South Saskatchewan Region

Status of Management Response for Environmental Management Frameworks, as of October 2018

Alberta

Environment and Parks, Government of Alberta

October 2020

South Saskatchewan Region Status of Management Response for Environmental Management Frameworks, as of October 2018

Any comments or questions on the content of this report, as well as any inquiries on management framework development and implementation, may be directed to:

Alberta Environment and Parks
Lands Division
Email: AEP.Planning@gov.ab.ca

For copies of this report, please contact:

Information Centre
Alberta Environment and Parks
Toll Free Alberta: 310-3773
Email: env.infocent@gov.ab.ca

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Executive Summary

As part of the Integrated Resource Management System, this report outlines the status of the Government of Alberta's management response to crossings of air quality triggers for the years 2014 to 2017, and surface water quality triggers and limits from April 2014 to March 2018 in the South Saskatchewan Region. It fulfils commitments made to Albertans in the South Saskatchewan Region Air Quality Management Framework for nitrogen dioxide (NO_2), ozone (O_3), and fine particulate matter ($PM_{2.5}$) and the South Saskatchewan Region Surface Water Quality Management Framework for the mainstem Bow, Milk, Oldman, and South Saskatchewan Rivers (Alberta).

Air Quality

Since the initial reporting period of 2014, no limits have been exceeded for air quality under the framework. This means that air quality objectives identified in the South Saskatchewan Regional Plan are being met.

However, some proactive triggers were crossed. As a result, the Ministry of Environment and Parks is leading the management response, which is focused on improving knowledge and understanding of what is contributing to the observed air quality. This report communicates the status of the response as of October 2018, and includes an update on the management response initiated in previous years. The following is a summary of some key findings and the management response to date:

- Investigation findings to date suggest that urban non-point source emissions are a major influence on the air quality surrounding the monitoring stations. However, further investigation into particulate matter composition and the spatial and temporal variations of pollutants are recommended to confirm this initial finding.
- Identified potential regional management actions range from policy or regulatory initiatives to reduce emissions, to voluntary actions and raising awareness and education surrounding air quality. The focus of the management actions underway includes gathering baseline information, improving scientific understanding and knowledge, learning from other jurisdictions, and identifying initiatives that are already committed to or underway that can lead to future management of air quality. Some actions apply to the province as a whole, while others will be undertaken locally.

Surface Water Quality

Overall, the state of environmental health remains within the range of acceptable conditions, and surface water quality regional objectives identified in the South Saskatchewan Regional Plan (SSRP) are being met. In the most recent 2017/2018 reporting period, two surface water quality indicators (total dissolved solids and specific conductance) exceeded limits during the winter, at one monitoring station, and several trigger exceedances were observed for surface water. The water quality limit exceedances are based on agricultural irrigation guidelines but occur at a time when irrigation is likely not occurring. Work is underway to assess whether the limit exceedances are resulting in unacceptable risk to aquatic life and other surface water quality uses at the affected location.

In accordance with the commitments made in the SSRP, the Ministry of Environment and Parks is leading the management response to current and previously observed limit exceedances. This report provides updates on the status of the management responses for 2014/2015, 2015/2016, and 2016/2017 exceedances, and the status of the management response for the 2017/2018 exceedances.

The following is a summary of some key findings, actions and planned activities of the management response to date:

- 2014/2015 Update – Flow-adjusted trend assessments are complete for parameters that crossed triggers at the monitoring stations where the crossing occurred (i.e. total nitrogen at Bow River at Cochrane, specific conductance at Bow River at Carseland, pH at Oldman River at Brocket, and specific conductance at Oldman River at Hwy 36). Specific conductance at Bow River at Carseland will move into the investigation phase, while further preliminary assessment work is ongoing for the remaining parameters.
- 2015/2016 Update – An investigation has been initiated to assess the winter limit exceedance of total dissolved solids in the Milk River at Hwy 880. Unadjusted and flow-adjusted trend assessments are complete for parameters that crossed triggers or guidelines at the monitoring stations where the crossing occurred (i.e. total nitrogen at Bow River at Cochrane, total nitrogen at Bow River at Ronalane, nitrate at Bow River at Ronalane, sodium adsorption ratio at Oldman River at Highway 3, and total selenium at Oldman River at Hwy 36). The management response will be closed for total selenium at Oldman River Hwy 36, while further preliminary assessment work is ongoing for the remaining parameters.
- 2016/2017 Update – Preliminary assessment work is ongoing for parameters that crossed triggers or guidelines at the monitoring stations where the crossing occurred (i.e. sulphate at Bow River at Cochrane, sulphate at Bow River at Carseland, total dissolved solids at Bow River at Cluny) and an investigation has been initiated to assess the winter limit exceedance of total dissolved solids in the Milk River at Hwy 880.
- 2017/2018 – Preliminary assessment work is ongoing for parameters that crossed triggers or guidelines at the monitoring stations where the crossing occurred (i.e. specific conductance at South Saskatchewan River at Hwy 1, sulphate at Bow River at Cochrane, nitrate at Bow River at Carseland, nitrate at Bow River at Cluny, specific conductance at Bow River at Ronalane, total dissolved solids at Bow River at Ronalane, total selenium at Milk River at Hwy 880, and total selenium at South Saskatchewan River at Hwy 1) and an investigation has been initiated to evaluate the winter limit exceedance of total dissolved solids and specific conductance in the Milk River at Hwy 880.

Updates on the status of this management response will be provided in future reports and will be publicly available on the Alberta Environment and Parks website (aep.alberta.ca).

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1.0 Introduction to the Status of Air Quality Management Response

Under the South Saskatchewan Regional Plan (SSRP) (Government of Alberta [GoA], 2018a), a management response is initiated when the Minister of Environment and Parks determines a trigger (ambient air quality reaches the threshold for a new Level, Table 2, 3) or limit (ambient air quality exceeds the limit into Level 4, Table 2, 3), as identified in the South Saskatchewan Region Air Quality Management Framework (Alberta Environment and Sustainable Resource Development [AESRD], 2014a), has been exceeded.

Alberta Environment and Parks (AEP) is the lead coordinator of the management response, and works with other government branches and regulators (e.g. Alberta Energy Regulator) and external parties, as required to implement a management response.

Presently, three substances (nitrogen dioxide (NO_2), ozone (O_3), and fine particulate matter ($PM_{2.5}$)) are reported annually under the South Saskatchewan Region Air Quality Management Framework (AESRD, 2014a) using data collected at monitoring stations in Calgary, Lethbridge, and Medicine Hat (Figure 1).

A management response was initiated for the South Saskatchewan Region after triggers were crossed for NO_2, O_3 and $PM_{2.5}$ during the first reporting cycle. As each annual report on conditions becomes available, the management response is re-evaluated and updated based on new information.

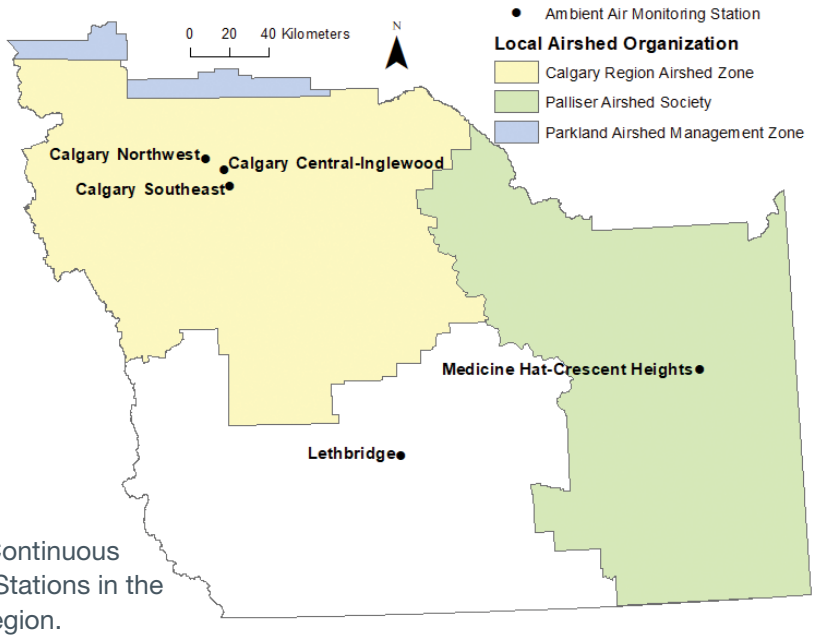

Figure 1. Location of Continuous Ambient Air Monitoring Stations in the South Saskatchewan Region.

This report provides an update on the management response since the last status report in October 2017. This is the third status report produced since the South Saskatchewan Regional Plan came into effect in September 2014.

A full description of the management system can be found in the South Saskatchewan Region Air Quality Management Framework (AESRD, 2014a). Initial steps include verification, preliminary assessment, and an investigation to determine the need for management actions. The management response for air quality considers a variety of factors, such as the type and location of the monitoring station, averaging time (hourly, 24 hour, or annual), and the ambient air quality trigger or limit that was exceeded.

The framework, as well as all air quality status and management response reports, can be found on the Environment and Parks website (aep.alberta.ca).

Steps of the Management Response

1.1 Understanding the Nature of Nitrogen Dioxide (NO_2), Ozone (O_3) and Fine Particulate Matter ($PM_{2.5}$)

In order to effectively develop a management response, it is important to first understand the nature of the pollutant(s) of concern and the potential cause(s).

Nitrogen dioxide (NO_2) is a reddish-orange-brown gas with an irritating, harsh, pungent odour. NO_2 occurs both naturally in the environment, (e.g. as a result of forest fires or atmospheric lightning), or can be human-caused, mainly the result of combustion processes, (e.g. combustion of fuel for vehicles or combustion of coal, oil, and natural gas for heating or industrial processes). NO_2 can be directly released into the air, but is more often produced by the conversion of nitrogen oxides (NO_x), which are released from combustion processes. In sunlight, NO_2 can lead to the formation of ozone, nitric acid, and nitrate-containing particles (Alberta Environment and Parks [AEP], 2011).

Ground-level ozone is a colourless gas, which can come from natural causes, such as vegetative processes, or from human-caused emissions. Ozone is not directly emitted into the atmosphere; it is formed through complex chemical reactions between emissions of nitrogen oxides (NO_x) and volatile organic compounds in the presence of heat and sunlight.

Particulate matter refers to solid or liquid particles suspended in the atmosphere. The size distribution and composition of particulate matter is a significant factor in determining risks posed to human health. Fine particulate matter ($PM_{2.5}$) has a diameter less than 2.5 µm. These smaller particles can penetrate deeper into the lungs, irritating the respiratory system and reducing the effective surface area for oxygen exchange. These particles can also transfer toxic compounds into the bloodstream (AEP, 2013).

$PM_{2.5}$ comes from both natural and human-caused sources. Natural sources of $PM_{2.5}$ include wind-blown dust and forest or grass fires. Examples of human-caused sources include transportation, industrial processes, home heating, and vegetation burning for land clearing and land-use change (AEP, 2013). $PM_{2.5}$ can be emitted directly into the atmosphere (known as primary $PM_{2.5}$) or derived as secondary $PM_{2.5}$ which is formed in the atmosphere from chemical reactions involving other gases under specific meteorological conditions (e.g. sulphur dioxide (SO_2), nitrogen oxides (NO_x), and volatile organic compounds (VOCs)). Management actions need to consider primary emissions of $PM_{2.5}$ and will also need to target the gases that contribute to the formation of secondary $PM_{2.5}$.

Air pollution from NO_2, 0_3, and $PM_{2.5}$ can have serious impacts on human and environmental health. Health impacts linked to these pollutants include chronic bronchitis, asthma, and premature death (Canadian Council of the Ministers of the Environment [CCME], 2017). Air pollution also results in increased costs and pressure on the health care system. Environmental effects of the framework indicators include reduced visibility, crop damage, and greater vulnerability to disease in some tree species (CCME, 2017).

2.0 Summary of Ambient Air Quality Levels Assigned

2.1 Verification and Preliminary Assessment

Alberta Environment and Parks conducts the annual assessment of ambient air quality data gathered from continuous ambient air monitoring stations in the South Saskatchewan region. Data are downloaded from Alberta's ambient air quality data warehouse and checked for accuracy and completeness. Once the data have been verified, the air quality metrics are used to assess ambient conditions relative to triggers and limits. Verification and preliminary assessment are reported in the 2017 Status of Air Quality, South Saskatchewan Region, Alberta (Brown, 2019).

For the fine particulate matter and ozone assessments, the methodology and procedures set out in the Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone (CCME, 2012) were followed to determine the Canadian Ambient Air Quality Standards (CAAQS) achievement status. This includes examination of data for transboundary flows and exceptional events (i.e., forest or grass fires).

2.2 Minister's Determination

The Minister's Determination for 2017 confirmed that no air quality limits were exceeded in the South Saskatchewan Region. However, air quality triggers were crossed at several of the monitoring stations in 2017, resulting in assigning ambient air quality levels described in the 2017 Status of Air Quality, South Saskatchewan Region, Alberta report (Brown, 2019) (Table 1) and described below. Results from status assessments in previous years can be found on the AEP website (aep.alberta.ca).

2.2.1 Nitrogen Dioxide

Based on the 2017 Status of Air Quality South Saskatchewan Region Report, Level 2 is assigned for nitrogen dioxide (NO_2) in Calgary and Level 1 for NO_2 in both Medicine Hat and Lethbridge. The Calgary Central (2) station was previously assigned Level 3 for NO_2 in 2014, but has been assigned Level 2 for the last two years of reporting since moving to the Calgary Central-Inglewood location in 2015. The Level 2 management intent is to improve knowledge and understanding.

2.2.2 Ozone and Fine Particulate Matter

To maintain consistency with reporting on achievement of the Canadian Ambient Air Quality Standards (CAAQS) under the national Air Quality Management System (AQMS), ozone (O_3) and fine particulate matter ($PM_{2.5}$) are reported for three-year periods. The 2016 (2014-2016 reporting period) CAAQS assessment results place the South Saskatchewan region into Level 2 for $PM_{2.5}$ and O_3. The Level 2 management intent is to improve knowledge and understanding. Management levels have not yet been assigned for $PM_{2.5}$ and O_3 for the 2015- 2017 reporting period because analysis is still underway.

For the most recent reporting year, $PM_{2.5}$ levels at all Calgary stations have dropped from a Level 3, in the previous three reporting years, to a Level 2. Levels for $PM_{2.5}$ at Lethbridge have varied between Level 2 and 3 among the four reporting years, and are at Level 2 in the most recent reporting year. Levels for $PM_{2.5}$ at Medicine Hat have varied between Level 2 and 3 among the initial three reporting years, and are at Level 2 or lower for the current reporting years.

For O_3, the Calgary Northwest and Southeast stations are at a Level 2, and the newly located Calgary Central-Inglewood station is reported as a Level 3. However, the Calgary Central-Inglewood station only has two years of data, not three, so is not included in the region's metric this reporting period. Ozone levels have been consistent at Level 2 for the Lethbridge and Medicine Hat stations for all reporting periods, including the most recent.

In a case where a station is assigned to an air quality level and needs management actions one year, then falls to a lower level the following year, management actions are still carried out but may be modified accordingly.

Table 1. Ambient Levels Assigned to Air Quality Monitoring Stations in the South Saskatchewan Region for 2014, 2015, 2016 and 2017 Based on Triggers and Limits Established in the Framework for the Average of the Annual Hourly Data and Interim Upper Range of Hourly Data triggers for NO_2 and 2011-2013, 2012-2014, 2013-2015, 2014-2016 Management Levels for the O_3, $PM_{2.5}$ 24-hour and $PM_{2.5}$ Annual Metrics (AEP 2017a, Brown et al. 2018, Brown 2019).

Station	NO_2 Levels*								CAAQS Management Levels**											
	Annual Average				Upper Range				Ozone				$PM_{2.5}$ 24-hour				$PM_{2.5}$ Annual			
	2014	2015	2016	2017	2014	2015	2016	2017	2011-13	2012-14	2013-15	2014-16	2011-13	2012-14	2013-15	2014-16	2011-13	2012-14	2013-15	2014-16
Calgary Central 2	3				2				1	1	1		n/a[a]	3	3		n/a[a]	3	3	
Calgary Central - Inglewood			2	2			2	2				3[b]				n/a[a]				n/a[a]
Calgary Northwest	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	2	3	3	3	2
Calgary Southeast		2	2	2		2	2	2		n/a[a]	2	2		n/a[a]	n/a[a]	2		n/a[a]	n/a[a]	2
Medicine Hat	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	2	2	2 or lwr[c]
Lethbridge	1	1	1	1	1	1	1	1	2	2	2	2	2	2	3	2	3	2	3	2

* The NO_2 trigger levels in the table indicate the management level assigned under the SSRP Air Quality Management Framework.
- Management Level 4: Ambient air quality exceeding the air quality limit
- Management Level 3: Ambient air quality below but approaching the air quality limits
- Management Level 2: Ambient air quality below air quality limits
- Management Level 1: Ambient air quality well below air quality limits

** The O_3 and $PM_{2.5}$ trigger levels in the table were assigned based on the annual CAAQS assessments as outlined in the SSRP Air Quality Management Framework.
- Management Level 4: CAAQS refers to these as Actions for Achieving Air Zone CAAQS, or Red Management Level
- Management Level 3; CAAQS refers to these as Actions for Preventing CAAQS Exceedance, or Orange Management Level
- Management Level 2: CAAQS refers to these as Actions for Preventing Air Quality Deterioration, or Yellow Management Level
- Management Level 1: CAAQS refers to these as Actions for Keeping Clean Areas Clean, or Green Management Level

a Data completeness criteria were not met for the reporting period.

b One of the three years of the assessment period did not meet completeness criteria. The 3-year average is based on two years and is not considered for the region's metric.

c Transboundary flows and exceptional events (TF/EE) analysis is completed for all stations in level 3 or 4 management levels. The 2014-2016 assessment identifies stations in level 2 management level as level "2 or lower" if TF/EE analysis may have brought the station to a level 1 management level.

⧄ Station was not in operation

3.0 Status of Air Quality Management Response

The management response is a set of steps that is taken (in full or in part) when an ambient trigger or limit is exceeded. The management response will support the management intent associated with each trigger level or limit exceeded (Table 2 and Table 3). A full description of the management system is found in the South Saskatchewan Region Air Quality Management Framework for Nitrogen Dioxide (NO_2), Ozone (O_3) and Fine Particulate Matter ($PM_{2.5}$). The status of management response is reported on a yearly basis and may be supported by supplementary technical reports.

Table 2. Description and Management Intent for Average of Annual Hourly Data for NO_2 and the $PM_{2.5}$ and O_3 Ambient Air Quality

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

Table 3. Description and Management Intent for Upper Range of the Hourly Data Ambient Air Quality Levels for NO_2

Level	Description	Management Intent
4	Peak ambient air quality concentrations are likely exceeding the hourly objective	Reduce probability that hourly objectives are exceeded during peak events
Trigger into Level 4		
3	Peak ambient air quality concentrations may be approaching or exceeding the hourly objective	Maintain air quality to reduce probability that objectives are exceeded during peak events
Trigger into Level 3		
2	Peak ambient air quality concentrations below hourly objective	Improve knowledge and understanding, and plan
Trigger into Level 2		
1	Peak ambient air quality concentrations are well below hourly objective	Maintain air quality through standard regulatory and non-regulatory approaches

This section of the report provides an update on the ongoing investigation, identifies potential mitigative management actions, and summarizes progress made on the management response reported in the two previous South Saskatchewan Region Status of the Management Response for Environmental Management Frameworks Reports.

3.1 Investigation Update

The purpose of the investigation is to determine the likely factors influencing the performance of an indicator and inform decisions about management actions. The scale of the investigation depends on the management level as well as the complexity of the issue identified. Support from the public, Indigenous Peoples, industry, non-governmental groups, government at multiple levels, and regulatory agencies may all be important for understanding regional issues and exploring options to address ambient concentrations. Analysis of ambient concentrations and trends, and the identification of potential emission sources leading to elevated ambient concentrations, are ongoing. A summary of the work completed since the last status report is described below and detailed information of the data analysis is included in Appendix A.

3.1.1 Nitrogen Dioxide (NO_2)

In previous reports, the NO_2 investigation focused on the Calgary Central station, where the trigger into Level 3 was exceeded in 2014. In order to gain a better understanding of NO_2 conditions across the region, historical data were analyzed from the Calgary Northwest, Lethbridge, and Medicine Hat stations for 2011-2017, as well as for Calgary Central-Inglewood and Calgary Southeast stations for 2016-2017. The Calgary Central station discussed previously was required to relocate, due to property redevelopment, and the new location was named Calgary Central-Inglewood. Since both Calgary Central-Inglewood and Calgary Southeast stations were new monitoring locations, 2016 was the first year that the two stations met data completeness requirements.

The data analysis, detailed in Appendix A explored temporal variations of NO_2 events. Elevated concentrations, or 'events', were defined as 1 hour averaged NO_2 concentrations greater than 16 ppb (30 µg/m^3) (the trigger into Level 3). Overall, the land use and the time of day (Figure A1) when elevated concentrations are occurring, implies traffic emissions could be a notable contributor to elevated concentrations.

The seasonal variation was similar between the NO_2 data measured at all the air monitoring stations in the South Saskatchewan Region (Figure A2). While elevated concentrations may be observed throughout the year, they were more likely measured in the winter months and during lower wind speed conditions. This was consistent for Calgary, Lethbridge, and Medicine Hat. Lower wind speeds inhibit dispersion of NO_2 and other pollutants.

Elevated concentrations occurred in all years of the time period studied (Figure A3), with marginal variations of high NO_2 concentrations observed by year at the South Saskatchewan Region stations.

3.1.2 Fine Particulate Matter ($PM_{2.5}$)

In order to gain a better understanding of $PM_{2.5}$ conditions across the region, historical data were analyzed from the Calgary Northwest, Lethbridge, and Medicine Hat air monitoring stations. Since both Calgary Central-Inglewood and Calgary Southeast stations were new monitoring locations they were not included in the analysis, as data were not available for many of the reporting periods or the station only exceeded the trigger into Level 2 in the initial assessments. The data analysis, detailed in Appendix A explored temporal variations of $PM_{2.5}$ events and associated meteorological conditions. Elevated concentrations or 'events' were defined as 1-hour averaged $PM_{2.5}$ concentrations greater than 19 $\mu g/m^3$ (the trigger into Level 3).

The data from all the available CAAQS assessment reporting periods were analyzed, including 2011-2013, 2012-2014, 2013-2015, and 2014-2016. As part of the CAAQS assessment, the sample days with identified transboundary and exceptional events (which includes days identified as impacted by forest or grass fires) were removed from the data in order to isolate the contribution from human-caused concentrations.

Boundary layer effects, described in Appendix A.1, are impacting $PM_{2.5}$ concentrations similarly to what is seen in the NO_2 analysis (Figure A5). The land use and time of day when elevated concentrations are occurring implies that motor vehicle traffic emissions could be a notable contributor to measured elevated concentrations.

The seasonal $PM_{2.5}$ variation was similar among the data from all the South Saskatchewan Region air monitoring stations (Figure A6). Although elevated concentrations may be observed throughout the year, such concentrations were more likely in the colder winter months (November through March) and least likely to be observed in the summer. March had the highest occurrence of elevated $PM_{2.5}$ days across the region. Although high and low concentrations were observed to occur for a number of wind speeds, high concentrations were more likely to be observed during lower wind speed conditions (Figure A8). This was consistent for Calgary, Lethbridge, and Medicine Hat stations. Lower wind speeds inhibit dispersion of $PM_{2.5}$ and other pollutant gases.

Elevated concentrations occurred in all years of the time period studied (Figure A7) at all of the South Saskatchewan Region stations. The frequency of elevated $PM_{2.5}$ concentration at the Calgary Northwest station dropped slightly from 2011 through 2014, with a slight increase after 2015. Marginal variations of high $PM_{2.5}$ concentrations were observed by year at the Lethbridge station; the year with the lowest occurrence of elevated concentrations was in 2016. For Medicine Hat, slight annual differences of elevated concentrations occurred from 2011-2013, with a significant drop in 2014.

3.1.3 Emission Source Inventory and Photochemical Modelling

Environment and Parks has acquired consultant support to compile emissions source inventory information to conduct provincial-scale photochemical modelling in order to better understand the sources of $PM_{2.5}$ in the province. The project not only considers primary $PM_{2.5}$, directly emitted into the air, but also studies the known gases that contribute to the formation of secondary $PM_{2.5}$. The study focuses on the 2013 calendar year because at the time of

the development of the study (Fall 2017), this was the most recent date for which CAAQS management levels had been determined for Alberta. Emission sector-based zero-out scenarios were also conducted to determine the contribution of specific sectors to ambient air quality. A zero-out scenario compares a base case, with all emission sources active, to a scenario with a specific sector turned off or "zeroed-out." The difference in predicted concentrations between the base case and the zero-out scenario is indicative of the contribution of that sector to the total mass of $PM_{2.5}$. The study's findings will inform the ongoing investigation and will be reported on in the 2019 Status of the Management Response Report.

3.1.4 Investigation Summary

The investigation completed to date provides valuable information to better understand the factors contributing to the elevated NO_2 and $PM_{2.5}$ concentrations in the region. Similar boundary layer effects are impacting $PM_{2.5}$ concentrations as seen in the NO_2 analysis. Traffic emissions could be a driver for elevated concentrations of both contaminants given the time of day they occur and the land uses around the stations. The seasonal variation was similar between the monitoring data measured at all the air monitoring stations in the South Saskatchewan Region. While elevated concentrations of NO_2 and $PM_{2.5}$ may be observed throughout the year, such concentrations were more likely in the winter months during calm wind conditions. The seasonal variation of event days and the association of event days with lower wind speeds suggest that dispersion limiting mechanisms are likely driving NO_2 and $PM_{2.5}$ events.

Overall, the investigation findings to date suggest that effective management should focus on urban non-point source emissions, however further investigation into particulate matter composition and the spatial and temporal variations of pollutants are recommended to confirm this assumption.

3.2 Identification of Management Actions

Achieving the goal of the management actions within the South Saskatchewan Region requires a proactive and future-focused approach. Management actions are intended to support or complement, rather than replace, existing policies and regulations. These actions range from policy or regulatory initiatives to reduce emissions, to voluntary actions and raising awareness and education surrounding air quality.

The focus of the management actions includes gathering baseline information, improving scientific understanding and knowledge, learning from other jurisdictions, and identifying initiatives that are already committed to or underway that can lead to near-term and future air quality management. It is important to recognize that the impact of implementing certain actions may take several years to be realized. Collaboration of all stakeholders is key to the success of the proactive air quality management actions.

Management of non- point source emitters is inherently complex; it is an inter-governmental and cross- jurisdictional issue. Given the multitude of contributing emissions, determining appropriate management approaches requires collaboration of a variety of stakeholders. Based on the current information and understanding about key sectors and pressures within

the South Saskatchewan Region, Alberta Environment and Parks (AEP) staff met previously with the Palliser Airshed Society, Calgary Region Airshed Zone (CRAZ), and Lethbridge area stakeholders to identify initiatives that are already underway that contribute to the overall management of particulate matter ($PM_{2.5}$). $PM_{2.5}$ was the substance of focus at the time, as the need to manage this substance was triggered for Calgary, Lethbridge, and Medicine Hat in the first reporting cycle. Some initiatives directly relate to $PM_{2.5}$ while others relate indirectly through the management of gases that can lead to PM formation (nitrogen oxides (NO_x), sulphur dioxide (SO_2) and volatile organic compounds (VOCs)). The added benefit of many of the listed actions is that NO_x emissions are directly or indirectly managed as well.

Recently, AEP staff have reconnected with several of the stakeholders to review and update the list of initiatives. The list allows AEP and stakeholders to consider what is occurring in some parts of the region that could be implemented elsewhere, and to consider where gaps in the system exist in the current Level 2 or a potential Level 3 situation. The list of current stakeholder initiatives underway across the South Saskatchewan Region (SSR) is included in Appendix B.

AEP will continue to engage with stakeholders on an ongoing basis to maintain an updated list of all current initiatives that consider air quality or have air quality co-benefits, and to identify new actions that may be required to meet the management intent. Opportunities for collaborative action amongst stakeholders will also be explored.

Ongoing investigation and studies will continue to inform and establish necessary and appropriate mitigative actions. A primary focus of the management actions is on knowledge improvement to better understand possible contributors to the elevated air quality concentrations in urban centres of the SSR. In addition to the ongoing temporal analysis of the monitoring data as reported above, short term data collected in Lethbridge and Medicine Hat will be reviewed to assess spatial conditions and information related to the PM composition will also be studied. The findings from the Community Multi-scale Air Quality (CMAQ) modelling and emissions inventory study will also inform the ongoing investigation (see Section 3.1.3).

The current identified management actions are detailed below. A series of recommended management actions were also identified as part of the South Saskatchewan Air Zone Government of Alberta Action Plan Canadian Ambient Air Quality Standards Response (AEP, 2017b) which are also included below. Several of the policies and management actions listed can also apply provincially to improve protection of air quality. The status of the continuing management actions are summarized in Section 3.3.

3.2.1 Knowledge Improvement

Currently, Alberta has the largest network of ambient air monitoring stations in Canada. Alberta Environment and Parks (AEP) will work with local airshed organizations and other partners to advance knowledge in priority areas and use collected information to determine management approaches.

Action	Description
Ambient data analysis	AEP will analyze available monitoring data to investigate possible causes or influences on elevated concentrations, look at links to meteorology and covariance between pollutants, and identify any long-term trends etc. Review available information (NAPS data collected at Calgary Central-Inglewood, existing studies in similar urban centres) on particulate matter composition to identify possible emission sources. Assess short-term monitoring survey results from City of Lethbridge AEP Mobile Air Monitoring Laboratory study and Palliser Airshed Society (PAS) mobile Airpointer Medicine Hat Airport location for additional spatial information.
Additional ambient air monitoring	PAS mobile Airpointer ambient monitor sited temporarily at the Medicine Hat Trap Club to assess air quality northeast of Medicine Hat. Calgary Region Airshed Zone proposed implementation of portable air monitoring station to address monitoring gaps and provide the Air Quality Health Index (AQHI) in previously unmonitored areas.
Provincial emissions inventory for photochemical modelling	AEP has acquired consultant support to compile a provincial emissions inventory for conducting photochemical modelling.
Provincial photochemical modelling	AEP has acquired consultant support to conduct provincial scale photochemical modelling to better understand the sources of fine particulate matter in the province. The study findings will be reported on in the 2019 Status of the Management Response Report.

3.2.2 Policy Actions

Alberta is assessing policies that can be applied in air zones that have triggered the need for management. While some of these actions may not be directly applicable to the South Saskatchewan air zone, pollution can be transported long distances, so actions taken in one air zone may lead to air quality improvements in others as well. Technology and equipment standards and policy for point sources, such as large industry, and non-point sources, such as transportation, will be assessed.

Action	Description
Action on non-point air emission sources such as transportation.	The Government collaborated with industry, non-government organizations, and airsheds cross- provincially through the Clean Air Strategic Alliance (CASA) to develop consensus-based recommendations for management actions on non-point sources such as transportation and wood burning. The CASA report, Recommendations to Reduce Non-Point Source Air Emissions in Alberta (March 2018), is helping to inform action on non-point sources. The CASA ROVER III Project, recommended by the CASA non-point source report, commenced May 2018 with roadside vehicle emissions testing planned to occur in Spring 2019.

3.2.3 Regulatory Process Actions

Industrial facilities in Alberta regulated by the *Environmental Protection and Enhancement Act* operate under the terms and conditions stipulated in their respective approval documents, which include emission control standards. These standards are typically updated when the facility approval is renewed on a 10-year cycle. Efforts are ongoing to ensure principles of continuous improvement are incorporated into the approval process to support environmental outcomes. The Government of Alberta is committed to taking actions to reduce emissions from existing sources and requires control technologies on par with leading jurisdictions for major new sources.

Action	Description
Action on industrial emissions	Industrial approvals in Alberta are issued for a maximum ten-year period. The Alberta Energy Regulator and Environment and Parks are requesting more stringent emissions standards be applied to all industrial sources in renewal applications that are in air zones which require management based on environmental frameworks or the Canadian Council of Ministers of the Environment (CCME) Air Quality Management System. Data and information on current operations, management practices and technologies will be collected.

3.2.4 Engagement Actions

Air quality management is multi-faceted, requiring the participation of numerous affected people, industries, and agencies. There are two aspects to engagement actions. The first is in recognizing the work required with stakeholders to achieve a better understanding of regional priorities to pursue appropriate management initiatives aligned with regional needs. The second is focused on outreach and education to inform the public and stakeholders on the state of air quality, how it impacts them, and what they can do the help.

Action	Description
Develop a provincial air literacy program.	AEP will update and develop, as required, suitable air quality literature for the public (i.e. social media campaigns to encourage being idle free, alternative transportation modes, fuel efficiency, vehicle maintenance, etc.).
Calgary Region Airshed Zone (CRAZ) Particulate Matter and Ozone / Air Quality Management Plan	AEP will continue to support the implementation of the PM and Ozone / Air Quality management plan by a multi-stakeholder group for the Calgary Region. Activities Include: Stakeholder forum for air quality management in the Calgary region, CRAZ Idle Free Tool Kit, and CRAZ Commuter Connect Options Toolkit

3.3 Oversight/Delivery of Management Actions

The previous 2014, 2015, and 2016 Status of the Management Response reporting suggested that management of point and non-point source emissions will be required. A number of actions were underway at that time. Table 4 provides the status of delivery of those management actions.

Table 4. Status of Delivery of Air Quality Management Actions

Action	Status	Description
Management Intent: Level 3 - Proactively maintain air quality below the limit Level 2 – Improve knowledge and understanding, and plan		
Establish provincial air emission policy, including defining standards / tools to apply to reduce emissions in air zones that require management based on environmental framework trigger crossings.	Ongoing	Jurisdictional review has been completed and published online (https://open.alberta.ca/publications/9781460130148).
Establish and update source standards for both industrial sectors and equipment to reduce emissions.	Ongoing	More stringent equipment standards for new boilers and heaters are undergoing internal review.
Reduce methane emissions in Alberta co-benefits in improving air quality as methane contributes to ozone formation.	Ongoing	Implementation is complete on the Carbon Competitiveness Incentive Regulation and development of key protocols and programs to incent significant methane reductions in the oil and gas sector. In collaboration with the Alberta Energy Regulator (AER) and Alberta Energy, draft methane reduction and reporting requirements were released in Spring 2016. Work on developing final requirements through revision to key AER directives is on track for fall 2018. Progress towards methane reduction target will be monitored and reported to Albertans through the Annual Progress Report.

Action	Status	Description
Action on non-point sources such as transportation.	Ongoing	The Clean Air Strategic Alliance (CASA) non-point source report, *Recommendations to Reduce Non-Point Source Air Emissions in Alberta* (CASA, 2018), and is helping to inform action on non-point sources. A CASA ROVER III Project, recommended by the CASA non-point source report, commenced May 2018 with roadside vehicle emissions testing planned to occur in Spring 2019. The Government continues to support the development of green transit alternatives and continues to collaborate with federal/provincial/territorial jurisdictions through the Canadian Council of Ministers of the Environment (CCME) Mobile Sources Working Group to help inform further transportation management actions in Alberta.
Better understand contributions from small businesses and manufacturing that do not require an *Environmental Protection and Enhancement Act* approval to the fine particulate matter issue.	Ongoing	Alberta Environment and Parks (AEP) has acquired consultant support to compile a provincial emissions inventory and conduct provincial-scale photochemical modelling in order to better understand the sources of fine particulate matter ($PM_{2.5}$) in the province.
Update Alberta Ambient Air Quality Objectives	Ongoing	The updated $PM_{2.5}$ objective is proceeding towards finalization in fall of 2018. Work is continuing on review of objectives for ozone, nitrogen dioxide, sulphur dioxide, and potential development of an objective for total reduced sulphur compounds. The review cycle is expected to be complete in early 2020.
Action on industrial emissions	Ongoing	The authorization process is used to adapt and improve environmental performance at regulated industrial facilities.
Ambient data analysis	Ongoing	Investigation is ongoing. Summaries of data analysis are provided in status of the management response reporting.

Action	Status	Description
Additional ambient air monitoring	Complete Complete Complete	Airdrie permanent, continuous monitoring station commissioned in April 2017. Conducted short-term mobile air monitoring survey in the City of Lethbridge to assess spatial variability of air quality in the City. Findings from this study will be reported on in the 2019 Status of the Management Response Report. Palliser Airshed Society mobile Airpointer ambient monitor sited at temporary Medicine Hat airport location to assess representativeness of permanent Crescent Heights ambient monitoring station.
Develop a provincial air literacy program.	Ongoing	AEP will undertake the development of an air literacy strategy. The strategy will complement the Ministry's development of literacy strategies for recreation on public land, water, land, biodiversity, and climate change. The air literacy strategy will reflect input from internal staff and partners to ensure strategic alignment and pragmatic implementation.
Collaborate with existing stakeholder connections and support management actions underway.	Ongoing	AEP carried on discussions with stakeholders and continues to support existing initiatives underway.
Calgary Region Airshed Zone (CRAZ) Particulate Matter and Ozone / Air Quality Management Plan.	Ongoing	AEP actively participates in implementation of the CRAZ Particulate Matter and Ozone Management Plan.

4.0 Air Quality Next Steps

Alberta Environment and Parks (AEP) will continue to oversee the delivery of the identified management actions while also continuing the investigation into the trigger crossings, particularly at the stations triggering into Level 3. AEP will work with specific stakeholders to inform the investigation and assist in identifying any additional management actions that may be necessary to address point and non- point source emissions.

Progress updates on the work outlined in this report will be communicated to the public in the 2019 Status of the Management Response report.

5.0 Introduction to the Status of the Surface Water Quality Management Response

Under the South Saskatchewan Regional Plan (Government of Alberta [GoA], 2018a), a management response must be initiated when the condition of one of the 15 primary indicators (Table 5) has exceeded a trigger or limit, as determined by the Minister of Environment and Parks. The South Saskatchewan Region Surface Water Quality Management Framework (SWQMF) (Alberta Environment and Sustainable Resource Development [AESRD], 2014b) also identifies six secondary indicators (Table 6). While no triggers or limits exist for secondary indicators (due to limited historical data), exceedances of relevant surface water quality guidelines must be reported, and a management response may be undertaken. Part of the management response is determining the need for management action(s).

There are nine ambient water quality monitoring stations in the South Saskatchewan Region where data are used for the annual assessment (Figure 2). The framework follows the water year, with assessments completed annually for the open water season (April to October) and winter season (November to March).

This is the third status of management response report produced since the South Saskatchewan Regional Plan came into effect in September 2014.

Table 5. List of Primary Indicators for South Saskatchewan Region SWQMF

Total Ammonia	Specific Conductivity
Chloride	Total Dissolved Solids (TDS)
Nitrate	Total Organic Carbon
Total Nitrogen	Total Suspended Solids
Total Dissolved Phosphorus	Turbidity
Total Phosphorus	pH
Sulphate	*Escherichia coli*
Sodium Adsorption Ratio (SAR)	

Table 6. List of Secondary Indicators for South Saskatchewan Region SWQMF

Mercury	Dicamba
Selenium	Methylchlorophenoxyacetic acid (MCPA)
2,4-Dichlorophenoxyacetic acid (2,4-D)	Mecoprop (MCPP)

A full description of the management system can be found in the South Saskatchewan Region SWQMF. The management response is a set of seven steps that must be undertaken (in full or in part) when an ambient water quality trigger or limit is exceeded. Since trigger crossings are based on historical data and statistically defined, they do not necessarily signal additional risk to the aquatic environment or water uses. Initial steps include verification and preliminary assessment to determine the need for further investigation and management actions.

The management response for surface water quality will consider a variety of factors including: the number and location of monitoring stations where exceedances were reported, trends in the data for multiple timeframes to understand temporal variability, an assessment of risk of the exceedances to the aquatic environment or water uses, and any additional influences (natural or human-caused) including the influence of flow.

This status report summarizes work that has been completed to date on the management response. It provides an update on the management responses that were initiated in 2015 (Alberta Environment and Parks [AEP], 2017c) in response to the 2014/2015 trigger crossings, and in 2017 (AEP, 2018) in response to the 2015/2016 and 2016/2017 trigger crossings, and describes the management response to date for the 2017/2018 exceedances. Environment and Parks is the lead in undertaking the management response and will work with other government organizations and external parties as required.

Steps of the Management Response

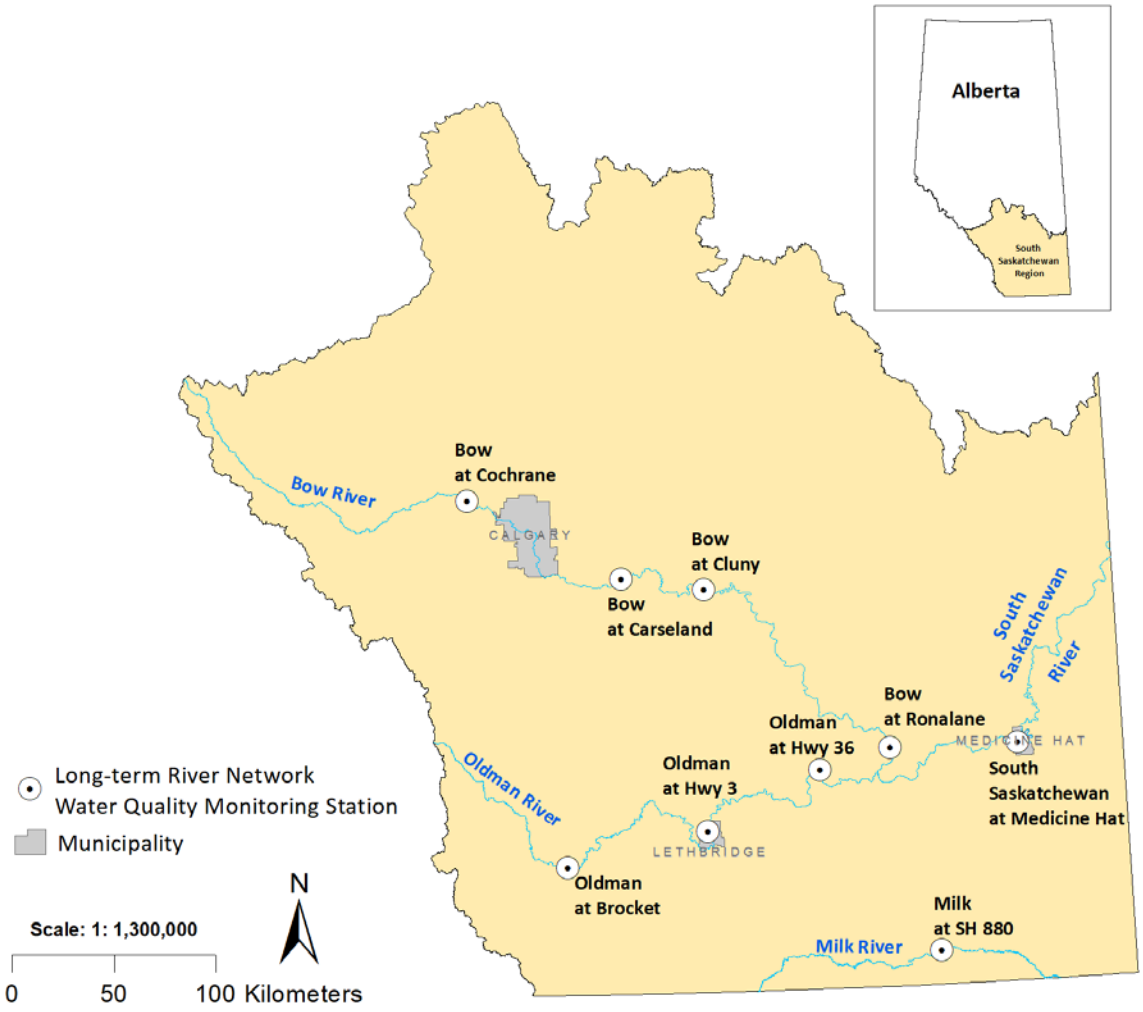

Figure 2. Location of Nine Long-term River Network Water Quality Monitoring Stations included in the South Saskatchewan Region Surface Water Quality Monitoring Framework.

6.0 Summary of Water Quality Exceedances

A visual summary of the exceedances to date is presented in Figure 3 (AEP 2017d; Kerr et.al. 2018a, 2018b, Chung et.al, 2019). Since the framework took effect in 2014, indicators have exceeded a trigger at a number of surface water quality monitoring stations:

- four trigger crossings in 2014/2015,
- four trigger crossings in 2015/2016,
- three trigger crossings in 2016/2017, and
- six trigger crossings in 2017/2018.

Two indicators have exceeded a limit for:

- total dissolved solids in the Milk River at Hwy 880 station in 2015/2016, 2016/2017, and 2017/2018, and
- specific conductance in the Milk River at Hwy 880 station in 2017/2018.

One of the secondary indicators (selenium) exceeded a guideline in:

- the Oldman River at Hwy 36 station in 2015/2016, and
- the Milk River at Hwy 880 station in 2017/2018.

One of the secondary indicators (selenium) was equal to (met) the guideline in:

- the South Saskatchewan River at Hwy 1 station in 2017/2018.

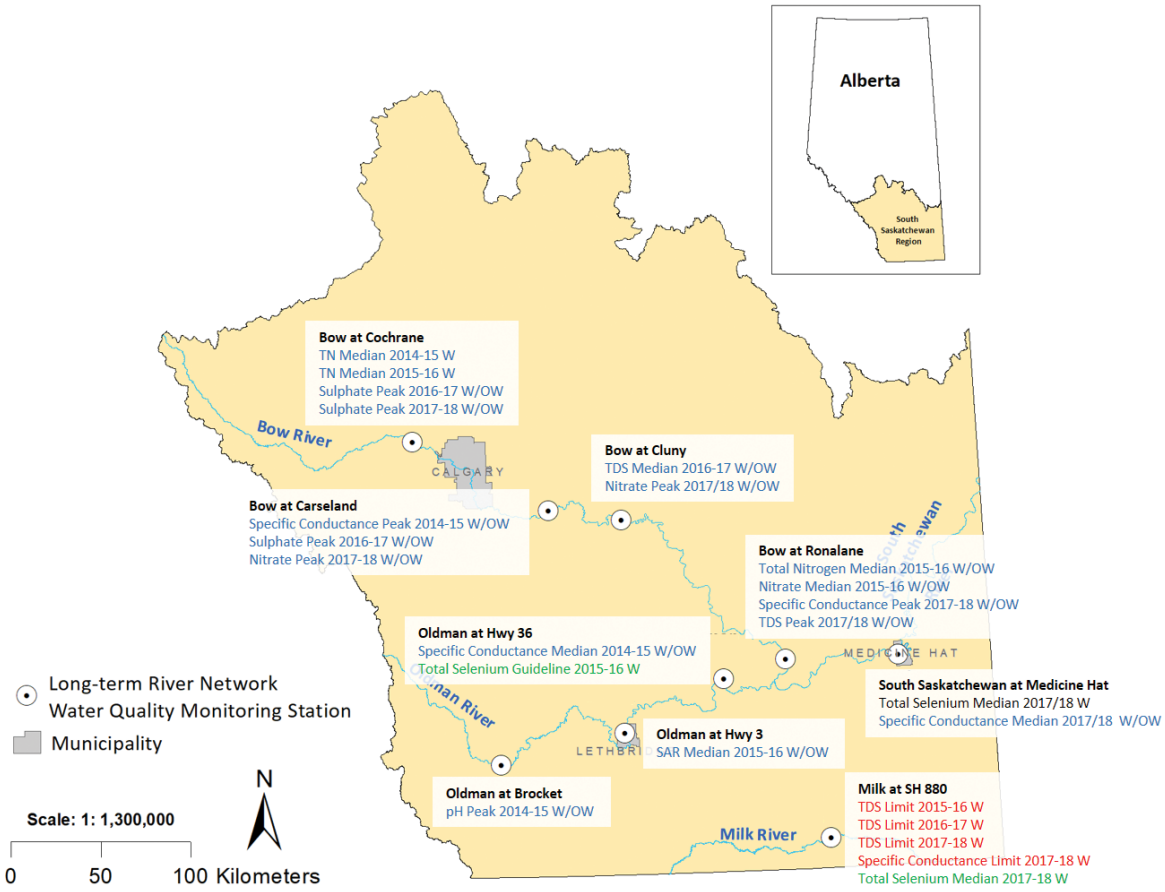

Figure 3. Summary of the Surface Water Quality Indicator Limit, Trigger or Guideline Exceedances at the South Saskatchewan Region SWQMF Monitoring Stations 2014-2018:

- Blue: trigger crossing of primary indicator (median or peak)
- Red: limit exceedance of primary indicator
- Green: guideline exceedance of secondary indicator
- Black: guideline value was equal to the secondary indicator median value
- W: exceedance/crossing occurred in the winter
- OW: exceedance/crossing occurred in the open water period

All indicators that crossed a trigger in a past reporting period are currently in the preliminary assessment phase of the management response. This report identifies the indicators that will proceed to the investigation phase or will have their management response closed based on these preliminary assessments. Indicators that exceeded a limit will proceed immediately to investigation. A management response for the secondary indicator that exceeded a guideline has also been initiated at the stations where the exceedances occurred, involving the same preliminary assessment steps as per the primary indicators. The scope of the preliminary assessment may change in the future.

The purpose of a preliminary assessment is to better understand the conditions, data, and circumstances that may have contributed to the crossing or exceedance. The outcome of the preliminary assessment will determine next steps in the management response. The principle steps in the preliminary assessment are:

- comparison of the recent annual data with all available data since the beginning of the South Saskatchewan Region SWQMF's historical dataset at the monitoring station where the exceedance occurred,
- comparison of data from upstream and downstream monitoring locations,
- completing unadjusted, seasonally-adjusted and/or flow-adjusted trend analyses on multiple timeframes, and
- consideration of other site-specific influences or factors.

The purpose of an investigation is to determine the spatial and temporal scope of observed changes in surface water quality and to identify causes of the observed changes. The steps in this process are case-specific but often include:

- assessment of data from point sources and water quality stations other than the nine long-term river network water quality monitoring stations included in the South Saskatchewan Region Surface Water Quality Monitoring Framework,
- additional trend, loading and modelling assessments to track the source and understand potential drivers of change,
- other assessments evaluating the influence of anthropogenic (human-caused) nonpoint sources (e.g. land use), point sources (e.g. wastewater effluent) and natural sources (e.g. geology) on observed changes.

Once the observed change is understood, risks to the aquatic environment or water use may be assessed and mitigative management actions may be developed as necessary.

7.0 Status of Surface Water Quality Management Response

Table 7 provides a summary of trigger crossings, guideline crossings and limit exceedances to date. It also provides a brief overview of management response activities to date and the stage of management response in which each threshold crossing currently resides. For more detailed information on management response activities, please see previous management response reports.

7.1 2014/2015 Management Response

All indicators remain in the preliminary assessment stage. Since the previous management response report, flow-adjusted trend assessments have been completed and are described below.

Specific Conductance – Bow River at Carseland, Open Water and Winter Peak Trigger Crossings

The maximum values observed are approximately two-thirds of the 1000 µS/cm limit value. Trend results of unadjusted and flow-adjusted assessments reveal statistically significant increasing trends for both the 1999-2015 and 2009-2015 timeframes (Table 8). These results justified opening an investigation.

Specific Conductance – Oldman River at Hwy 36 Open Water and Winter Median Trigger Crossings

The maximum values observed are approximately two-thirds the 1000 µS/cm limit value. Trend results of unadjusted and flow-adjusted assessments reveal statistically significant increasing trends for the 1999-2015 timeframe, however, there are no statistically significant unadjusted or flow-adjusted trends for the 2009-2015 or 2005-2015 timeframes (Table 8). Further preliminary assessments will be done to inform the need for investigation and management actions.

pH – Oldman River at Brocket, Open Water and Winter Peak Trigger Crossings

The maximum values observed are within the 6.0 – 9.0 limit value range. Trend results of unadjusted and flow-adjusted assessments reveal statistically significant increasing trends for the 1999-2015 timeframe; however, there are no statistically significant unadjusted or flow-adjusted trends for the 2009-2015 or 2005-2015 timeframes (Table 8). Further preliminary assessments will be done to help determine the need for investigation and management actions.

Total Nitrogen – Bow River at Cochrane, Winter Median Trigger Crossings

No limit value is currently established for this indicator. Trend results of unadjusted assessments reveal statistically significant increasing trends for the 1999-2015 timeframe, however, there are no statistically significant flow-adjusted trends for the 1999-2015 timeframe and no statistically significant unadjusted or flow-adjusted trends for the 2009-2015 or 2005-2015 timeframes (Table 8). Further preliminary assessments will be done to help determine the need for investigation and management actions.

Table 7. History of Median (M), Peak (P) Trigger and Guideline (G) Crossings, and Median Limit (ML) Exceedances for Which Current Management Response is Ongoing.

Crossing or Exceedance	2014/2015		2015/2016		2016/2017		2017/2018		Management Response When Last Reported	Management Response as of Oct. 2018	Next Steps
	Open Water	Winter	Open Water	Winter	Open Water	Winter	Open Water	Winter			
Bow River at Cochrane Total Nitrogen		M		M					Verification complete. Comparison to historical data and up and down-stream stations complete (AEP, 2017c) Unadjusted and seasonally- adjusted trend assessments complete (AEP, 2018)	Unadjusted and flow-adjusted trend analysis completed (see Section 7.1)	Further Analysis
Bow River at Carseland Specific Conductance	P	P									Investigation
Oldman River at Brocket pH	P	P									Further Analysis
Oldman River at Hwy 36 Specific Conductance	M	M									Further Analysis
Milk River at Hwy 880 Total Dissolved Solids (TDS)				ML		ML		ML	Verification complete Comparison to historical data and up and down-stream stations complete (AEP, 2018)	Unadjusted and flow-adjusted trend analysis completed (see Section 7.2)	Investigation
Bow River at Ronalane Total Nitrogen			M	M							Further Analysis
Bow River at Ronalane Nitrate			M	M							Further Analysis
Oldman River at Hwy 3 Sodium Adsorption Ratio			M	M							Further Analysis
Oldman River at Hwy 36 Total Selenium				G							Close Management Response
Bow River at Cochrane Sulphate					P	P	P	P	Verification complete Comparison to historical data and up and down-stream stations complete (AEP, 2018)	Additional analysis on pause until flow data is available (see Section 7.3)	Further Analysis
Bow River at Carseland Sulphate					P	P					Further Analysis
Bow River at Cluny Total Dissolved Solids (TDS)					M	M					Further Analysis
Milk River at Hwy 880 Specific Conductance								ML		Verification complete. Comparison to historical data and up and down-stream stations complete. Unadjusted and seasonally-adjusted trend assessments complete (see Section 7.4)	Investigation
Bow River at Carseland Nitrate							P	P			Further Analysis
Bow River at Cluny Nitrate							P	P			Further Analysis
Bow River at Ronalane Specific Conductance							P	P			Further Analysis
Bow River at Ronalane Total Dissolved Solids (TDS)							P	P			Further Analysis
South Saskatchewan River at Highway 1 Specific Conductance							M	M			Further Analysis
Milk River at Hwy 880 Total Selenium								G			Further Analysis
South Saskatchewan River at Highway 1 Total Selenium								G*			Further Analysis

*guideline was met but not exceeded

Table 8. Status of Trend Assessments for the 2014/2015 Management Response. NT indicates no trend, + indicates significant (P<0.05) increasing trend, blank cells indicate no assessment completed. *Caution should be used when interpreting trend results with short timeframes.

Preliminary Assessment 2014/15 Trend Results								
	Season	Flow-adjusted Trend			Unadjusted Trend (Concentration)			Action
		1999-2015	2009-2015*	2005-2015	1999-2015	2009-2015*	2005-2015	
Trigger Exceedance								
Specific Conductance Peak Bow Carseland	Open Water	+	+		+	+		Investigation
	Winter	+	+		+	NT		
Specific Conductance Median Oldman at Hwy 36	Open Water	+	NT	NT	+	NT	NT	Further Analysis
	Winter	+	NT	NT	+	NT	NT	
Total Nitrogen Median (winter only) Bow Cochrane	Open Water	NT	NT	NT	+	NT	NT	Further Analysis
	Winter	NT	NT	NT	NT	NT	NT	
pH Peak Oldman Brocket	Open Water	+	NT	NT	+	NT	NT	Further Analysis
	Winter		NT	NT		NT	NT	

7.2 2015/2016 Management Response Update

The indicators that crossed a trigger or exceeded guideline are in the preliminary assessment phase of the management response, which will determine the need for an investigation. Total dissolved solids (TDS) at Milk River at Hwy 880 exceeded a limit and was moved to the investigation stage, which will be informed by the results of the preliminary assessment. Since the last management response report, unadjusted and flow-adjusted trend assessments have been completed and are described below (Table 9).

Table 9. Status of Trend Assessments for the 2015/2016 Management Response. NT indicates no trend, + indicates significant (P<0.05) increasing trend, - indicates significant (P<0.05) decreasing trend, Neg T indicates decreasing trend. Diss Se indicates dissolved selenium, T Se indicates total selenium. ^Some datasets have different time frames (i.e. TDS Milk 2003-2016, Selenium 2004-2016). *Caution should be used when interpreting trend results with short time frames.

Preliminary Assessment 2015/16 Trend Results								
		Flow-adjusted Trend			Unadjusted Trend (Concentration)			
	Season	1999-2016^	2009-2016*	2006-2016	1999-2016^	2009-2016*	2006-2016	Action
Trigger Exceedance								
Total Nitrogen Median (Winter only) Bow Cochrane	Open Water	NT	NT	NT	NT	NT	NT	Further Analysis
	Winter	+			NT			
Total Nitrogren Median Bow Ronalane	Open Water	NT	NT	NT	+	NT	NT	Further Analysis
	Winter	NT			NT			
Nitrate Median Bow Ronalane	Open Water	+	NT	NT	+	NT	NT	Further Analysis
	Winter	NT			NT			
SAR Median Oldman Hwy 3	Open Water	+	NT	NT	+	NT	NT	Further Analysis
	Winter	+			+			
Guideline Exceedance								
Total & Dissolved Selenium Median (Winter only) Oldman Hwy 36	Open Water	NT	-	NT	NT	NT	NT	Close Management Response
	Winter				Diss Se Neg T, T Se NT	NT	Diss Se Neg T, T Se NT	
Limit Exceedance								
Total Dissolved Solids Median (Winter only) Milk Hwy 880	Open Water	NT	NT	NT	NT	NT	NT	Investigation
	Winter		NT	NT	+	NT	NT	

Total Dissolved Solids – Milk River at Hwy 880, Winter Median Limit Exceedance

The winter median value of 510 mg/L for 2015/2016 is above the 500 mg/L limit value, therefore the indicator at this station automatically entered the investigation phase. Trend results of unadjusted assessments reveal statistically significant increasing trends for the 2003-2016 (winter only) timeframe, however, there are no statistically significant flow-adjusted trends for the 2003-2016 timeframe and no statistically significant unadjusted or flow-adjusted trends for the 2009-2016 or 2006-2016 timeframes. What follows is a summary of the activities that were performed as part of the investigation. Details of this work will be provided in a separate document and will be publicly available on the Environment and Parks website (aep.alberta.ca).

- Literature review of 67 documents, including state of the watershed reports, studies commissioned by the Milk River Watershed Council Canada, peer-reviewed scientific literature, and government reports.

- Compiled monthly surface water quality (grab) samples from sampling efforts made by the Milk River Watershed Council Canada, Alberta Environment and Parks, and the Groundwater Observation Well Network (GOWN). Data were collected between October 1976 and December 2017; however, data were not available for every month and/or year at every location. Similarly, not all of the sites measured the same suite of parameters. Data were available from the following sources:
    - 7 tributaries that feed into the Milk River;
    - 9 lakes or reservoirs that do not feed into the Milk River;
    - 10 groundwater monitoring wells from GOWN;
    - 2 surface water stations along the North Milk River; and
    - 10 surface water stations along the Milk River, including the south fork.
- Compiled high frequency information (data recorded every 15 minutes by a datasonde) for temperature, specific conductance, pH, and dissolved oxygen at Writing-on-Stone Provincial Park (winter 2011) and Highway 880 (summer 2008 and 2010; winter 2008, 2010, and 2011).
- Compiled ancillary information, including Milk River flow rates (from Environment and Climate Change Canada), air temperature, total precipitation, snow depth, and radiance (from Alberta Agriculture and Forestry).
- Compared TDS concentrations between open water periods and winter periods.
- Completed unadjusted and flow-adjusted trend assessments.
- Quantified the amount of variability in TDS concentrations at Highway 880 with different time scales.
- Quantified the amount of variability in high frequency specific conductance measurements.
- Created a model to predict specific conductance values based on historical measurements of air temperature and radiance.
- Geochemical indicators and plots were used to create “fingerprints” of different water types along the Milk River, Red Creek, Deer Creek, and groundwater from GOWN.
- Potential rock types and interactions were identified that were consistent with the geochemistry of the surface and groundwater samples.
- A system of equations was derived and solved for the dissolution/precipitation of calcite, dolomite, gypsum, and ion exchange.
- The estimate of ion exchange from the system of equations was used to propose a spatial location for the source of TDS.

- Groundwater chemistry from around the Milk River aquifer was compared to Milk River surface water chemistry.
- Flow rates along the Milk River were compared to identify locations and volumes of potential water loss/gain.
- The change in Milk River flow rates between the North Fork of the Milk River (near the border) and South Fork of the Milk River (at western crossing) and Milk River (at the Town of Milk River) was used to estimate a potential groundwater input.
- A mass balance between river input and groundwater was explored but found to be not feasible due to a lack of data.

Total Nitrogen – Bow River at Cochrane, Winter Median Trigger Crossing

No limit value is currently established for this indicator. Trend results of flow-adjusted assessments reveal statistically significant increasing trends for the 1999-2016 timeframe, however, there are no statistically significant unadjusted trends for the 1999-2016 timeframe and no statistically significant unadjusted or flow-adjusted trends for the 2009-2016 or 2006-2016 timeframes (Table 9). Further preliminary assessments will be done to help determine the need for investigation and management actions.

Total Nitrogen – Bow River at Ronalane, Open Water and Winter Median Trigger Crossings

No limit value is currently established for this indicator. Trend results of unadjusted assessments reveal statistically significant increasing trends for the 1999-2016 timeframe, however, there are no statistically significant flow-adjusted trends for the 1999-2016 timeframe and no statistically significant unadjusted or flow-adjusted trends for the 2009-2016 or 2006-2016 timeframes (Table 9). Further preliminary assessments will be done to help determine the need for investigation and management actions.

Nitrate – Bow River at Ronalane, Open Water and Winter Median Trigger Crossings

The maximum values observed are approximately half of the 3 mg/L limit value. Trend results of unadjusted and flow-adjusted assessments reveal statistically significant increasing trends for the 1999-2015 timeframe, however, there are no statistically significant unadjusted or flow-adjusted trends for the 2009-2015 or 2006-2016 timeframes (Table 9). Further preliminary assessments will be done to help determine the need for investigation and management actions.

Sodium Adsorption Ratio – Oldman River at Hwy 3 Open Water and Winter Median Trigger Crossings

The maximum values observed are approximately one fifth the limit value of 5. Trend results of unadjusted and flow-adjusted assessments reveal statistically significant increasing trends for the 1999-2016 timeframe, however, there are no statistically significant unadjusted or flow-adjusted trends for the 2009-2016 or 2006-2016 timeframes (Table 9). Further preliminary assessments will be done to help determine the need for investigation and management actions.

Total Selenium – Oldman River at Hwy 36, Winter Median Guideline Exceedance

The winter median value of 1.05 ug/L for 2015/2016 is above the guideline (1 ug/L) in place at the time of measurement (AESRD, 2014c). It is noteworthy that a revised guideline has recently been adopted (2 ug/L) (GoA, 2018b). Alberta Environment and Parks recently revised this guideline, as selenium guidelines have been updated by other jurisdictions based on recent scientific data. The new guideline 2 ug/L is above the observed and historical medians at Oldman River at Hwy 36. Trend results reveal statistically significant decreasing unadjusted trend, but no statistically significant flow-adjusted trends for the 2004-2016 and 2006-2016 timeframes and no statistically significant unadjusted trend, but a statistically significant decreasing flow-adjusted trend for the 2009-2016 timeframe (Table 9). These results justified closing the management response.

7.3 2016/2017 Management Response Update

Since total dissolved solids in the Milk River at Hwy 880 again exceeded a limit, it will remain in the investigation phase. The remaining three trigger exceedances, all for stations on the Bow River, are in the preliminary assessment phase, which will determine the need for an investigation

The preliminary assessment of triggers that were exceeded will continue once validated flow data is available for flow-adjusted trend assessments.

7.4 2017/2018 Management Response

The Minister's Determination for 2017/2018 (monthly water quality data collected and assessed for the period April 2017 to March 2018) confirmed that two limits and six triggers were exceeded for the primary indicators, and one guideline was met and one exceeded for the secondary indicators (Chung, et.al, 2019). These exceedances were reported as follows:

- Milk River at Hwy 880 station exceedance of the total dissolved solids limit for the winter period, similar to exceedances reported for the winter periods of 2015/2016 and 2016/2017.
- Milk River at Hwy 880 station exceedance of the specific conductance limit for the winter period.
- Bow River at Cochrane station crossing of the sulphate peak triggers for both the open water and winter periods, similar to reported exceedances in 2016/2017.
- Bow River at Carseland station crossing of the nitrate peak triggers for both the open water and winter periods.
- Bow River at Cluny station crossing of the nitrate peak triggers for both the open water and winter periods.
- Bow River at Ronalane station crossing of the specific conductance peak triggers for both the open water and winter periods.

- Bow River at Ronalane station crossing of the total dissolved solids peak triggers for both the open water and winter periods.
- South Saskatchewan River at Hwy 1 station crossing of the specific conductance median triggers for both the open water and winter periods.
- Milk River at Hwy 880 station median exceedance of the total selenium guideline for the winter period.
- South Saskatchewan River at Hwy 1 station median meeting of the total selenium guideline for the winter period.

Since total dissolved solids in the Milk River at Hwy 880 again exceeded a limit, it will remain in the investigation phase. The limit exceedance for specific conductance in the Milk River at Hwy 880 will move directly into the preliminary assessment and investigation phase, while the remaining trigger and guideline exceedances will move into the preliminary assessment phase.

7.4.1 Verification and Preliminary Assessment

Verification of the 2017/2018 data is complete. The 2017/2018 data were downloaded from the Alberta Environment and Parks Water Data System and the median and 90th percentile values were calculated and compared against historical triggers and limits. This work was undertaken by Environment and Parks, Environmental Monitoring and Science Division in preparation of the 2017/2018 Status of Surface Water Quality Report (Chung, et.al, 2019).

Preliminary assessment of the 2017/2018 management response is partially complete. The preliminary assessment of triggers that were crossed also involve looking at all data available since April 1999. This includes additional data from April 2009 to March 2016 that were not included in the annual assessment of trigger crossings. These additional years of data are included in the preliminary assessment data examination, since they represent recent water quality.

The first steps in the assessment, comparison with historical data and data from up and down-stream stations, are presented below. Additionally, unadjusted and seasonally-adjusted trend assessments (HDR Corporation, 2011) are completed and described below. However, flow-adjusted trend assessments are on hold pending validated flow data. Appendix C contains directions on how to interpret the box plots below.

Total Dissolved Solids – Milk River at Hwy 880, Winter Median Limit Exceedance

As in 2015/16 and 2016/2017, the 2017/2018 winter median was over the limit for total dissolved solids (TDS) in the Milk River at Hwy 880 station so total dissolved solids in the Milk River at Hwy 880 will continue in the investigation phase to better understand potential sources and risks that existing conditions may pose.

Examination of the dataset revealed that TDS has a considerable amount of variability from year to year. While the winter median value of 640 mg/L for 2017/2018 is above the 500 mg/L limit value and above the winter median trigger value of 606 mg/L, it is a lower median value than has been observed in other winters in the dataset (Figure 4). Trend results of unadjusted and seasonally-adjusted assessments reveal no statistically significant increasing trends for the 2003-2018 and 2009-2018 timeframes, however, the 2003-2009 timeframe reveals an increasing seasonally-adjusted trend and, in the winter only, an increasing unadjusted trend (Table 10).

Overall, the TDS concentrations during the winter in the Milk River at Hwy 880 are higher than those seen in the Oldman, Bow, or South Saskatchewan Rivers. Further analysis is needed to evaluate the influence of river flow on TDS concentrations observed at this station for this year. Moreover, the Milk River is an international river whose waters are apportioned under the 1909 Boundary Waters Treaty; consequently, the Milk River flow is heavily modified and further assessment will be considered regarding that influence on TDS at Hwy 880.

Preliminary review of activities requiring an Environment and Parks approval did not indicate any existing point sources of total dissolved solids to the Milk River at Hwy 880; however, potential diffuse point sources, as well as other influences such as withdrawal, runoff, and groundwater will continue to be explored. The limit for TDS is based on an irrigation guideline, since the exceedance occurred during the winter period, the risk is therefore expected to be low. A more detailed risk assessment will be conducted for confirmation. This investigation will inform the need for management actions.

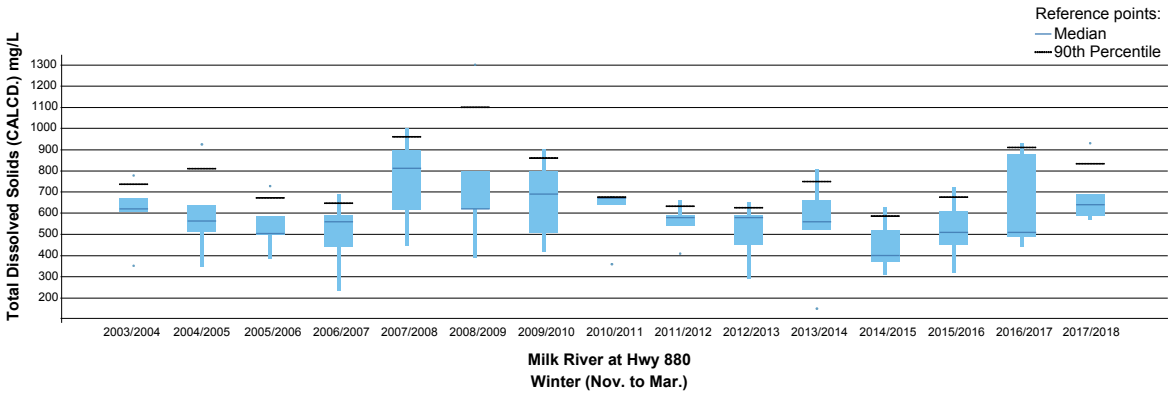

Figure 4. Box Plots of the Total Dissolved Solids Data in the Milk River at Hwy 880 Station During Winter from November 2003 to March 2018.

Specific Conductance – Milk River at Hwy 880, Winter Median Limit Exceedance

The 2017/2018 winter median was over the limit for specific conductance in the Milk River at Hwy 880 station.

Examination of the dataset revealed that specific conductance has a considerable amount of variability from year to year. While the winter median value of 1100 µS/cm for 2017/2018 is above the 1000 µS/cm limit value, and above the winter median trigger value of 916 µS/cm, it is a lower median value than has been observed in other winters in the dataset (Figure 5). Trend results of unadjusted and seasonally-adjusted assessments reveal no statistically significant increasing trends for the 2003-2018 and 2009-2018 timeframes, however, the 2003-2009 timeframe reveal an increasing seasonally-adjusted trend and, in the winter only, an increasing unadjusted trend (Table 10).

Overall, the specific conductance values during the winter in the Milk River at Hwy 880 are higher than those seen in the Oldman, Bow, or South Saskatchewan Rivers. Further analysis is needed to evaluate the influence of river flow on specific conductance values observed at this station. This work will be undertaken to complete the preliminary assessment. Moreover, the Milk River is an international river whose waters are apportioned under the 1909 Boundary Waters Treaty. Consequently, the Milk River flow is heavily modified and further assessment will be considered regarding that influence on specific conductance at Hwy 880.

Since this was a limit exceedance, specific conductance in the Milk River at Hwy 880 will be moved into the investigation phase to better understand potential sources and risks that existing conditions may pose. Specific conductance and total dissolved solids are closely linked parameters and their relationship at this station will be further explored. Preliminary review of activities requiring an Environment and Parks approval did not indicate any existing point sources of specific conductance to the Milk River at Hwy 880; however, potential diffuse point sources, as well as other influences such as withdrawal, runoff, and groundwater, will continue to be explored. The limit for specific conductance is based on an irrigation guideline, and is a combination of sodium adsorption ratio (SAR) and specific conductance values. A more detailed assessment of associated SAR values will be conducted as part of the assessment of this exceedance. The outcome of the investigation will inform the need for management actions.

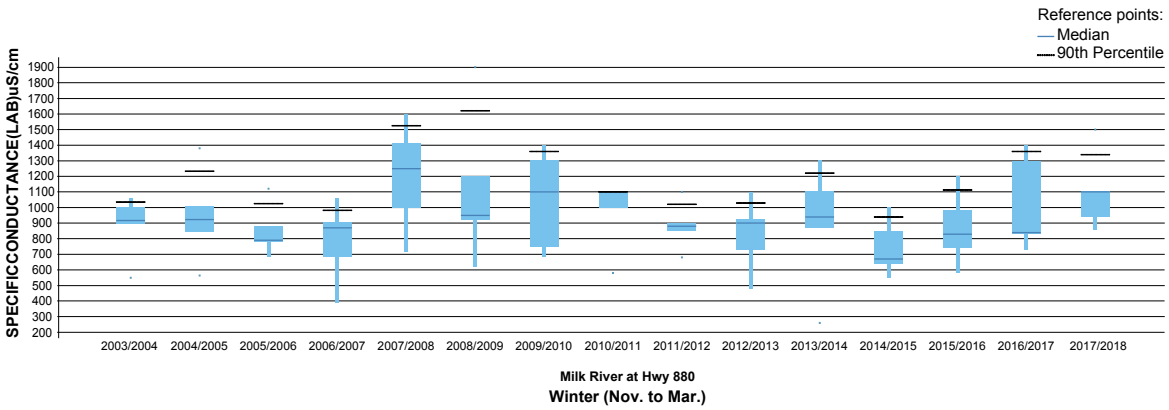

Figure 5. Box Plots of the Specific Conductance Data in the Milk River at Hwy 880 Station During Winter from November 2003 to March 2018.

Sulphate – Bow River at Cochrane, Open Water and Winter Peak Trigger Crossings

Statistically significant increases in the 2017/2018 open water and winter 90th percentile values (compared to the 1999-2009 historical data) occurred for sulphate in the Bow River at Cochrane station.

Examination of the dataset revealed that although the 2017/2018 90th percentile values are the highest observed in the dataset at this station (Figure 6), no samples exceeded the calculated limit value (based on hardness). Trend results of seasonally-adjusted assessments reveal statistically significant increasing trends for the 1999-2018, 1999-2009, and 2009-2018 timeframes, while the unadjusted assessments reveal statistically significant increasing trends for the 1999-2018, 1999-2009 (open water only), and 2009-2018 (winter only) timeframes (Table 10).

Overall, the sulphate concentrations in the Bow River at Cochrane are lower than the downstream stations (Carseland, Cluny, and Ronalane) and are similar to those seen in the corresponding most upstream station (Brocket) on the Oldman River. Further data analysis is needed to determine what influence river flow has on sulphate concentrations. Moreover, the Cochrane station is less than 20 km downstream of the power generating Ghost Dam outlet and further assessment may be considered regarding the dam's influence on sulphate at Cochrane.

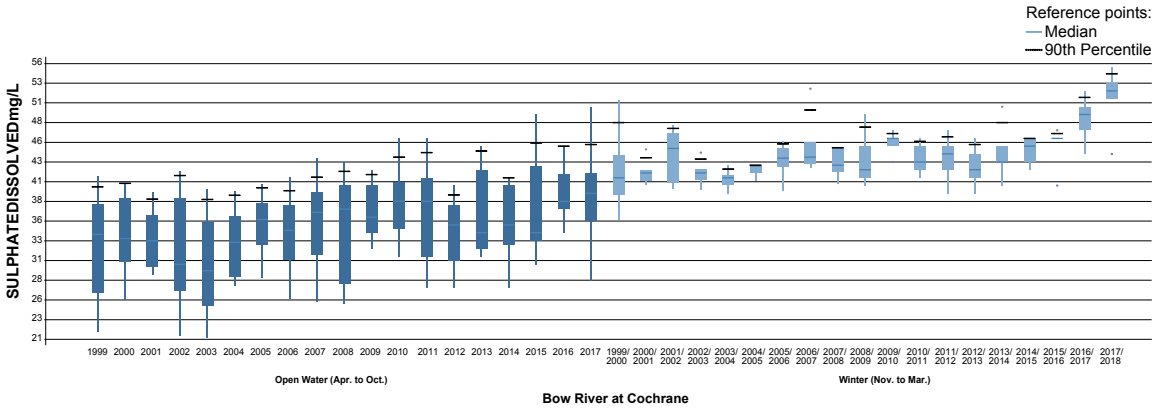

Figure 6. Box Plots of the Sulphate Data in the Bow River at Cochrane Station During Open Water and Winter from April 1999 to March 2018.

Nitrate – Bow River at Carseland, Open Water and Winter Peak Trigger Crossings

Statistically significant increases in the 2017/2018 open water and winter 90th percentile values (compared to the 1999-2009 historical values) occurred for nitrate in the Bow River at Carseland station.

Examination of the dataset revealed that although the 2017/2018 90th percentile values are the highest observed in the dataset (in the winter, but not open water) at this station, the maximum values observed are approximately two-thirds the 3 mg/L limit value (Figure 7). Trend results of seasonally-adjusted assessments reveal statistically significant increasing trends for the 1999-2018, 1999-2009, and 2009-2018 timeframes, while the unadjusted assessments reveal statistically significant increasing trends for the 2009-2018 (winter only), and no statistically significant unadjusted trend for the 1999-2018, 1999-2009, and 2009-2018 (open water only) timeframes (Table 10).

Overall, the nitrate concentrations in the Bow River at Carseland are higher than observed at the upstream station (Cochrane), are similar to the downstream stations (Cluny and Ronalane), and are higher than those observed at the comparable stations on the Oldman River (Hwy 3 and Hwy 36). Further data analysis is needed to determine what influence river flow has on nitrate concentrations at Carseland.

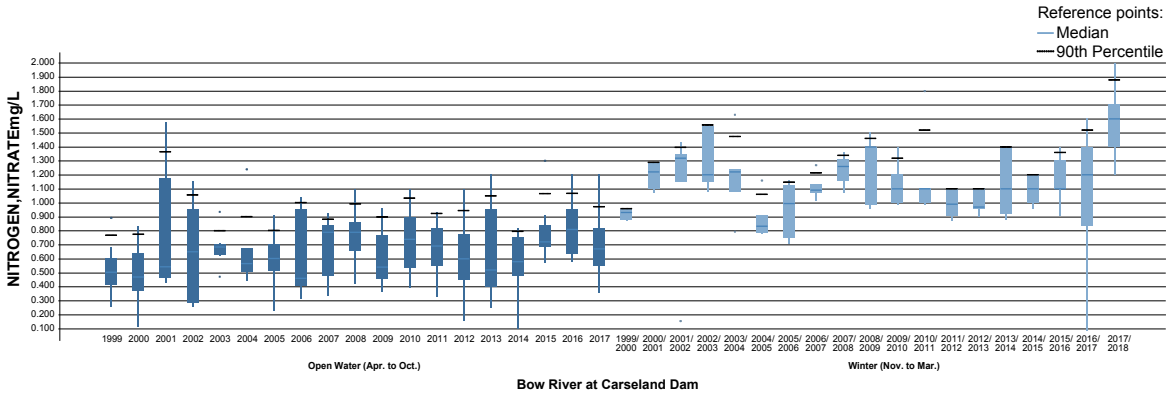

Figure 7. Box Plots of the Nitrate Data in the Bow River at Carseland Station During Open Water and Winter from April 1999 to March 2018.

Nitrate – Bow River at Cluny, Open Water and Winter Peak Trigger Crossings

Statistically significant increases in the 2017/2018 open water and winter 90th percentile values (compared to the 1999-2009 historical values) occurred for nitrate in the Bow River at Cluny station.

Examination of the dataset revealed that although the 2017/2018 90th percentile values are the highest observed in the dataset at this station, the maximum values observed are also approximately half the 3 mg/L limit value (Figure 8). Trend results of seasonally-adjusted assessments reveal statistically significant increasing trends for the 1999-2018, 1999-2009, and 2009-2018 timeframes, while the unadjusted assessments reveal statistically significant increasing trends for the 1999-2018, 1999-2009 (open water only), and 2009-2018 (winter only) timeframes (Table 10).

Overall, the nitrate concentrations in the Bow River at Cluny appear similar to the upstream and downstream stations (Carseland and Ronalane), are higher than the most upstream station (Cochrane), and are higher than those observed at the comparable stations on the Oldman River (Hwy 3 and Hwy 36). Further data analysis is needed to determine what influence river flow has on nitrate concentrations at Cluny.

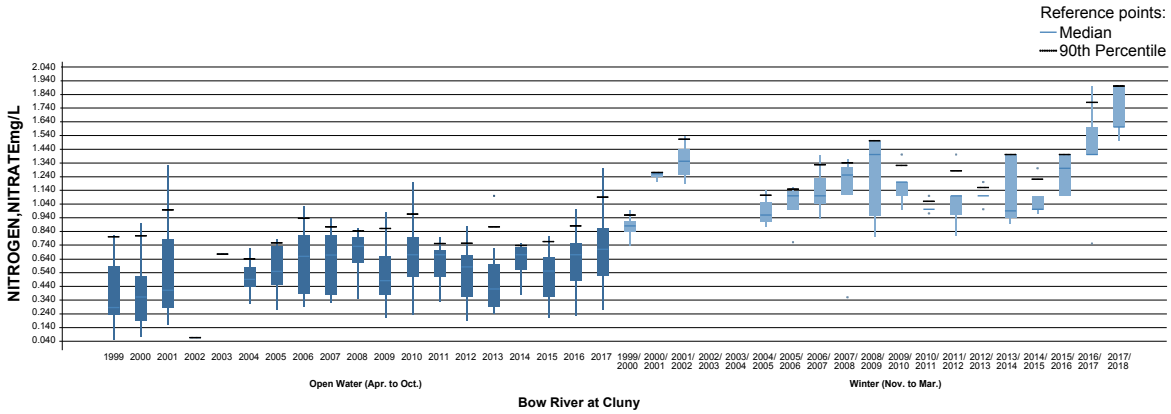

Figure 8. Box Plots of the Nitrate Data in the Bow River at Cluny Station During Open Water and Winter from April 1999 to March 2018.

Specific Conductance – Bow River at Ronalane, Open Water and Winter Peak Trigger Crossings

Statistically significant increases in the 2017/2018 open water and winter 90th percentile values (compared to the 1999-2009 historical values) occurred for specific conductance in the Bow River at Ronalane station.

Examination of the dataset revealed that the 2017/2018 90th percentile values are not the highest observed in the dataset at this station and the maximum values observed are also approximately two-thirds the 1000 µS/cm limit value (Figure 9). Trend results of seasonally-adjusted assessments reveal statistically significant increasing trends for the 1999-2018 and 1999-2009 timeframes, and no statistically significant trends for the 2009-2018 timeframe. The unadjusted assessments reveal statistically significant increasing trends for the 1999-2018 and 1999-2009 (open water only) timeframes, but no statistically significant trends for the 1999-2009 (winter only) and 2009-2018 timeframes (Table 10).

Overall, the specific conductance values in the Bow River at Ronalane appear similar to the upstream stations (Carseland and Cluny), are higher than the most upstream station (Cochrane), similar to the downstream station (South Saskatchewan River at Hwy 1), and are higher than observed at the comparable stations on the Oldman River (Hwy 3 and Hwy 36). Further data analysis is needed to determine what influence river flow has on specific conductance values at Ronalane.

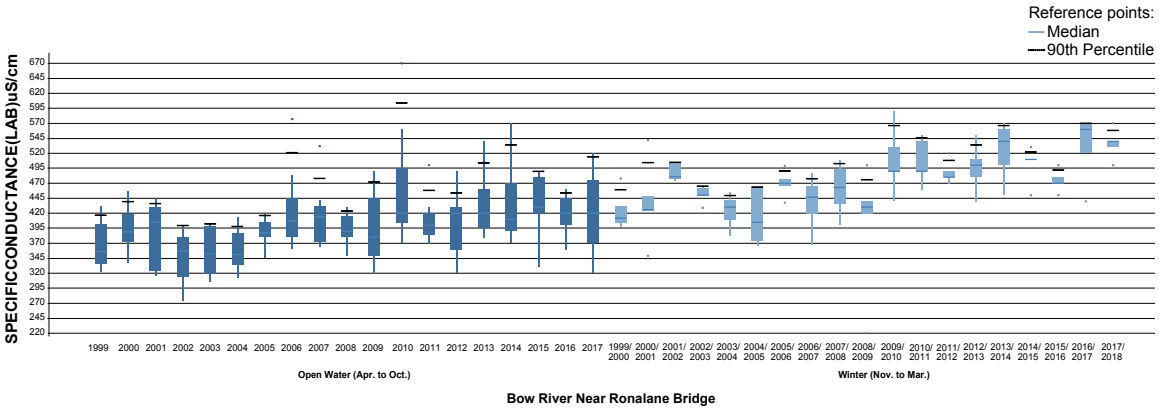

Figure 9. Box Plots of the Specific Conductance Data in the Bow River at Ronalane Station During Open Water and Winter from April 1999 to March 2018.

Total Dissolved Solids – Bow River at Ronalane, Open Water and Winter Peak Trigger Crossings

Statistically significant increases in the 2017/2018 open water and winter 90th percentile values (compared to the 1999-2009 historical values) occurred for total dissolved solids (TDS) in the Bow River at Ronalane station.

Examination of the dataset revealed that the 2017/2018 90th percentile values are not the highest observed in the dataset at this station, and (except during 2010 open water) the maximum values observed are approximately two-thirds the 500 mg/L limit value (Figure 10). Trend results of seasonally-adjusted assessments reveal statistically significant increasing trends for the 1999-2018 and 1999-2009 timeframes, and no statistically significant trend for the 2009-2018 timeframe. The unadjusted assessments reveal statistically significant increasing trends for the 1999-2018 and 1999-2009 (open water only) timeframes, and no statistically significant trends for the 1999-2009 (winter only) and 2009-2018 timeframes (Table 10).

Overall, the TDS concentrations in the Bow River at Ronalane appear similar to the upstream stations (Carseland and Cluny), higher than the most upstream station (Cochrane), similar to the downstream station (South Saskatchewan River at Hwy 1), and similar to or higher than observed at the comparable stations on the Oldman River (Hwy 3 and Hwy 36). Further data analysis is needed to determine what influence river flow has on TDS concentrations at Ronalane.

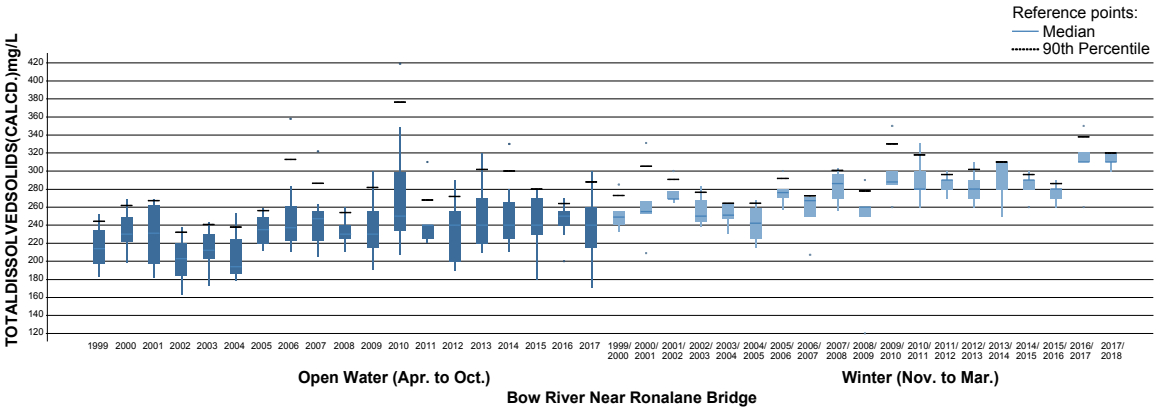

Figure 10. Box Plots of the Total Dissolved Solids Data in the Bow River at Ronalane Station During Open Water and Winter from April 1999 to March 2018.

Specific Conductance – South Saskatchewan River at Hwy 1 Open Water and Winter Median Trigger Crossings

A statistically significant increase in the measure of central tendency for the 2017/2018 open water and winter data (compared to the 1999-2009 historical data) occurred for specific conductance in the South Saskatchewan River at Hwy 1 station.

Examination of the dataset revealed that the 2017/2018 specific conductance medians are not the highest observed in the dataset at this station and (except for 2005 winter) the maximum values observed are approximately half the 1000 µS/cm limit value (Figure 11). Trend results of seasonally-adjusted assessments reveal statistically significant increasing trends for the 1999-2018 and 1999-2009 timeframes, and no statistically significant trend for the 2009-2018 timeframe. The unadjusted assessments reveal statistically significant increasing trends for the 1999-2018 and 1999-2009 (open water only) timeframes, and no statistically significant trends for the 1999-2009 (winter only) and 2009-2018 timeframes (Table 10).

Overall, the specific conductance values in the South Saskatchewan River at Hwy 1 appear similar to the upstream station on the Bow River (Ronalane) and similar to the upstream station on the Oldman River (Hwy 36), but appear higher than the most upstream stations on the Bow and Oldman Rivers (Cochrane and Brocket). Further data analysis is needed to determine what influence river flow has on specific conductance values at Hwy 1.

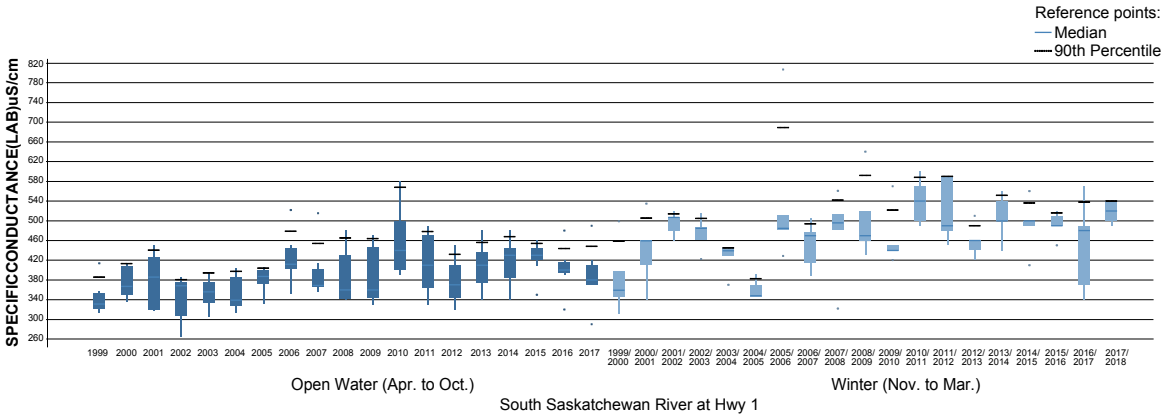

Figure 11. Box Plots of the Specific Conductance Data in the South Saskatchewan River at Hwy 1 Station During Open Water and Winter from April 1999 to March 2018.

Total Selenium – Milk River at Hwy 880, Winter Median Guideline Exceedance

The 2017/2018 winter median was over the guideline (1 ug/L) at the time for total selenium in the Milk River at Hwy 880 station (AESRD, 2014c). Since the 2014 guideline was in place during the time of the exceedance, it is being reported in the interest of transparency. Alberta Environment and Parks recently revised this guideline, as selenium guidelines have been updated by other jurisdictions based on recent scientific data (GoA, 2018b). The new guideline of 2 ug/L is above the observed and historical medians at Milk River at Hwy 880.

Examination of the dataset revealed total selenium has a considerable amount of variability from year to year, and though the winter median value of 1.10 ug/L for 2017/2018 is above the prior guideline (1 ug/L), it is below the historical winter median value of 1.20 ug/L and the new 2018 guideline. Total selenium is a secondary indicator due to its limited historical data; while recent years have more winter data points, it is apparent that historical winter values are similar to those observed in winter 2017/2018 (Figure 12). Trend results of unadjusted and seasonally-adjusted assessments reveal no statistically significant trends for the 2004-2018, 2004-2009, and 2009-2018 timeframes (Table 10).

Overall, the total selenium concentrations in the Milk River at Hwy 880 appear similar to those seen in the Oldman, Bow, and South Saskatchewan Rivers. Further analysis is needed to evaluate the influence of river flow on total selenium concentrations observed at this station.

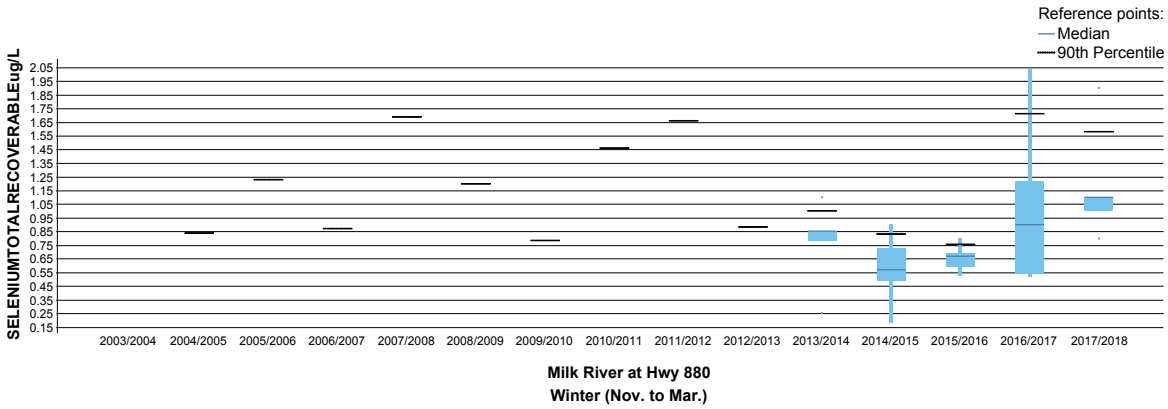

Figure 12. Box Plots of the Total Selenium Data in the Milk River at Hwy 880 Station During Winter from November 2004 to March 2018.

Total Selenium – South Saskatchewan River at Hwy 1, Winter Median Meeting the Guideline

The 2017/2018 winter median was equal to (met) the guideline (1 ug/L) at the time (AESRD, 2014c) for total selenium in the South Saskatchewan River at Hwy 1 station. Since the 2014 guideline was in place during the time of the exceedance it is being reported in the interest of transparency; however, a revised guideline has recently been adopted (GoA, 2018b), selenium guidelines have been updated by other jurisdictions based on recent scientific data. The new guideline of 2 ug/L is above the observed and historical medians at South Saskatchewan River at Hwy 1. Since the winter median value was not above the prior guideline, it is not an exceedance and is only being reported in the interest of transparency.

Examination of the dataset revealed total selenium has a considerable amount of variability from year to year, and while the winter median value of 1.00 ug/L for 2017/2018 was equal to the prior guideline (1 ug/L), it is the same as the historical median value of 1.00 ug/L. Total selenium is a secondary indicator due to its limited historical data; while recent years have more winter data points, it is apparent that historical winter values are similar to those observed in winter 2017/2018 (Figure 13). Trend results of unadjusted and seasonally-adjusted assessments reveal no statistically significant trends for the 2004-2018, 2004-2009, and 2009-2018 timeframes (Table 10).

Overall, the total selenium concentrations in the South Saskatchewan River at Hwy 1 appear similar to those seen in the Oldman or Bow Rivers. Further analysis is needed to evaluate the influence of river flow on total selenium concentrations observed at this station.

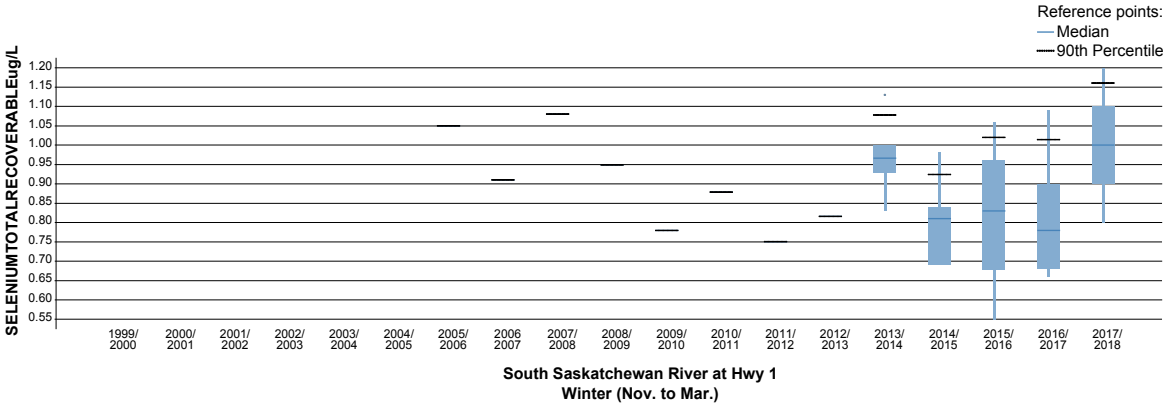

Figure 13. Box Plots of the Total Selenium Data in the South Saskatchewan River at Hwy 1 Station During Winter from November 2004 to March 2018.

Table 10. Status of Trend Assessments for the 2017/2018 Management Response. NT indicates no trend, + indicates significant (P<0.05) increasing trend. ^Some datasets have different time frames (i.e. TDS Milk 2003-2009 and 2003-2018, Selenium 2004-2009 and 2004-2018). *Caution should be used when interpreting trend results with short time frames.

Preliminary Assessment 2017/2018 Trend Results								
		Unadjusted Trend			Seasonally Adjusted Trend			
	Season	1999-2018^	1999-2009^	2009-2018*	1999-2018^	1999-2009^	2009-2018*	Flow-adjusted Trend
Trigger Exceedance								
Specific Conductance Median SSR Medicine Hat Hwy 1	Open Water	+	+	NT	+	+	NT	Ongoing
	Winter	+	NT	NT				
Sulphate Peak Bow Cochrane	Open Water	+	+	NT	+	+	+	Ongoing
	Winter	+	NT	+				
Nitrate Peak Bow Carseland	Open Water	NT	NT	NT	+	+	+	Ongoing
	Winter	NT	NT	+				
Nitrate Peak Bow Cluny	Open Water	+	+	NT	+	+	+	Ongoing
	Winter	+	NT	+				
Specific Conductance Peak Bow Ronalane	Open Water	+	+	NT	+	+	NT	Ongoing
	Winter	+	NT	NT				
Total Dissolved Solids Peak Bow Ronalane	Open Water	+	+	NT	+	+	NT	Ongoing
	Winter	+	NT	NT				
Limit Exceedance								
Specific Conductance Limit (Winter only) Milk Hwy 880	Open Water	NT	NT	NT	NT	+	NT	Ongoing
	Winter	NT	+	NT				
Total Dissolved Solids Limit (Winter only) Milk Hwy 880	Open Water	NT	NT	NT	NT	+	NT	Ongoing
	Winter	NT	+	NT				
Guideline Exceedance								
Total Selenium Guideline (Winter only) Milk Hwy 880	Open Water	NT	NT	NT	NT	NT	NT	Ongoing
	Winter	NT	NT	NT				
Total Selenium Guideline (Winter only) SSR Medicine Hat Hwy 1	Open Water	NT	NT	NT	NT	NT	NT	Ongoing
	Winter	NT	NT	NT				

8.0 Next Steps

Alberta Environment and Parks will complete the preliminary assessment for all indicators exceeding a trigger, limit, or guideline in 2014/2015, 2015/2016, 2016/2017, and 2017/2018. This includes:

- further analysis on the remaining 2014/2015 and 2015/2016 indicators with trigger crossings to help determine the need for investigation and management actions;
- flow-adjusted trend assessments on the indicators that exceeded a trigger, limit, or guideline in 2016/2017 or 2017/2018, at the stations where the exceedance occurred.

The following indicators have been moved into the investigation phase:

- specific conductance in the Bow River at Carseland
- specific conductance in the Milk River at Hwy 880

Total dissolved solids in the Milk River at Hwy 880 will continue in the investigation phase, with analyses focusing on understanding sources of salinity and the risk current conditions pose for aquatic life and other uses.

The management response will be closed for total selenium in the Oldman River at Hwy 36.

The status of this management response will be further updated in successive reports and will be publicly available on the Environment and Parks website.

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Appendices

Appendix A - Investigation - Ambient Air Quality Data Analysis Summary

A.1 Investigation – Nitrogen Dioxide (NO_2)

In previous reporting, the NO_2 investigation has focused on the Calgary Central station where the trigger into Level 3 was exceeded in 2014. In order to gain a better understanding of NO_2 conditions across the region, historical data were analyzed from the Calgary Northwest, Lethbridge, and Medicine Hat stations for 2011-2017, as well as for Calgary Central-Inglewood and Calgary Southeast stations for 2016-2017. The Calgary Central station discussed in previous reporting was required to relocate, due to property redevelopment, and the new location was named Calgary Central-Inglewood. Since both Calgary Central-Inglewood and Calgary Southeast stations were new monitoring locations, 2016 was the first year that the two stations met data completeness requirements. The data analysis explored temporal variations of NO_2 events.

Elevated concentrations or 'events' were defined as 1 hour averaged NO_2 concentrations greater than 16 ppb (30 µg/m^3) (the trigger into Level 3). Figure A1 shows the variation of high concentrations by hour of the day for both the 2011-2017 and the 2016-2017 time periods. Although elevated concentrations occur at all hours of the day a period of higher NO_2 concentrations is noted in the morning hours peaking between 7 and 10 am at all of the five monitoring stations. Higher ambient concentrations are common during this time of day due to the combined effect of vehicle emissions from the morning rush hour and a low atmospheric boundary layer. The lowest portion of the atmosphere is known as the boundary layer, and is the part of the atmosphere where ground level emissions may be dispersed and diluted as a result of mixing. The height of this atmospheric layer varies throughout a 24 hour period. It is higher during the day, allowing for more mixing, and lower at night (also known as nocturnal boundary layer). The nocturnal boundary layer forms after sunset, when the ground begins to cool, in turn cooling the air immediately above it. This creates a thick blanket of cold, calm air close to the earth's surface. Cool air sinks, preventing the vertical mixing that usually disperses pollutants into the atmosphere during the day.

Ambient NO_2 is most often due to combustion activities, such as commercial and residential heating, traffic, or industrial activities. The monitoring stations are located in urban centres, thus the surrounding land use includes residential, commercial, and industrial areas, as well as roadways. The land use and time of day that elevated concentrations are occurring implies that traffic emissions could likely be a notable contributor for elevated concentrations. A frequency of higher concentrations is less evident during the afternoon rush hours as the boundary layer is higher, allowing for more mixing and dispersion of emissions.

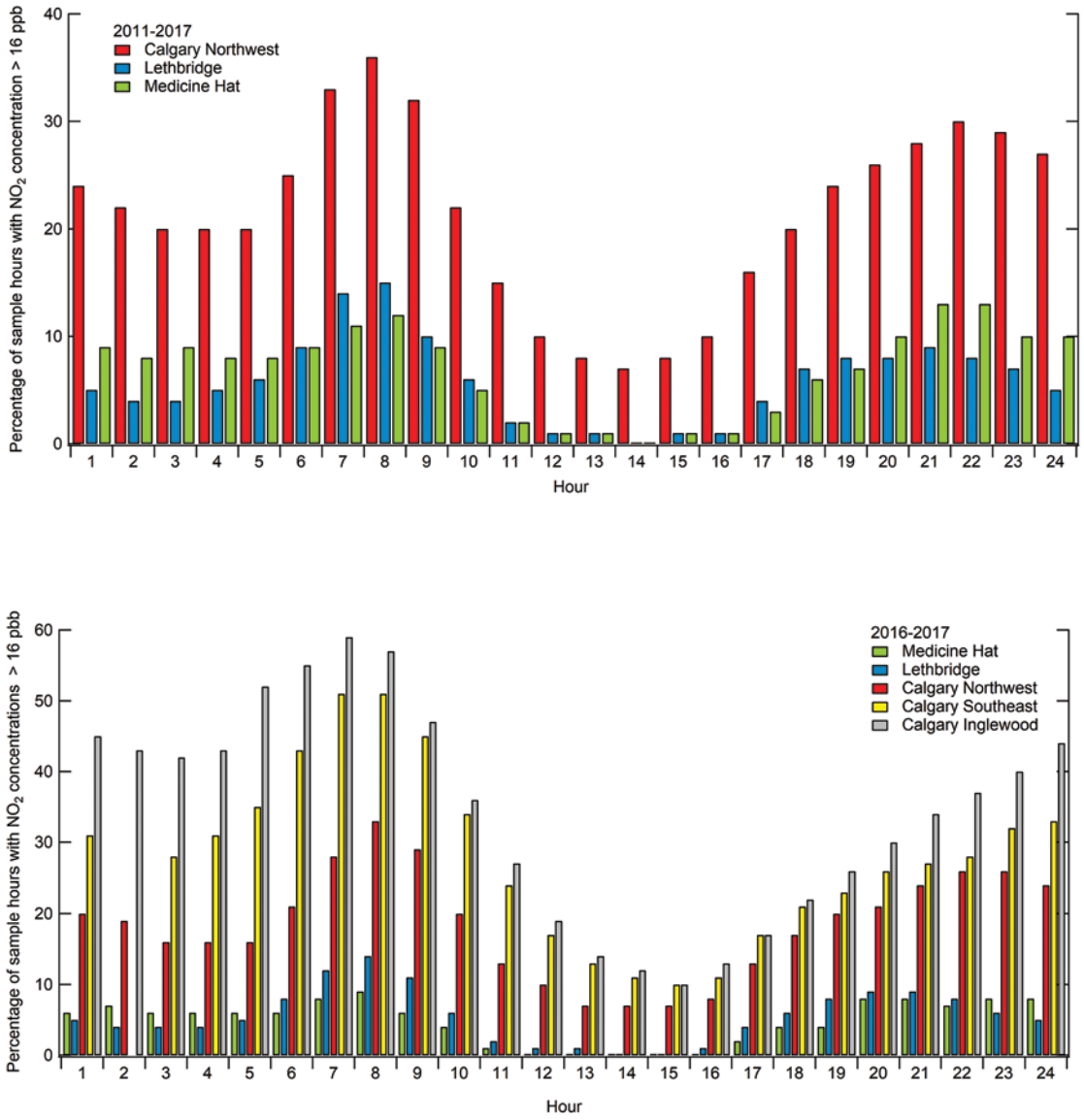


Figure A1. Percentage of One Hour NO_2 Samples with Concentrations Greater Than 16 ppb for Each Hour of the Day at the Calgary Northwest, Lethbridge and Medicine Hat Monitoring Stations for 2011-2017 (top) and for 2016-2017 including Calgary Central-Inglewood and Calgary Southeast Monitoring Stations (bottom).

Figure A2 shows the variation of high concentrations of NO_2 by month of the year for both the 2011-2017 and the 2016-2017 time periods. Although elevated concentrations occur during every month of the year, higher events occurred more often in the winter months (October through March). This is a common occurrence across Alberta due to meteorological conditions that prevent dispersion, such as inversions, occurring more often in the winter season. Inversions are frequent during the winter months, when nights are long and the sun, low on the horizon, heats the atmosphere more than the earth's surface, thus preventing the vertical movement of air from the surface. Without vertical mixing, pollution in the cooler air closer to ground level gets trapped below the warmer layer of air above.

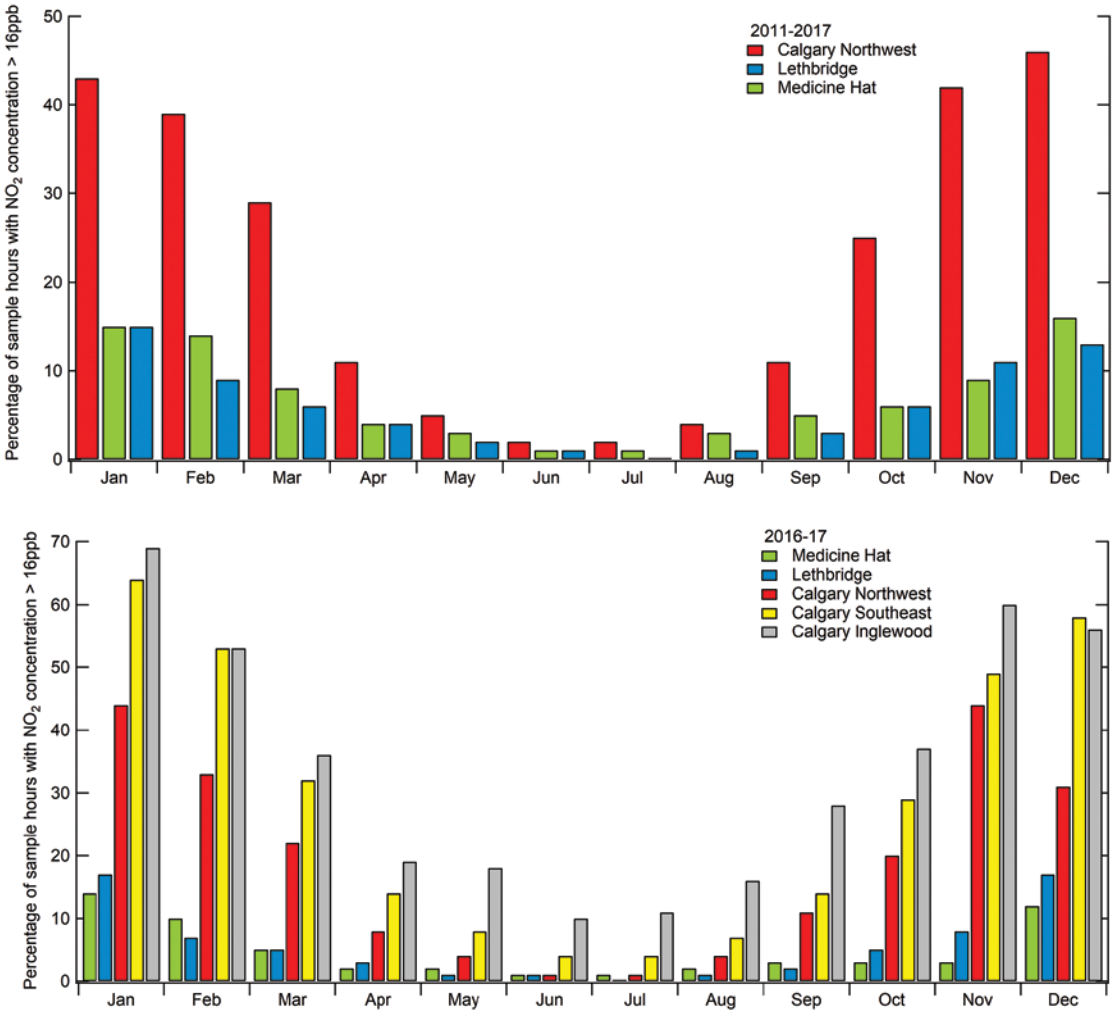


Figure A2 Percentage of One Hour NO_2 Samples with Concentrations Greater Than 16 ppb for Each Month of the Year at the Calgary Northwest, Lethbridge and Medicine Hat Monitoring Stations for 2011-2017 (top) and for 2016-2017 including Calgary Central-Inglewood and Calgary Southeast Monitoring Stations (bottom).

Figure A3 shows the variation of high concentrations of NO_2 by year for 2011 through 2017. Although elevated concentrations occurred in all years of the time period studied, 2013 had marginally higher frequency of occurrence of elevated concentrations for Calgary Northwest and Medicine Hat, while 2016 had the overall lowest frequency of occurrence of elevated concentrations at the two stations. Marginal variations of high NO_2 concentrations were observed by year at the Lethbridge station, with the overall lowest frequency of occurrence of elevated concentrations observed in 2013.

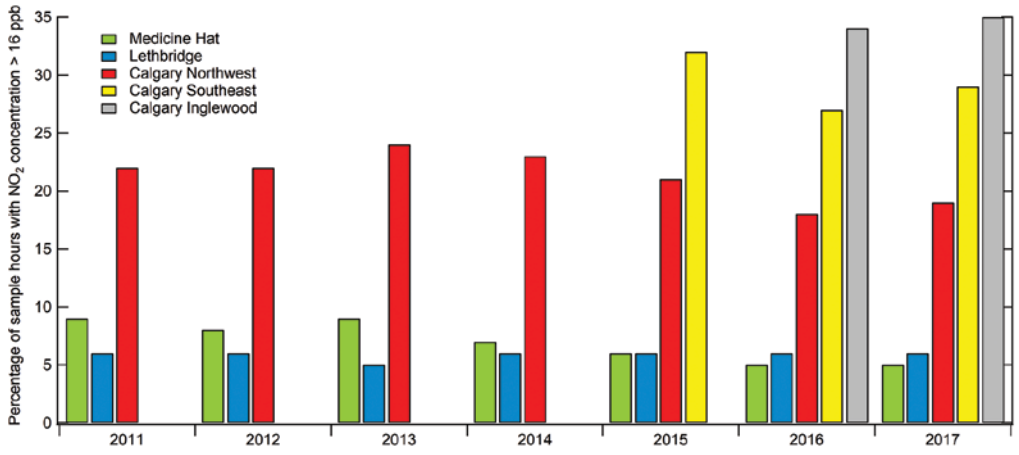


Figure A3. Percentage of One Hour NO_2 Samples With Concentrations Greater Than 16 ppb by Year for 2011, 2012, 2103, 2014, 2015, 2016 and 2017 for the South Saskatchewan Region Air Monitoring Stations.

Figure A4 shows the percentage of data when 1 hour NO_2 concentrations were high (greater than 16 ppb) and low (less than or equal to 8 ppb) plotted by wind speed for the 2011-2017 assessment years at the Calgary Northwest, Lethbridge, and Medicine Hat stations. Although high and low concentrations were observed to occur for a number of wind speeds, the greatest percentage of high concentrations were more frequently observed during lower wind speed conditions. Lower wind speeds inhibit dispersion of nitrogen dioxide and other pollutants.

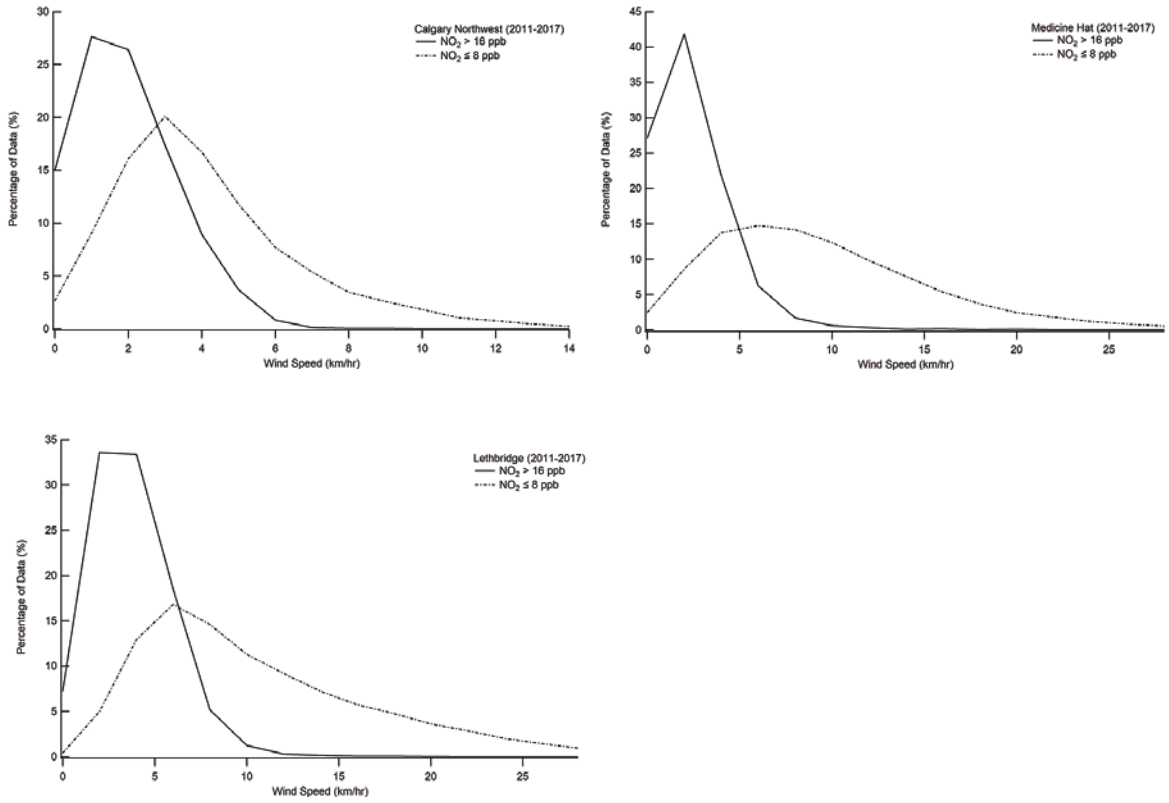


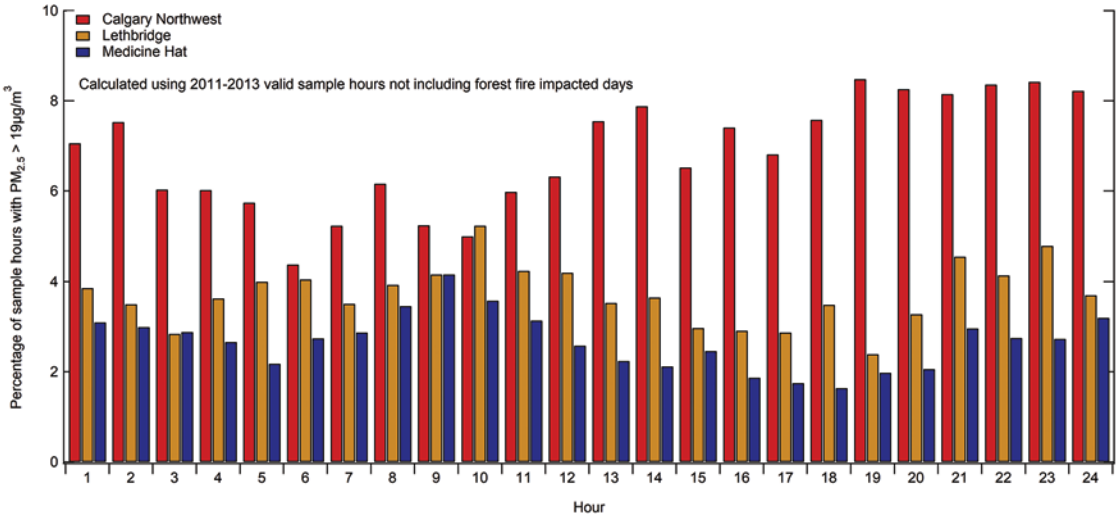
Figure A4 Percentage of Data (%) for 1 Hour NO_2 Concentrations When High (greater than 16 ppb, solid line) and Low (less than or equal to 8 ppb, dashed line) Plotted by Wind Speed (km/h) for the 2011-2017 Assessment Years at the Calgary Northwest, Lethbridge and Medicine Hat Stations.

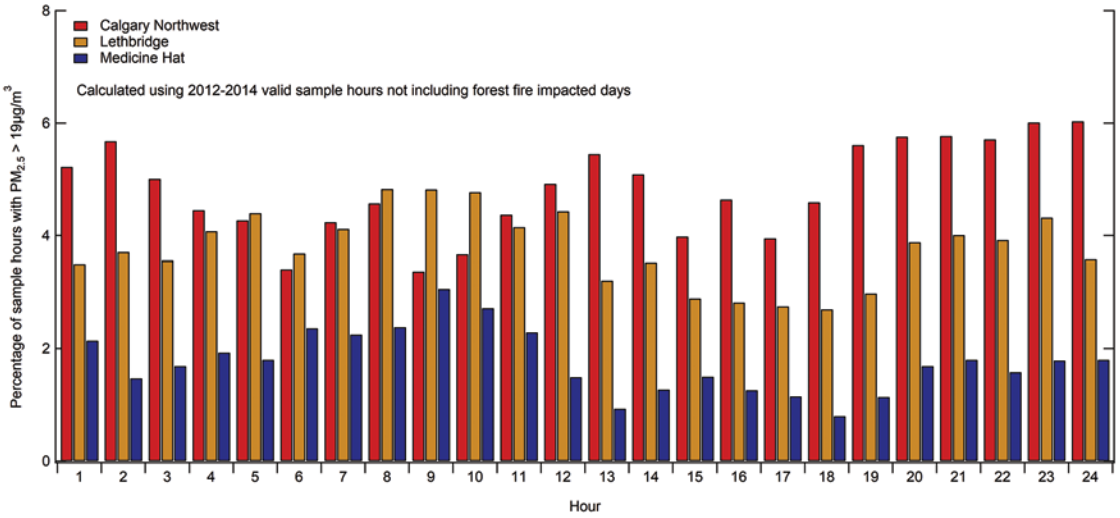
A.2 Investigation – Fine Particulate Matter ($PM_{2.5}$)

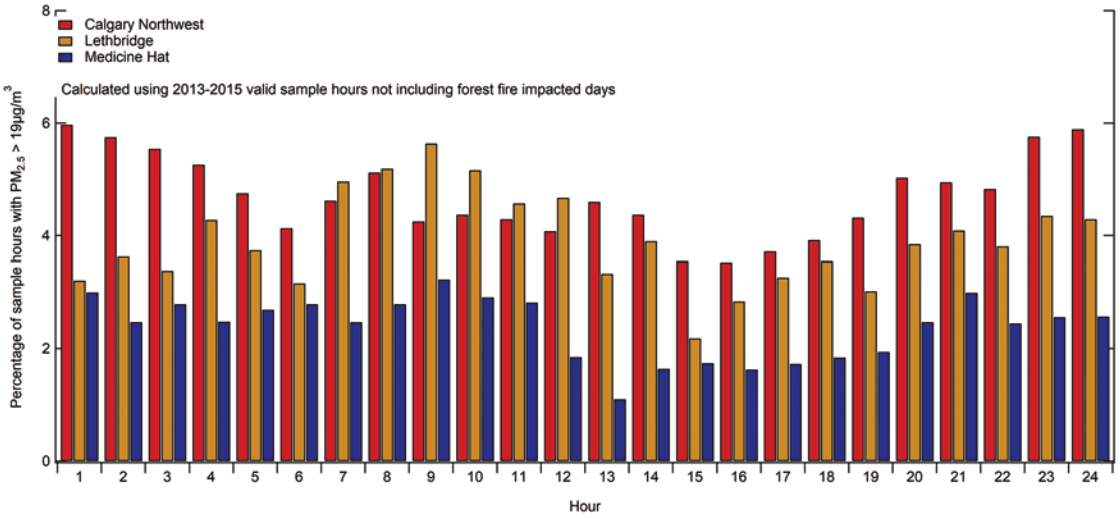
In order to gain a better understanding of $PM_{2.5}$ conditions across the region, historical data was analyzed from the Calgary Northwest, Lethbridge, and Medicine Hat air monitoring stations. Since both Calgary Central-Inglewood and Calgary Southeast stations were new monitoring locations, they were not included in the analysis, as the data was not available for many of the reporting periods analyzed, or the station only exceeded the trigger into Level 2 in the initial assessments. The data analysis explored temporal variations of $PM_{2.5}$ events and associated meteorological conditions. Elevated concentrations or 'events' were defined as 1-hour averaged $PM_{2.5}$ concentrations greater than 19 $\mu g/m^3$ (the trigger into Level 3).

The data from all the available CAAQS assessment reporting periods were analyzed, including 2011-2013, 2012-2014, 2013-2015, and 2014-2016. As part of the CAAQS assessment, the sample days with identified transboundary and exceptional events (which includes days identified as impacted by forest or grass fires) were removed from the data in order to isolate the human-caused concentrations.

Figure A5 shows the variation of high concentrations by hour of the day for the Calgary Northwest, Lethbridge, and Medicine Hat stations during the 2011-2013, 2012-2014, 2013-2015, and 2014-2016 time periods. Although elevated concentrations occur at all hours of the day, a period of higher $PM_{2.5}$ concentrations is noted in the morning hours peaking between 7 and 10 am at the Lethbridge and Medicine Hat stations. Similar boundary layer effects are impacting $PM_{2.5}$ concentrations as seen in the NO_2 analysis. The land use and the time of day that elevated concentrations are occurring implies that traffic emissions could be a notable contributor to elevated concentrations.


Calgary Northwest
Lethbridge
Medicine Hat
Calculated using 2011-2013 valid sample hours not including forest fire impacted days
Percentage of sample hours with PM2.5 > 19µg/m3
Hour


Calgary Northwest
Lethbridge
Medicine Hat
Calculated using 2012-2014 valid sample hours not including forest fire impacted days
Percentage of sample hours with PM2.5 > 19µg/m3
Hour


Calgary Northwest
Lethbridge
Medicine Hat
Calculated using 2013-2015 valid sample hours not including forest fire impacted days
Percentage of sample hours with PM2.5 > 19µg/m3
Hour

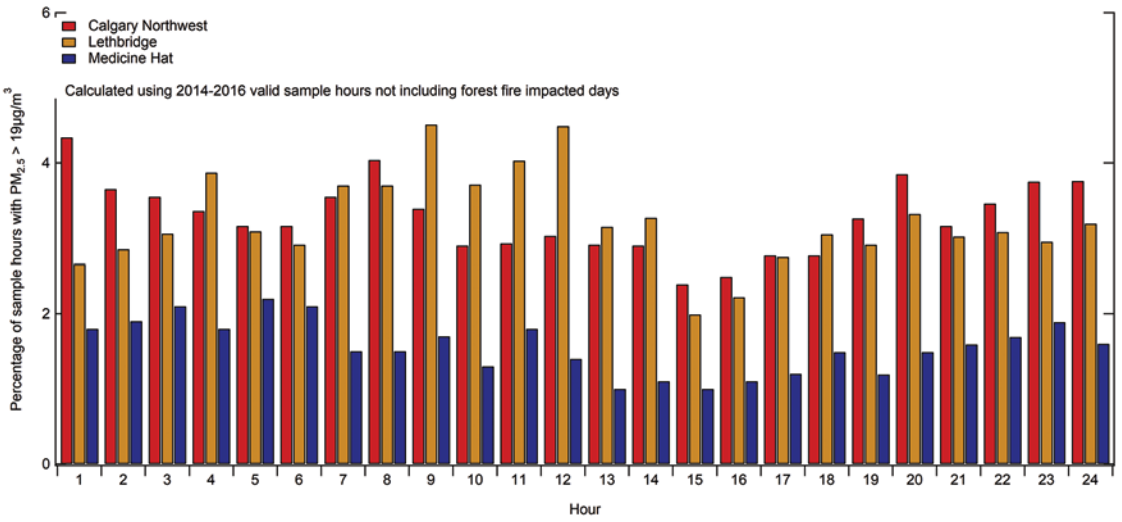
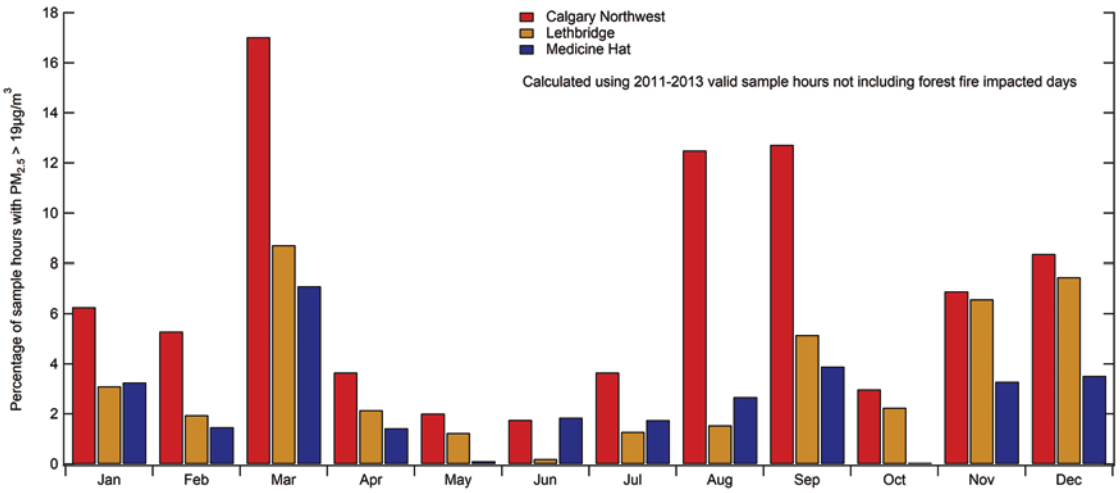


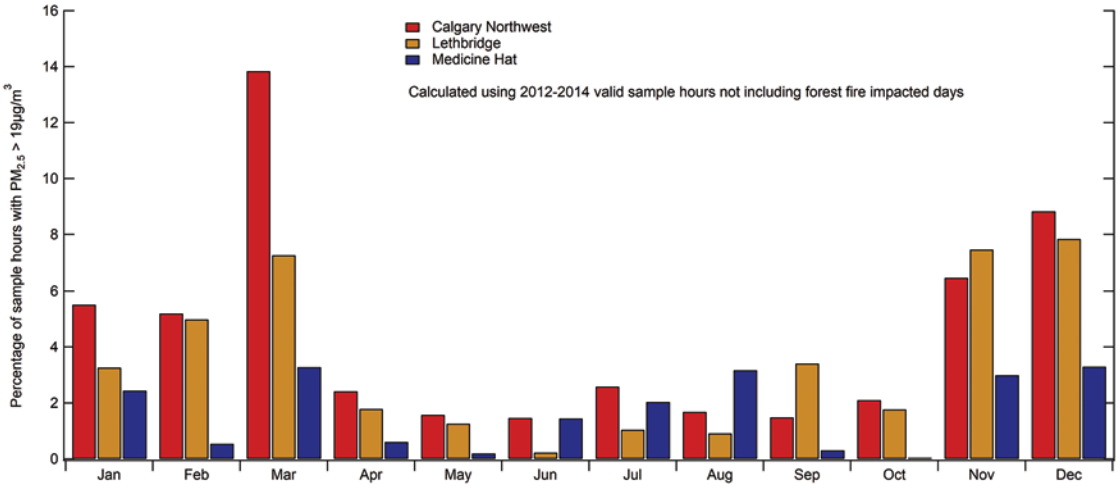
Figure A5. Percentage of 1 Hour $PM_{2.5}$ Samples with Concentrations Greater than 19 µg/m^3 for Each Hour of the Day for 2011-2013, 2012-2014, 2013-2015, 2014-2016 at the Calgary Northwest, Lethbridge and Medicine Hat Monitoring Stations

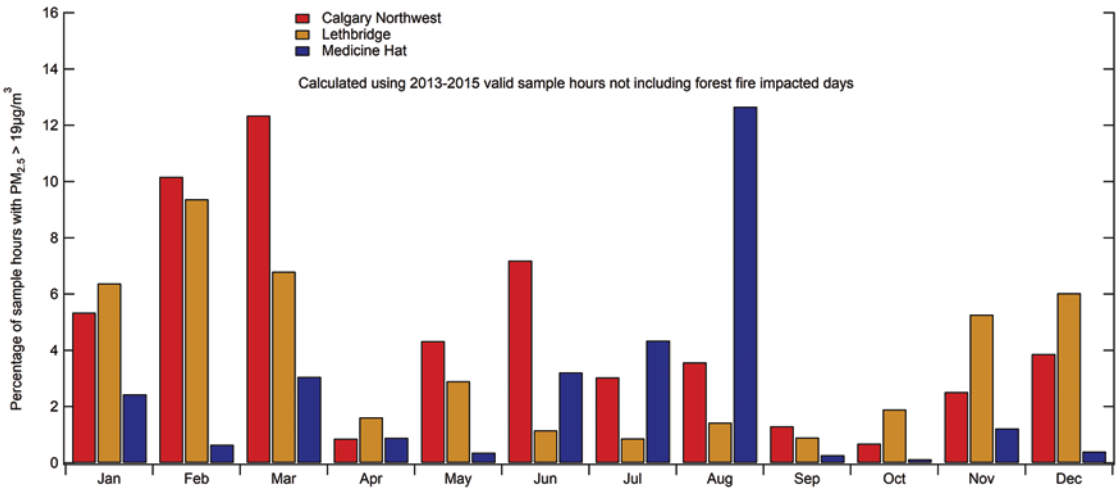
Elevated $PM_{2.5}$ concentrations at the Calgary Northwest station were most likely to occur in the early afternoon and later into the evening under the nocturnal boundary layer during the 2011-2013 and 2012-2014 assessment periods.

The seasonal $PM_{2.5}$ variation was similar at all the South Saskatchewan air monitoring stations, as indicated in Figure A6. Although elevated concentrations may be observed throughout the year, such concentrations were more likely in the colder winter months (November through March) and least likely to be observed in the summer. March had the highest occurrence of elevated particulate matter days across the region. The frequency of elevated concentrations was also higher in August and September at all three stations. These are most likely due to residual forest fire effects, where some days were not identified for exclusion by the transboundary and exceptional events identification criteria, as part of the CAAQS data processing, although they are adjacent to days that were experiencing forest fire smoke events.

Figure A7 shows the variation of high $PM_{2.5}$ concentrations by year for 2011 through 2016. At the Calgary Northwest station, the frequency of elevated $PM_{2.5}$ concentration events appear to be slightly dropping from 2011 through 2014, with a slight increase after 2015. For Lethbridge, the percentage of data with elevated concentrations occurred similarly across all seven years, with only slight differences of annual occurrence. The 2016 year had the lowest occurrence of elevated concentrations at the Lethbridge station. For Medicine Hat, slight annual differences of elevated concentrations occurred from 2011-2013, with a significant drop in 2014.The overall trend will be further examined as additional years of data become available.


Calgary Northwest
Lethbridge
Medicine Hat
Calculated using 2011-2013 valid sample hours not including forest fire impacted days
Percentage of sample hours with PM2.5 > 19µg/m3
0
2
4
6
8
10
12
14
16
18
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Calgary Northwest
Lethbridge
Medicine Hat
Calculated using 2012-2014 valid sample hours not including forest fire impacted days
Percentage of sample hours with PM2.5 > 19µg/m3
0
2
4
6
8
10
12
14
16
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Calgary Northwest
Lethbridge
Medicine Hat
Calculated using 2013-2015 valid sample hours not including forest fire impacted days
Percentage of sample hours with PM2.5 > 19µg/m3
0
2
4
6
8
10
12
14
16
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

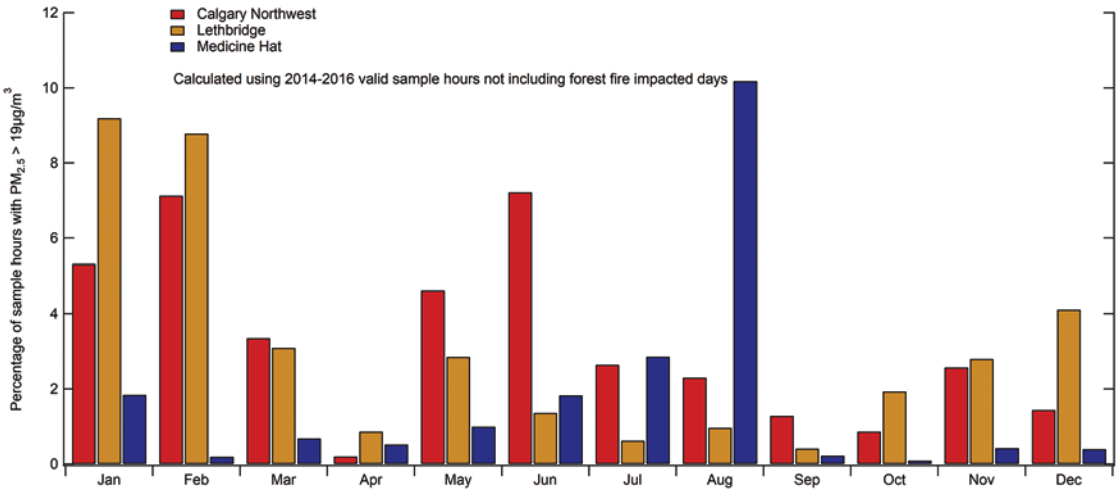


Figure A6 Percentage of 1 Hour PM2.5 Samples with Concentrations Greater than 19 µg/m^3 for Each Month of the Year for 2011-2013, 2012-2014, 2013-2015, 2014-2016 at the Calgary Northwest, Lethbridge and Medicine Hat Monitoring Stations.

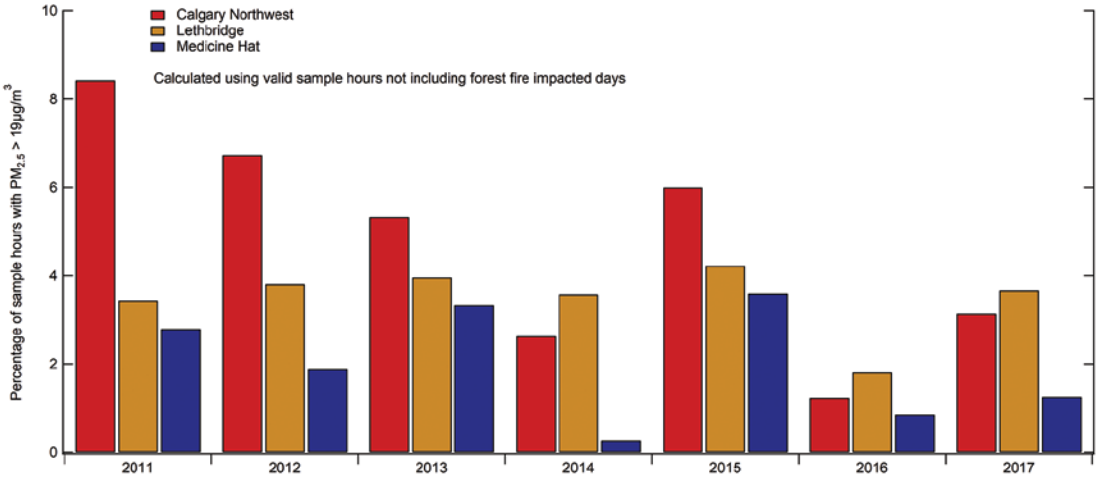


Figure A7 Percentage of 1 Hour $PM_{2.5}$ Samples with Concentrations Greater than 19 µg/m^3 by Year for 2011, 2012, 2013, 2014, 2015, and 2016 at the Calgary Northwest, Lethbridge and Medicine Hat Monitoring Stations.

Figure A8 shows the percentage of data when 1 hour $PM_{2.5}$ concentrations were high (greater than 19 µg/m^3 , solid line) and low (less than or equal to 4 µg/m^3, dashed line) plotted by wind speed for the 2011-2016 assessment years at the Calgary Northwest, Lethbridge, and Medicine Hat stations. Although high and low concentrations were observed to occur for a number of wind speeds, the greatest percentage of high concentrations were more frequently observed during lower wind speed. Lower wind speeds inhibit dispersion of fine particulate matter and other pollutant gases.

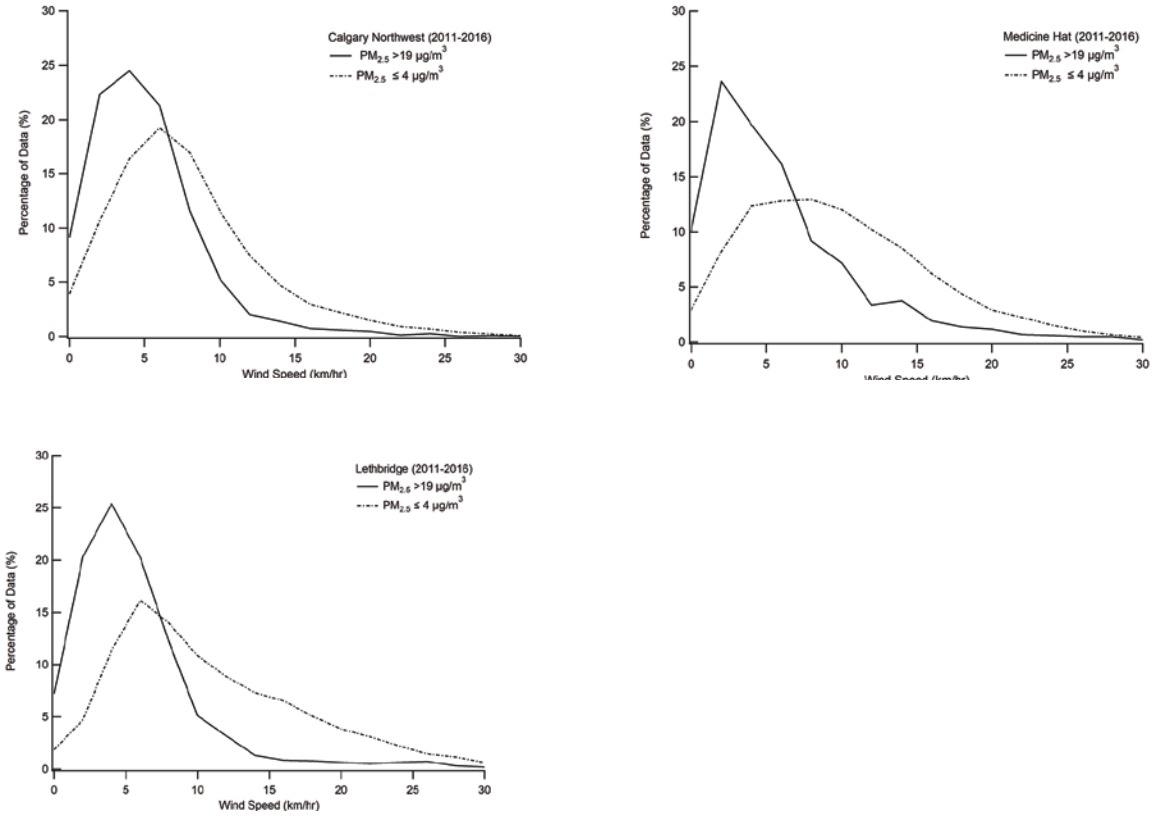


Figure A8 Percentage of Data (%) for 1 Hour $PM_{2.5}$ Concentrations when High (greater than 19 µg/m^3) and Low (less than or equal to 4 µg/m^3) Plotted by Wind Speed (km/h) for the 2011-2016 Assessment Years at the Calgary Northwest, Lethbridge and Medicine Hat Stations.

Appendix B - South Saskatchewan Region Air Quality Initiatives Underway

Goal

The goal of the management actions identified for the South Saskatchewan region are to proactively maintain air quality below the limit and improve air quality through active air management and prevent a Level 4 (or Canadian Ambient Air Quality Standards (CAAQS)) exceedance.

Achievement

Achieving the goal of the management actions within the South Saskatchewan Region requires a proactive and future-based approach. Management actions are intended to support, rather than replace, existing policies and regulations. These actions range from policy or regulatory initiatives to reduce emissions, to voluntary actions and raising awareness and education surrounding air quality.

The focus of the management actions includes gathering baseline information, improving scientific understanding and knowledge, learning from other jurisdictions, and identifying initiatives that are already committed or underway that can lead to near and future management of fine particulate matter.

Collectively the management initiatives list allows Alberta Environment and Parks (AEP) and stakeholders to consider what is occurring in some parts of the region that could be implemented elsewhere and to consider where gaps in the system exist in the current Level 2, or potential Level 3, situation.

Collective responsibility

It is important to recognize the impact of implementing certain actions may take several years before being realized. All levels of government have the responsibility of implementing management actions and CAAQS achievement (Canadian Council of Ministers of the Environment [CCME], 2012). Collaboration of all stakeholders is key to the success of the proactive air management actions.

AEP will continue to engage with stakeholders on an ongoing basis to maintain an updated list of all current initiatives that consider air quality or have air quality co-benefits, and to identify new actions that may be required to meet the management intent.

	Management Action Initiative	Description	Initiative Type
National			
	Canadian Council of Ministers of the Environment (CCME) Mobile Sources Working Group	The Alberta Government continues to collaborate with federal/provincial/territorial jurisdictions through the CCME Mobile Sources Working Group to help inform further transportation management actions in Alberta.	Policy
	BLIERS	Base-level Industrial Emission Requirements (BLIERS) to ensure all industrial sources in Canada meet a good base-level of performance.	Policy
Provincial			
	Clean Air Strategic Alliance (CASA) Non-Point Source Project	The CASA non-point source report, titled *Recommendations to Reduce Non-Point Source Air Emissions in Alberta* (CASA, 2018), is helping to inform action on non-point sources.	Knowledge Improvement
	AAAQO Review	Review and update of select Alberta Ambient Air Quality Objectives (AAAQO) in consideration of increased stringency of national Canadian Ambient Air Quality Standards (CAAQS).	Regulatory, Policy
	Climate Leadership Plan	Alberta will invest in cross-ministry work to lower greenhouse gas emissions and address climate change in Alberta through a renewed climate change action plan. Climate Change actions have co-benefits of improving air quality.	Policy
	Ambient Data Analysis	Analyze available monitoring data to investigate possible cause of influences on elevated concentrations. Consider meteorology (wind/wind direction) and covariance between pollutants.	Knowledge Improvement
	Redesign of the Air Quality Health Index (AQHI) Map Website	Unify three components: community AQHI table, station/air monitoring data and historical data query/download into one website.	Education and Engagement
	Further Knowledge of Particulate Matter ($PM_{2.5}$) Composition	Analysis of Calgary Central Station $PM_{2.5}$ speciation data.	Knowledge Improvement

	Management Action Initiative	Description	Initiative Type
	Odour and Air Quality Strategy	Implementation of the CASA Confined Feeding Operations (CFO) Strategic Plan. Research projects related to Best Management Practices (BMP) for managing ammonia (NH_3) and N_2O emissions. CFO Air Quality BMP Extension Plan including online Air Quality Resources for Alberta Livestock Producers. The Environmentally Sustainable Agricultural Tracking Survey (ESATS).	Knowledge Improvement, Education and Engagement
	Use of Emissions Reductions Tools in Regulatory Process	Utilize the authorization process to adapt and improve environmental performance at regulated industrial facilities.	Regulatory
	Air Quality Notification and Advisories	Provincial agencies including AEP, Alberta Health and Alberta Health Services (AHS) collaborate with federal (Environment and Climate Change Canada and Health Canada) to redesign the Ambient Air Quality (AAQ) Notification Protocol to enhance the notification of AAQ events and communicate health messages to the public thorough Special Air Quality Statements or Air Quality Advisories.	Education and Engagement
	Simplified Wildfire Smoke Guide	AHS, CRAZ, the City of Calgary and the Alberta Airsheds Council collaborated to develop a guide to provide resources and information to help airsheds, municipalities, companies, schools and other organizations to plan for and respond to wildfire smoke events.	Education and Engagement

	Management Action Initiative	Description	Initiative Type
	Air Quality and Health Surveillance	Alberta Health Services (AHS) developed and continues to enhance the AAQ Health Surveillance Dashboard by comparing health outcomes obtained from various databases including the Alberta Real Time Syndromic (ARTSSN) data (eg. Healthlink Calls, Emergency Department Visits) and Alberta Pharmaceutical Information Network (PIN) data (i.e. Salbutamol Dispensation) to air quality data including both AQHI and individual air pollutant indicators. This on-going health surveillance will contribute to the assessment of public health impacts from air pollution.	Knowledge Improvement
	Healthy Community by Design	AHS is working to identify and support communities and agencies interested in creating Healthy Environments through the planning process. Benefits of improved air quality can be facilitated through planning features that address: 1. Neighbourhood Design 2. Transportation Networks 3. Natural Environments 4. Food Systems 5. Housing. One of the initiatives under this umbrella is the Healthy Communities Hub and Dashboard. albertahealthycommunities.healthiertogether.ca/ www.healthiertogether.ca/prevention-data/alberta-community-health-dashboard/	Education and Engagement

	Management Action Initiative	Description	Initiative Type
Local			
	Industrial Emissions	Continuous improvement and regulatory emission requirements through the *Environmental Protection and Enhancement Act*. Fugitive dust mitigation plans upon regulatory approval requirement. Air quality monitoring as per regulatory approval. Membership in local airsheds.	Regulatory, Emissions Reduction, Knowledge Improvement
	Calgary Region Airshed Zone	Particulate Matter and Ozone management plan implemented by a multi stakeholder group. Provide publicly accessible air quality monitoring data. Stakeholder forum for air quality management in the Calgary region. Idle Free Toolkit. Commuter Connect Toolkit – Workplace commuter options.	Knowledge Improvement, Education and Engagement, Voluntary Emission Reduction
	Palliser Airshed Society	Report ambient air quality data in compliance with the Air Monitoring Directive. Post real time and historic air quality data accessible by industry, municipalities and the public. Provide a stakeholder forum to promote discourse on air quality management in southeastern Alberta. Relocate the airpointer portable station to monitor effects of urban Medicine Hat and Red Cliff.	Knowledge Improvement, Education and Engagement

	Management Action Initiative	Description	Initiative Type
	Urban Municipalities	Updates to Municipal Development Plans and/or bylaws to consider air quality. Municipal building upgrades (solar panels, LED lighting, etc.) and sustainable maintenance practices. "Greening" of municipal vehicle fleets (transit buses, garbage trucks, etc.) to compressed natural gas (CNG), hybrid, electric, etc. Street sweeping to reduce road dust. Traffic management (light optimization, demand management, congestion, easing traffic circles, anti-idling). Upgrades and expansion of pedestrian/ cyclist pathway networks. Development and implementation of fire permits and bans. Incorporation of efficient and renewable energy production technologies into municipal power generation facilities. Purchasing electricity from renewable sources. Education and incentive programs for residents (for example the HAT Smart program in Medicine Hat, Eco-Leaders program in Calgary, Mayor's Environment Expo in Calgary) and employees (for example Employee Mobility Choices program in the City of Calgary) Development and implementation of plans, policies, strategies and programs (for example, transportation plans, cycling plans, environmental policies, green driving policies, climate change programs, procurement policies, urban forestry programs, sustainability strategies) Membership in local airsheds.	Regulatory, Policy, Voluntary Emission Reduction, Education and Engagement

	Management Action Initiative	Description	Initiative Type
	Rural Municipalities	Updates to Municipal Development Plans and/or bylaws to consider air quality. Municipal building upgrades (solar panels, LED lighting, showers to promote alternative modes of transportation, etc.) and sustainable maintenance practices. “Greening” of municipal fleets (newer more fuel efficient vehicles with better emissions controls). Street sweeping to reduce road dust in Hamlets. Gravel road dust mitigation. Road paving programs. Base stabilization programs. Traffic management (traffic models, traffic counting, etc.) Upgrades and expansion of pedestrian/ cyclist pathway networks and sidewalks. Development and implementation of fire permits and bans. Educational newsletters and website resources for residents (landscaping, burning, agricultural BMPs, etc.) Educational programs for employees (for example idling awareness campaign in Wheatland County). Development and implementation of plans, policies, strategies and programs (for example, pathway plans, servicing agreements, environmental policies and programs, urban forestry plans, etc.) Membership in local airsheds.	Regulatory, Policy, Voluntary Emission Reduction, Education and Engagement

Appendix C - How to Interpret a Box Plot