South Saskatchewan Region

Status of Management Response for Environmental Management Frameworks, as of October 2019

Alberta

Environment and Parks, Government of Alberta

October 2020

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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 exceedances of air quality triggers for the years 2014 to 2018, and surface water quality triggers and limits from April 2014 to March 2019 in the South Saskatchewan Region. It fulfills 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 have been crossed. As a result, the Ministry of Environment and Parks is leading the required management response, which is focused on improving knowledge and understanding of what is contributing to the observed air quality, in alignment with the applicable management intents. This report communicates the status of the response as of October 2019, 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 have 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 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 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 2018/2019 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 historical trigger and limit exceedances (from 2014/2015 to 2017/2018), and the status of the management response for the most recent 2018/2019 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 is in the investigation phase, while further preliminary assessment work is ongoing for the remaining parameters.
- 2015/2016 Update – An investigation is underway 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 has been 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 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 is underway to assess the winter limit exceedance of total dissolved solids in the Milk River at Hwy 880.
- 2017/2018 Update – Preliminary assessment 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 Medicine Hat - 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 Medicine Hat - Hwy 1) and an investigation is underway to evaluate the winter limit exceedance of total dissolved solids and specific conductance in the Milk River at Hwy 880.
- 2018/2019 – Preliminary assessment is ongoing for parameters that crossed triggers or guidelines at the monitoring stations where the crossing occurred (i.e. chloride at South Saskatchewan River at Medicine Hat - Hwy 1; sulphate at Bow River at Cochrane; chloride, nitrate and specific conductance at Bow River at Carseland; nitrate and pH at Bow River at Cluny; chloride, nitrate and total nitrogen at Bow River at Ronalane; sulphate and E. Coli at Oldman River at Hwy 3; total selenium at Milk River at Hwy 880) and an investigation is underway 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 or limit 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, ozone, and fine particulate matter) are reported annually under the South Saskatchewan Region Air Quality Management Framework using data collected at monitoring stations in Airdrie, Calgary, Lethbridge, and Medicine Hat (Figure 1).

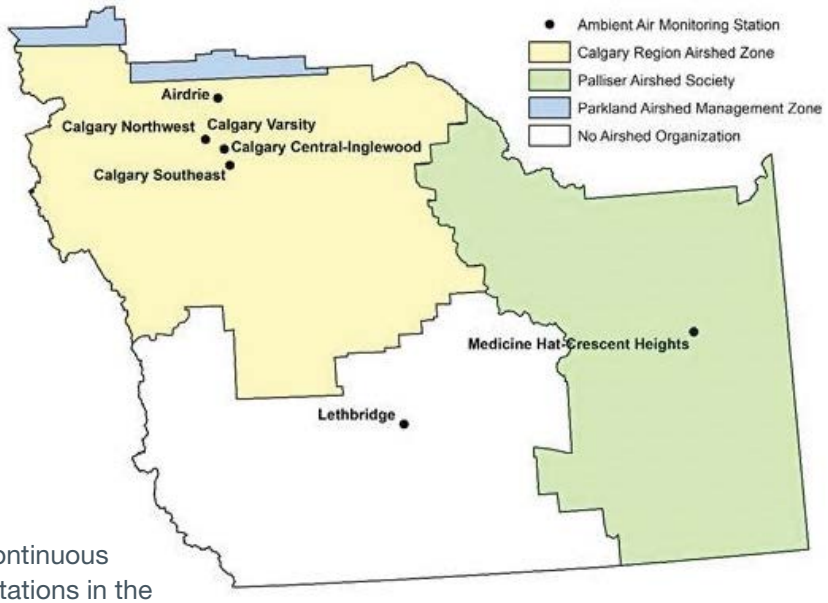

Figure 1. Location of Continuous Ambient Air Monitoring Stations in the South Saskatchewan Region.

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.

This report provides an update on the management response since the last status report in October 2018 (AEP, 2020). This is the fourth 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 (www.alberta.ca/south-saskatchewan-regional-planning.aspx).

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 nitric oxide (NO_x), which is released from combustion processes. In sunlight, NO_2 can lead to the formation of ozone, nitric acid, and nitrate-containing particles (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 (VOCs) 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 burning of vegetation for land clearing (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), nitrous oxides (NO_x), and volatile organic compounds (VOCs)). Management actions for $PM_{2.5}$ 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 nitrogen dioxide, ozone, and fine particulate matter 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

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 2018 Status of Air Quality, South Saskatchewan Region, Alberta (Thi, 2020).

For the $PM_{2.5}$ and O_3 assessments, the methodology and procedures set out in the Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards (CAAQS) for Fine Particulate Matter and Ozone (CCME, 2012) were followed to determine the CAAQS achievement status. This includes examination of data for transboundary flows and exceptional events (i.e., forest or grass fires).

A new continuous air monitoring station in Airdrie began operations in April of 2017. The 2018 calendar year is the first reporting year the Airdrie station met the completeness criteria of at least 75% data completeness required for reporting. In Calgary, the Northwest Station was required to relocate, due to land redevelopment, and was subsequently decommissioned. The new location, a few 100 metres away, is named Calgary Varsity and started operation in June of 2018, thus the station did not meet data completeness for the current reporting year.

2.2 Minister's Determination

The Minister's Determination for 2018 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 2018, resulting in assigning ambient air quality levels described in the 2018 Status of Air Quality South Saskatchewan Region Report (Thi, 2020) (Table 1) and below. Results from status assessments in previous years can be found on the AEP website (https://www.alberta.ca/environment-and-parks.aspx).

2.2.1 Nitrogen Dioxide

Based on the 2018 Status of Air Quality South Saskatchewan Region Report, Level 3 is assigned for nitrogen dioxide (NO_2) at Calgary Central-Inglewood station and Level 2 is assigned for NO_2 at Calgary Southeast station. Level 1 for NO_2 is assigned in Airdrie, Medicine Hat and Lethbridge.

Calgary Northwest station was decommissioned in May 2018; therefore, the station did not meet the data completeness criteria of at least 75% data completeness for NO_2 in 2018. Calgary Varsity station was operational starting June 2018; therefore, the station did not meet the data completeness criteria of at least 75% data completeness for NO_2 in 2018.

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), O_3 and $PM_{2.5}$ are reported for three-year periods. The 2017 (2015-2017 reporting period) CAAQS assessment results place the South Saskatchewan Region into Level 2 for $PM_{2.5}$ and Level 3 for O_3. Management levels have not yet been assigned for $PM_{2.5}$ and O_3 for the 2016-2018 reporting period because analysis is still underway.

For the most recent reporting years (2015-2017), $PM_{2.5}$ levels at all Calgary and Lethbridge stations have remained at a Level 2, consistent with the previous three reporting years. Levels for $PM_{2.5}$ at Medicine Hat have remained at Level 2 or lower consistent with the previous three reporting years.

For O_3, the Calgary and Lethbridge stations continue to be reporting at a Level 2. Medicine Hat, however, has triggered into a Level 3 for the most recent reporting period.

Table 1. Ambient Levels Assigned to Air Quality Monitoring Stations in the South Saskatchewan Region for 2014-2018

(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 2011-2017 Management Levels for the Ozone, $PM_{2.5}$ 24-hour and $PM_{2.5}$ Annual Metrics [AEP, 2017a; Brown and Ross, 2018; Brown, 2019; Thi, 2020]).

Station	NO_2 Levels*									
	Annual Average					Upper Range				
	2014	2015	2016	2017	2018	2014	2015	2016	2017	2018
Airdrie					1					2
Calgary Central 2	3					2				
Calgary Central - Inglewood			2	2	3			2	2	2
Calgary Northwest	2	2	2	2	n/a[a]	2	2	2	2	n/a[a]
Calgary Southeast		2	2	2	2		2	2	2	2
Calgary Varsity					n/a[a]					n/a[a]
Medicine Hat	1	1	1	1	1	1	1	1	1	
Lethbridge	1	1	1	1	1	1	1	1	1	1

Station	CAAQS Management Levels**														
	Ozone					$PM_{2.5}$ 24-hour					$PM_{2.5}$ Annual				
	2011-13	2012-14	2013-15	2014-16	2015-17	2011-13	2012-14	2013-15	2014-16	2015-17	2011-13	2012-14	2013-15	2014-16	2015-17
Airdrie					n/a[a]					n/a[a]					n/a[a]
Calgary Central 2	1	1	1			n/a[a]	3	3			n/a[a]	3	3		
Calgary Central - Inglewood				3[b]	2				n/a[a]	2				n/a[a]	2
Calgary Northwest	2	2	2	2	2	3	3	3	2	2	3	3	3	2	2
Calgary Southeast		n/a[a]	2	2	2		n/a[a]	n/a[a]	2	2		n/a[a]	n/a[a]	2	2
Calgary Varsity					n/a[a]					n/a[a]					n/a[a]
Medicine Hat	2	2	2	2	3	2	2	2	2	2	3	2	2	2 or lwr[c]	2 or lwr[c]
Lethbridge	2	2	2	2	2	2	2	3	2	2	3	2	3	2	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 and 2015-2017 assessments 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 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 ($PM_{2.5}$) (AESRD 2014a). The status of management response is reported on a regular 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 three previous South Saskatchewan Region Status of the Management Response for Environmental Management Frameworks Reports (AEP, 2017b, 2018, 2020).

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, industry, non-governmental groups, government at multiple levels, and regulatory agencies may all be important for both understanding regional issues and exploring options to address ambient air quality issues. 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.

3.1.1 Nitrogen Dioxide (NO_2)

As in previous reports, the NO_2 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). Analysis of the 2018 data resulted in findings similar to those reported in the previous management response report (AEP, 2020, Appendix A).

The seasonal variation was similar between the NO_2 data measured at all the air monitoring stations in the South Saskatchewan Region. While elevated concentrations may be observed throughout the year, they were more likely measured in the winter months and during lower wind speed conditions. Lower wind speeds inhibit dispersion of NO_2 and other pollutants. This was consistent for Airdrie, Calgary, Lethbridge, and Medicine Hat. Overall, the land use around stations and the time of day when elevated concentrations are occurring implies that traffic emissions could be a notable contributor to elevated NO_2 concentrations.

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

The 2015-2017 data were analyzed from the Calgary Central-Inglewood, Calgary Northwest, Calgary Southeast, Lethbridge, and Medicine Hat air monitoring stations. Since both the Airdrie and Calgary Varsity stations were new monitoring locations they were not included in the analysis, as data did not meet data completeness criteria for the entire reporting period. 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 µg/m^3 (the trigger into Level 3). Analysis of the 2015-2017 data resulted in findings similar to those reported in the previous management response report (AEP, 2020, Appendix A).

The seasonal $PM_{2.5}$ variation was similar for 2015-2017 among all the South Saskatchewan Region air monitoring stations reporting during the time period. Although elevated concentrations may be observed throughout the year, such concentrations were more likely in the colder winter months (November through February) and least likely to be observed in

the summer. 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. Similar boundary layer effects, detailed in the previous management response report (AEP, 2020), are impacting $PM_{2.5}$ concentrations as seen in the NO_2 analysis. 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.

3.1.3 Ozone (O_3)

Ozone concentrations at the reporting South Saskatchewan Region monitoring stations have lingered at or just below the trigger into Level 3 for recent reporting time periods. Detailed O_3 data analysis has not previously been conducted as none of the reporting stations had triggered into a Level 3 for an entire reporting period. For the 2015–2017 reporting period, because Medicine Hat exceeded the trigger into Level 3 for O_3, an analysis was conducted. The data analysis explored temporal variations of O_3 events and associated meteorological conditions. Elevated concentrations or 'events' were defined as 1-hour averaged O_3 concentrations greater than 56 ppb (the trigger into Level 3).

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.

Since O_3 is a photochemical produced pollutant (described in Section 1.1), it is expected that elevated concentrations are most often observed during the warmest part of the day, midafternoon, which is shown in Figure 2.

Similarly, elevated O_3 concentrations occur most often during the warmer months of the year April through September, with a large proportion occurring in May through August (Figure 3).

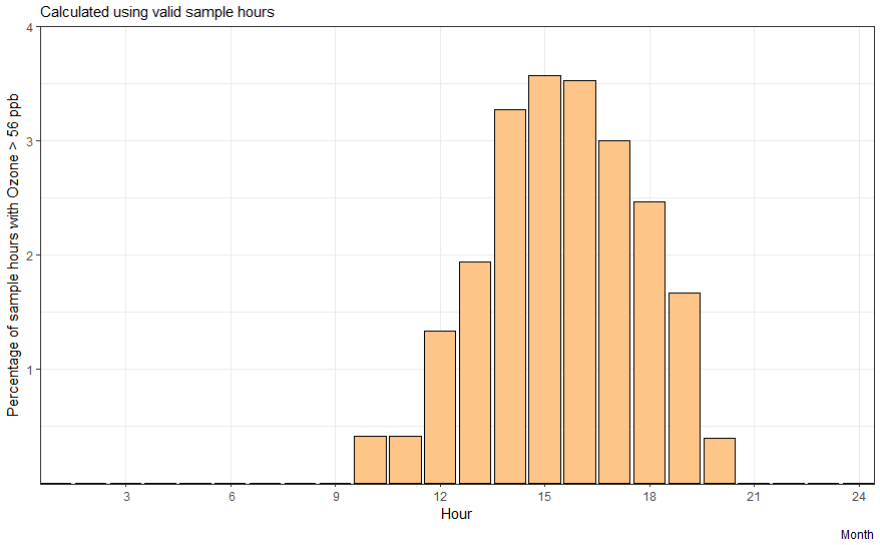

Figure 2. Percentage of one hour O_3 samples with concentrations greater than 56 ppb for each hour of the day at the Medicine Hat monitoring station for the years 2015-2017.

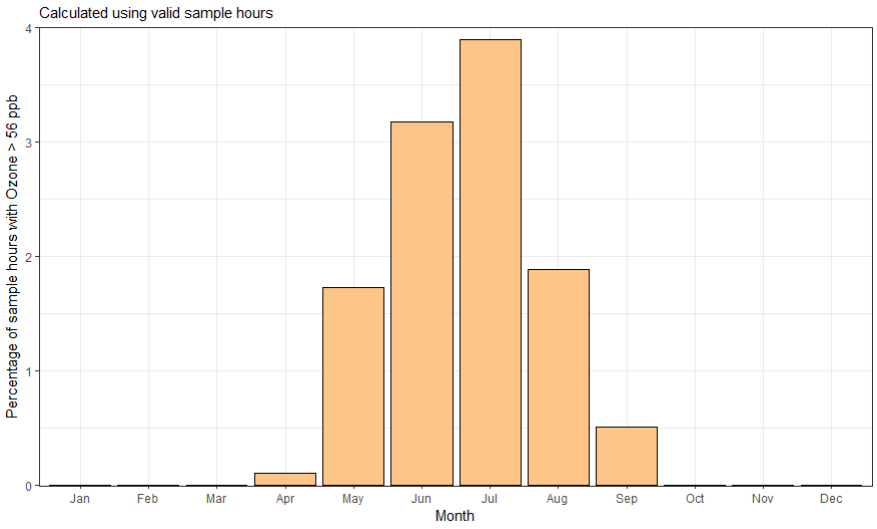

Figure 3. Percentage of one hour O_3 samples with concentrations greater than 56 ppb for each month of the year at the Medicine Hat monitoring station for the years 2015-2017.

Elevated ozone concentrations occurred in all years of the time period studied, with 2017 having a higher occurrence of elevated concentrations and 2016 having the least amount of elevated concentration occurrence of the study period (Figure 4). Overall, the elevated O_3 concentrations occur in the diurnal and seasonal warm periods as expected due to the nature of the formation of the substance.

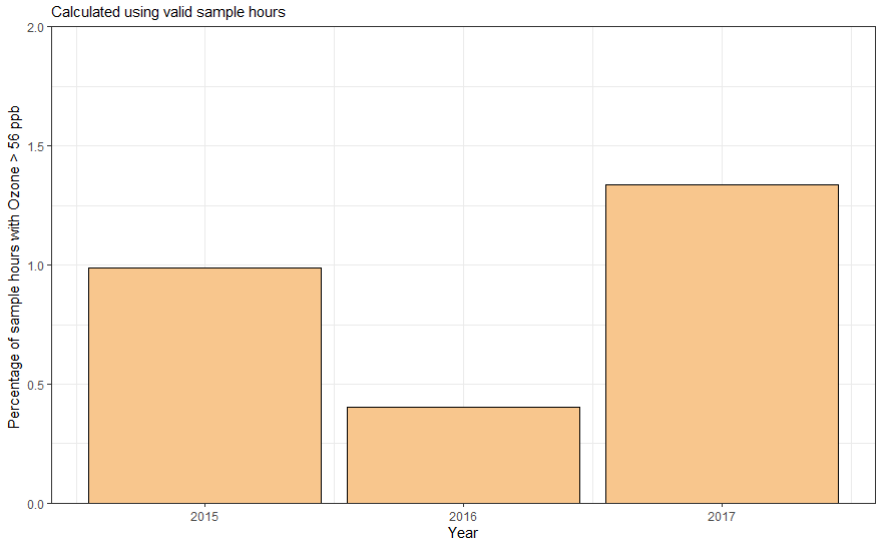

Figure 4. Percentage of one hour O_3 samples with concentrations greater than 56 ppb by year at the Medicine Hat monitoring station for the years 2015-2017.

It is difficult to assess O_3 trends because measured concentrations not only depend on available precursors during the short warmer period but also on conducive meteorological conditions. Due to its nature as a secondary pollutant (not directly emitted), pollutant transport into the region often has a role in O_3 concentrations, be it the precursors that lead to O_3 formation or O_3 itself. This further complicates understanding of potential elevated O_3 concentrations. Scoping of further investigation into O_3 concentrations across the South Saskatchewan Region has been initiated.

3.1.4 Photochemical Modelling

Modelling of ambient air quality is valuable as it provides a snapshot that enables evaluation of how pollutant concentrations vary spatially and temporally, and how different source sectors contribute to pollutant concentrations throughout the province. Environment and Parks 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 (GoA, 2018b). The project not only considered primary particulate matter, directly emitted into the air, but also studied the known compounds that contribute to the formation of secondary $PM_{2.5}$. The study focused 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 conducted as part of the modelling study 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 predicted pollutant concentration.

The following are important observations realized through this study that may help inform the investigation and management planning activities (GoA, 2018b):

- The upstream oil and gas sector has the largest and most widespread impact on the ground level concentration of all pollutants analyzed. The impacts from this sector are especially large outside of urban areas or in areas with high concentrations of upstream oil and gas activities. Widespread NO_2 reductions were predicted with the removal of the upstream oil and gas sector. NO_2 emissions impacts from other industrial sources were only predicted to occur close to the emitting source.
- Within urban areas and surrounding municipalities, on-road mobile sources (i.e., vehicles) and other non-industrial sources are key contributors to the ground level concentration of $PM_{2.5}$, O_3 and NO_2. NO_2 emissions from these sectors also result in the formation of $PM_{2.5}$ and O_3 in and around major urban areas.
- The agriculture sector has widespread impacts on ground level $PM_{2.5}$ concentrations across much of Alberta, but especially central and southern Alberta. The agricultural sector is a significant emitter of primary $PM_{2.5}$ (e.g. dust) as well as NH_3 from intensive livestock operations and fertilization. Ammonia is an important precursor to the formation

of secondary $PM_{2.5}$ and as such, this sector is an important contributor to the formation of $PM_{2.5}$ outside of urban areas. Agricultural produced NO_2 produced predicted concentrations are low.

- The contribution of dust emissions to overall ground-level $PM_{2.5}$ concentrations are likely overstated in this study. In part, this can be attributed to emissions distribution and the challenges with the approach used to spatially allocate emissions. Therefore it is likely that the provincial scale emissions estimates for dust are overstated in the emissions inventory itself. The end result is that ground-level $PM_{2.5}$ concentrations are generally over-predicted in locations of higher population (i.e. urban areas). If the 'other particulate matter' emission source sector (which is dominated by dust emissions) are removed from the predicted concentrations, the CMAQ model performance is substantially improved in populated areas, providing evidence to conclude that dust emissions are overstated.

Emission sector-based zero-out scenarios do not represent a sector contribution exactly, due to the non-linear nature of the photochemical reactions involved, but it does provide a good relative measure of a sector's contribution to pollution in the modelling domain. As such, it is a valuable tool for management response planning. This information can help to identify sectors that have larger impacts, such as upstream oil and gas in this study, and can ultimately help to inform the selection and targeting of management actions. The modelling confirms previous investigation findings that urban non-point sources are a significant contributor to air quality surrounding the reporting stations in the South Saskatchewan Region.

3.1.5 Spatial Variability of Air Quality in Lethbridge and Medicine Hat

Initial discussions with stakeholders raised the question for both Medicine Hat and Lethbridge of how representative one reporting monitoring station is of air quality in the respective city overall. Focused monitoring studies to assess spatial variability were initiated to address these concerns.

The Palliser Airshed Society (PAS) located its portable ambient air monitoring station near the Medicine Hat Airport in the southwest quadrant of the City. The permanent Medicine Hat – Crescent Heights ambient air monitoring station, used for reporting, is located in the opposite northeast quadrant of the City. The portable monitor was deployed to the airport location in the fall of 2016 and collected air quality measurements until the summer of 2018. A subsequent comparison between the airport data and the corresponding data collected at the Crescent Heights station was undertaken. Overall, the monitored concentrations were comparable with slightly higher concentrations recorded at the Medicine Hat Airport location which could be due to the proximity of a gravel road and airport traffic or analyzer stability (a portable monitoring station is less stable than a permanent station and more sensitive to environmental fluctuations) (PAS, 2018).

The Alberta Environment and Parks Mobile Air Monitoring Laboratory (MAML) was deployed to Lethbridge to conduct a study with the objective of investigating the spatial variability of air quality in the City (AEP, 2019). The MAML provides a snapshot of air quality in a given location, in a given timeframe and was deployed from November 2016 to October 2017 to six different locations in the City with monitoring conducted once each season at each of these locations.

To assess the representativeness of the Lethbridge continuous station of the air quality in Lethbridge, the measurements made at the continuous station were compared with those made at the MAML monitoring locations. With only a few hours of data available at each MAML monitoring location to compare with the continuous station, the representativeness of this comparison is limited. Overall the NO_2 concentrations measured at the MAML locations were generally lower than measurements made by the continuous station, while $PM_{2.5}$ concentrations were generally higher but no extreme differences were observed.

A similar undertaking has not been proposed for Calgary as spatial coverage is provided by the three continuous stations operating throughout the City.

3.1.6 Investigation Summary

The investigation completed to date provides valuable information to better understand the factors contributing to elevated NO_2, $PM_{2.5}$ and O_3 concentrations in the region. Similar boundary layer effects are impacting NO_2 and $PM_{2.5}$ concentrations. 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.

At the Medicine Hat monitoring station, elevated O_3 concentrations occur most frequently during the warmest, sunniest part of the day as well as the warmer months of the year. This is expected because of the formation of O_3 from the interaction of NOx and VOCs with sunlight.

Provincial CMAQ modelling predictions indicate that the upstream oil and gas sector has the largest and most widespread impact on the ground level concentration of all pollutants analyzed, especially in rural areas. Within and surrounding urban areas, on-road mobile sources and other non-industrial sources (e.g., commercial and home heating, off-road mobile sources, dust from construction activities, etc.) are key contributors to the ground level concentration of $PM_{2.5}$, O_3 and NO_2.

Overall, the investigation findings to date suggest that effective management around South Saskatchewan Region reporting monitoring stations should focus on urban non-point source (e.g. transportation) 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 air quality goals 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.

Management actions may range from policy or regulatory initiatives to reduce emissions, to voluntary actions and raising awareness and understanding surrounding air quality. Knowledge improvement actions including gathering baseline information, improving scientific understanding and knowledge and learning from other jurisdictions may also be included.

Several management actions for addressing air quality in the South Saskatchewan Region were identified in the South Saskatchewan Region Air Zone Canadian Ambient Air Quality Standards Response Government of Alberta Action Plan which was developed in 2017 and is currently being implemented (GoA, 2017). Additional management actions have also been identified in previous Status of the Management Response Reports.

A full list of the management actions identified and the progress to date under each action is provided in the following section. It is important to recognize that some management actions can take a number of years to initiate and the impact of implementing certain actions may take several years to be realized. Management of non-point source emitters is inherently complex; it is an inter-governmental and cross-jurisdictional issue. Collaboration of all stakeholders is key to the success of proactive air quality management actions.

Ongoing investigation and studies will continue to inform and establish necessary and appropriate mitigative actions as required.

3.3 Oversight/Delivery of Management Actions

The current identified management actions and progress updates on ongoing management actions described in previous management response reporting are detailed below. Management actions are separated into Knowledge Improvement Actions, Policy Actions, Regulatory Process Actions and Engagement Actions.

Several of the policies and management actions listed can also apply provincially to improve protection of air quality.

Knowledge Improvement Actions:

Currently, Alberta has the largest network of ambient air monitoring stations in Canada. Alberta Environment and Parks 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	Status	Progress Update
Ambient data analysis	Environment and Parks will conduct analysis of ambient data as required to inform the investigation including: • Analyze available monitoring data to investigate possible causes or influences on elevated concentrations, look at links to meteorology (wind/ wind direction) and covariance between pollutants, 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 mobile Airpointer Medicine Hat Airport location for additional spatial information.	Ongoing	During previous Status of the Management Response for Environmental Management Frameworks reports, analysis of ambient NO_2 and $PM_{2.5}$ data was presented. Analysis of ambient O_3 data was not included because O_3 had been at a Level 2 or below at that time. For the 2015-2017 reporting period, O_3 reached a Level 3 at the Medicine Hat monitoring station, so ambient data analysis for O_3 was initiated and is included in Section 3.1.3 of this Status of the Management Response Report. Scoping of further analysis of O3 concentrations across the South Saskatchewan Region has been initiated. Work planning and scheduling has initiated for analysis of existing PM composition data and prioritization of potential future PM composition data collection locations. Short-term monitoring survey results from the City of Lethbridge and City of Medicine Hat are summarized in Section 3.1.5 of this Status of the Management Response Report.

Action	Description	Status	Progress Update
Additional ambient air monitoring	Environment and Parks and partners will conduct additional ambient air quality monitoring as required to inform the investigation including, for example, the following: • Palliser Airshed Society (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 (CRAZ) deployment of portable air monitoring laboratory (PAML) to address monitoring gaps and provide the Air Quality Health Index (AQHI) in previously unmonitored areas.	Ongoing	The Palliser Airshed Society (PAS) mobile Airpointer ambient monitor was sited temporarily at the Medicine Hat Trap Club to assess air quality northeast of Medicine Hat. The Airpointer is scheduled to relocate fall of 2019 to an alternate location in the Palliser Airshed to further augment the existing spatial understanding of air quality. The CRAZ PAML was deployed for four-month rotations starting in Cochrane in November of 2018 and Foothills County in spring 2019. The PAML is scheduled to relocate to Canmore in fall of 2019. Lethbridge Air Quality Focused Study report available at: https://open.alberta.ca/publications/9781460143674
Provincial modelling emissions inventory and photochemical modelling	Environment and Parks acquired consultant support to conduct a provincial scale photochemical modelling study, including an update to the Alberta provincial emissions inventory and "zero-out" scenarios to assess the relative contributions of various source sectors to primary and secondary $PM_{2.5}$.	Complete	A summary of the findings of the study is included in Section 3.1.4. The final report prepared by the consultant was published January 2019 and is available at: https://open.alberta.ca/publications/9781460142387
Alberta Air Quality Management Action Toolbox	Environment and Parks, in collaboration with partners, is working on the development of an inventory of possible management actions for addressing air quality. This inventory is filterable by the source sectors and the criteria air contaminants addressed by each management action. Inclusion of information on whether the action is already being implemented in Alberta and various selection criteria (including cost-effectiveness and public support) is also planned. When complete, the intent of the tool will be to support the informed selection of various management actions for inclusion in the management response.	In-Progress	The development of the toolbox was initiated in July 2019 as a collaboration across multiple AEP Divisions. Phase I of the project is to compile available information from jurisdictional reviews that have been contracted by Environment and Parks in the past to develop an initial draft inventory of possible actions. Phase I is anticipated to be complete in October 2019. The next step is for Environment and Parks to engage with Government of Alberta Integrated Resource Management System partners to refine the draft inventory and expand the inventory to include additional details

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	Status	Progress Update
Action on non-point air emission sources such as transportation.	The Government of Alberta continues to undertake initiatives to address non-point source air emissions. Some examples include: • 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 Government of Alberta has been taking steps to manage non-point source emissions such as through funding to support Emissions Reduction Alberta's BEST Challenge for sustainable transportation and to help expand Alberta's transit system, green Alberta's transit fleet, and support the transition to electric vehicles. • The Government continues to collaborate with federal/ provincial/ territorial jurisdictions through the Canadian Council of Ministers of the Environment (CCME) Mobile Sources Working Group.	Ongoing	The CASA report, Recommendations to Reduce Non-Point Source Air Emissions in Alberta (CASA, 2018), is helping to inform action on non-point sources. • A CASA ROVER III Project, recommended by the CASA Non-Point Source Report, commenced in May 2018 with roadside vehicle emissions testing planned to occur in Spring 2020, and a final report is anticipated in 2020. • The Government of Alberta is considering implementation of additional non-point source recommendations through CASA, including pursuing a Statement of Opportunity in Fall 2019 related to construction and road dust. • The BEST Challenge was launched in July 2018 to provide funding for biotechnology, electricity and sustainable transportation projects. 180 expressions of interest were submitted in September 2018. Twenty-four were invited to submit full project proposals. Funding recipients were selected in March 2019. All recipients are required to produce a final outcomes report. • Work with the CCME Mobile Sources Working group is ongoing which will help inform further transportation management actions in Alberta.

Action	Description	Status	Progress Update
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 exceedances.	Environment and Parks has contracted a jurisdictional review of regulatory strategies, tools and practices used to manage and improve air quality in “non-attainment” areas.	Ongoing	The International Review of Non-Attainment Area Air Quality Management Tools and Techniques Report is available at: https://open.alberta.ca/publications/9781460130148. This report is being used in Phase I of the Air Quality Management Action Toolbox project (see above).
Establish and update source standards for both industrial sectors and equipment to reduce emissions.	Environment and Parks is working on the development of more stringent equipment standards for new boilers and heaters.	Ongoing	These standards are undergoing internal review.
Reduce methane emissions in Alberta for co-benefits in improving air quality as methane contributes to ozone formation.	Reduction in methane emissions will have co-benefits in improving air quality. Methane reduction and reporting requirements have been incorporated into Alberta Energy Regulator directives.	Complete	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 has been completed and the new regulations will come into effect in 2020.
Annual Emissions Inventory Reporting Requirements	Environment and Parks has put in place new annual emissions inventory reporting requirements for *Environmental Protection and Enhancement Act* (EPEA) approved industrial operations as set out in the Air Monitoring Directive (AMD) Reporting Chapter and the Substance Release Regulation.	Complete	Beginning in September 2019, *Environmental Protection and Enhancement Act* (EPEA) approved industrial facilities are required to carry out an inventory of their sources and air emissions, and to report if they exceed certain thresholds. For more information on the Annual Emissions Inventory Reporting Program, see https://www.alberta.ca/amd-resources.aspx.
Update Alberta Ambient Air Quality Objectives	Alberta's Ambient Air Quality Objectives (AAAQOs) are intended to provide protection of the environment and human health to an extent technically and economically feasible, as well as socially and politically acceptable. The department has been reviewing these objectives through multi-stakeholder consultation since 2000. Alberta now has air quality objectives for more than 30 substances that could be released to the atmosphere.	Ongong	The 24-hour $PM_{2.5}$ AAAQO was updated effective January 1, 2019, and the 1-hour daily maximum ozone objective was updated effective April 1, 2019. Work is continuing on review of objectives for, nitrogen dioxide, sulphur dioxide and potential development of a guideline for total reduced sulphur compounds.

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	Status	Progress Update
Action on industrial emissions	The Alberta Energy Regulator and Environment and Parks are requesting more stringent emissions standards be applied to all industrial sources in industrial approval applications that are in air zones which require management based on Environmental Management Frameworks or the CCME Air Quality Management System.	Ongoing	More stringent emission standards are being applied to industrial sources on an ongoing basis through continuous improvement in the approvals process.

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 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	Status	Progress Update
Develop a provincial air literacy program.	Alberta Environment and Parks 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.). As a part of this work, Environment and Parks will undertake the development of an air literacy strategy. The air literacy strategy will reflect input from internal staff and partners to ensure strategic alignment and pragmatic implementation.	In-Progress	Work on the Air Literacy Strategy was initiated in fall of 2018 and continues. Environment and Parks' Community Engagement Branch (CEB) is currently working on the development of an Air Literacy Strategy for the province. The Air Literacy Strategy will align with other strategies that are being developed for other media.
Collaborate with existing stakeholder connections and support management actions underway.	Environment and Parks carried on discussions with stakeholders and continues to support existing initiatives underway. As a part of this work, Environment and Parks will host a regular forum to update stakeholders on progress made under the management response and next steps.	Ongoing	The first SSR Air Forum was hosted by Environment and Parks via Zoom technology in November 2018. Invitations were sent to members of the Calgary Region Airshed Zone (CRAZ) and the Palliser Airshed Society (PAS) as well as to Lethbridge area stakeholders. Additional forums will be hosted as needed as new information becomes available that would be of interest to South Saskatchewan Region air quality stakeholders.

Action	Description	Status	Progress Update
Calgary Region Airshed Zone (CRAZ) Air Quality Management Plan	The Calgary Region Airshed Zone (CRAZ) Air Quality Management Plan is a multi-stakeholder plan to address air quality in the CRAZ region that was first developed in 2008.	Ongoing	CRAZ works toward the implementation of its Air Quality Management Plan on an ongoing basis and conducts regular reviews and updates of the plan. In 2018, an Achievement Report was prepared by the CRAZ Air Quality Management Planning Committee to summarize progress made under the plan since the 2014 update. Following the completion of the achievement report, the plan was updated in 2019. The updated CRAZ Air Quality Management Plan was approved by the CRAZ Board in September 2019. Environment and Parks will continue to support the implementation of the CRAZ PM and Ozone / Air Quality management plan by a multi-stakeholder group for the Calgary Region.

4.0 Air Quality Next Steps

Environment and Parks will continue to oversee the delivery of the identified management actions while also continuing the investigation into the trigger exceedances, particularly at the stations triggering into Level 3. A primary focus of the management actions is on knowledge improvement to better understand possible contributors to the elevated air quality concentrations around the reporting monitoring stations in the South Saskatchewan Region.

Further work is planned to gain a better understanding of the NO_2 emission source sectors, such as upstream oil and gas, which modelling has shown as a possible significant contributor to NO_2 concentrations across the South Saskatchewan Region. Stations in Calgary have triggered the need for NO_2 management in 2014 and 2018 and it is anticipated to reoccur with the expected adoption of the more stringent NO_2 CAAQS in 2020. This pollutant is also an important contributor to the formation of both $PM_{2.5}$ and O_3.

Although assessments to date have only shown Medicine Hat to trigger into Level 3 for O_3, concentrations at the other South Saskatchewan Region stations have lingered at or just below the trigger into Level 3 in recent years. Scoping of further investigation into O_3 concentrations across the region has been initiated. Since O_3 is not directly emitted into the environment, the gases that contribute to its formation need to be targeted in order to manage ambient O_3 concentrations.

Next steps will also include completing the development of the Alberta Environment and Parks (AEP) Air Literacy Strategy which will be leveraged to provide tools to raise awareness of poor air quality, air quality management and to promote action. Additionally, compilation of an inventory of possible management actions and identifying effective actions that are reasonable for implementation in the management response are also planned.

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 subsequent Status of the Management Response Reports.

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

Under the South Saskatchewan Regional Plan (GoA, 2018a), a management response must be initiated when the condition of one of the 15 primary indicators (Table 4) 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) (AESRD, 2014b) also identifies six secondary indicators (Table 5). 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 5). 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 fourth status of management response report produced since the South Saskatchewan Regional Plan came into effect in September 2014.

Table 4. 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 5. 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 ongoing management responses that were initiated in response to trigger and limit exceedances observed between 2014/2015 and 2017/2018 (AEP, 2017b, 2018, 2020), and describes the management response to date for the 2018/2019 exceedances. Environment and Parks is the lead in undertaking the management response and will work with other government organizations and external parties as required.

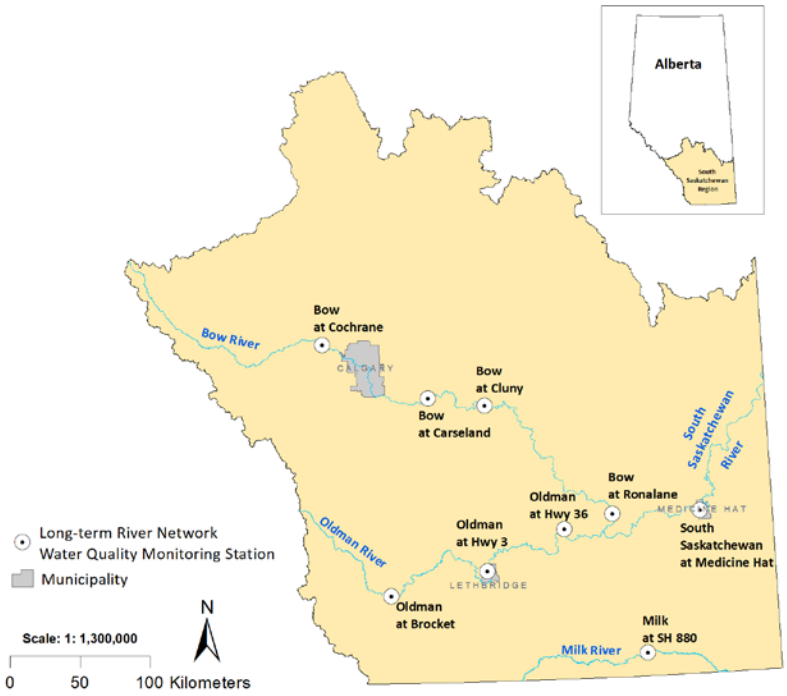

Figure 5. Location of Nine Long-term River Network Water Quality Monitoring Stations included in the South Saskatchewan Region Surface Water Quality Management Framework.

Steps of the Management Response

6.0 Summary of Water Quality Exceedances

A summary of the exceedances to date is presented in Figure 6 (AEP 2017c; Kerr et.al. 2018a, 2018b, Chung et.al, 2019; Taube and Kerr, 2020). 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,
- six trigger crossings in 2017/2018, and
- fifteen trigger crossings in 2018/2019.

Two indicators have exceeded a limit:

- total dissolved solids (TDS) in the Milk River at Hwy 880 station in 2015/2016, 2016/2017, 2017/2018, and 2018/2019, and
- specific conductance in the Milk River at Hwy 880 station in 2017/2018 and 2018/2019.

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

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

One secondary indicator (selenium) exceeded a guideline alert concentration[1] in:

- the Milk River at Hwy 880 station in 2018/2019.

[1] In 2018, Alberta adopted updated guidelines for selenium, based on advances in scientific data and understanding (GoA 2018b). What was previously considered as a chronic guideline (1 ug/L) is now considered an “alert concentration”. Exceedance of the alert concentration in sensitive environments indicates the need for increased monitoring of water and other ecosystem compartments to support early detection of potential selenium bioaccumulation and provide earlier opportunities to commence proactive management actions. Therefore, the guideline that was met or exceeded in 2015/2016 and 2017/2018 is equivalent to the alert concentration that was exceeded in 2018/2019. The new chronic exposure guideline for the protection of aquatic health is 2 ug/L.

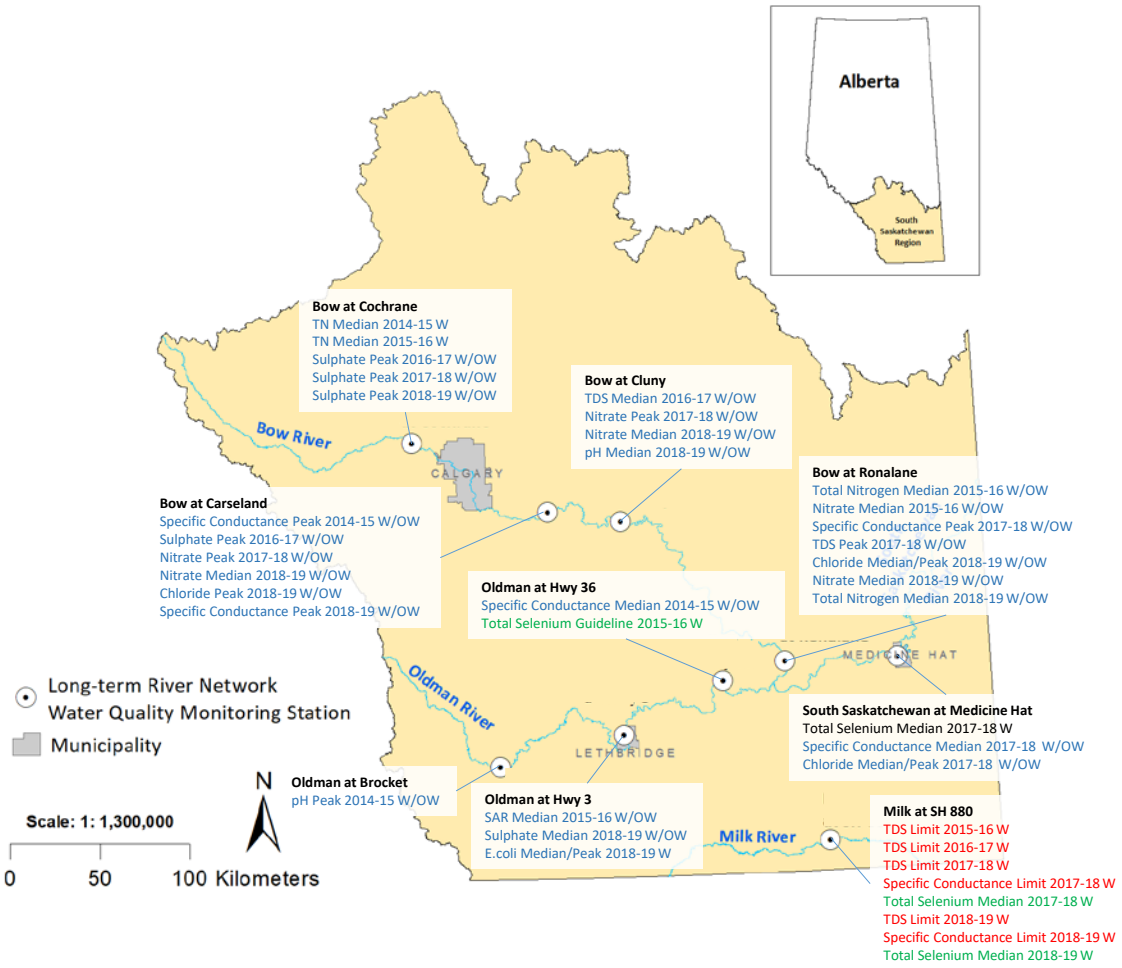

Figure 6. Summary of the Surface Water Quality Indicator Limit, Trigger or Guideline Exceedances at the South Saskatchewan Region SWQMF Monitoring Stations 2014/2015 to 2018/2019:

- 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

7.0 Status of Surface Water Quality Management Response

Table 6 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.

The majority of indicators that crossed a trigger in a past reporting period are in the preliminary assessment phase of the management response. One indicator (specific conductance at Bow River at Carseland) was moved into the investigation phase based on findings from the preliminary assessment, and the management response for one indicator (selenium at Oldman River at Hwy 3) was closed (AEP, 2020). Indicators that crossed a limit in this or past reporting periods are in the investigation phase. This report provides an update on these ongoing preliminary assessments and investigations, in response to recent and historical exceedances. A management response for selenium (secondary indicator) has also been initiated, 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 Management 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.

The following sections provide additional detail on the management response for each year's threshold crossings and a complete description of the work completed can be found in previous management response reports (AEP, 2017b, 2018, 2020).

Table 6. History of Median (M), Peak (P) Trigger and Guideline (G) Crossings, and Median Limit (ML) Exceedances for Which Current Management Response is Ongoing. Open Water (OW); Winter (W)

Crossing or Exceedance	2014/2015		2015/2016		2016/2017		2017/2018		2018/2019		Management Response When Last Reported	Management Response as of October, 2018	Next Steps
	OW	W	OW	W	OW	W	OW	W	OW	W			
Bow River at Cochrane Total Nitrogen		M		M							Verification complete Comparison to historical data and up and down-stream stations complete (Brown and Ross, 2018) Unadjusted and seasonally-adjusted trend assessments complete (AEP, 2018) Unadjusted and flow-adjusted trend analysis completed (AEP2020)	Comparison to historical data and up and down- stream stations and unadjusted and seasonally adjusted trend assessment updated for 2018/2019 exceedance.	Further Analysis
Bow River at Carseland Specific Conductance	P	P							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		ML	Verification complete Comparison to historical data and up and down-stream stations complete (AEP, 2018) Unadjusted and flow-adjusted trend analysis completed (AEP 2020)	Comparison to historical data and up and down- stream stations and unadjusted and seasonally-adjusted trend assessment updated for 2018/2019 exceedances. Source attribution for TDS at Milk River Hwy 880 advanced as part of investigation.	Investigation
Bow River at Ronalane Total Nitrogen			M	M					M	M			Further Analysis
Bow River at Ronalane Nitrate			M	M					M	M			Further Analysis
Oldman River at Hwy 3 Sodium Adsorption Ratio			M	M									Further Analysis
Oldman River at Hwy 36 Total Selenium				G				G					Close Management Response
Bow River at Cochrane Sulphate					P	P	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 (AEP 2020)	Comparison to historical data and up and down- stream stations and unadjusted and seasonally-adjusted trend assessment updated for 2018/2019 exceedances. Additional analysis on pause until flow data is available)	Further Analysis
Bow River at Carseland Sulphate					P	P							Further Analysis
Bow River at Cluny Total Dissolved Solids (TDS)					M	M							Further Analysis

Table 6. cont'd History of Median (M), Peak (P) Trigger and Guideline (G) Crossings, and Median Limit (ML) Exceedances for Which Current Management Response is Ongoing. Open Water (OW); Winter (W)

Crossing or Exceedance	2014/2015		2015/2016		2016/2017		2017/2018		2018/2019		Management Response When Last Reported	Management Response as of October, 2018	Next Steps
	OW	W	OW	W	OW	W	OW	W	OW	W			
Milk River at Hwy 880 Specific Conductance								ML		ML	Verification complete. Comparison to historical data and up and down-stream stations complete. Unadjusted and seasonally-adjusted trend assessments complete (AEP 2020)	Comparison to historical data and up and down- stream stations and unadjusted and seasonally-adjusted trend assessment updated for 2018/2019 exceedances. Additional analysis on pause until flow data is available. Understanding of specific conductance limit exceedance at Milk River Hwy 880 advanced as part of investigation.	Investigation
Bow River at Carseland Nitrate							P	P	M	M			Further Analysis
Bow River at Cluny Nitrate							P	P	M	M			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 Medicine Hat - Hwy 1 Specific Conductance							M	M					Further Analysis
Milk River at Hwy 880 Total Selenium								G		G			Further Analysis
South Saskatchewan River at Highway 1 Total Selenium								G*					Further Analysis
South Saskatchewan River at Medicine Hat - Hwy 1 Chloride									M/P	M/P	Not Applicable	Verification complete. Comparison to historical data and up and down-stream stations complete. Unadjusted and seasonally-adjusted trend assessments complete Additional analysis on pause until flow data is available	Further Analysis
Bow River at Ronalane Chloride									M/P	M/P			Further Analysis
Oldman River at Hwy 3 Sulphate									M	M			Further Analysis
Bow River at Cluny pH									M	M			Further Analysis
Oldman River at Hwy 3 E.coli										M/P			Further Analysis
Bow River at Carseland Chloride									P	P			Further Analysis

7.1 2014/2015 Management Response

Flow-adjusted trend assessments were completed in 2017 for the indicators that crossed a trigger in 2014/2015, covering three different time periods (AEP, 2020). Based on the observation of statistically significant increasing trends, specific conductance (Bow River at Carseland) was moved into the investigation phase. The remaining indicators will continue in the preliminary assessment phase and further analysis will be conducted to determine the need to move anymore into the investigation phase.

7.2 2015/2016 Management Response Update

Flow-adjusted trend assessments were completed in 2018 for the indicators that crossed a trigger in 2015/2016, covering three different time periods (AEP, 2020). Statistically significant increasing trends were observed for these indicators in only the longest of the three time periods assessed (which included the historical dataset used to determine trigger values); therefore these indicators remain in the preliminary assessment phase and further analysis will be conducted to determine the need to move any into the investigation phase.

Either no trend, or a statistically significant decreasing trend were observed for the selenium guideline exceedance (Oldman River at Hwy 36); therefore, this management response was closed (AEP, 2020).

A statistically significant increasing trend was observed in only one of the three time periods for TDS (Milk River Hwy 880), not considering the influence of flow. All other trend assessments indicated no trend. However, because the concentration of TDS exceeded a limit, the indicator remains in investigation phase. A list of additional analyses completed as part of the investigation are provided in the previous report (AEP, 2020). These analyses focused on understanding sources of salinity. Highlights of the winter TDS limit exceedances investigation findings to date include:

- Variability in water quality between the open water and winter season is primarily due to the addition of (relatively low TDS) water that is diverted into the Milk River from the St. Mary River during the summer months, which makes up 97% of the North Milk River flow during the open water season.
- The assessment of groundwater studies, water chemistry, flow volumes and groundwater springs collectively suggest that groundwater is likely the primary source of TDS to the Milk River in the winter.
- A physics-based ice volume model demonstrated that the variability in winter TDS concentrations, from year to year, is related to the volume of ice present in the river and the exclusion of salts from the ice formation process, concentrating in the remaining flowing water.

The investigation of TDS in the Milk River at Hwy 880 will continue and key next steps are provided in Section 8.0. Details of this investigation and its findings will be provided in a separate report.

7.3 2016/2017 Management Response Update

Since TDS in the Milk River at Hwy 880 again exceeded a limit, it remains in the investigation phase (see Section 7.2). The remaining three trigger exceedances, all for stations on the Bow River, remain 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

In response to 2017/2018 limit exceedances on the Milk River at Hwy 880, the investigation for TDS is continuing from previous years and an investigation for specific conductance has been initiated. Specific conductance and TDS are closely linked parameters and their relationship at this station has been explored. Those results and that of the investigation will be reported on in a separate document. The outcome of the investigation will inform the need for management actions. Highlights of the investigation findings are provided in Section 7.2.

Preliminary assessment is ongoing for the remaining six trigger exceedances. Preliminary assessment is also continuing for selenium in response to meeting and exceeding the former guideline at South Saskatchewan River at Medicine Hat - Hwy 1 and Milk River at Hwy 880, respectively. Preliminary assessment will continue once validated flow data is available for flow-adjusted trend assessments.

7.5 2018/2019 Management Response

The Minister's Determination for 2018/2019 (monthly water quality data collected and assessed for the period April 2018 to March 2019) confirmed that two limits and 15 triggers were exceeded for the primary indicators, and one guideline alert concentration was exceeded for the secondary indicators (Taube and Kerr, 2020). These exceedances were reported as follows:

- Bow River at Cochrane:
    - peak sulphate trigger exceedance (open water and winter seasons)
- Bow River at Carseland:
    - peak chloride trigger exceedance (open water and winter seasons)
    - median nitrate trigger exceedance (open water and winter seasons)
    - peak specific conductance trigger exceedance (open water and winter seasons)

- Bow River at Cluny:
  - median nitrate trigger exceedance (open water and winter seasons)
  - median pH trigger exceedance (open water and winter seasons)
- Bow River at Ronalane:
  - median chloride trigger exceedance (open water and winter seasons)
  - peak chloride trigger exceedance (open water and winter seasons)
  - median total nitrogen trigger exceedance (open water and winter seasons)
  - median nitrate trigger exceedance (open water and winter seasons)
- Oldman River at Hwy 3:
  - median sulphate trigger exceedance (open water and winter seasons)
  - median E.coli trigger exceedance (winter season)
  - peak E.coli trigger exceedance (winter season)
- South Saskatchewan River at Medicine Hat - Hwy 1:
  - median chloride trigger exceedance (open water and winter seasons)
  - peak chloride trigger exceedance (open water and winter seasons)
- Milk River at Hwy 880:
  - median specific conductance limit exceedance (winter)
  - median TDS limit exceedance (winter)
  - median total selenium guideline alert concentration exceedance (winter)

Since TDS and specific conductance in the Milk River at Hwy 880 again exceeded a limit, they remain in the investigation phase. The trigger and guideline exceedances are in the preliminary assessment phase.

7.5.1 Verification and Preliminary Assessment

Verification of the 2018/2019 data is complete. The 2018/2019 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 in preparation of the 2018/2019 Status of Surface Water Quality Report (Taube and Kerr, 2020).

Preliminary assessment of the 2018/2019 threshold exceedances is partially complete. The preliminary assessment involves looking at all data available since April 1999. This includes additional data from April 2009 to March 2018 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 and unadjusted and seasonally-adjusted trend assessments (HDR Corporation, 2011), are presented below. Appendix A contains directions on how to interpret the box plots to understand the historical data and Table 7 provides an overview of the trend assessment results for all exceedances. Flow-adjusted trend assessments are on hold pending validated flow data.

Table 7. Status of Trend Assessments for the 2018/2019 Management Response

NT indicates no trend, + indicates significant (P<0.05) increasing trend, - indicates significant (P<0.05) decreasing trend, blank cells indicate no assessment completed.

Preliminary Assessment 2018/19 Trend Results				
	Season	**Unadjusted Trend**	**Seasonal Adjusted Trend**	**Flow Adjusted Trend**
Trigger Exceedance		**2009-2019**		
Chloride Median and Peak SSR Hwy 1	Open Water	NT	+	Ongoing
	Winter	+		
Sulphate Peak Bow Cochrane	Open Water	+	+	Ongoing
	Winter	+		
Nitrate Median Bow Carseland	Open Water	NT	+	Ongoing
	Winter	+		
Chloride Peak Bow Carseland	Open Water	NT	NT	Ongoing
	Winter	NT		
Specific Conductance Peak Bow Carseland	Open Water	NT	+	Ongoing
	Winter	+		
Nitrate Median Bow Cluny	Open Water	NT	+	Ongoing
	Winter	+		
pH Median Bow Cluny	Open Water	+	+	Ongoing
	Winter	NT		
Nitrate Median Bow Ronalane	Open Water	-	NT	Ongoing
	Winter	+		
Total Nitrogen Median Bow Ronalane	Open Water	NT	NT	Ongoing
	Winter	NT		
Chloride Median and Peak Bow Ronalane	Open Water	NT	+	Ongoing
	Winter	+		

continued	Preliminary Assessment 2018/19 Trend Results			
	Season	**Unadjusted Trend**	**Seasonal Adjusted Trend**	**Flow Adjusted Trend**
Sulphate Median Oldman Hwy 3	Open Water	NT	NT	Ongoing
	Winter	NT		
E.coli (winter only) Median and Peak Oldman Hwy 3				
	Winter	NT	NT	Ongoing
Limit Exceedance		**2009-2019**		
Specific Conductance Limit (winter only) Milk Hwy 880	Open Water		NT	Ongoing
	Winter	NT		
Total Dissolved Solids Limit (winter only) Milk Hwy 880	Open Water		NT	
	Winter	NT		
Guideline Exceedance		**2009-2019**		
Total Selenium Guideline Alert Concentration (winter only)	Open Water			Ongoing
	Winter	NT	+	

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

Statistically significant increases in the 2018/2019 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 the 2018/2019 90th percentile values are not the highest observed in the dataset (Figure 7) and no samples exceeded the calculated limit value (based on hardness) at this station. Trend results of seasonally-adjusted and unadjusted assessments reveal statistically significant increasing trends for the 2009-2019 timeframe.

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 in the comparable most upstream station (Brocket) on the Oldman River. Further data analysis is needed to determine what influence river flow has on sulphate concentrations at Cochrane.

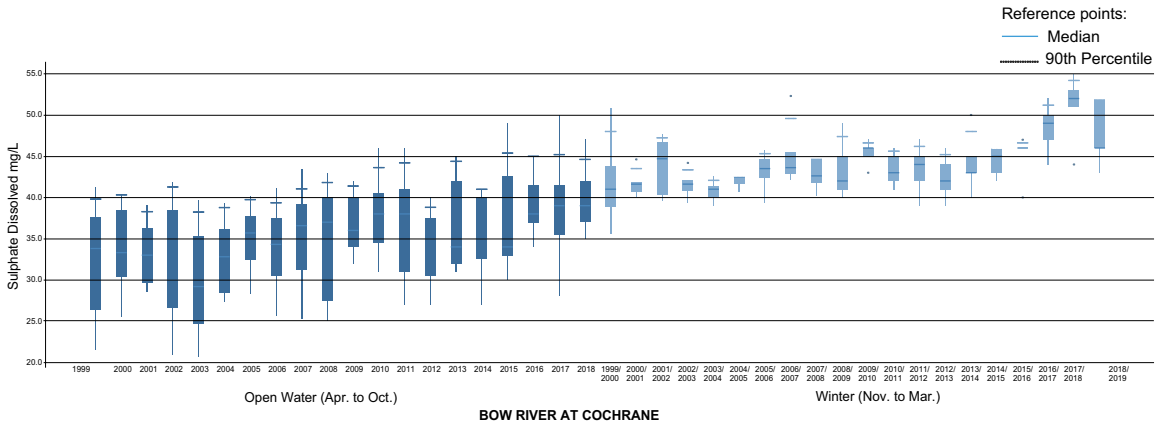

Figure 7. Box Plots of the Sulphate Data in the Bow River at Cochrane Station During Open Water and Winter from April 1999 to March 2019.

Chloride – Bow River at Carseland, Open Water and Winter Peak Trigger Exceedances

Statistically significant increases in the 2018/2019 open water and winter 90th percentile values (compared to the 1999-2009 historical values) occurred for chloride in the Bow River at Carseland station.

Examination of the dataset revealed that the 2018/2019 90th percentile values are not the highest observed in the dataset at this station, and (except April 2011 and 2013) the maximum values are approximately half the 100 mg/L limit value (Figure 8). Trend results of seasonally-adjusted and unadjusted assessments reveal no statistically significant trends for the 2009-2019 timeframe.

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

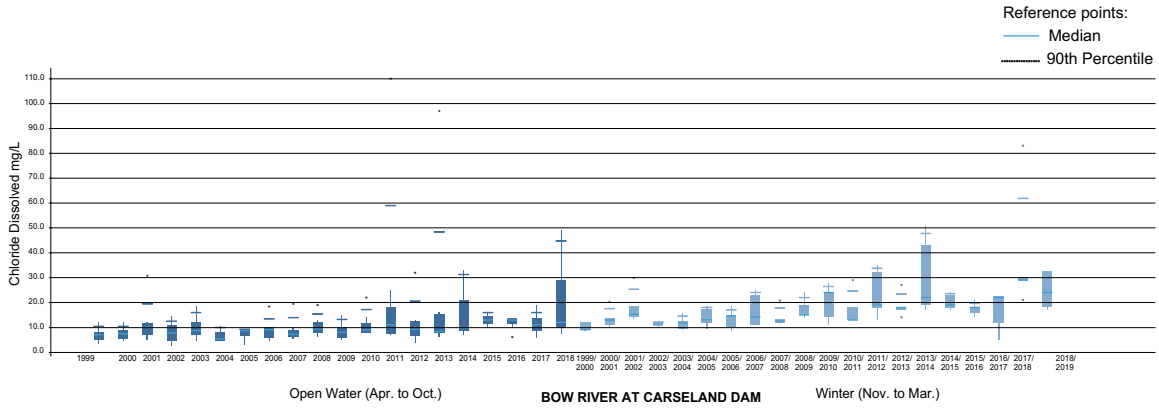

Figure 8. Box Plots of the Chloride Data in the Bow River at Carseland Station During Open Water and Winter from April 1999 to March 2019.

Nitrate – Bow River at Carseland, Open Water and Winter Median Trigger Exceedances

Statistically significant increases in the measure of central tendency for the 2018/2019 open water and winter data (compared to the 1999-2009 historical data) occurred for nitrate in the Bow River at Carseland station.

Examination of the dataset revealed that although the 2018/2019 median values are the highest observed in the dataset (in the winter but not open water) at this station, the maximum values are approximately two-thirds the 3 mg/L limit value (Figure 9). Trend results of seasonally-adjusted assessments reveal a statistically significant increasing trend for the 2009-2019 timeframe, while the unadjusted assessments reveal a statistically significant increasing trend for the 2009-2019 (winter only) timeframe and no statistically significant unadjusted trend for the 2009-2019 (open water only) timeframe.

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

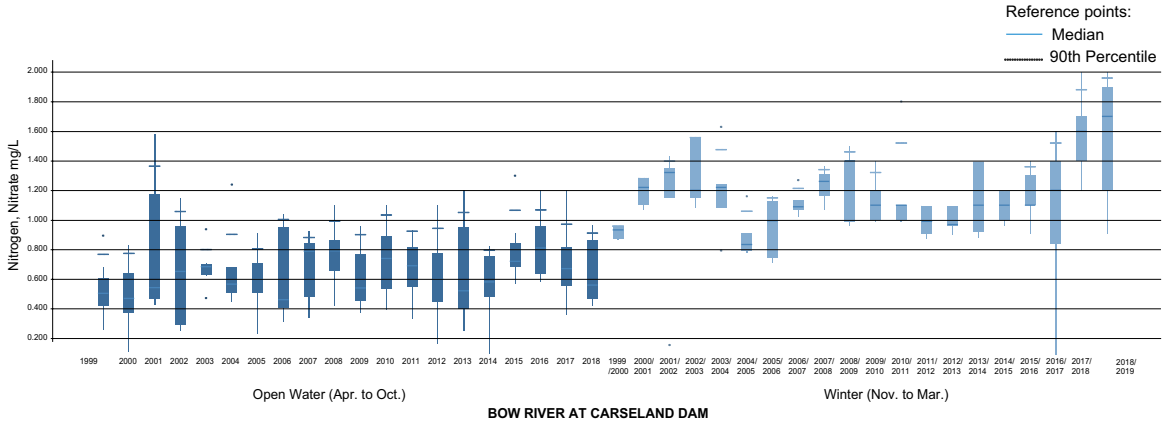

Figure 9. Box Plots of the Nitrate Data in the Bow River at Carseland Station During Open Water and Winter from April 1999 to March 2019.

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

Statistically significant increases in the 2018/2019 open water and winter 90th percentile values (compared to the 1999-2009 historical values) occurred for specific conductance in the Bow River at Carseland station.

Examination of the dataset revealed that the 2018/2019 90th percentile values are not the highest observed in the dataset at this station and (except April 2011 and 2013) the maximum values are approximately half the 1000 µS/cm limit value (Figure 10). Trend results of seasonally-adjusted assessments reveal a statistically significant increasing trend for the 2009-2019 timeframe. The unadjusted assessments reveal a statistically significant increasing trend for the 2009-2019 (winter only) timeframe and no statistically significant trend for the 2009-2019 (open water only) timeframe.

Overall, the specific conductance values in the Bow River at Carseland appear higher than the most upstream station (Cochrane), similar to the downstream stations (Cluny and Ronalane) and 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 Carseland.

Specific conductance in the Bow River at Carseland is currently under investigation from an earlier exceedance (2014/2015) and since this trigger was again exceeded in 2018/2019 the investigation phase will continue. The results will be reported on in a separate document.

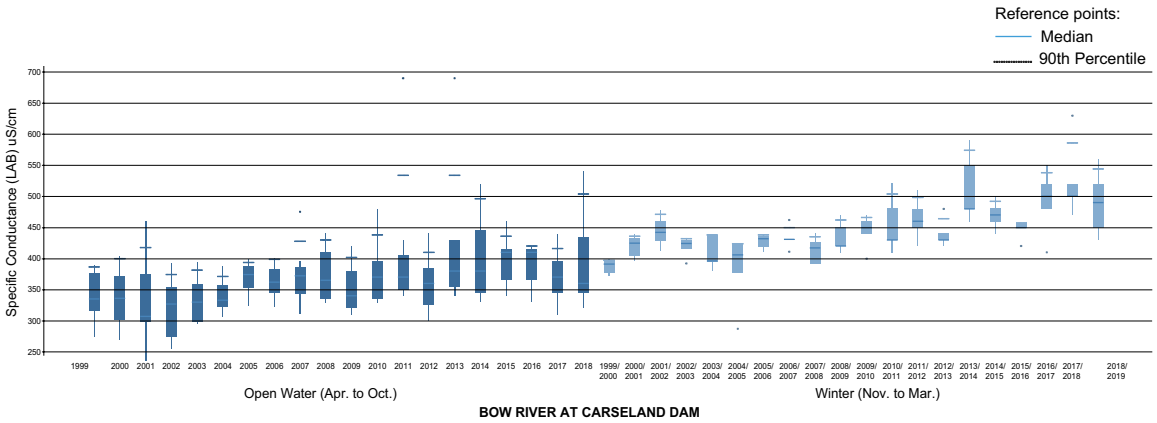

Figure 10. Box Plots of the Specific Conductance Data in the Bow River at Carseland Station During Open Water and Winter from April 1999 to March 2019.

Nitrate – Bow River at Cluny, Open Water and Winter Median Trigger Exceedances

Statistically significant increases in the measure of central tendency for the 2018/2019 open water and winter data (compared to the 1999-2009 historical data) occurred for nitrate in the Bow River at Cluny station.

Examination of the dataset revealed that the 2018/2019 median values are not the highest observed in the dataset at this station and the maximum values are approximately one third (open water) or two thirds (winter) the 3 mg/L limit value (Figure 11). Trend results of seasonally-adjusted assessments reveal a statistically significant increasing trend for the 2009-2019 timeframe, while the unadjusted assessments reveal a statistically significant increasing trend for the 2009-2019 (winter only) timeframe and no statistically significant trend for the 2009-2019 (open water only) timeframe.

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

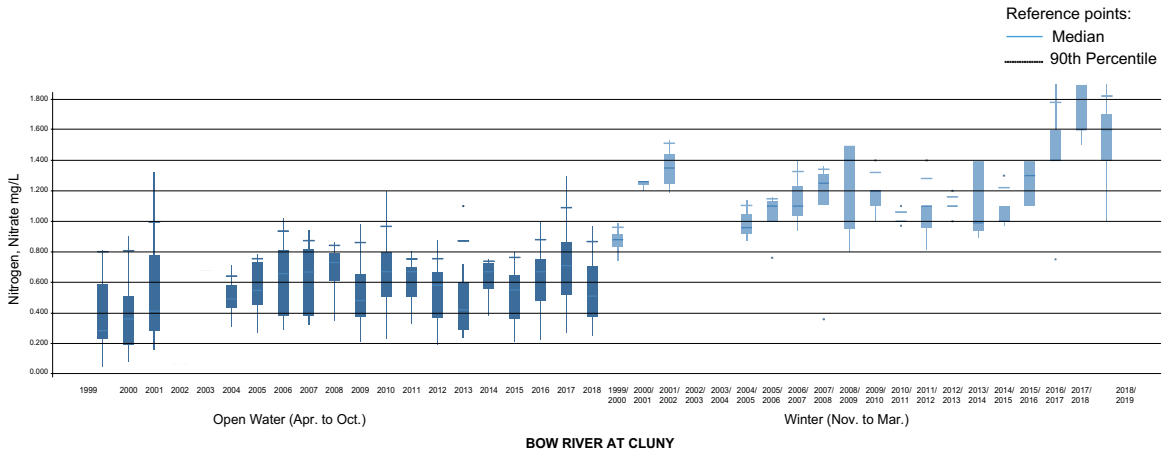

Figure 11. Box Plots of the Nitrate Data in the Bow River at Cluny Station During Open Water and Winter from April 1999 to March 2019.

pH – Bow River at Cluny, Open Water and Winter Median Trigger Exceedances

Statistically significant increases in the measure of central tendency for the 2018/2019 open water and winter data (compared to the 1999-2009 historical data) occurred for pH in the Bow River at Cluny station.

Examination of the dataset revealed that the 2018/2019 median values are not the highest observed in the dataset at this station and the maximum values do not exceed the upper limit value of 9.0 (Figure 12). Trend results of seasonally-adjusted assessments reveal a statistically significant increasing trend for the 2009-2019 timeframe, while the unadjusted assessments reveal a statistically significant increasing trend for the 2009-2019 (open water only) timeframe and no statistically significant trend for the 2009-2019 (winter only) timeframe.

Overall, the pH values in the Bow River at Cluny appear similar to the other stations on the Bow River and the Oldman River. Further data analysis is needed to determine what influence river flow has on pH at Cluny.

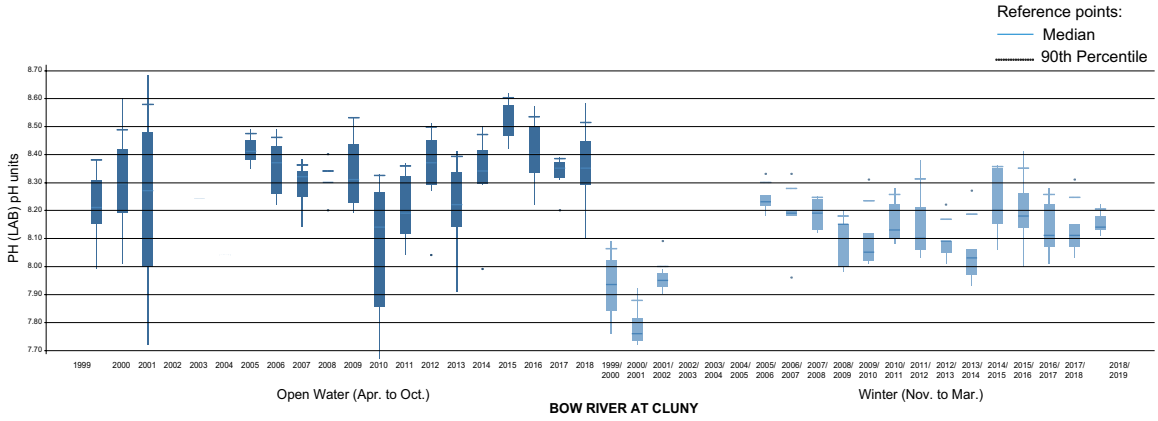

Figure 12. Box Plots of the pH Data in the Bow River at Cluny Station During Open Water and Winter from April 1999 to March 2019.

Chloride – Bow River at Ronalane, Open Water and Winter Median and Peak Trigger Exceedances

A statistically significant increase in the measure of central tendency and 90th percentile values for the 2018/2019 open water and winter data (compared to the 1999-2009 historical data) occurred for chloride in the Bow River at Ronalane station.

Examination of the dataset revealed that the 2018/2019 chloride medians and 90th percentile values are the highest observed in the dataset at this station and the maximum values are approximately one half (open water) or two thirds (winter) the 100 mg/L limit value (Figure 13). Trend results of seasonally-adjusted assessments reveal a statistically significant increasing trend for the 2009-2019 timeframe. The unadjusted assessments reveal a statistically significant increasing trend for the 2009-2019 (winter only) timeframe and no statistically significant trend for the 2009-2019 (open water only) timeframe.

Overall, the chloride values in the Bow River at Ronalane appear similar to the upstream stations on the Bow River (Carseland and Cluny) but appear higher than the most upstream station on the Bow River (Cochrane) and higher than the stations on the Oldman River. Further data analysis is needed to determine what influence river flow has on chloride concentrations at Ronalane.

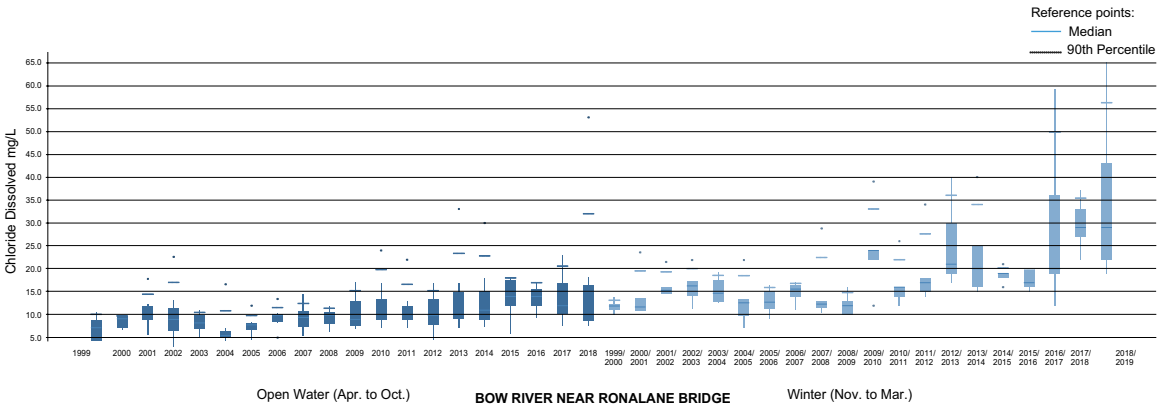

Figure 13. Box Plots of the Chloride Data in the Bow River at Ronalane Station During Open Water and Winter from April 1999 to March 2019.

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

Statistically significant increases in the measure of central tendency for the 2018/2019 open water and winter data (compared to the 1999-2009 historical data) occurred for total nitrogen in the Bow River at Ronalane station.

Examination of the dataset revealed that the 2018/2019 median values are not the highest observed in the dataset at this station (Figure 14). No limit value is currently established for this indicator. Trend results of seasonally-adjusted and unadjusted assessments reveal no statistically significant trends for the 2009-2019 timeframe.

Overall, the total nitrogen concentrations in the Bow River at Ronalane appear similar to the upstream stations (Carseland and Cluny) but higher than the most upstream station (Cochrane), and are higher than the stations on the Oldman River. Further data analysis is needed to determine what influence river flow has on total nitrogen concentrations at Ronalane.

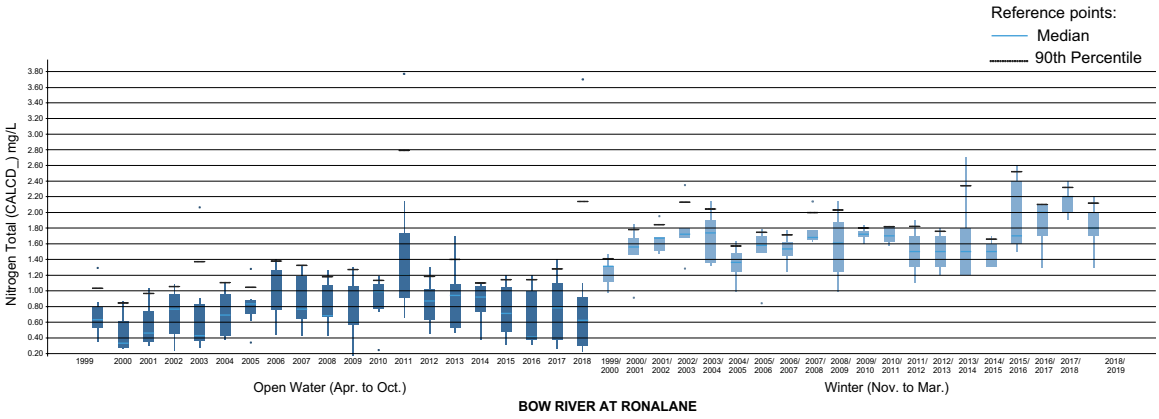

Figure 14. Box Plots of the Total Nitrogen Data in the Bow River at Ronalane Station During Open Water and Winter from April 1999 to March 2019.

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

Statistically significant increases in the measure of central tendency for the 2018/2019 open water and winter data (compared to the 1999-2009 historical data) occurred for nitrate in the Bow River at Ronalane station.

Examination of the dataset revealed that the 2018/2019 median values are not the highest observed in the dataset at this station and the maximum values are approximately one third (open water) or two thirds (winter) the 3 mg/L limit value (Figure 15). Trend results of seasonally-adjusted assessments reveal no statistically significant trend for the 2009-2019 timeframe, while the unadjusted assessments reveal a statistically significant increasing trend for the 2009-2019 (winter only) timeframe and no statistically significant trend for the 2009-2019 (open water only) timeframe.

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

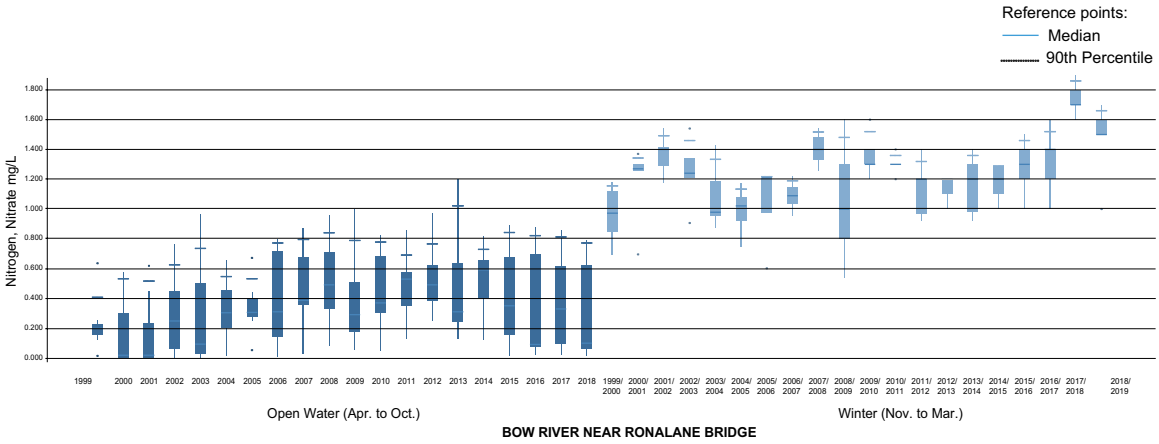

Figure 15. Box Plots of the Nitrate Data in the Bow River at Ronalane Station During Open Water and Winter from April 1999 to March 2019.

Sulphate – Oldman River at Hwy 3, Open Water and Winter Median Trigger Exceedance

Statistically significant increases in the measure of central tendency for the 2018/2019 open water and winter data (compared to the 1999-2009 historical data) occurred for sulphate in the Oldman River at Hwy 3 station.

Examination of the dataset revealed that the 2018/2019 median values are not the highest observed in the dataset (Figure 16) and no samples exceeded the calculated limit value (based on hardness) at this station. Trend results of seasonally-adjusted and unadjusted assessments reveal no statistically significant trends for the 2009-2019 timeframe.

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

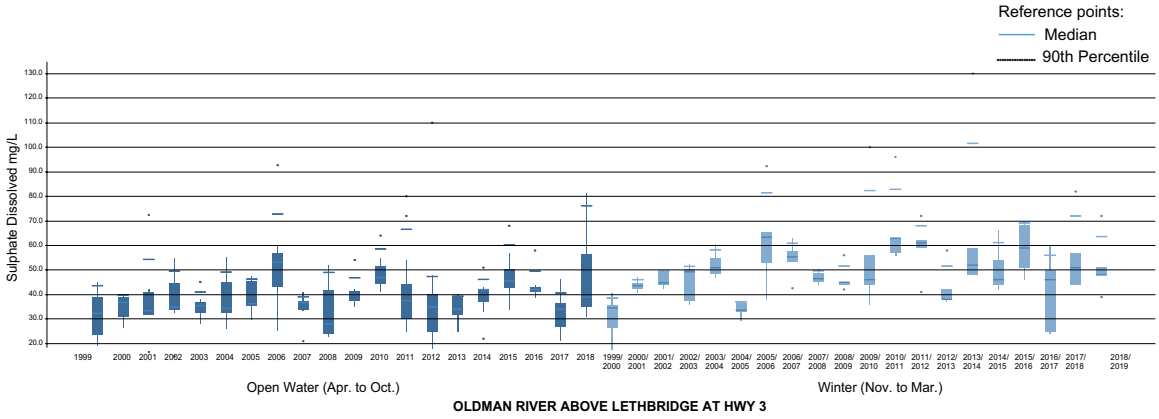

Figure 16. Box Plots of the Sulphate Data in the Oldman River at Hwy 3 Station During Open Water and Winter from April 1999 to March 2019.

Escherichia coli – Oldman River at Hwy 3 Winter Median and Peak Trigger Exceedances

A statistically significant increase in the measure of central tendency and 90th percentile values for the 2018/2019 winter data (compared to the 1999-2009 historical data) occurred for Escherichia coli in the Oldman River at Hwy 3 station.

Examination of the dataset revealed that the 2018/2019 winter Escherichia coli median and 90th percentile values are the highest observed in the dataset at this station and the maximum value is above the 100 cfu per 100mL limit value, however, the median value is approximately one half the limit value (Figure 17). Trend results of seasonally-adjusted and unadjusted assessments reveal no statistically significant trends for the 2009-2019 (winter only) timeframe.

Overall, the Escherichia coli values in the Oldman River at Hwy 3 appear similar to the other stations on the Oldman River (Brocket and Hwy 36) and the comparable station on the Bow River (Carseland). Further data analysis is needed to determine what influence river flow has on Escherichia coli values at Hwy 3.

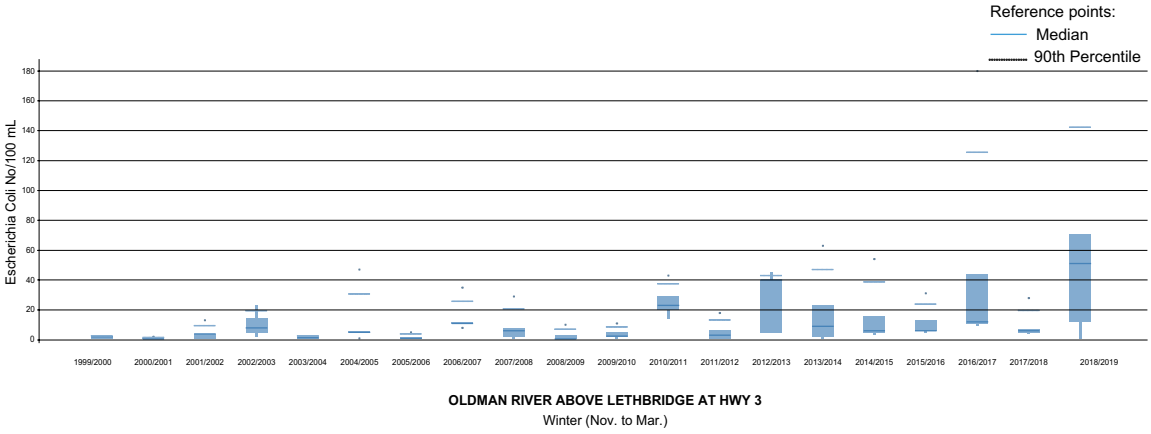

Figure 17. Box Plots of the Escherichia coli Data in the Oldman River at Hwy 3 Station During Winter from November 1999 to March 2019.

Chloride – South Saskatchewan River at Medicine Hat - Hwy 1, Open Water and Winter Median and Peak Trigger Exceedances

A statistically significant increase in the measure of central tendency and 90th percentile values for the 2018/2019 open water and winter data (compared to the 1999-2009 historical data) occurred for chloride in the South Saskatchewan River at Medicine Hat - Hwy 1 station.

Examination of the dataset revealed that the 2018/2019 chloride medians and 90th percentile values are the highest observed in the dataset at this station and the maximum values are approximately one third the 100 mg/L limit value (Figure 18). Trend results of seasonally-adjusted assessments reveal a statistically significant increasing trend for the 2009-2019 timeframe. The unadjusted assessments reveal a statistically significant increasing trend for the 2009-2019 (winter only) timeframe and no statistically significant unadjusted trend for the 2009-2019 (open water only) timeframe.

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

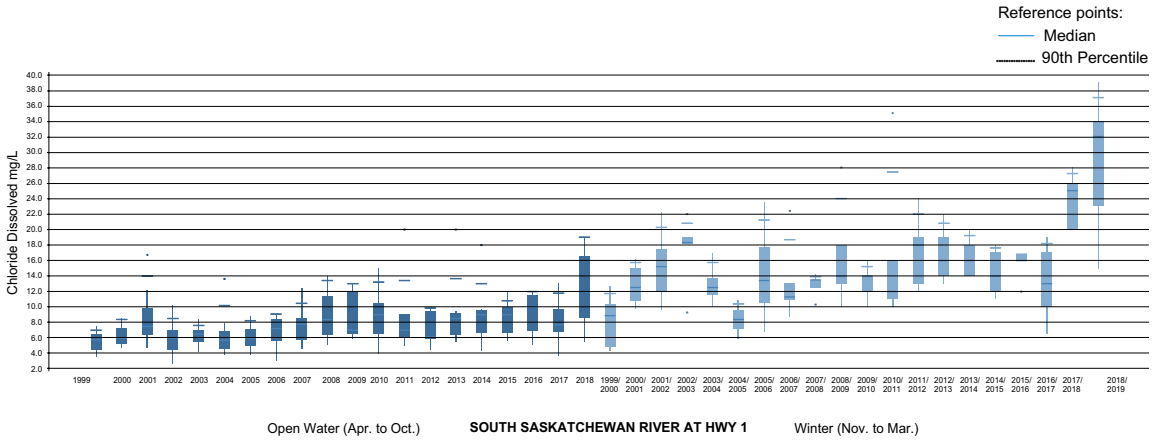

Figure 18. Box Plots of the Chloride Data in the South Saskatchewan River at Medicine Hat - Hwy 1 Station During Open Water and Winter from April 1999 to March 2019.

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

As in 2017/2018, the 2018/2019 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 1200 µS/cm for 2018/2019 is above the 1000 µS/cm limit value and above the winter median trigger value of 916 µS/cm, it is not the highest winter median observed in the dataset (Figure 19). Trend results of seasonally-adjusted and unadjusted assessments reveal no statistically significant trends for the 2009-2019 timeframe.

Overall, the winter specific conductance values in the Milk River at Hwy 880 are higher than in the Oldman, Bow or South Saskatchewan Rivers. Further analysis is needed to evaluate the influence of river flow on specific conductance values at this station for this year.

The limit for specific conductance is based on an irrigation guideline, and is a combination of sodium adsorption ratio (SAR) and specific conductance values (Alberta Agriculture, Food and Rural Development 2002). While both values are about half of that which would make water unsuitable for irrigation, as part of the assessment of this exceedance, a more detailed assessment of both values will be conducted to determine suitability for irrigation.

Specific conductance and TDS are closely related. The investigation into the TDS limit exceedances at Milk River at Hwy 880 is providing insight relevant to specific conductance (Section 7.2).

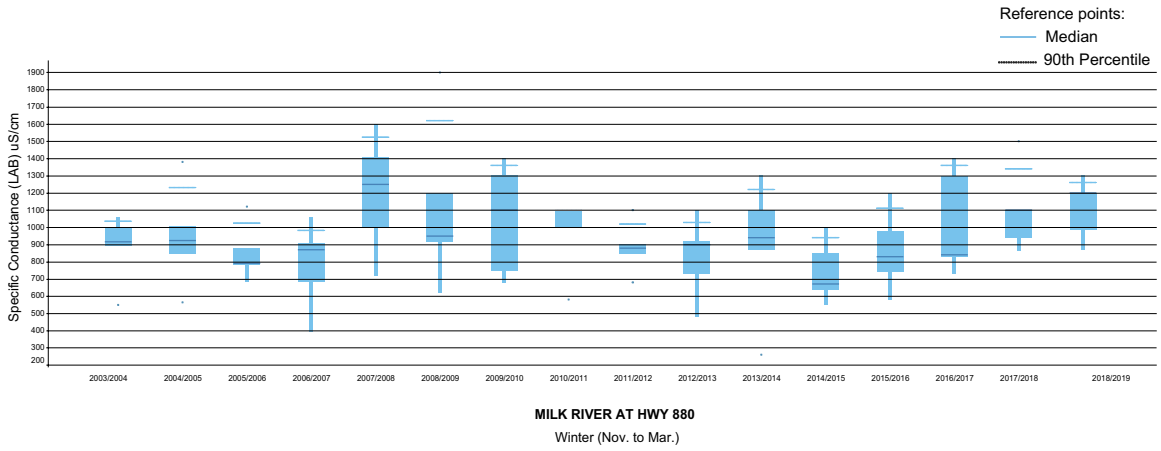

Figure 19. Box Plots of the Specific Conductance Data in the Milk River at Hwy 880 Station During Winter from November 2003 to March 2019.

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

As in 2015/2016, 2016/2017 and 2017/2018, the 2018/2019 winter median was again over the limit for TDS in the Milk River at Hwy 880 station.

Examination of the dataset revealed that TDS has a considerable amount of variability from year to year. While the winter median value of 730 mg/L for 2018/2019 is above the 500 mg/L limit value and above the winter median trigger value of 606 mg/L, it is not the highest winter median observed in the dataset (Figure 20). Trend results of seasonally-adjusted and unadjusted assessments reveal no statistically significant trends for the 2009-2019 timeframe.

Overall, the TDS concentrations during the winter in the Milk River at Hwy 880 are higher than in the Oldman, Bow or South Saskatchewan Rivers. Further analysis is needed to evaluate the influence of river flow on TDS concentrations at this station for this year. This work will be undertaken to complete the preliminary assessment for this year. Preliminary findings from the investigation to date are provided in Section 7.2.

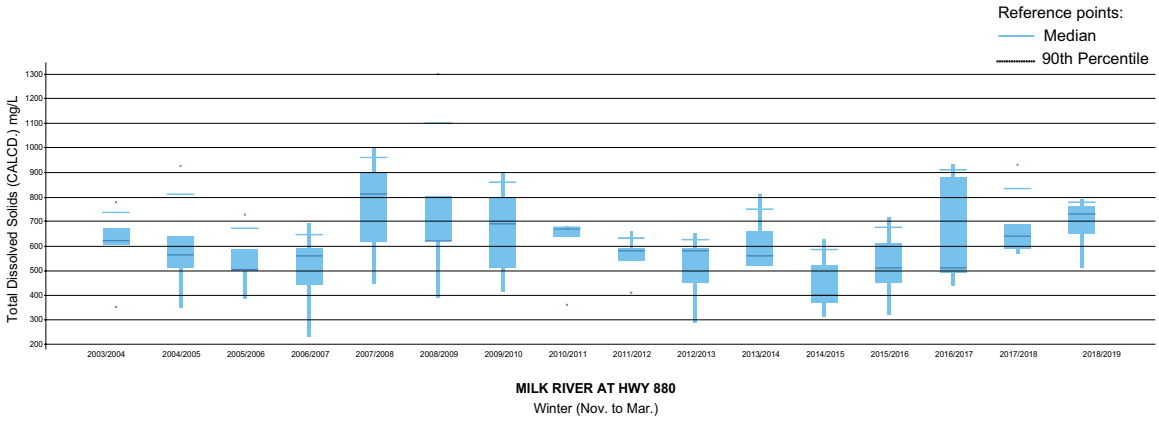

Figure 20. Box Plots of the Total Dissolved Solids Data in the Milk River at Hwy 880 Station During Winter from November 2003 to March 2019.

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

The 2018/2019 winter median was over the alert concentration of 1 ug/L for total selenium (GoA, 2018c) in the Milk River at the Hwy 880 station. Since it is not a chronic guideline, the exceedance is only being reported in the interest of transparency. The 2 ug/L protection of aquatic life guideline is above the observed and historical medians at Milk River at Hwy 880. The alert concentration is targeted at sensitive environments and exceedances may indicate the need for increased monitoring (GoA, 2018c). It is noteworthy that total selenium is a secondary indicator due to a paucity of data and that, in 2013, monitoring already increased from quarterly to monthly to address the data gap.

Examination of the dataset revealed that total selenium has a considerable amount of variability from year to year and while the winter median value of 1.40 ug/L for 2018/2019 is above the alert concentration (1 ug/L) and the historical winter median value of 1.20 ug/L, it is below the chronic guideline (2 ug/L). Total selenium historical winter values are similar to those observed in winter 2018/2019 (Figure 21). Trend results of unadjusted assessments reveal no statistically significant trends while the seasonally-adjusted assessments do reveal a statistically significant trend for the winter 2009-2019 timeframe.

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

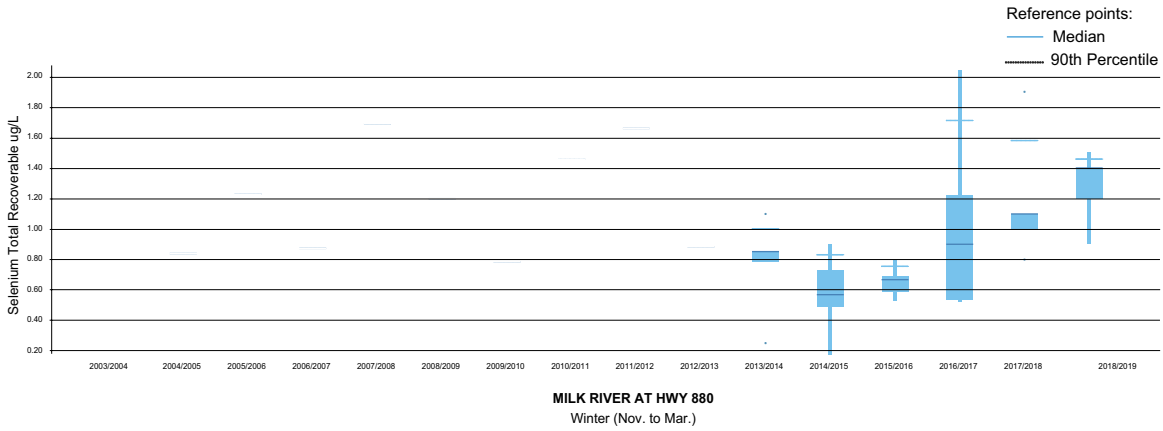

Figure 21. Box Plots of the Total Selenium Data in the Milk River at Hwy 880 Station During Winter from January 2005 to March 2018.

8.0 Water Quality Next Steps

Alberta Environment and Parks will complete the preliminary assessment for all indicators exceeding a trigger, limit, or guideline in 2018/2019 and in previous reporting periods. 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 with trigger crossings in 2016/2017, at the stations where the crossing occurred; and
- unadjusted and flow-adjusted trend assessments on the indicators that exceeded a trigger, limit, or guideline in 2017/2018 and 2018/2019, at the stations where the exceedance occurred.

The following indicators are in the investigation phase:

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

Next steps in the investigation for TDS and specific conductance on the Milk River will focus on further understanding sources of salinity and the risk current conditions pose for aquatic life and other uses. Recommended steps include:

- Evaluating the risk current conditions pose for aquatic life and other winter water uses.
    - The limit for TDS is based on an irrigation guideline, but since the exceedances happen during the winter period, anticipated risk is low. A more detailed risk assessment will be conducted for confirmation.
- Evaluating the need for development of site-specific water quality objectives for the parameters that exceeded limits at the Milk River at Hwy 880 station.
- Considering adjusting the seasons at the Milk River at Hwy 880 station to reflect the timing of the water diverted from the St Mary River, when the framework is updated.
- Identify whether any further management actions are required to mitigate any environmental impacts.

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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Appendix A - How to Interpret a Box Plot