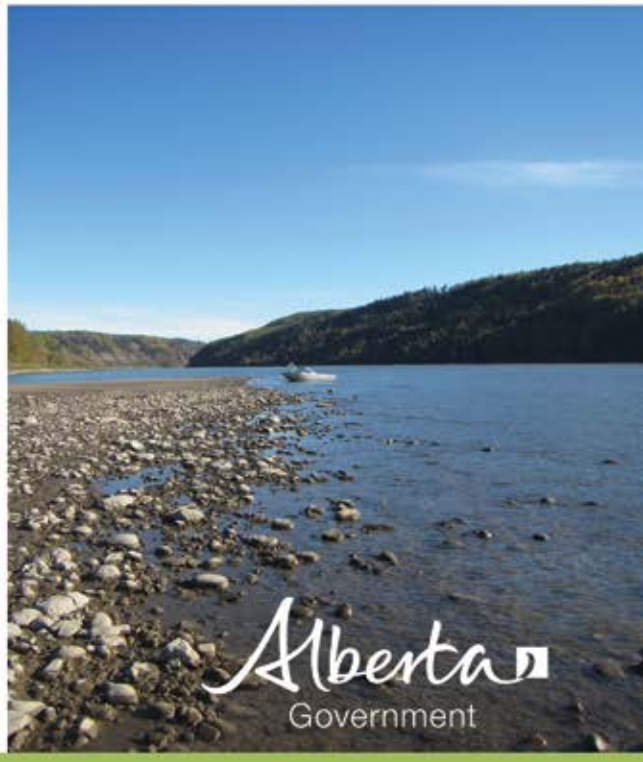
Lower Athabasca Region

Status of Ambient Environmental Condition 2013

Air Quality Management Framework
Surface Water Quality Management Framework



Any comments or questions on the content of this report may be directed to:

Alberta Environment and Parks
Lower Athabasca Region, Operations Division
Box 450, 2nd Floor, Provincial Building
9503 Beaverhill Road
Lac La Biche, Alberta
T0A 2C0

General inquiries on management framework development and implementation can be directed to:

Alberta Environment and Parks
Planning Branch, Policy and Planning Division
3rd floor, South Petroleum Plaza
9915-108 Street, Edmonton, Alberta
T5K 2G8

For copies of this report, please contact:

Information Centre
Alberta Environment and Parks
Phone: 780-427-4976
Email: env.infocent@gov.ab.ca
Website: http://aep.alberta.ca

ISBN: 978-1-4601-3039-1 (PDF Online)

http://open.alberta.ca/publications/9781460130391

July 2016

Executive Summary

The Government of Alberta is reporting to Albertans on the condition of air and surface water in the Lower Athabasca Region for the year 2013. Through the *Lower Athabasca Region Air Quality Management Framework for Nitrogen Dioxide and Sulphur Dioxide* and the *Lower Athabasca Region Surface Water Quality Management Framework for the Lower Athabasca River*, commitments made under the *Lower Athabasca Regional Plan* to annual and ongoing monitoring, evaluation and reporting are being fulfilled.

The Lower Athabasca Regional Plan (LARP) was passed in September 2012, and is the first plan completed under the Land-use Framework. The air and water quality management frameworks help balance environmental protection with economic growth and development by supporting specific objectives established in the LARP:

1) Releases from various sources are managed so that they do not collectively result in unacceptable air quality.
2) Water quality in the lower Athabasca River is managed so current and future water uses are protected.

Annual monitoring of indicators provides information about whether or not we are meeting these objectives. This information is compared to established limits and triggers that correspond to specific management responses if exceeded.

Limits are established as the upper boundaries that are not to be crossed. If a limit is exceeded, the risk to environmental quality is heightened and a mandatory response will be undertaken. Triggers are intended to give early warning of less favourable conditions or trends and they allow sufficient time to plan and respond proactively before a limit could be reached.

2013 Results

In 2013, two air quality indicators, nitrogen dioxide (NO_2) and sulphur dioxide (SO_2), were continuously measured at 15 air monitoring stations; 38 water quality indicators were measured monthly at the Old Fort monitoring station on the lower Athabasca River. The findings were as follows:

- No limits were exceeded for air quality and surface water quality indicators.
- Triggers were exceeded at 11 air monitoring stations for NO_2 and/or SO_2.
- Triggers were exceeded at the Old Fort water quality station for five out of 38 indicators (total nitrogen, dissolved aluminum, dissolved iron, dissolved uranium, and total lithium).

For comparison, in 2012, there were also no limit exceedences for either air or surface water quality. Triggers were exceeded at ten air monitoring stations and for three of the 38 water quality indicators at Old Fort station.

The finding of trigger exceedances in 2013 does not signal that environmental conditions have placed human health or the environment at risk. However, because triggers were exceeded, Environment and Parks has initiated a proactive management response that will ensure air and water quality are maintained at acceptable levels. This response began with an assessment to determine the appropriate next steps and may include potential management actions to be taken. Initial steps are outlined in the companion report: *Status of Management Response for Environmental Management Frameworks (as of December 2014)*.

Table of Contents

Report on Air Quality Status

Figures

Tables

Minister's Determination on Ambient Air Quality Levels

In accordance with the Lower Athabasca Regional Plan (Part 4, Regulatory Details Plan) the Minister may make determinations with respect to ambient air quality triggers and limits in the Lower Athabasca Regional Air Quality Management Framework for Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2).

Based on the analysis of data from monitoring stations in the Lower Athabasca Region provided in this report, I have made the following determinations for 2013:

- Ambient air quality limits were not exceeded for NO_2 or SO_2.
- Ambient air quality triggers for NO_2 have been exceeded, as set out in Table A.
- Ambient air quality triggers for SO_2 have been exceeded, as set out in Table B.

To define the corresponding management response, ambient levels (Levels 1-4) have been assigned to each station for each indicator as described in the Air Quality Management Framework.

Our monitoring in 2013 tells us we need to improve our understanding and knowledge of what caused triggers to be exceeded. Be assured that trigger exceedances do not mean that ambient air quality concentrations are placing human health or the environment at risk.

Based on 2013 findings, I have directed my department to initiate a management response consistent with the framework. This response builds on the management response initiated for the trigger exceedances observed in 2012. A report on the status of the management response should be completed as soon as possible.

Our government's proactive management ensures that we will continue to protect the environment and human health in the Lower Athabasca Region.

[original signed by]

Honourable Shannon Phillips
Minister of Environment and Parks

Table A. Nitrogen Dioxide Ambient Air Quality Level Assignment in 2013

Station Name	Annual Average	Upper Range of the Hourly Data[a]
Shell Muskeg River	2	2
Anzac	1	1
CNRL Horizon	1	2
Cold Lake South	1	1
Fort Chipewyan (WBEA)	1	1
Bertha Ganter – Fort McKay	1	2
Fort McMurray – Athabasca Valley	2	2
Fort McMurray – Patricia McInnes	1	2
Maskwa	1	1
Millennium Mine[3]	2	2
Fort McKay South[4]	1	2

[a] as represented by the annual 99th percentile of the hourly data

Table B. Sulphur Dioxide Ambient Air Quality Level Assignment in 2013

Station Name	Annual Average	Upper Range of the Hourly Data[a]
Shell Muskeg River[1]	1	2
Anzac	1	1
Buffalo Viewpoint	1	2
CNRL Horizon	1	2
Cold Lake South	1	1
Fort Chipewyan (WBEA)	1	1
Bertha Ganter – Fort McKay[2]	1	2
Fort McMurray – Athabasca Valley	1	1
Fort McMurray – Patricia McInnes	1	2
Lower Camp	1	2
Mannix	1	3
Maskwa	1	1
Mildred Lake	1	2
Millennium Mine[3]	1	2
Fort McKay South[4]	1	2

[a] as represented by the annual 99th percentile of the hourly data

1. Formerly referred to as Albian Muskeg River
2. Formerly referred to as Fort McKay (WBEA)
3. Formerly referred to as Millennium
4. Formerly referred to as Syncrude UE1

1.0 Introduction

This is the second annual report to Albertans on the *Lower Athabasca Region Air Quality Management Framework for Nitrogen Dioxide and Sulphur Dioxide* (the Air Quality Framework). It fulfills commitments made under the LARP to ongoing monitoring, evaluation and reporting of air quality conditions and verification of conditions in relation to triggers and limits.

The *2013 Report on Air Quality Status* communicates the status of two air quality indicators, nitrogen dioxide (NO_2) and sulphur dioxide (SO_2), at air monitoring stations identified in the Air Quality Framework. This information is used by the Minister of Environment and Parks (the Minister) in determining whether ambient triggers or limits have been exceeded.

If the Minister determines that a trigger or limit has been exceeded, an appropriate official or officials from Environment and Parks will be designated to lead the management response described in the Air Quality Framework.

Reports on air quality status are completed on an annual basis.

2.0 Background

2.1. LARP and the Framework

The LARP sets the following regional objective for air quality in support of regional outcomes:

Releases from various sources are managed so that they do not collectively result in unacceptable air quality.

The Air Quality Framework includes indicators of air quality to support the achievement of desired regional objectives using triggers and limits as part of the management of cumulative effects of development. The Framework was developed with input from different stakeholders within the LAR including industry, First Nations and Métis peoples and non-governmental organizations.

2.2. Location

This Air Quality Framework applies to the LAR which covers approximately 93,200 square kilometres in the northeast corner of Alberta.

Two local airshed zone organizations operate in, and cover most of, the region (Figure 1):

- Wood Buffalo Environmental Association (WBEA) at www.wbea.org
- Lakeland Industry and Community Association (LICA) at www.lica.ca

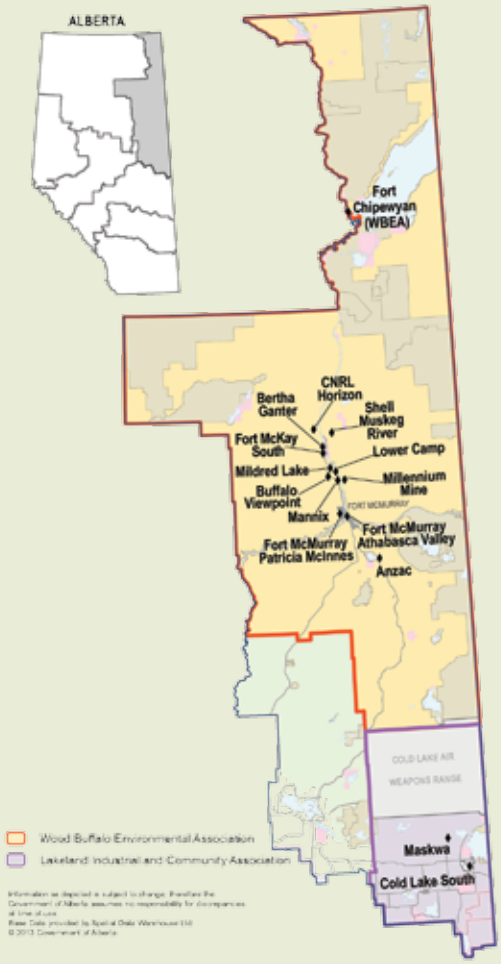


Figure 1
Location of Ambient Air Quality Monitoring Stations

2.3. Monitoring Stations

Ambient air quality for the purposes of the Air Quality Framework is measured at continuous air monitoring stations (industry, community and background) maintained by WBEA and LICA (Figure 1). In 2013, this regional monitoring network consisted of eleven air monitoring stations that measured NO_2 concentrations and fifteen stations that measured SO_2 concentrations on an hourly basis (Table 1).

Environment and Parks analyzed the 2013 hourly data from these continuous air monitoring stations for the purposes of this annual report.

Table 1
Stations included in the 2013 Report on Air Quality Status for the Lower Athabasca Region

Station Name	SO_2	NO_2
Anzac	X	X
Bertha Ganter – Fort McKay[1]	X	X
Buffalo Viewpoint	X	
CNRL Horizon	X	X
Cold Lake South	X	X
Fort Chipewyan (WBEA)	X	X
Fort McKay South[2]	X	X
Fort McMurray – Athabasca Valley	X	X
Fort McMurray – Patricia McInnes	X	X
Lower Camp	X	
Mannix	X	
Maskwa	X	X
Mildred Lake	X	
Millennium Mine[3]	X	X
Shell Muskeg River[4]	X	X

[1] Formerly referred to as Fort McKay (WBEA)
[2] Formerly referred to as Syncrude UE1
[3] Formerly referred to as Millennium
[4] Formerly referred to as Albian Muskeg River

2.4. Air Quality Indicators

Nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) are the indicators used in the Air Quality Framework.

2.5. Ambient Air Quality Triggers and Limits

The LARP sets the following values for the triggers and limits for NO_2 and SO_2 as shown in Table 2 and Table 3, respectively.

As discussed in the Air Quality Framework, ambient air quality limits (based on annual averages of the hourly data) are determined by existing Alberta Ambient Air Quality Objectives (AAAQOs) and air quality triggers are set at 1/3 and 2/3 of the limit (Table 2). These triggers and limits consider average air quality over the course of the year (long-term). Ambient air quality triggers based on the upper range of the hourly data (as represented by the 99th percentile of the hourly data) are also established as a statistical measure of the peak air quality concentrations (Table 3). These triggers consider peak air quality conditions that occur over the short-term. The methods of derivation for triggers based on the upper range of the hourly data are found in Appendix A of the Air Quality Framework. By using two types of triggers (annual averages and upper range), management actions can be tailored to prevent reaching undesirable air quality conditions.

Table 2
Ambient Air Quality Triggers and Limits for the Annual Average of the Hourly Data

Description	NO	SO
Limit[1]	45 µg/m^3 (24 ppb)	20 µg/m^3 (8 ppb)
Trigger for Level 3	30 µg/m^3 (16 ppb)	13 µg/m^3 (5 ppb)
Trigger for Level 2	15 µg/m^3 (8 ppb)	8 µg/m^3 (3 ppb)

[1] Annual air quality limits are determined by the annual Alberta Ambient Air Quality Objectives (AAAQOs)

Table 3
Ambient Air Quality Triggers for the Upper Range of Hourly Data (as represented by the 99th Percentile of the hourly data)

Description	NO	SO
Trigger for Level 4[1]	176 µg/m^3 (92 ppb)	94 µg/m^3 (36 ppb)
Trigger for Level 3	118 µg/m^3 (62 ppb)	63 µg/m^3 (24 ppb)
Trigger for Level 2	57 µg/m^3 (30 ppb)	31 µg/m^3 (12 ppb)

[1] 99th percentile triggers are calculated in relation to the hourly AAAQOs

2.6. Ambient Air Quality Levels

To help define how ambient air quality conditions compare to triggers and limits, ambient air quality levels are assigned to each indicator. The Air Quality Framework describes the management intent for four ambient air quality levels (Table 4).

Table 4
Ambient Air Quality Levels

Level	Description	Management Intent
4	Ambient air quality exceeding air quality limit or level 4 trigger	Improve ambient air quality to below limits
Limit or Trigger		
3	Ambient air quality below but approaching the air quality limit or level 4 trigger	Proactively maintain air quality below limits or level 4 trigger
Trigger		
2	Ambient air quality below air quality level 3 trigger	Improve knowledge and understanding, and plan
Trigger		
1	Ambient air quality well below air quality level 2 trigger	Apply standard regulatory and non-regulatory approaches

3.0
Summary of Methodology and Findings

The process for assigning ambient air quality levels is described in Figure 2. It begins with collecting the monitoring data, verifying that the data sets are complete, calculating the annual average and upper range of the hourly data, and then assigning an air quality level to each indicator based on that analysis. The next step (not shown in Figure 2), is for the Minister to determine whether triggers or limits in the Air Quality Framework have been exceeded.

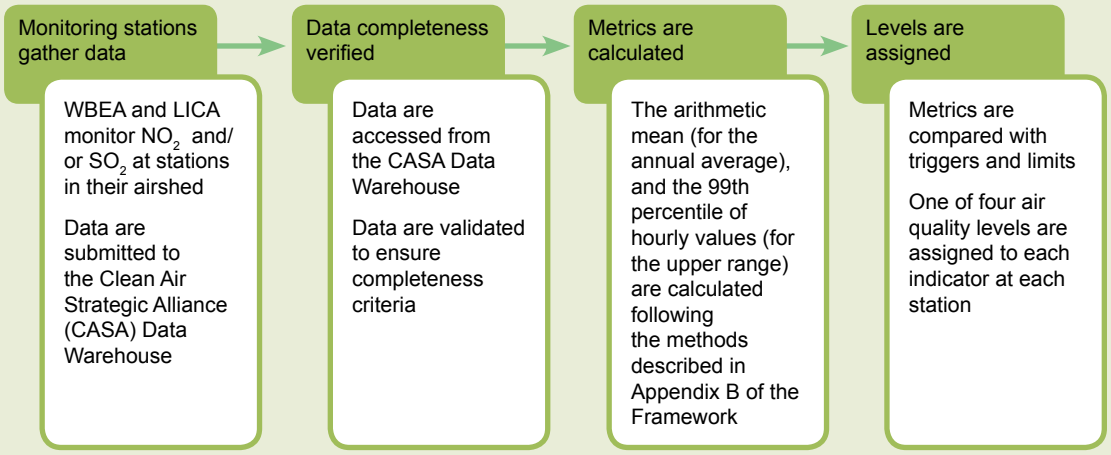


Figure 2
Process for Assignment of Ambient Air Quality Levels

3.1. Data Verification and Metric Calculation

As described in the Air Quality Framework, ambient air quality data collected by WBEA and LICA are validated and made publicly available on an annual basis through the Clean Air Strategic Alliance (CASA) Data Warehouse (www.casadata.org). Environment and Parks included all continuous air monitoring stations in the Lower Athabasca Region that reported hourly NO_2 and/or SO_2 to the CASA Data Warehouse in the 2013 assessment (provided they met the data completeness criteria outlined in the framework). The data were converted from parts per million (ppm) to parts per billion (ppb) for comparison with the triggers and limits.

Calculation of the annual average and upper range of the hourly data for NO_2 and SO_2 in 2013 was conducted in accordance with the framework. These metrics consider two perspectives on the annual hourly data.

3.2. Nitrogen Dioxide (NO_2)

3.2.1. Annual Average of the Hourly Data for NO_2

In 2013, none of the eleven air monitoring stations measured annual average ambient concentrations of NO_2 above the trigger value for Level 3 (16 ppb) (Figure 3). Three stations (Fort McMurray-Athabasca Valley, Millennium Mine and Shell Muskeg River) had ambient concentrations above the trigger value for Level 2 (8 ppb). The same three stations also exceeded the trigger value for Level 2 in 2012. The remaining eight stations had ambient air quality concentrations below the trigger for Level 2.

The two stations with the highest NO_2 concentrations (Shell Muskeg River and Millennium Mine) are industrial stations located close to mining sites. The Fort McMurray-Athabasca Valley community station is located adjacent to main commuter roads.

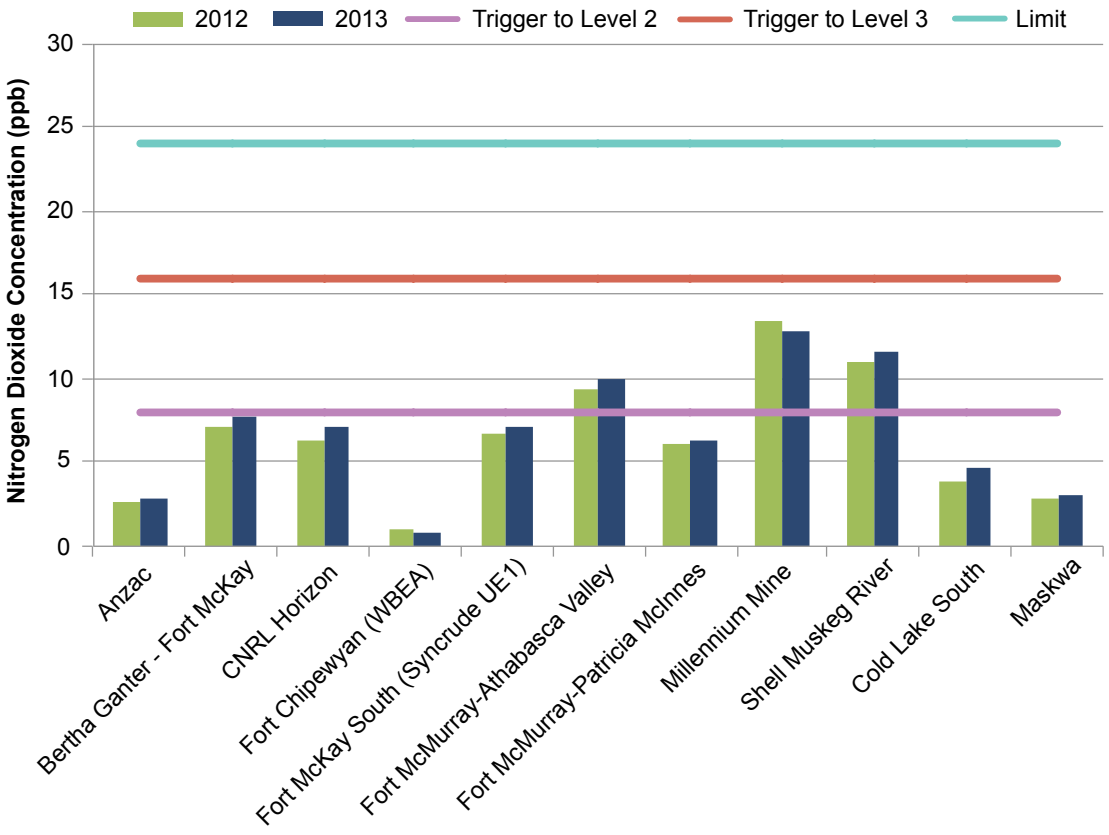


Figure 3
Annual Average of the Hourly Data for 2012 and 2013 from air monitoring stations in the Lower Athabasca region for NO_2

3.2.2. Upper Range of the Hourly Data for NO_2

In 2013, none of the eleven air monitoring stations had an upper range of ambient concentrations of NO_2 above the trigger for Level 3 (62 ppb) (Figure 4). Seven stations had ambient concentrations that were above the trigger for Level 2 (30 ppb). Of these, Fort McMurray–Patricia McInnes was the only station that did not also exceed the trigger for Level 2 in 2012. Three of the seven stations are located close to industrial sites (CNRL Horizon, Millennium Mine and Shell Muskeg River) and four are community stations (Bertha Ganter–Fort McKay, Fort McMurray-Athabasca Valley, Fort McMurray–Patricia McInnes and Fort McKay South[1]).

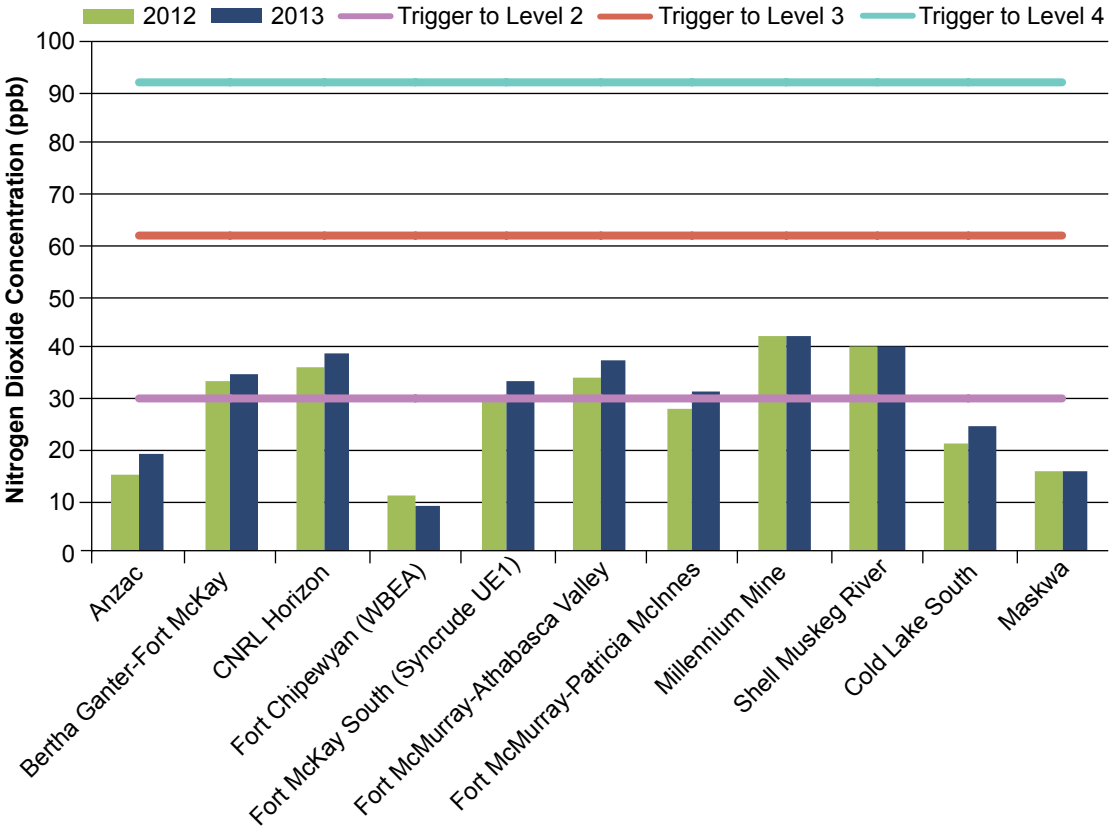


Figure 4
Upper Range of the Hourly Data for 2012 and 2013 from air monitoring stations in the Lower Athabasca region for NO_2

[1] The Fort McKay South station was listed as an industrial monitoring station in the 2012 Report on Air Quality Status; however it is now considered a community station due to the limited effects of industrial activity observed at this location.

3.3. Sulphur Dioxide (SO_2)

3.3.1. Annual Average of the Hourly Data for SO_2

In 2013, none of the fifteen air monitoring stations measured average ambient concentrations of SO_2 above the trigger for Level 2 (3 ppb) (Figure 5). Although there was some variability in ambient air quality among stations, all of the continuous air monitoring stations recorded average annual SO_2 concentrations below the trigger values. Similar results were observed in 2012.

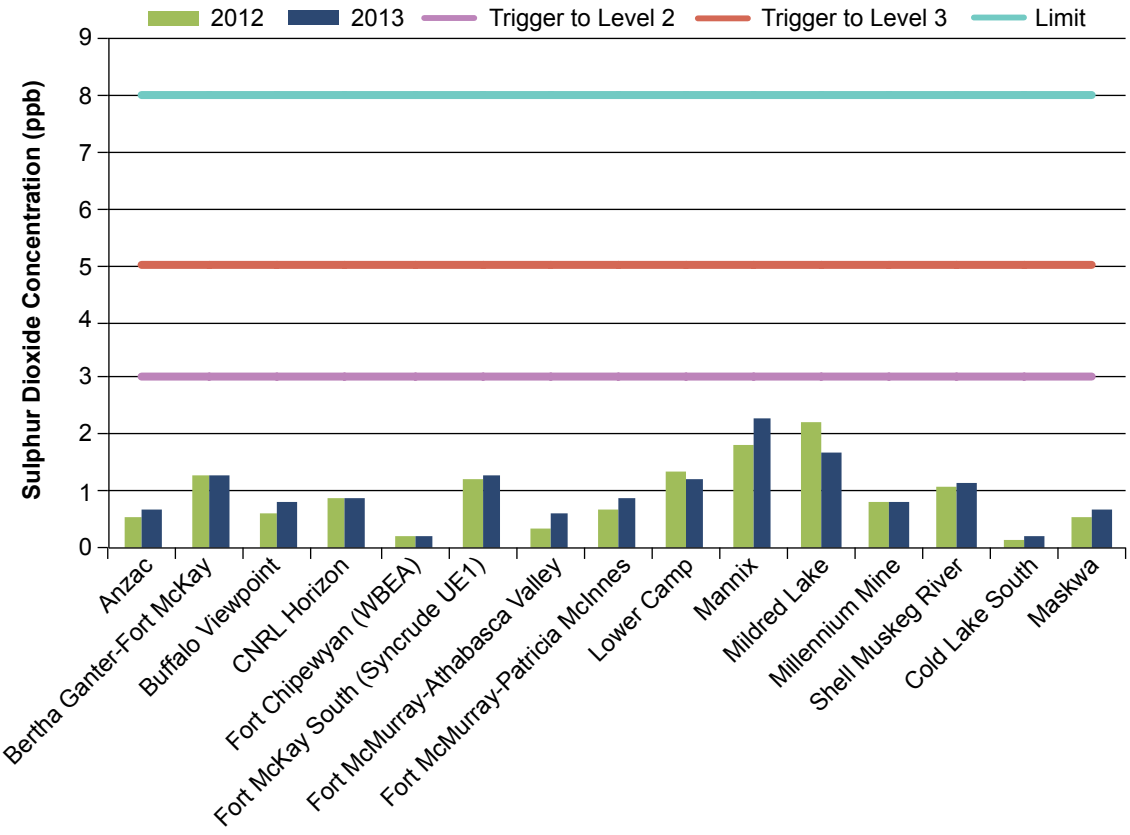


Figure 5
Annual Average of the Hourly Data for 2012 and 2013 from air monitoring stations in the Lower Athabasca region for SO_2

3.3.2. Upper Range of the Hourly Data for SO_2

In 2013, one of the fifteen air monitoring stations had an upper range of ambient SO_2 concentration above the trigger for Level 3 (24 ppb), and nine monitoring stations had ambient concentrations above the trigger for Level 2 (12 ppb) (Figure 6). One station, Mildred Lake, exceeded the trigger to Level 3 in 2012 but dropped below that trigger to Level 2 in 2013. The Fort McMurray–Patricia McInnes station was close to the trigger for Level 2 in 2012 and above the trigger for Level 2 in 2013.

The station measuring SO_2 above the Level 3 trigger (Mannix) is sited close to industrial point sources of SO_2. In 2013, there was one exceedance of the 1-hour AAAQO for SO_2 reported at the Mannix site. The trigger values are set far below the 1-hour AAAQO and are derived so that there should be no or very few exceedances of the hourly AAAQO at the trigger for Level 3.

Of the nine stations with concentrations above the Level 2 trigger, six of the stations are close to industrial sites (Buffalo Viewpoint, CNRL Horizon, Lower Camp, Mildred Lake, Millennium Mine, and Shell Muskeg River) and three are community stations (Bertha Ganter–Fort McKay, Fort McKay South and Fort McMurray–Patricia McInnes).

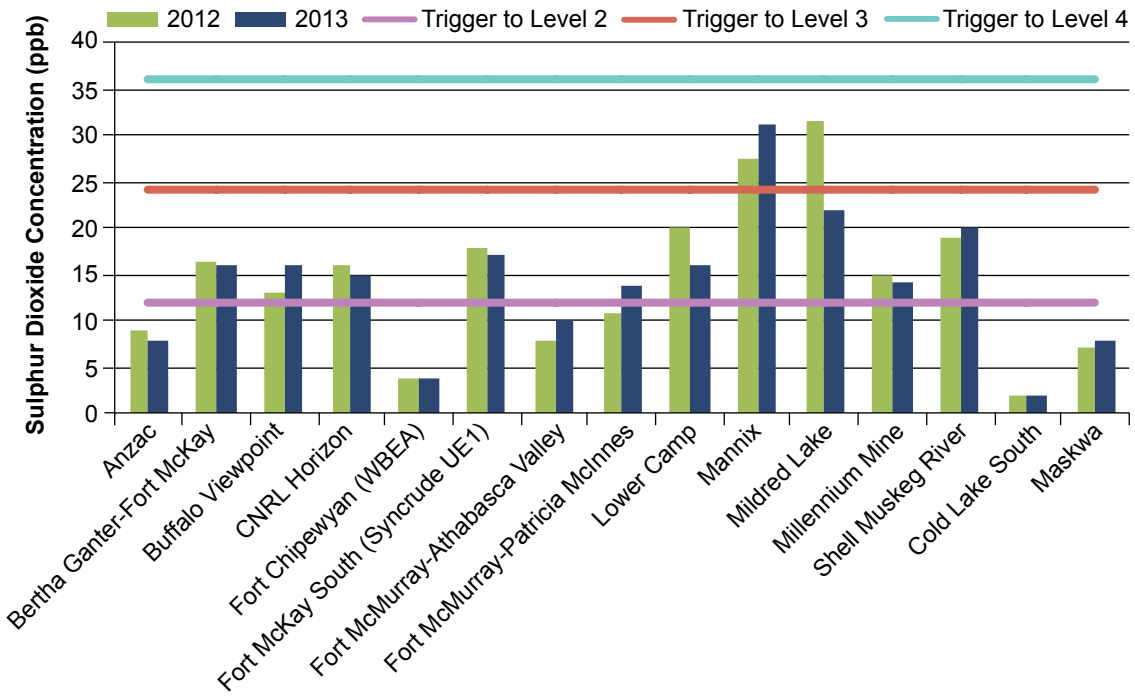


Figure 6
Upper Range of the Hourly Data for 2012 and 2013 from air monitoring stations in the Lower Athabasca region for SO_2

4.0
Assigning Ambient Levels

In 2013, no air monitoring stations in the LAR measured ambient NO_2 or SO_2 concentrations above the limits or triggers for Level 4 established in the Air Quality Framework. Eleven stations (Bertha Ganter–Fort McKay, Buffalo Viewpoint, CNRL Horizon, Fort McKay South, Fort McMurray–Athabasca Valley, Fort McMurray–Patricia McInnes, Lower Camp, Mannix, Mildred Lake, Millennium Mine, and Shell Muskeg River) had ambient NO_2 and/or SO_2 concentrations higher than the Level 2 or 3 trigger values. The 2013 level assignments are given in Table 5, including a comparison with levels assigned in 2012.

For triggers based on the Annual Average of the Hourly Data:

- Three stations were assigned to Level 2 for NO_2: Fort McMurray–Athabasca Valley, Millennium Mine, and Shell Muskeg River

For triggers based on the Upper Range of the Hourly Data:

- One station was assigned to Level 3 for SO_2: Mannix
- Nine stations were assigned to Level 2 for SO_2: Bertha Ganter–Fort McKay, Buffalo Viewpoint, CNRL Horizon, Fort McKay South, Fort McMurray–Patricia McInnes, Lower Camp, Mildred Lake, Millennium Mine and Shell Muskeg River
- Seven stations were assigned to Level 2 for NO_2: Bertha Ganter–Fort McKay, CNRL Horizon, Fort McKay South, Fort McMurray–Athabasca Valley, Fort McMurray–Patricia McInnes, Millennium Mine and Shell Muskeg River

The management intent for each ambient air quality level is described in detail in the Air Quality Framework. Where the Minister determines that a trigger has been exceeded, an appropriate official or officials from Environment and Parks must initiate a management response.

Table 5
Status of Air Quality Indicators at Monitoring Stations in 2012 and 2013 Relative to Ambient Air Quality Levels in the Framework

Level	Description	Management Intent	2012 Status of Indicators[1]	2013 Status of Indicators
4	Ambient air quality exceeding air quality limit or Level 4 trigger	Improve ambient air quality to below limit or Level 4 trigger	No stations with NO_2 or SO_2 above the limit or Level 4 trigger in 2012	No stations with NO_2 or SO_2 above the limit or Level 4 trigger in 2013
Limit or Trigger for Level 4				
3	Ambient air quality below but approaching air quality limit or Level 4 trigger	Proactively maintain air quality below limit or Level 4 trigger	SO_2 was above the Level 3 upper range trigger at: • Mannix • Mildred Lake	SO_2 was above the Level 3 upper range trigger at: • Mannix
Trigger for Level 3				
2	Ambient air quality below air quality Level 3 trigger	Improve knowledge and understanding and plan	NO_2 was above the Level 2 annual average trigger at: • Fort McMurray Athabasca-Valley • Millennium Mine • Shell Muskeg River NO_2 was above the Level 2 upper range trigger at: • Bertha Ganter – Fort McKay • CNRL Horizon • Fort McKay South • Fort McMurray Athabasca-Valley • Millennium Mine • Shell Muskeg River SO_2 was above the upper range trigger at: • Bertha Ganter – Fort McKay • Buffalo Viewpoint • CNRL Horizon • Fort McKay South • Lower Camp • Millennium Mine • Shell Muskeg River	NO_2 was above the Level 2 annual average trigger at: • Fort McMurray - Athabasca Valley • Millennium Mine • Shell Muskeg River NO_2 was above the Level 2 upper range trigger at: • Bertha Ganter – Fort McKay • CNRL Horizon • Fort McKay South • Fort McMurray Athabasca-Valley • Fort McMurray – Patricia McInnis • Millennium Mine • Shell Muskeg River SO_2 was above the upper range trigger at: • Bertha Ganter – Fort McKay • Buffalo Viewpoint • CNRL Horizon • Fort McKay South • Fort McMurray – Patricia McInnis • Lower Camp • Mildred Lake • Millennium Mine • Shell Muskeg River
Trigger for Level 2				
1	Ambient air quality well below air quality Level 2 trigger	Apply standard regulatory and non-regulatory approaches	All remaining stations	All remaining stations

[1] Stations listed here use the 2013 naming convention, although they were reported in 2012 using their previous name, 2012 station names are given in Table 1.

Table of Contents

Report on Surface Water Quality Status

Figures

Tables

Minister's Determination on Ambient Surface Water Quality Levels

In accordance with the Lower Athabasca Regional Plan (Part 5, Regulatory Details Plan) the Minister may make determinations with respect to ambient surface quality triggers and limits in the *Lower Athabasca Region Surface Water Quality Management Framework for the Lower Athabasca River*.

Based on the analysis of data from the lower Athabasca River at Old Fort monitoring station provided in this report, I have made the following determinations for 2013:

- Ambient surface water quality limits were not exceeded for general or metal indicators.
- Ambient surface water quality mean and peak triggers have been exceeded, as set out in Table A.

To define the corresponding management response, ambient levels (Levels 1-3) have been assigned to the Old Fort monitoring station for each indicator described in the Surface Water Quality Management Framework. Due to the extensive list of water quality indicators, the table presented is limited to those indicators with trigger exceedances; the remaining 33 indicators have been assigned to Level 1.

Table A: Nitrogen Dioxide Ambient Air Quality Level Assignment in 2013

Indicator	Mean Trigger	Peak Trigger
Total Nitrogen	2	1
Dissolved Uranium	2	2
Total Lithium	1	2
Dissolved Aluminum	1	2
Dissolved Iron	2	1

Our monitoring in 2013 tells us we need to improve our understanding and knowledge of what caused triggers to be exceeded. Be assured that trigger exceedances do not mean that ambient surface water quality concentrations are placing human health or the environment at risk.

Based on 2013 findings, I have directed my department to initiate a management response consistent with the framework. This response builds on the management response initiated for the trigger exceedances observed in 2012. A report on the status of the management response should be completed as soon as possible.

Our government's proactive management ensures that we will continue to protect the environment and human health in the Lower Athabasca Region.

[original signed by]

Honourable Shannon Phillips
Minister of Environment and Parks

1.0 Introduction

This is the second annual report to Albertans on the *Lower Athabasca Region Surface Water Quality Management Framework for the Lower Athabasca River* (the Surface Water Quality Framework). It fulfills commitments made under the *Lower Athabasca Regional Plan* (LARP) to ongoing monitoring, evaluation and reporting of surface water quality conditions and verification of conditions in relation to triggers and limits.

The *2013 Report on Surface Water Quality Status* communicates the status of 38 water quality indicators from the Surface Water Quality Framework. Ambient surface water quality condition is described in terms of the ambient surface water quality levels for the indicators, as measured at the Old Fort monitoring station on the lower Athabasca River. This information is used by the Minister of Environment and Parks (the Minister) in determining whether ambient triggers or limits have been exceeded.

If the Minister determines that a trigger or limit has been exceeded, an appropriate official or officials from Environment and Parks will be designated to lead the management response described in the Surface Water Quality Framework.

Reports on surface water quality status are completed on an annual basis.

2.0 Background

2.1 LARP and the Framework

The LARP sets the following regional objective for surface water quality in support of regional outcomes:

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

The Surface Water Quality Framework includes indicators of water quality to support the achievement of the desired regional objective using triggers and limits as part of the management of cumulative effects of development. The Framework was developed with input from different stakeholders within the Lower Athabasca Region including industry, First Nations and Métis peoples and non-governmental organizations.

2.2 Location

The Surface Water Quality Framework applies to the lower section of the Athabasca River from downstream of the Grand Rapids (approximately 135 kilometres upstream of Fort McMurray) to the Athabasca River Delta (Figure 1).

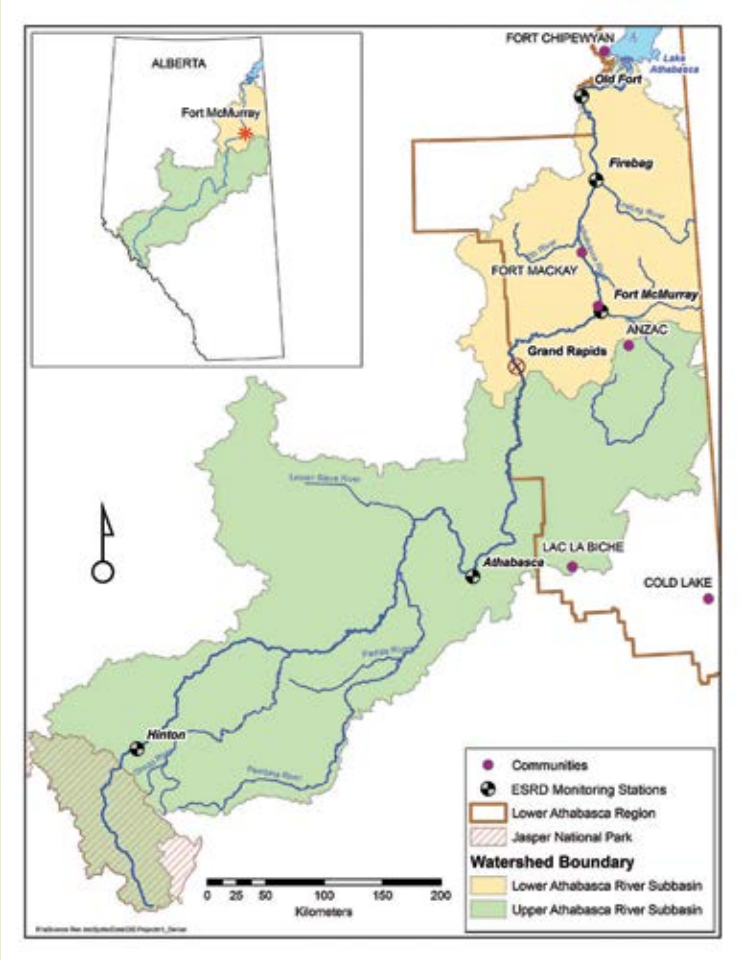


Figure 1
Location of Environment and Parks Surface Water Quality Monitoring Stations in the Athabasca River Basin

2.3 Monitoring Stations

Ambient surface water quality for the purposes of the Surface Water Quality Framework is measured at the Old Fort monitoring station on the lower Athabasca River. The Old Fort station is located approximately 200 kilometres downstream of Fort McMurray (Figure 1) and is part of Environment and Parks' Long-term River Network (LTRN).

As described in the Surface Water Quality Framework, ambient surface water triggers and limits were developed for the lower Athabasca River as measured at the Old Fort monitoring station due to the availability of long-term data for this site and its location downstream of oil sands development. Triggers and limits have not yet been set for the other monitoring stations on the lower Athabasca River (e.g. Fort McMurray and Firebag) because of the lack of long-term data for those sites. Since September 2010, all of the water quality indicators in the Surface Water Quality Framework (and additional water quality variables) are monitored monthly at all three monitoring stations. Data collected from other regional monitoring stations on the Athabasca River and its tributaries, including those added through the Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring, may provide information to assist with investigations if a management response is required.

2.4 Surface Water Quality Indicators, Triggers and Limits

The LARP identifies 38 surface water quality indicators for the Athabasca River at the Old Fort station. Of these, 11 are classified as general indicators and 27 as metal indicators. Surface water quality triggers (WQTs) and limits (WQLs) for the list of indicators can be found in Tables 2 and 3 of the Surface Water Quality Framework.

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 as defined by the 95th percentile) in relation to historical data. The limits are derived from provincially accepted guidelines and represent conditions where the risk of adverse effects is heightened.

2.5 Ambient Surface Water Quality Levels

To help define how ambient surface water quality conditions compare to the WQTs and WQLs, ambient surface water quality levels are assigned for each indicator. The Surface Water Quality Framework describes three levels and the management intent for each of the levels (Table 1).

Table 1
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

3.0
Summary of Methodology and Findings

The process used for assigning ambient water quality levels is described in Figure 2. The process involves gathering the monitoring data, accessing the validated data through the Long-term River Network, calculating the values (or metrics) and comparing to trigger and limit values, and then assigning the surface water quality level to each indicator based on that analysis. The next step (not shown in Figure 2), is for the Minister to determine whether triggers or limits in the Surface Water Quality Framework have been exceeded.

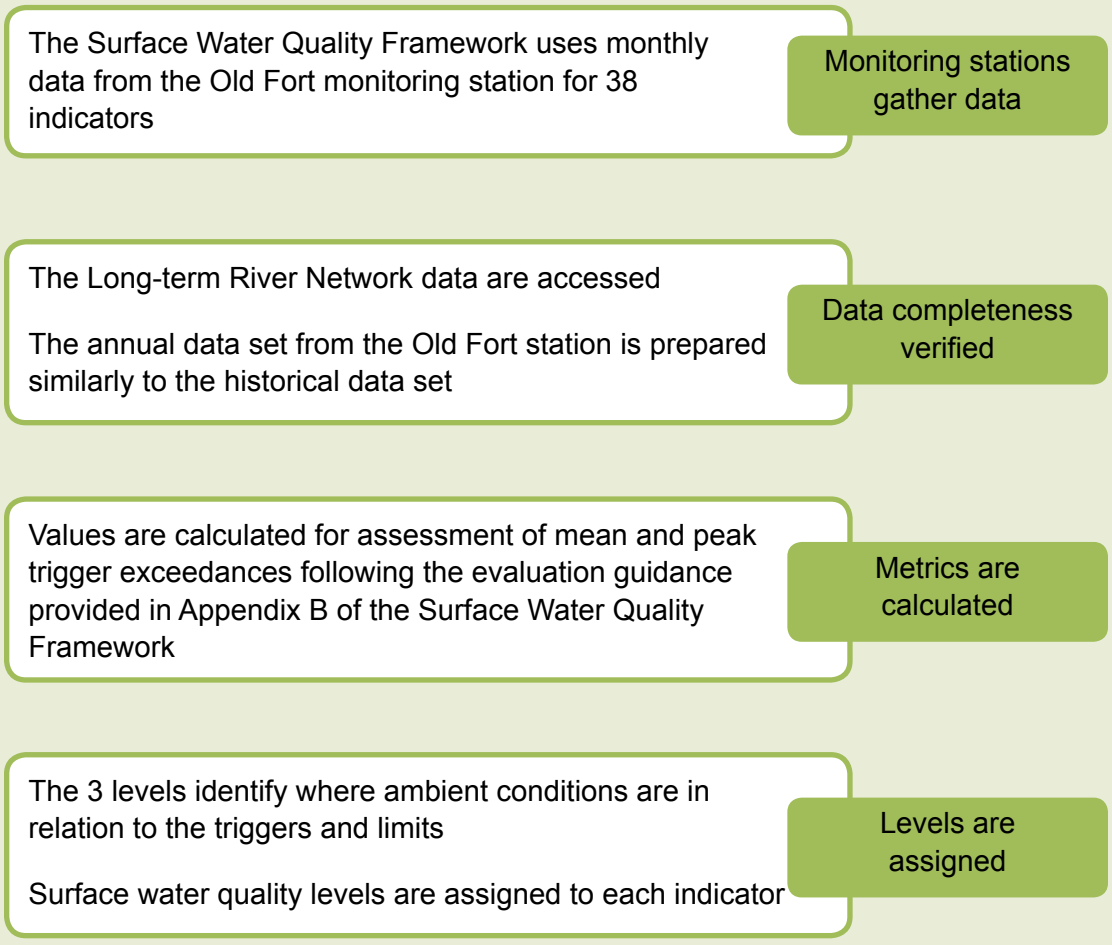


Figure 2
Process for Assignment of Ambient Surface Water Quality Levels

3.1 Data Verification and Metric Calculation

The data used in this status report were collected monthly at the Old Fort monitoring station in 2013. These data were used to calculate summary statistics for each indicator and to conduct the statistical analyses described in Appendix B of the Surface Water Quality Framework for comparison of indicators with the WQTs and WQLs.

Summary statistics for the general and metal indicators are presented in Appendix B of this report (Table B1 and Table B2, respectively). The 2013 data are also presented graphically in relation to historical data in Figures B1 and B2. The water quality data for 2013 and the historical data for both the Athabasca River at Old Fort and the Athabasca River upstream of Fort McMurray stations (included for comparison), are available through the Government of Alberta's Oil Sands Information Portal website at http://osip.alberta.ca.

3.2 Ambient Surface Water Quality Triggers and Limits

Appendix A of this report provides additional information on the assessment of the surface water quality indicators in comparison to the mean and peak triggers and presents the detailed results of the statistical analyses. A summary is provided below.

3.2.1 Annual Means Compared to Mean Triggers

In 2013, a total of 28 indicators were subject to statistical evaluation at the Old Fort station. Twenty-seven of these indicators had annual means higher than the mean trigger established in the Surface Water Quality Framework. In addition the annual mean for calcium was lower than the mean trigger, which is a direction of concern for this indicator (Table A1). However, the difference was only statistically significant for three of the indicators: total nitrogen, dissolved iron, and dissolved uranium (Table 2, Table A1). In 2012, only total nitrogen and dissolved uranium had a statistically significant increase in the annual mean, above the mean trigger values.

Mean triggers focus on determining whether water quality during 2013 is different from the historic mean. Exceedences of mean triggers act as an "early warning system" that signal potential change in ambient environmental water quality in the lower Athabasca River. Statistical analysis helps to draw conclusions on whether water quality is similar or different than what was observed in the past. If the difference is statistically significant, it means that water quality in 2013 may be shifting away from historical conditions. If this is the case, more work is needed to explore if and why an unfavourable trend is developing. Water quality is affected by a variety of natural and human factors, and management actions may or may not be required depending on what is driving the change and whether that change can be influenced by management actions.

Table 2
Comparison of the 2012 and 2013 Ambient Means Against the Ambient Means Surface Water Quality Triggers at Old Fort

Metal Indicator	Units	Mean Trigger	2013 Mean[2]	2012 Mean[3]
Calcium (Ca^{2+})[1]	mg/L	34.7	33.5	33.3
Chloride (Cl^-)	mg/L	20.2	16.6	14.5
Magnesium (Mg^+)	mg/L	9.5	9.6	9.8
Nitrate (NO_3-N)	mg/L	0.092	0.101	0.081
Potassium (K^+)	mg/L	1.4	1.5	1.6
Sodium (Na^+)	mg/L	21.5	20.2	19.8
Sulphate (SO_4-)	mg/L	26.7	29.8	30.3
Total Ammonia (NH_{3+4}-N)	mg/L	0.05	0.05	0.04
Total Dissolved Phosphorus (TDP)	mg/L	0.016	0.017	0.016
Total Nitrogen (TN)	mg/L	0.597	0.794	0.751
Total Phosphorus (TP)	mg/L	0.074	0.054	0.080

Note: Only the indicators with concentrations that were statistically significant (shaded in green) exceeded the mean trigger in 2013.

		Dissolved Metals			Total Metals		
Metal Indicator	**Units**	**Mean Trigger**	**2013 Mean***	**2012 Mean**	**Mean Trigger**	**2013 Mean***	**2012 Mean**
Aluminum	µg/L	16	30	21	1533	3575	1543
Antimony	µg/L	0.107	0.068	0.070	0.202	0.069	0.071
Arsenic	µg/L	0.5	0.5	0.5	0.7	1.2	1.0
Barium	µg/L	52.6	49.6	51.8	79.3	89.9	77.4
Beryllium	µg/L	---	---	---	0.077	0.114	0.093
Bismuth	µg/L	---	---	---	0.0172	0.0122	0.0093
Boron	µg/L	26	28	28	48	32	33
Cadmium	µg/L	0.0997	0.0126	0.0217	0.3	0.1	0.1
Chromium	µg/L	0.41	0.4	0.25	3	3	2
Cobalt	µg/L	0.07	0.07	0.05	0.08	1	0.7
Copper	µg/L	1.6	1.2	1.2	3.1	2.8	2.3
Iron	µg/L	185	267	204	1899	3321	1797

	Dissolved Metals				Total Metals		
Metal Indicator	**Units**	**Mean Trigger**	**2013 Mean***	**2012 Mean**	**Mean Trigger**	**2013 Mean***	**2012 Mean**
Lead	µg/L	0.56	0.11	0.52	3.3	2.2	4.7
Lithium	µg/L	6	8	7	9	10	8
Manganese	µg/L	12	13	11	65	86	64
Mercury	µg/L	---	---	---	0.0051	0.0046	0.0045
Molybdenum	µg/L	0.7	0.5	0.5	0.9	0.7	0.5
Nickel	µg/L	1.6	1	0.7	3.4	3.1	2.1
Selenium	µg/L	0.229	0.207	0.241	0.333	0.288	0.281
Silver	µg/L	---	---	---	0.0243	0.0546	0.0091
Strontium	µg/L	215	199	196	225	207	197
Thallium	µg/L	0.0238	0.0052	0.0058	0.0546	0.0481	0.0309
Thorium	µg/L	0.0284	0.0315	0.0223	0.35	0.53	0.28
Titanium	µg/L	2	3	2	30	26	21
Uranium	µg/L	0.313	0.363	0.359	0.4	0.5	0.4
Vanadium	µg/L	0.45	0.37	0.338	4.4	5.5	3.8
Zinc	µg/L	4.5	1.1	1.9	12.3	8.3	7.0

[1] A statistically significant decrease in calcium may also indicate a water quality concern.

[2] n=12

3.2.2 Annual Data Compared to Peak Triggers

In 2013, three indicators had a significantly significant number of sampling occasions where the measured concentrations were higher than the peak triggers established in the Surface Water Quality Framework. These were: dissolved aluminum (three occasions), dissolved uranium (three occasions), and total lithium (five occasions). In order for a peak trigger to be exceeded, the number of samples higher than the peak trigger must be greater than would be expected by chance, and this difference must be significantly significant. (Table 3, Table A2).

A total of 30 indicators had one or more samples where the measured concentration was higher than the peak trigger (Table A2); however, the number of samples above the peak trigger was only statistically significant for the three indicators listed above. In 2012, only dissolved lithium and dissolved uranium exceeded the peak triggers.

3.2.3 Ambient Surface Water Quality Limits

None of the limits established in the Surface Water Quality Framework were exceeded in 2013 (Tables A3 and A4), or in 2012.

Table 3
Comparison of the 2013 Peak Values Against Maximum Values and Ambient Peak Surface Water Quality Triggers at Old Fort

Metal Indicator	Units	Peak Trigger	Maximum Value	Number of Occurrences Higher than Trigger in 2013	Number of Occurrences High Than Trigger in 2012
Calcium (Ca^{2+})	mg/L	48.9	41.0	0	0
Chloride (Cl^{-})	mg/L	45	33.0	0	0
Magnesium (Mg^{+})	mg/L	13.7	12.0	0	0
Nitrate (NO_3-N)	mg/L	0.264	0.260	0	0
Potassium (K^{+})	mg/L	2.1	2.1	0	2
Sodium (Na^{+})	mg/L	43.7	34.0	0	0
Sulphate (SO_4-)	mg/L	41.4	41.0	0	2
Total Ammonia (NH_{3+4}-N)	mg/L	0.12	0.12	0	0
Total Dissolved Phosphorus (TDP)	mg/L	0.032	0.027	0	1
Total Nitrogen (TN)	mg/L	1.041	1.800	2	1
Total Phosphorus (TP)	mg/L	0.261	0.120	0	0

		Dissolved Metals				Total Metals			
Metal Indicator	Units	Peak Trigger	Maximum Value	Number of Occurrences Higher than Trigger in 2013	Number of Occurrences High Than Trigger in 2012	Peak Trigger	Maximum Value	Number of Occurrences Higher than Trigger in 2013	Number of Occurrences Higher than Trigger in 2012
Aluminum	ug/L	49	110	3	1	6454	14500	2	0
Antimony	ug/L	0.202	0.107	0	0	0.388	0.108	0	0
Arsenic	ug/L	0.7	0.7	1	2	2.5	2.9	1	0
Barium	ug/L	73.7	60.6	0	0	147.6	262	1	1
Beryllium	ug/L	---	---	---	---	0.269	0.52	2	0
Bismuth	ug/L	---	---	---	---	0.0564	0.0562	0	0
Boron	ug/L	40	42	1	0	69	44	0	0
Cadmium	ug/L	0.515	0.0335	0	0	1.2	0.3	0	0
Chromium	ug/L	0.65	0.77	1	0	8	12	2	0
Cobalt	ug/L	0.11	0.14	1	0	2.2	5.4	2	1
Copper	ug/L	3.6	2.2	0	0	7.2	10.7	2	0
Iron	ug/L	372	430	1	1	5821	14800	2	0
Lead	ug/L	0.56	0.34	0	1	7	10.6	2	1
Lithium	ug/L	9	16	2	3	12	18	3	0
Manganese	ug/L	36	31	0	0	141	351	1	1
Mercury	ug/L	---	---	---	---	0.0159	0.0113	0	0
Molybdenum	ug/L	1.2	0.7	0	0	1.6	2.8	1	0
Nickel	ug/L	4.7	2.6	0	0	8.2	14.4	2	0
Selenium	ug/L	0.409	0.332	0	2	0.581	0.428	0	1

		Dissolved Metals				Total Metals			
Metal Indicator	**Units**	**Peak Trigger**	**Maximum Value**	**Number of Occurrences Higher than Trigger in 2013**	**Number of Occurrences High Than Trigger in 2012**	**Peak Trigger**	**Maximum Value**	**Number of Occurrences Higher than Trigger in 2013**	**Number of Occurrences Higher than Trigger in 2012**
Silver	ug/L	---	---	---	---	0.0677	0.361	2	0
Strontium	ug/L	361	248	0	0	361	252	0	0
Thallium	ug/L	0.1137	0.0071	0	0	0.1751	0.232	1	0
Thorium	ug/L	0.0942	0.137	2	1	1.44	2.75	2	0
Titanium	ug/L	7	12	2	0	104	78	0	0
Uranium	ug/L	0.381	0.438	5	3	0.7	1.4	2	0
Vanadium	ug/L	0.698	0.63	0	0	16	21.4	1	0
Zinc	ug/L	12.4	2.5	0	0	25.6	34.1	2	0

4.0
Assigning Ambient Levels

In 2013, none of the water quality indicators had concentrations higher than the limits established in the Surface Water Quality Framework; therefore, none of the indicators at the Old Fort station were assigned to Level 3. The same results were observed in 2012.

Annual means were significantly higher than mean triggers for total nitrogen, dissolved iron, and dissolved uranium, while the number of samples higher than a peak trigger was statistically significant for dissolved aluminum, dissolved uranium, and total lithium. Five of the indicators at Old Fort station were therefore assigned to Level 2 (total nitrogen, dissolved aluminum, dissolved iron, dissolved uranium, and total lithium). Compared to 2012, in 2013 there were two new indicators assigned to Level 2.

In 2013, 33 indicators were assigned to Level 1 (Table 4).

The management intent for each ambient water quality level is described in detail in the Surface Water Quality Framework. Where the Minister determines that a trigger has been exceeded, an appropriate official or officials from Environment and Parks will initiate a management response.

Table 4
Status of Surface Water Quality Indicators in 2012 and 2013 Relative to Ambient Surface Water Quality Levels

Level	Description	Management Intent	2012 Status of Indicators	2013 Status of Indicators
3	Exceedance of water quality limits.	Improve ambient water quality to below limits.	No indicators were higher than limits in 2012.	No indicators were higher than limits in 2013.
Limit				
2	Exceedance of water quality triggers.	Proactively maintain water quality below limits. Improve knowledge and understanding of trends.	Differences were found for 3 indicators (total nitrogen, dissolved lithium and dissolved uranium). Annual means were higher than mean triggers for: • Total nitrogen • Dissolved uranium The number of samples higher than peak triggers was statistically significant for: • Dissolved lithium • Dissolved uranium	Differences were found for 5 indicators (total nitrogen, dissolved aluminum, dissolved iron, dissolved uranium, and total lithium). Annual means were higher than mean triggers for: • Total nitrogen • Dissolved iron • Dissolved uranium The number of samples higher than peak triggers was statistically significant for: • Dissolved aluminum • Dissolved uranium • Total lithium
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.	35 of 38 indicators	33 of 38 indicators

5.0
Appendix A

Statistical Methodology Used to Assess Mean and Peak Triggers

The Surface Water Quality Framework includes 38 indicators with 61 mean trigger values and 61 peak trigger values, as many of the metal indicators include triggers for both total and dissolved metals (i.e. 27 total metals, 23 dissolved metals and 11 general). Water samples for the general indicators were analysed by Maxxam Analytics, and the metal indicators by Alberta Innovates Technology Futures.

The 2013 data set was prepared similarly to the historical data set. Observations below the method detection limit were replaced with half the detection limit to be consistent with the development of the water quality triggers from the historical data. With the exception of total ammonia and total bismuth, all indicators had 30 per cent or fewer of the 2013 observations below detection, as was the case with the historical data. The proportion of non-detects in the 2013 data for total ammonia (67 per cent) was considerably higher than in the historical data set (21 per cent), as was the case for total bismuth (50 per cent non-detects in 2013 compared to 29 per cent in the historical data set).

Mean triggers

Welch's two sample t-tests and Wilcoxon-Mann-Whitney tests were conducted to test the null hypothesis that the 2013 water quality indicator means are not different from the historical means (i.e. mean triggers). These tests were only conducted when the 2013 indicator mean was higher than the mean trigger (or in the case of calcium and magnesium, higher or lower). The "exact rank tests" package in R was used to compute the Wilcoxon-Mann-Whitney tests (Hothorn and Hormik, 2012). Quantile-quantile (Q-Q) plots and the Shapiro-Wilk test were used to assess the normality of the historical data, as annual samples sizes are too small to provide distributional information. If the water quality indicator was non-normal prior to transformation, but was not significantly non-normal after log transformation, the Welch's test was run on the log-transformed data. Because much of the historical data are not normally distributed, and given that water quality data often have outliers that can affect the outcome of parametric comparisons, both parametric (Welch's two sample t-tests) and non-parametric comparisons (Wilcoxon-Mann-Whitney tests) were conducted to enhance the robustness of the conclusions.

Of the 61 mean triggers examined (11 general, 27 total metal, 23 dissolved metal), 27 annual means were higher than the historical mean triggers, while calcium was lower. Consequently, 28 indicators were examined statistically (i.e., the 27 that were higher, plus calcium, which was lower). Parametric and non-parametric test results were consistent for all the indicators tested (Table A1).

Table A1

Results of the Statistical Assessment of the 2013 Data Against the Ambient Mean Surface Water Quality Triggers

Note: Only indicators with 2013 means higher than historical mean triggers and calcium were statistically evaluated. Two-sided tests were conducted for both calcium and magnesium and one-sided tests for the remaining indicators. p-value=level of significance, D=dissolved, T=total. Bolded values are statistically different.

Indicator	Mean Trigger	2013 Mean	Welch's two sample t-test			Wilcoxin rank sum test	
			t-statistic	df	p-value	w-statistic	p-value
General Indicators							
Calcium (Ca2+)	34.7	33.5	-0.551	12.37	0.591	1338	0.769
Magnesium (Mg+)	9.5	9.6	0.194	12.06	0.850	1544.5	0.582
Nitrate (NO3-N)	0.092	0.101	0.334	13.89	0.372	800	0.231
Potassium (K+)	1.4	1.5	1.074	14.70	0.150	1750.5	0.080
Sulphate (SO4-)	26.7	29.8	1.051	12.12	0.157	1690.5	0.125
Total Dissolved Phosphorus (TDP)	0.016	0.017	0.831	15.84	0.209	1750	0.052
Total Nitrogen (TN)	0.597	0.794	1.846	11.52	0.045	1932	0.010
Metal Indicators							
Aluminum D	16	30	1.340	12.34	0.102	380	0.060
Aluminum T*	1533	3575	1.504	14.49	0.077	398	0.112
Arsenic D	0.5	0.5	1.502	21.40	0.074	364	0.104
Arsenic T	1.1	1.2	0.234	17.13	0.409	317.5	0.464
Barium T	79.3	89.9	0.586	13.28	0.284	329	0.388
Beryllium T	0.077	0.114	0.764	13.53	0.229	226.5	0.236
Boron D	26	28	0.905	26.69	0.187	346.5	0.174
Cobalt T	0.8	1.0	0.503	12.06	0.312	260	0.813
Iron D	185	267	3.085	25.71	0.002	1167	<0.001
Iron T	1899	3321	1.046	11.94	0.158	363.5	0.259
Lithium D	6	8	1.419	12.92	0.090	362	0.111
Lithium T	9	10	0.551	33.22	0.293	379.5	0.101
Manganese D	12	13	0.153	14.73	0.440	790	0.291
Manganese T	65	86	0.772	12.26	0.227	323	0.509

Indicator	Mean Trigger	2013 Mean	Welch's two sample t-test			Wilcoxin rank sum test	
			t-statistic	df	p-value	w-statistic	p-value
Silver T	0.0243	0.0546	0.988	11.57	0.172	225	0.361
Thorium D	0.0284	0.0315	0.213	14.09	0.417	156	0.885
Thorium T	0.35	0.53	0.677	13.36	0.255	212.5	0.478
Titanium D*	2	3	1.133	15.27	0.137	365.5	0.099
Uranium D	0.313	0.363	2.683	20.51	0.007	300.5	0.007
Uranium T	0.4	0.5	1.278	12.26	0.113	394	0.081
Vanadium T	4.4	5.5	0.542	13.83	0.298	317	0.468

* The data for this indicator were log-normally distributed, so the t-tests were performed on the log-transformed data.

Peak Triggers

Binomial tests were conducted to test the null hypothesis that in 2013 the historical 95th percentile (i.e. peak trigger) for a given indicator was not exceeded more than 5 per cent of the time (the expected frequency given no change). Binomial tests were only run for a water quality indicator when one or more of the annual samples were higher than a peak trigger (Tables 3 and Table A2).

Table A2
Results of the Statistical Assessment of the 2013 Data Against the Ambient Peak Surface Water Quality Triggers

Note: Bolded values are statistically significant. p-value=level of significance, D=dissolved, T=total

Indicator	Peak	Number of Occurrences Higher Than Trigger	Binomial Test p-value
General Indicators			
Total Nitrogen (TN)	1.041	2	0.118
Metal Indicators			
Aluminum D	49	3	**0.020**
Aluminum T	6454	2	0.118
Arsenic D	0.7	1	0.460
Arsenic T	2.5	1	0.460
Barium T	147.6	1	0.460
Beryllium T	0.269	2	0.118
Boron D	40	1	0.460
Chromium D	0.65	1	0.460
Chromium T	8	2	0.118
Cobalt D	0.11	1	0.460
Cobalt T	2.2	2	0.118
Copper T	7.2	2	0.118
Iron D	372	1	0.460
Iron T	5821	2	0.118
Lead T	7	2	0.118
Lithium D	9	2	0.118
Lithium T	12	3	**0.020**
Manganese T	141	1	0.460
Molybdenum T	1.6	1	0.460

Indicator	Peak	Number of Occurrences Higher Than Trigger	Binomial Test p-value
Nickel T	8.2	2	0.118
Silver T	0.0677	2	0.118
Thallium T	0.1751	1	0.460
Thorium D	0.0942	2	0.118
Thorium T	1.44	2	0.118
Titanium D	7	2	0.118
Uranium D	0.381	5	**<0.001**
Uranium T	0.7	2	0.118
Vanadium T	16	1	0.460
Zinc T	25.6	2	0.118

* Based on 12 samples.

Limit

A limit will have been exceeded if the annual mean for a given water quality indicator exceeds the surface water quality limit for that indicator (Table A3). 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 when more than 50 per cent of the monthly samples exceed the limit in a given year (Table A4).

Table A3
Assessment of the 2013 Data Against Surface Water Quality Limits
Note: D=dissolved, T=total

Indicator	Unit	Surface Water Quality Limit	Sample Size	Percent of 2013 Samples Higher than a Limit	2013 Mean
General Indicators					
Calcium (Ca^{2+})	mg/L	1000	12	None	33.5
Chloride (Cl^{-})	mg/L	100	12	None	16.6
Sodium (Na^{+})	mg/L	200	12	None	20.2
Sulphate (SO_4-)	mg/L	500	12	None	29.8
Total Ammonia (NH_{3+4}-N)	mg/L	Varies with pH and temperature*	12	None	0.05
Nitrate (NO_3-N)	mg/L	2.935	12	None	0.101
Metal Indicators					
Antimony T	ug/L	6	12	None	0.069
Arsenic T	ug/L	5	12	None	1.2
Barium T	ug/L	1000	12	None	89.9
Beryllium T	ug/L	100	12	None	0.114
Boron T	ug/L	500	12	None	32
Chromium T	ug/L	50	12	None	3
Cobalt T	ug/L	50	12	None	1
Lithium T	ug/L	2500	12	None	10
Molybdenum T	ug/L	10	12	None	0.7
Nickel T	ug/L	Varies with hardness*	12	None	3.1
Selenium T	ug/L	1	12	None	0.288
Silver T	ug/L	0.1	12	17 (2 of 12)	0.0546
Thallium T	ug/L	0.8	12	None	0.0481
Uranium T	ug/L	10	12	None	0.5
Vanadium T	ug/L	100	12	None	5.5

*See Table A4 for computed limits for water quality indicators with toxicity modifying factors.

Table A4:
Calculated Total Ammonia and Total Nickel Limits for 2013 Samples

Note: It is necessary to calculate sample-specific limits for total ammonia and total nickel as these water quality indicators have toxicity modifying factors that vary across samples.

Sample Date	Water Temperature (ºC)	pH (pH Units)	Total Ammonia (mg/L)	Calculated Total Ammonia Limit (mg/L)	Hardness (mg/L)	Total Nickel (µg/L)	Calculated Total Nickel Limit (µg/L)
4/9/2013	0.06	7.48	<0.05	4.44	140	0.404	140
5/14/2013	10.37	7.56	<0.05	4.13	68	14.4	68
6/18/2013	16.4	7.5	<0.05	3.87	74	8.53	74
7/16/2013	17.42	7.76	<0.05	2.77	89	4.33	89
8/13/2013	20.8	7.92	<0.05	1.82	93	2.21	93
9/19/2013	12.75	7.48	<0.05	4.44	110	1.54	110
10/16/2013	6.32	7.47	<0.05	4.48	110	1.27	110
11/12/2013	0.11	8.23	0.057	1.71	130	2.25	130
12/10/2013	0.04	6.7	0.11	6.44	140	0.629	140
1/15/2013	0.08	6.98	0.12	5.95	120	0.499	120
2/12/2013	0.1	7.06	0.085	5.77	130	0.562	130
3/12/2013	0.05	7.13	<0.05	5.59	130	0.479	130

References

Hothorn, T. and Hormik, K. 2012. Package ‘exactRankTests’.
URL: http://cran.r-project.org/web/packages/exactRankTests/exactRankTests.pdf.

R Development Core Team. 2012. R: a language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
URL: www.r-project.org/.

6.0
Appendix B

Table B1
Summary Statistics for the 2013 Data from the Athabasca River at Old Fort Monitoring Station – General Indicators

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

General Indicator	n	Max	Min	Median	Mean	P99.9	P99	P95	Variance	SD
Calcium (Ca^{2+})	12	41.0	20.0	35.5	33.5	41.0	40.9	40.5	53.4	7.3
Chloride (Cl^{-})	12	33.0	3.7	17.5	16.6	32.9	32.5	30.3	106.2	10.3
Magnesium (Mg^{+})	12	12.0	4.7	10.2	9.6	12.0	12.0	12.0	6.2	2.5
Nitrate (NO_3-N)	12	0.260	0.002	0.075	0.101	0.260	0.258	0.249	0.009	0.095
Potassium (K^{+})	12	2.1	0.9	1.5	1.5	2.1	2.1	2.0	0.1	0.4
Sodium (Na^{+})	12	34.0	8.6	20.0	20.2	34.0	33.7	32.4	91.8	9.6
Sulphate (SO_4^{-})	12	41.0	14.0	30.5	29.8	41.0	40.9	40.5	93.3	9.7
Total Ammonia (NH_{3+4}-N)	12	0.12	0.03	0.03	0.05	0.12	0.12	0.11	0.00	0.04
Total Dissolved Phosphorus (TDP)	12	0.027	0.007	0.019	0.017	0.027	0.027	0.026	0.000	0.006
Total Nitrogen (TN)	12	1.800	0.420	0.675	0.794	1.792	1.723	1.415	0.134	0.366
Total Phosphorus (TP)	12	0.120	0.023	0.037	0.054	0.120	0.118	0.108	0.001	0.033

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	12	110	5	12	30	110	108	99	1285	36
Aluminum T	12	14500	80	1625	3575	14455	14049	12245	22076386	4699
Antimony D	12	0.107	0.037	0.062	0.068	0.107	0.106	0.103	0.001	0.026
Antimony T	12	0.108	0.039	0.063	0.069	0.108	0.107	0.104	0.001	0.026
Arsenic D	12	0.7	0.4	0.5	0.5	0.7	0.7	0.7	0.0	0.1
Arsenic T	12	2.9	0.5	0.8	1.2	2.9	2.9	2.7	0.7	0.8
Barium D	12	60.6	34.7	50.8	49.6	60.6	60.6	60.6	82.0	9.1
Barium T	12	262.0	54.5	63.6	89.9	260.6	248.4	193.8	3518.4	59.3
Beryllium T	12	0.520	0.002	0.040	0.114	0.518	0.499	0.417	0.025	0.158
Bismuth T	12	0.0562	0.0005	0.0028	0.0122	0.0562	0.0559	0.0549	0.0004	0.0204
Boron D	12	42	19	28	28	42	41	36	37	6
Boron T	12	44	23	31	32	44	43	42	47	7

Metal Indicator	n	Max	Min	Median	Mean	99.9th P	99th P	95th P	Variance	SD
Cadmium D	12	0.0335	0.0048	0.0105	0.0126	0.0334	0.0322	0.0270	0.0001	0.0081
Cadmium T	12	0.3	0.0	0.0	0.1	0.2	0.2	0.2	0.0	0.1
Chromium D	12	0.77	0.04	0.38	0.40	0.76	0.75	0.70	0.05	0.23
Chromium T	12	12	0	1	3	12	12	10	15	4
Cobalt D	12	0.14	0.04	0.07	0.07	0.14	0.14	0.12	0.00	0.03
Cobalt T	12	5.4	0.1	0.4	1.0	5.4	5.2	4.1	2.6	1.6
Copper D	12	2.2	0.6	1.1	1.2	2.2	2.2	2.2	0.3	0.5
Copper T	12	10.7	0.7	1.6	2.8	10.7	10.3	8.9	9.7	3.1
Iron D	12	430	116	260	267	429	419	376	5462	74
Iron T	12	14800	457	1070	3321	14748	14283	12215	21263202	4611
Lead D	12	0.34	0.04	0.07	0.11	0.34	0.33	0.28	0.01	0.09
Lead T	12	10.6	0.1	0.4	2.2	10.6	10.6	10.5	15.2	3.9
Lithium D	12	16	4	7	8	16	15	13	11	3
Lithium T	12	18	6	8	10	18	18	17	16	4
Manganese D	12	31	1	12	13	31	30	28	110	11
Manganese T	12	351	20	53	86	349	327	233	8447	92
Mercury T	12	0.0113	0.0006	0.0032	0.0046	0.0113	0.0112	0.0108	0.0000	0.0040
Molybdenum D	12	0.7	0.1	0.6	0.5	0.7	0.7	0.7	0.0	0.2
Molybdenum T	12	2.8	0.1	0.6	0.7	2.8	2.6	1.7	0.5	0.7
Nickel D	12	2.6	0.3	0.7	1.0	2.6	2.5	2.4	0.6	0.8
Nickel T	12	14.4	0.4	1.4	3.1	14.3	13.8	11.2	18.1	4.3
Selenium D	12	0.332	0.152	0.190	0.207	0.332	0.330	0.320	0.003	0.058
Selenium T	12	0.428	0.202	0.263	0.288	0.428	0.424	0.407	0.006	0.079
Silver T	12	0.3610	0.0003	0.0109	0.0546	0.3586	0.3374	0.2428	0.0109	0.1046
Strontium D	12	248	98	213	199	248	248	248	2469	50
Strontium T	12	252	111	222	207	252	252	251	2174	47
Thallium D	12	0.0071	0.0026	0.0049	0.0052	0.0071	0.0071	0.0069	0.0000	0.0015
Thallium T	12	0.2320	0.0028	0.0174	0.0481	0.2309	0.2212	0.1781	0.0048	0.0691
Thorium D	12	0.1370	0.0002	0.0085	0.0315	0.1367	0.1339	0.1216	0.0022	0.0467
Thorium T	12	2.75	0.01	0.14	0.53	2.74	2.64	2.21	0.74	0.86
Titanium D	12	12	1	2	3	12	12	11	13	4
Titanium T	12	78	2	24	26	77	76	69	582	24
Uranium D	12	0.438	0.271	0.358	0.363	0.438	0.436	0.430	0.003	0.054
Uranium T	12	1.4	0.4	0.4	0.5	1.4	1.4	1.1	0.1	0.3
Vanadium D	12	0.630	0.166	0.312	0.370	0.630	0.626	0.611	0.030	0.174
Vanadium T	12	21.4	0.4	2.6	5.5	21.3	20.7	18.0	44.7	6.7
Zinc D	12	2.5	0.5	1.0	1.1	2.5	2.4	2.0	0.3	0.6
Zinc T	12	34.1	1.3	3.1	8.3	34.0	33.3	30.0	117.8	10.9

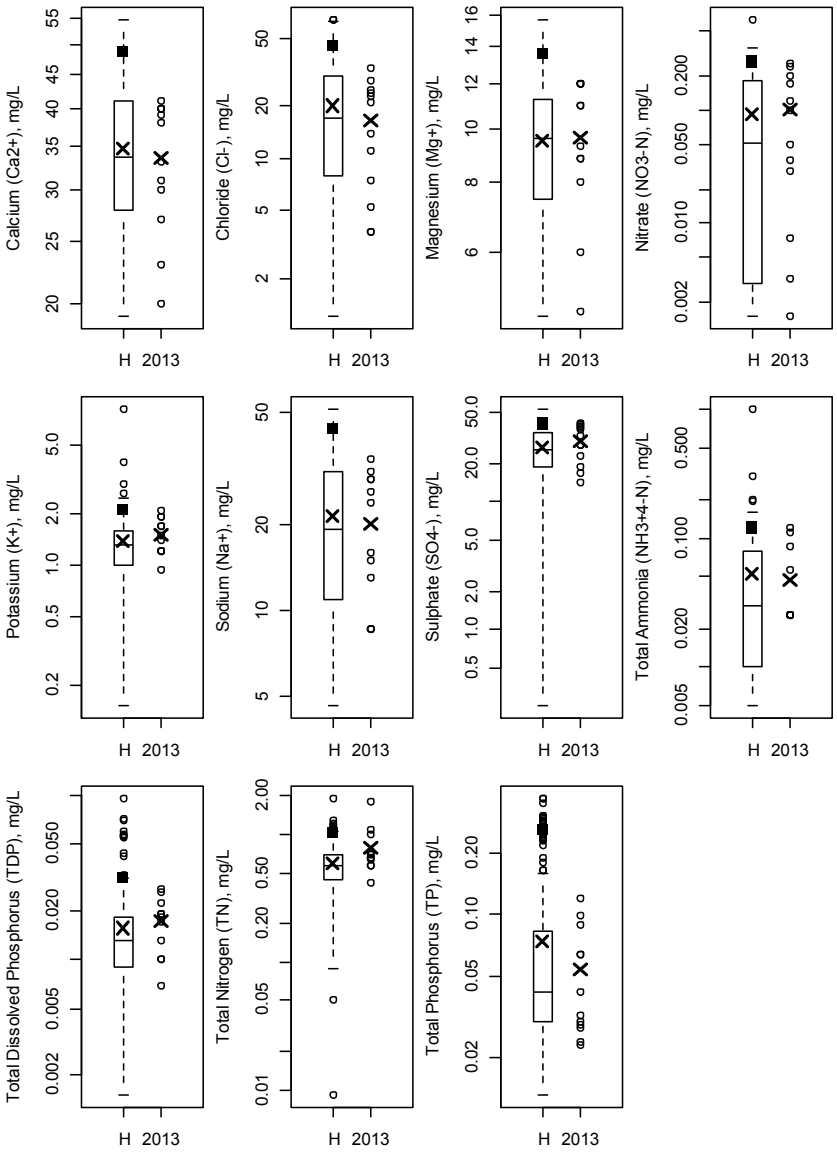


Figure B1
Graphical Presentation of the Historical and 2013 Data for the Athabasca River at Old Fort Monitoring Station – General Indicators.

Note: Historical data (H) are summarized with boxplots while all the 2013 data are shown. Crosses are the mean triggers calculated from the historical data or the mean of the 2013 data; boxes are the peak trigger calculated from the historical data.

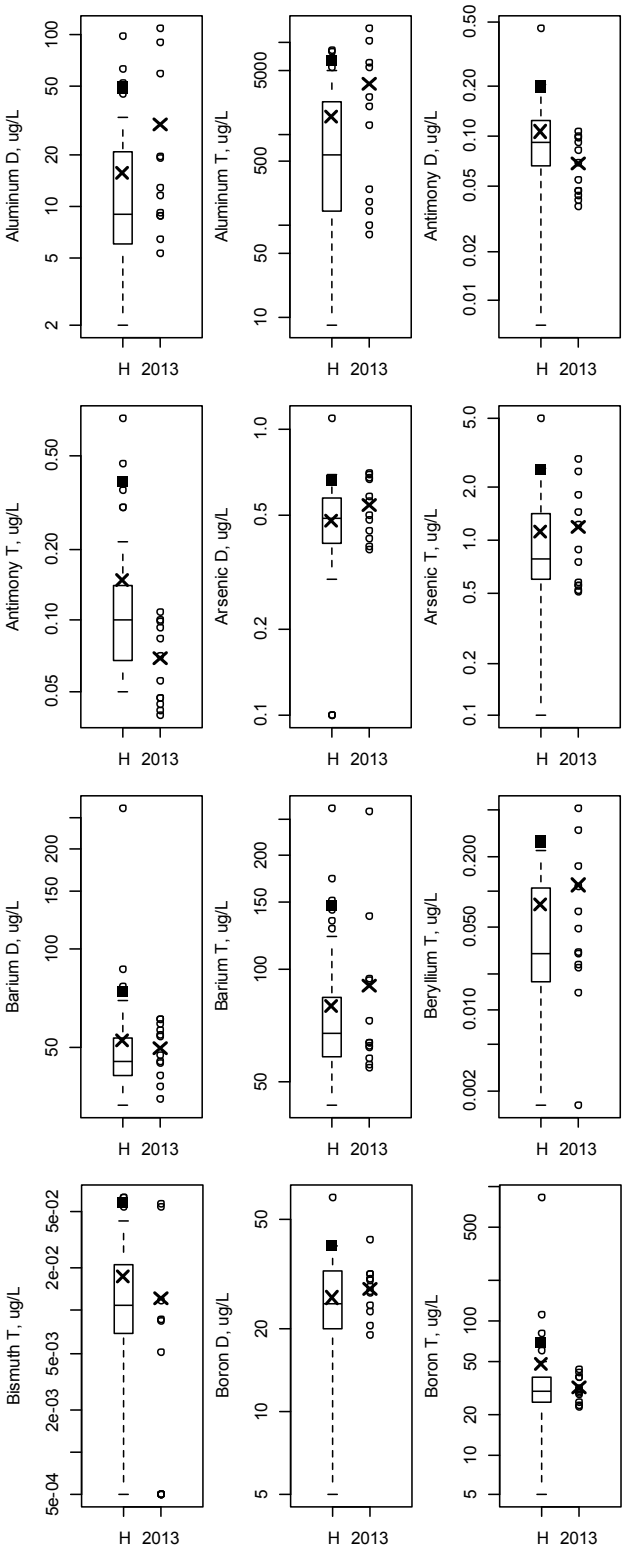
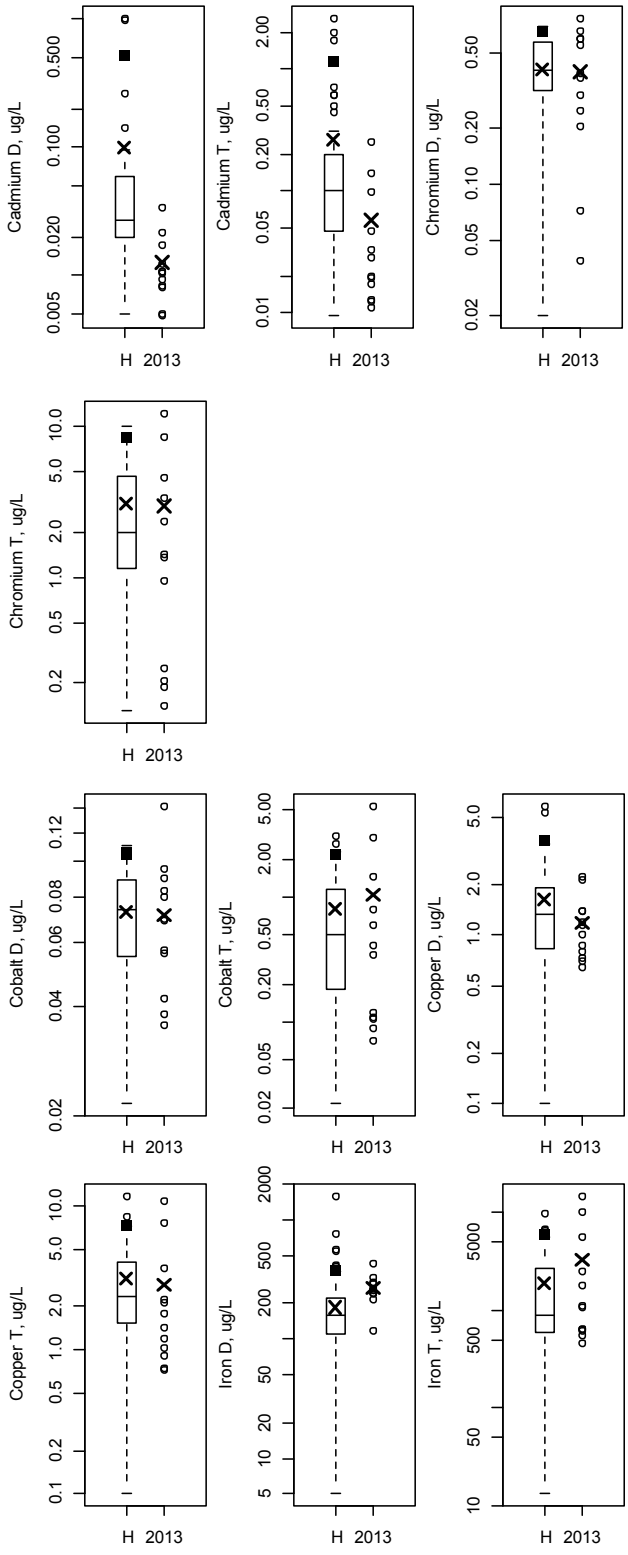
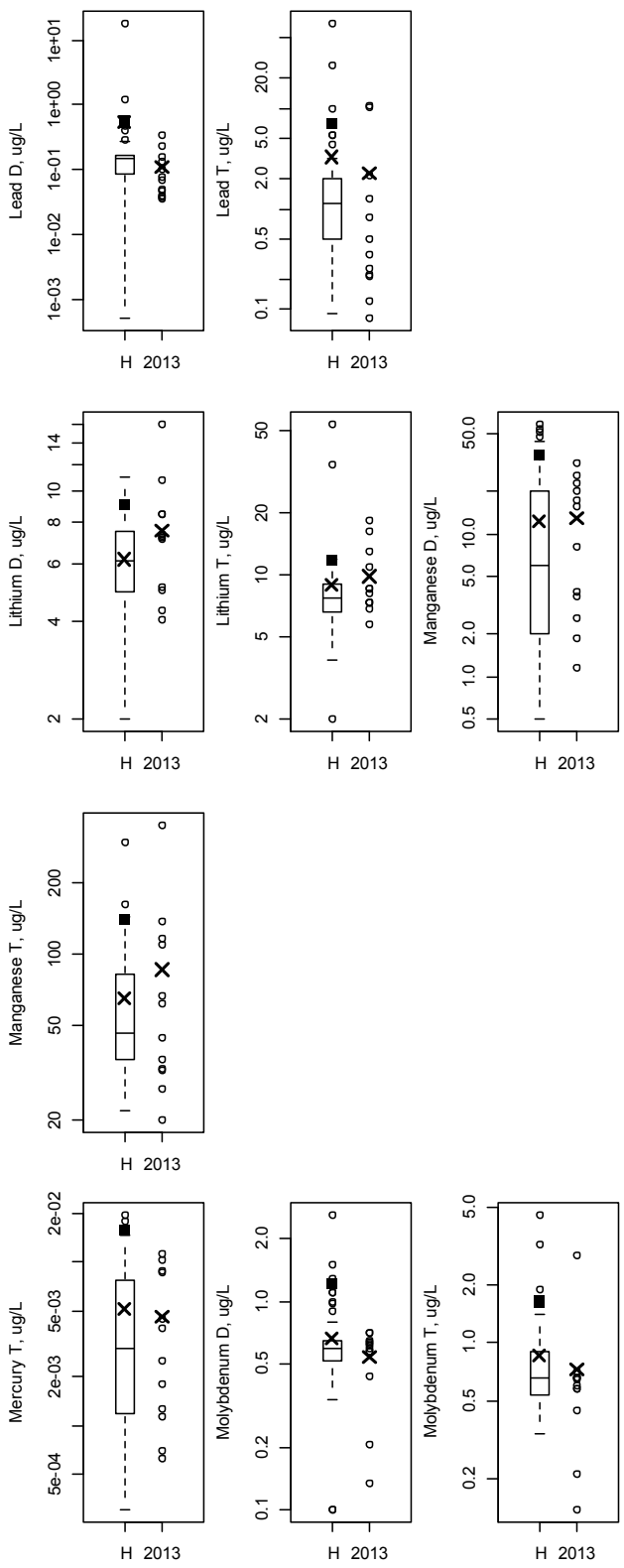


Figure B2
Graphical Presentation of the Historical and 2013 Data for the Athabasca River at Old Fort Monitoring Station – Metal Indicators.

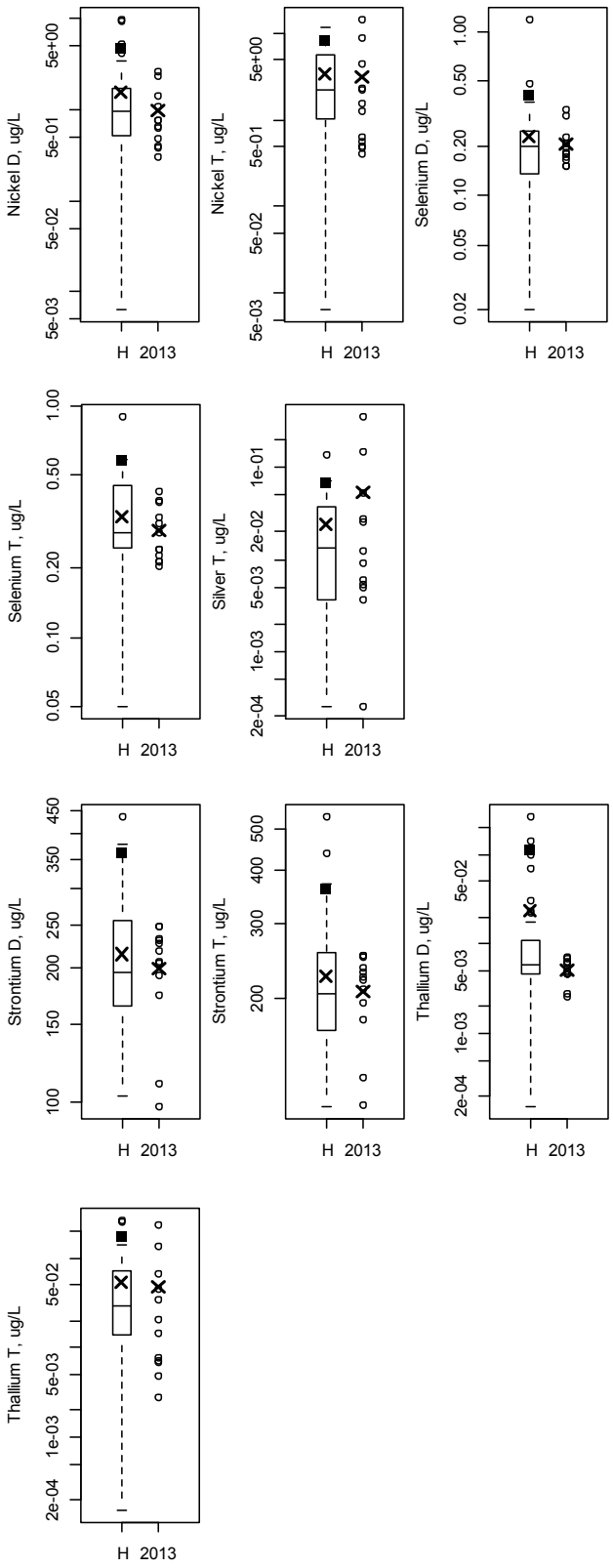
Note: Historical data (H) are summarized with boxplots while all the 2013 data are shown. Crosses are the mean triggers calculated from the historical data or the mean of the 2013 data; boxes are the peak triggers calculated from the historical data.



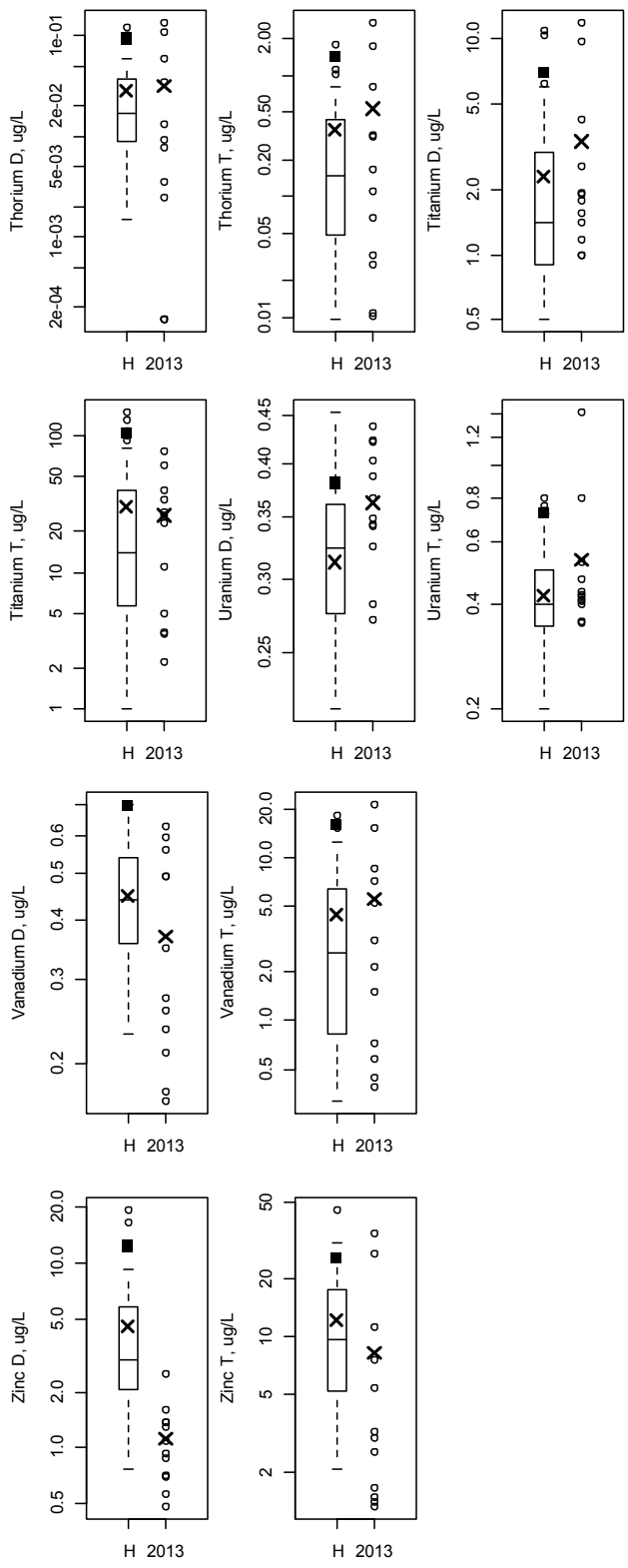
Cont'd Figure B2



Cont'd Figure B2



Cont'd Figure B2



Cont'd Figure B2