329 | 0.1136 | 0.0677 | 0.0008 | 0.0286 |
| Strontium D | 49 | 437 | 103 | 196 | 215 | 434 | 408 | 361 | 5688 | 75 |
| Strontium T | 51 | 538 | 110 | 205 | 225 | 533 | 488 | 361 | 6937 | 83 |
| Thallium D | 34 | 0.2700 | 0.0002 | 0.006 | 0.0238 | 0.2657 | 0.2268 | 0.1137 | 0.0028 | 0.0525 |
| Thallium T | 35 | 0.2700 | 0.0002 | 0.0297 | 0.0546 | 0.2696 | 0.2656 | 0.1751 | 0.0044 | 0.0662 |
| Thorium D | 34 | 0.1200 | 0.0015 | 0.0169 | 0.0284 | 0.1193 | 0.1134 | 0.0942 | 0.0008 | 0.0289 |
| Thorium T | 35 | 1.77 | 0.01 | 0.15 | 0.35 | 1.76 | 1.66 | 1.44 | 0.22 | 0.47 |
| Titanium D | 49 | 11 | 1 | 1 | 2 | 11 | 11 | 7 | 6 | 2 |
| Titanium T | 51 | 150 | 1 | 14 | 30 | 149 | 140 | 104 | 1282 | 36 |
| Uranium D | 34 | 0.455 | 0.217 | 0.325 | 0.313 | 0.453 | 0.431 | 0.381 | 0.003 | 0.058 |
| Uranium T | 52 | 0.8 | 0.2 | 0.4 | 0.4 | 0.8 | 0.8 | 0.7 | 0.0 | 0.1 |
| Vanadium D | 34 | 0.702 | 0.230 | 0.443 | 0.450 | 0.702 | 0.701 | 0.698 | 0.018 | 0.135 |
| Vanadium T | 52 | 18 | 0 | 3 | 4 | 18 | 17 | 16 | 24 | 5 |
| Zinc D | 47 | 19.6 | 0.8 | 3.0 | 4.5 | 19.5 | 18.3 | 12.4 | 16.7 | 4.1 |
| Zinc T | 46 | 45.6 | 2.1 | 9.7 | 12.3 | 44.9 | 38.9 | 25.6 | 85.5 | 9.2 |

Table A3: Temperature and pH-dependent Values of the CCC (chronic criterion) for Ammonia for Fish Early Life Stages Present

**CCC for Ammonia for Fish Early Life Stages Present (mg N/L)**

| | Temperature (°C) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| pH | 0 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 |
| 6.5 | 6.67 | 6.67 | 6.06 | 5.33 | 4.68 | 4.12 | 3.62 | 3.18 | 2.8 | 2.46 |
| 6.6 | 6.57 | 6.57 | 5.97 | 5.25 | 4.61 | 4.05 | 3.56 | 3.13 | 2.75 | 2.42 |
| 6.7 | 6.44 | 6.44 | 5.86 | 5.15 | 4.52 | 3.98 | 3.5 | 3.07 | 2.7 | 2.37 |
| 6.8 | 6.29 | 6.29 | 5.72 | 5.03 | 4.42 | 3.89 | 3.42 | 3 | 2.64 | 2.32 |
| 6.9 | 6.12 | 6.12 | 5.56 | 4.89 | 4.3 | 3.78 | 3.32 | 2.92 | 2.57 | 2.25 |
| 7 | 5.91 | 5.91 | 5.37 | 4.72 | 4.15 | 3.65 | 3.21 | 2.82 | 2.48 | 2.18 |
| 7.1 | 5.67 | 5.67 | 5.15 | 4.53 | 3.98 | 3.5 | 3.08 | 2.7 | 2.38 | 2.09 |
| 7.2 | 5.39 | 5.39 | 4.9 | 4.31 | 3.78 | 3.33 | 2.92 | 2.57 | 2.26 | 1.99 |
| 7.3 | 5.08 | 5.08 | 4.61 | 4.06 | 3.57 | 3.13 | 2.76 | 2.42 | 2.13 | 1.87 |
| 7.4 | 4.73 | 4.73 | 4.3 | 3.78 | 3.32 | 2.92 | 2.57 | 2.26 | 1.98 | 1.74 |
| 7.5 | 4.36 | 4.36 | 3.97 | 3.49 | 3.06 | 2.69 | 2.37 | 2.08 | 1.83 | 1.61 |
| 7.6 | 3.98 | 3.98 | 3.61 | 3.18 | 2.79 | 2.45 | 2.16 | 1.9 | 1.67 | 1.47 |
| 7.7 | 3.58 | 3.58 | 3.25 | 2.86 | 2.51 | 2.21 | 1.94 | 1.71 | 1.5 | 1.32 |
| 7.8 | 3.18 | 3.18 | 2.89 | 2.54 | 2.23 | 1.96 | 1.73 | 1.52 | 1.33 | 1.17 |
| 7.9 | 2.8 | 2.8 | 2.54 | 2.24 | 1.96 | 1.73 | 1.52 | 1.33 | 1.17 | 1.03 |
| 8 | 2.43 | 2.43 | 2.21 | 1.94 | 1.71 | 1.5 | 1.32 | 1.16 | 1.02 | 0.897 |
| 8.1 | 2.1 | 2.1 | 1.91 | 1.68 | 1.47 | 1.29 | 1.14 | 1 | 0.879 | 0.773 |
| 8.2 | 1.79 | 1.79 | 1.63 | 1.43 | 1.26 | 1.11 | 0.973 | 0.855 | 0.752 | 0.661 |
| 8.3 | 1.52 | 1.52 | 1.39 | 1.22 | 1.07 | 0.941 | 0.827 | 0.727 | 0.639 | 0.562 |
| 8.4 | 1.29 | 1.29 | 1.17 | 1.03 | 0.906 | 0.796 | 0.7 | 0.615 | 0.541 | 0.475 |
| 8.5 | 1.09 | 1.09 | 0.99 | 0.87 | 0.765 | 0.672 | 0.591 | 0.52 | 0.457 | 0.401 |
| 8.6 | 0.92 | 0.92 | 0.836 | 0.735 | 0.646 | 0.568 | 0.499 | 0.439 | 0.386 | 0.339 |
| 8.7 | 0.778 | 0.778 | 0.707 | 0.622 | 0.547 | 0.48 | 0.422 | 0.371 | 0.326 | 0.287 |
| 8.8 | 0.661 | 0.661 | 0.601 | 0.528 | 0.464 | 0.408 | 0.359 | 0.315 | 0.277 | 0.244 |
| 8.9 | 0.565 | 0.565 | 0.513 | 0.451 | 0.397 | 0.349 | 0.306 | 0.269 | 0.237 | 0.208 |
| 9 | 0.486 | 0.486 | 0.442 | 0.389 | 0.342 | 0.3 | 0.264 | 0.232 | 0.204 | 0.179 |

Source: U.S. EPA 1999 Update of Ambient Water Quality Criteria for Ammonia

Table A4: Summary Statistics for Toxicity Modifying Factors from the Athabasca River at Old Fort Monitoring Station

*Note: n = sample size, P = percentile, SD = standard deviation.*

| Modifying Factor | n | Max | Min | Median | Mean | 99.9th P | 99th P | 95th P | Variance | SD |
|---|---|---|---|---|---|---|---|---|---|---|
| Alkalinity ($CaCO_3$ mg/L) | 235 | 185.0 | 65.1 | 114.0 | 116.7 | 184.1 | 169.3 | 159.6 | 708.3 | 26.6 |
| Field pH (pH units) | 131 | 9.32 | 6.06 | 7.80 | 7.76 | 9.25 | 8.76 | 8.35 | 0.20 | 0.45 |
| Water Temperature (°C) | 190 | 23.5 | -0.3 | 1.0 | 6.9 | 23.4 | 22.6 | 20.5 | 64.2 | 8.0 |

# Appendix B

### Annual Evaluation of Surface Water Quality Triggers and Limits

The primary purpose of the *Lower Athabasca Region Surface Water Quality Management Framework* is to monitor and manage cumulative, long-term changes in water quality at the Old Fort monitoring station. This type of change is best evaluated through periodic trend assessment, where monitoring data collected over multiple years is examined statistically. Periodic trend assessments will be conducted regularly as part of implementing the *Framework*, yet there is also a need for more frequent, transparent evaluation and reporting on the annual monitoring data collected as part of this *Framework*.

There is considerable value in evaluating the data collected at the Old Fort monitoring station annually, so that changes in water quality are detected early and the source of these changes are understood and acted upon where appropriate. Nevertheless, there are challenges associated with conducting annual evaluations given the limited amount of annual water quality data (i.e., monthly samples) supporting the evaluation, and given that the data are affected by variability in both natural conditions and human activities.

The annual evaluation of water quality data from the Old Fort monitoring station aims to balance the goal of early detection of water quality changes with the desire to avoid unnecessary effort and the costs associated with false positives (i.e., concluding there is a change in a water quality indicator when in fact there is not). For this reason, statistical approaches that reduce the likelihood of false positives and maximize the use of the monitoring data will be used to evaluate changes, where possible. To ensure this balance and to assess a variety of operational and technical considerations, it will be important to review the methodologies used to evaluate changes in water quality indicators regularly.

### Surface Water Quality Triggers

The purpose of assessing the surface water quality triggers annually is to evaluate whether changes are occurring that that may be shifting water quality to a less desirable state. The triggers are coarse metrics intended to detect changes in the distribution of the monitoring data including shifts in central tendency (mean triggers) and changes in the frequency of observed extreme values (peak triggers).

### How will trigger exceedances be assessed?

Mean triggers are calculated as the arithmetic mean of all historical observations for a given indicator (measured at Old Fort). Annual assessment of changes from historical mean triggers (Tables 2 and 3) will be evaluated by conducting Welch's two sample t-tests when annual means are higher (or in the case of calcium and magnesium are higher or lower) than mean triggers. The intent is to test the null hypothesis that the annual mean is not different from the historical mean for that indicator. A mean trigger will have been exceeded[1] if a statistically significant difference is found to have occurred in a direction of concern.

Because water quality data are often non-normally distributed and have outliers that can affect the outcome of parametric comparisons, nonparametric comparisons such as the Wilcoxin-Mann-Whitney test will also be conducted to cross-check results. Differences in results between these two types of statistical tests will be carefully examined and will provide additional context for the annual evaluation.

Peak triggers (Tables 2 and 3) are calculated as the 95$^{th}$ percentile of all the historical observations measured for a given indicator. Annual assessment of changes from the historical 95$^{th}$ percentile will be evaluated using the Binomial test when one or more samples are higher than a peak trigger. The intent is to test the null hypothesis that the frequency of new, annual observations exceeding the historical 95$^{th}$ percentile does not exceed 5% (the expected frequency given no change). A peak trigger will have been exceeded if the results of the Binomial test are found to be statistically significant.

### Surface Water Quality Limits

The purpose of assessing the surface water quality limits annually is to evaluate whether water uses are being protected. The limits are derived from provincially-accepted water quality guidelines and represent conditions where the risk of adverse effects is heightened (Tables 2 and 3). Mandatory management action will be required where an exceedance is found to be the result of human contributions and those contributions are suspected of posing additional, unacceptable risk to human or ecosystem health.

### How will limit exceedances be assessed?

A limit will have been exceeded if the annual mean (i.e., average conditions) for a given water quality indicator exceeds the surface water quality limit for that indicator. For water quality indicators where the limit is calculated using toxicity modifying factors (i.e., total ammonia and total nickel), a limit exceedance will have occurred if more than 50% of the monthly samples exceed the limit within a given year. Because Alberta Environment and Sustainable Resource Development is also interested in trends in guideline exceedances that may not result in limit exceedances (for example a recurring guideline exceedance during freshet), annual evaluations and periodic trend assessment will aim to identify these types of emerging patterns as well.

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[1] In the case of calcium and magnesium indicators, either statistically significant increases or decreases are a concern.