South Saskatchewan Region

Status of Management Response for
Environmental Management Frameworks, as of December 2021

Alberta

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Executive Summary

Air Quality

This report communicates the status of the Government of Alberta's management response to crossings of air quality triggers as of December 2021. This fulfils commitments made to Albertans in the South Saskatchewan Region Air Quality Management Framework for Nitrogen Dioxide (NO_2), Ozone (O_3), and Fine Particulate Matter ($PM_{2.5}$). The report informs engaged stakeholders, Indigenous Peoples and those involved in the implementation of the Air Quality Management Framework and is available to the public.

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 triggers have been crossed (in the last 5 reporting periods one station has been at Level 3 for NO_2, four stations have been at Level 3 for $PM_{2.5}$ and four stations have been at Level 3 for O_3). 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, and proactively maintaining air quality below the limit, in alignment with the applicable management intents. This report communicates the status of the response as of December 2021, 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.

This report considers data and assessment status available at the time of writing. New and more stringent Canadian Ambient Air Quality Standards have since come into effect. Moving forwards, air management in the South Saskatchewan Region will be in response to these new and more stringent standards, which are expected to result in higher management levels for the region.

Surface Water Quality

This report communicates the status of the Government of Alberta's management response to nine water quality indicators that crossed a trigger and two water quality indicators that exceeded a limit in 2020/2021. This fulfils commitments made to Albertans in the South Saskatchewan Region Surface Water Quality Management Framework: for the Mainstem Bow, Milk, Oldman and South Saskatchewan Rivers (Alberta). The report informs engaged stakeholders, Indigenous Peoples and those involved in the implementation of the framework, and is available to the public.

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

- Based on water quality monitored during 2020/2021, median trigger crossings occurred for four indicators (nitrate, total nitrogen, sulphate, total dissolved solids) at three stations, and peak trigger crossings occurred for seven indicators (chloride, sulphate, specific conductance, pH, total dissolved solids, sodium adsorption ratio (SAR) and *Escherichia coli*) at five stations. A limit exceedance was detected for total dissolved solids during the winter and *Escherichia coli* in the open water season, in the Milk River at Hwy 880. There were no exceedances of guideline values for secondary indicators. Exceedances were identified in the Status of Surface Water Quality, South Saskatchewan Region, Alberta for April 2020 – March 2021 (Laceby et. al, 2022).

- Investigations underway include the following:
    - The investigation of total dissolved solids (TDS) and specific conductance in the Milk River to address the winter limit exceedances at Hwy 880 is complete and has been moved to the management actions phase of the SWQMF management response process. The results of the investigation suggest that groundwater is likely the primary source of TDS to the Milk River in the winter, the lower TDS values in the open-water season compared to the winter season are primarily due to the addition of relatively low TDS water from the St. Mary River during the summer months and 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 salt ions into the remaining flowing water. The next step in the management response processes included work to further understand the risk current conditions pose for aquatic life and other uses and the need for management actions. The results of the risk assessment are outlined in this report.
    - An investigation is being initiated in the Bow and South Saskatchewan Rivers to address the total dissolved solids, specific conductance, sulphate, chloride, pH, nitrate and total nitrogen trigger crossings reported among the one South Saskatchewan River station and the four Bow River stations since 2014.
    - An investigation is being initiated for *E.coli* in the Milk River at Hwy 880 for the limit exceedance in the open water season (2020/2021).
- After preliminary assessment, the management response was closed for indicators at the following locations: total selenium (Oldman River at Hwy 36, Milk River at Hwy 880 and South Saskatchewan River at Medicine Hat Hwy 1), sodium adsorption ratio (Oldman at Hwy 3), specific conductance (Oldman at Hwy 36, South Saskatchewan River at Medicine Hat Hwy 1), sulphate (Oldman at Hwy 3) and *E.coli* (Oldman at Hwy 3).
- Preliminary assessment is underway for: the pH trigger crossing in the Oldman at Brocket (2014/2015), to help determine the need for investigation and management actions; and on the indicators with trigger crossings in 2019/2020 and 2020/2021 to complete the flow-adjusted trend assessments.

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Part 1: Air Quality

1.0 Introduction to Air Quality

Under the *South Saskatchewan Regional Plan* (SSRP) (GoA, 2018), 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 (AQMF) (AESRD, 2014) has been crossed or exceeded.

Alberta Environment and Parks (AEP) is the lead coordinator of the management response, and works with other government branches, regulators (e.g. Alberta Energy Regulator) and external parties, as required, to identify and 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 (AESRD, 2014) using data collected at monitoring stations in Airdrie, Calgary, Lethbridge, and Medicine Hat, as shown in Figure 1.

Alignment with Canadian Ambient Air Quality Standards (CAAQS)

Through the Canadian Council of Ministers of the Environment (CCME), Alberta agreed to implement a national Air Quality Management System (AQMS), which included reporting annually on NO_2, SO_2, O_3, and $PM_{2.5}$ against the Canadian Ambient Air Quality Standards (CAAQS)

The intent is to update the South Saskatchewan Region Air Quality Management Framework to align with the CAAQS indicators and thresholds.

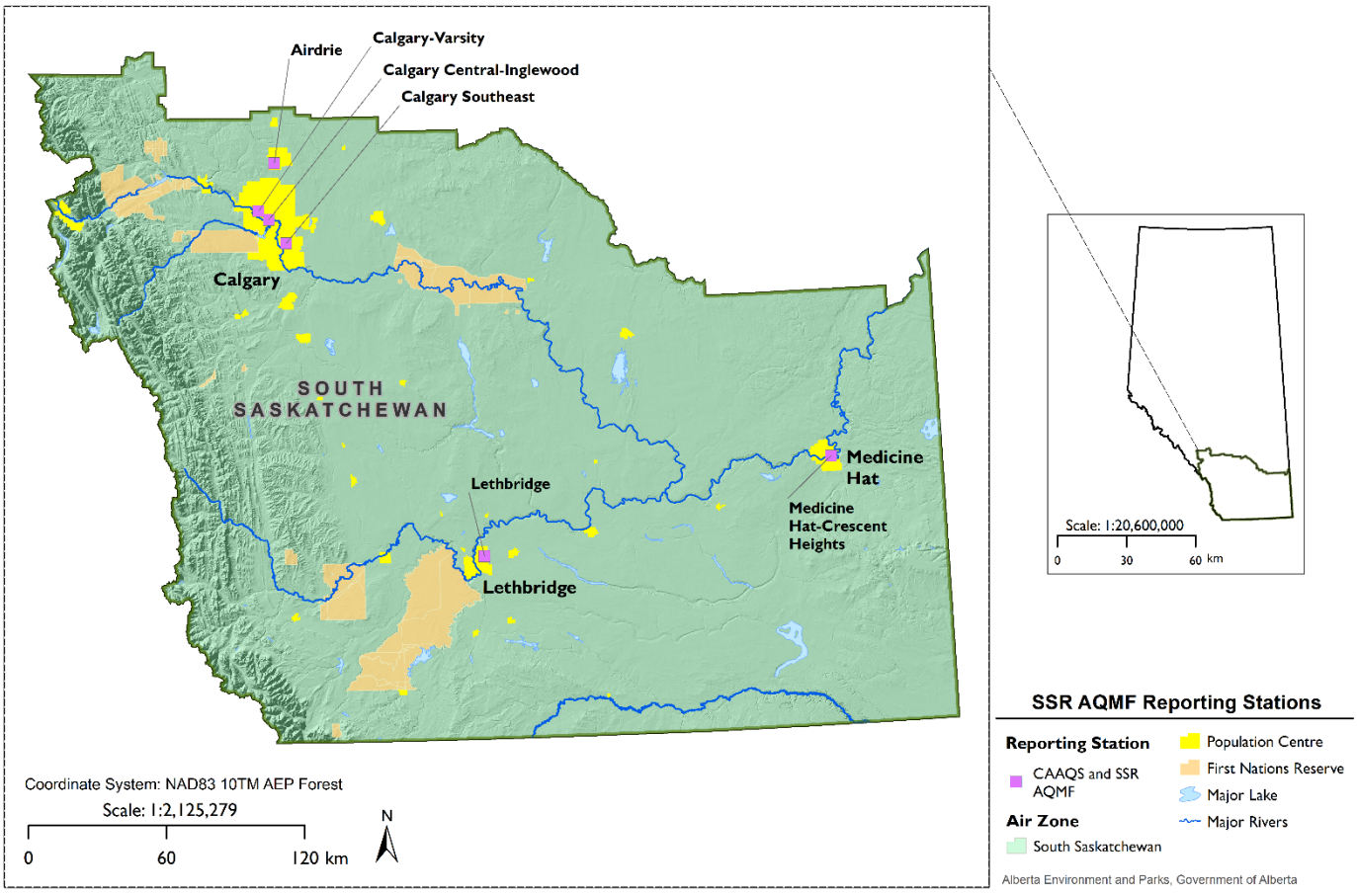

Figure 1: Map of the continuous monitoring stations in the South Saskatchewan Region used in the current assessment and reporting.

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 period. 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 2020. This is the sixth 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, 2014). Initial steps include verification, preliminary assessment, and an investigation to determine the need for management actions. These steps are taken, in full or in part, when an ambient air quality trigger is crossed or limit is exceeded.

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 crossed or exceeded.

The framework, as well as all condition and management response reports are on the Open Government portal as well as AEP website: https://www.alberta.ca/south-saskatchewan-regional-planning.aspx.

1.1 Evolving Context for Air Management in Alberta

This report considers data and assessment status available at the time of writing, in alignment with Alberta's annual environmental management framework reporting cycle. Recently, new and more stringent CAAQS have come into effect. Moving forwards, air management in the South Saskatchewan Region will be in response to these new and more stringent standards, which are expected to result in higher management levels for the region.

Alberta will be developing a provincial management plan in response to new CAAQS management levels. Following CCME requirements, this will be reported within two years of level determination.

Reporting under the Air Quality Management Framework is being integrated with the provincial CAAQS reporting structure. The Status of Air Quality in Alberta: Air Zones Report 2018-2020 (Brown *et al*, 2022) report represents the first integrated status of conditions report, including metrics reported under the AQMF as well as the most recent CAAQS analysis. The first integrated management report will be released within two years of the Status of Air Quality in Alberta: Air Zones Report 2018-2020 report, replacing this regional status of management response report.

The intention is to align the SSR Air Quality Management Framework with these new CAAQS, at the next opportunity for framework amendment.

1.2 Understanding the Nature of Air Quality Pollutants

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 source(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 sources, 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 $PM_{2.5}$ as well as 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 Levels Assigned for Air Quality

2.1 Verification and Preliminary Assessment

AEP conducts the annual assessment of ambient air quality data gathered from continuous ambient air monitoring stations in the South Saskatchewan Region. Data is downloaded from Alberta's air 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 the triggers and limits in the South Saskatchewan Region Air Quality Management Framework.

Verification and preliminary assessment are reported in the annual status of air quality conditions report (Brown *et al*, 2022).

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 (e.g. forest or grass fires).

More information on the methodology, procedures, and preliminary assessments are reported in the annual status of air quality conditions report (Brown *et al*, 2022).

The Airdrie monitoring station began operations in April of 2017. The station meets the NO_2 and O_3 data completeness criteria for the current reporting period (2020 for NO_2 and 2017-2019 for O_3) but has not collected enough data to meet the $PM_{2.5}$ data completeness criteria for the 2017-2019 reporting period. In Calgary, the Northwest Station was required to relocate, due to land redevelopment, and was subsequently decommissioned. The new location, approximately 100 metres away, is named Calgary Varsity and started operation in June of 2018.The station only reported for NO_2 this assessment period (2020) as it did not meet data completeness for $PM_{2.5}$ and O_3 for the 2017-2019 reporting period.

Steps of the management response

2.2. Minister's Determination

The Minister's Determination for 2020 confirmed that no air quality limits were exceeded under the South Saskatchewan Region AQMF. However, air quality triggers were crossed at several of the monitoring stations in 2020, resulting in assigning ambient air quality levels described in the annual status of air quality conditions report (Brown *et al*, 2022) and below (Table 1).

2.2.1 Nitrogen Dioxide

Based on the annual status of air quality conditions report, Level 2 is assigned at Calgary Central-Inglewood, Calgary Southeast and Calgary Varsity stations for nitrogen dioxide (NO_2) for the 2020 reporting year. Three stations (Airdrie, Lethbridge and Medicine Hat) had ambient air quality concentrations below the trigger for Level 2.

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 2017-2019 reporting period CAAQS assessment results are presented below, building on the 2016-2018 results reported in the previous management response report. At the time of writing, management levels had not yet been assigned for $PM_{2.5}$ and O_3 for the 2018-2020 reporting period as analysis was still underway.

For the 2017-2019 reporting period, $PM_{2.5}$ levels at the Calgary Central–Inglewood and Calgary Southeast stations have triggered into a Level 3 as in the previous reporting period. $PM_{2.5}$ levels for Lethbridge have also triggered into Level 3. Levels for $PM_{2.5}$ at Medicine Hat have remained at Level 2 or lower, consistent with the previous four reporting years. As mentioned previously, Airdrie and Calgary Varsity did not meet data completeness requirements for the 2017-2019 reporting period, however Airdrie triggers into Level 2 based on two years of available data.

For O_3, the Airdrie, Lethbridge and Medicine Hat stations triggered into a Level 3 for the most recent reporting period. Levels at the Calgary Central Inglewood and Calgary Southeast stations reported at a Level 2 for O_3. Calgary Varsity did not meet data completeness requirements.

TABLE 1: AMBIENT LEVELS ASSIGNED TO AIR QUALITY MONITORING STATIONS IN THE SOUTH SASKATCHEWAN REGION FOR 2013-2020 BASED ON TRIGGERS ANDS LIMITS ESTABLISHED IN THE FRAMEWORK

Station	NO_2 Levels*									
	Annual Average					Upper Range				
	2016	2017	2018	2019	2020	2016	2017	2018	2019	2020
Airdrie			1	1	1			2	2	1
Calgary Central - Inglewood	2	2	3	2	2	2	2	2	2	2
Calgary Northwest	2	2	n/a[a]			2	2	n/a[a]		
Calgary Southeast	2	2	2	2	2	2	2	2	2	2
Calgary Varsity			n/a[a]	2	2			n/a[a]	2	2
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				
	2013 - 15	2014 - 16	2015 - 17	2016 - 18	2017-19	2013 - 15	2014 - 16	2015 - 17	2016 - 18	2017 - 19	2013 - 15	2014 - 16	2015 - 17	2016 - 18	2017 - 19
Airdrie			n/a[a]	3[b]	3			n/a[a]	n/a[a]	2[b]			n/a[a]	n/a[a]	2[b]
Calgary Central – Inglewood		3[b]	2	3	2		n/a[a]	2	3	3		n/a[a]	2	3	3
Calgary Northwest	2	2	2	2[b]		3	2	2	2[b]		3	2	2	2[b]	
Calgary Southeast	2	2	2	2	2	n/a[a]	2	2	3	3	n/a[a]	2	2	3	3
Calgary Varsity			n/a[a]	n/a[a]	n/a[a]			n/a[a]	n/a[a]	n/a[a]			n/a[a]	n/a[a]	n/a[a]
Medicine Hat	2	2	3	3	3	2	2	2	2	2 or lwr[c]	2	2 or lwr[c]	2 or lwr[c]	2 or lwr[c]	2 or lwr[c]
Lethbridge	2	2	2	3	3	3	2	2	2	3	3	2	2	2 or lwr[c]	2

* 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, 2015-2017, 2016-2018 and 2017-2019 assessments identify 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 Management Response for Air Quality

The management response is a set of steps taken, in full or in part, when an ambient trigger is crossed or limit is exceeded. The management response supports the management intent associated with each trigger crossed or limit exceeded (Table 2 and Table 3). A full description of the management system is found in the South Saskatchewan Air Quality Management Framework (AESRD, 2014). The status of management response is reported on a regular basis and may be supported by supplemental technical reports.

TABLE 2: DESCRIPTION AND MANAGEMENT INTENT FOR AVERAGE OF ANNUAL DATA FOR NO_2, $PM_{2.5}$ 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

3.1 Investigation

The purpose of 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 understanding regional issues and exploring options to address the ambient air quality issues. Analysis of ambient concentrations and trends, and the identification of potential emission sources leading to elevated ambient concentration are ongoing. A summary of the work completed to date is described below.

3.1.1 Nitrogen Dioxide (NO_2)

For the current assessment period, an examination into the NO_2 data was not conducted as the levels were below the trigger into Level 3 at all reporting stations in Airdrie, Calgary, Lethbridge and Medicine Hat. Detailed data analysis was undertaken for preceding reporting periods as detailed in previous management response reports.

In general, past evaluations indicated that the seasonal variation in NO_2 concentration 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.

During the current reporting period, Alberta declared a COVID-19 public health emergency, specifically, on March 17, 2020. A staggered set of measures, including closure of schools and requirements to work from home when possible were implemented. These measures had the potential to reduce air emissions, most notably from motor vehicles. Therefore, the public health emergency provided an unprecedented real-world opportunity to examine the impact of traffic on air quality. AEP initiated a province-wide study to examine the impact of measures taken to reduce the spread of COVID-19 on air quality (AEP, 2021). Stations located within Alberta urban centres of various sizes were included in the study and the historically typical observations (2015-2019) were compared to concentrations measured in the spring 2020 (March 16 to June 12, 2020). Although traffic emissions constitute several pollutants, initial analysis was conducted for NO_2 as it is commonly measured, primarily enters the atmosphere through fossil fuel combustion (e.g. motor vehicles, power generation and industrial activity) and is commonly used as an air quality status indicator.

Initial findings from the study indicate that mobility did change during the time period studied, with more Albertans spending time at home. On average 2020 NO_2 concentrations were lower at most sites, with the greatest change observed during the morning commute period. This implies the reduced rush hour traffic contributed to lower NO_2 concentrations, especially in large urban centres. The NO_2 reductions were less pronounced during the afternoon rush hour, likely due to better atmospheric mixing conditions. Decreases were notable in large urban centres like Calgary and Edmonton, which saw mean NO_2 concentrations decrease by 20-25% or ~3 parts per billion (ppb). Results were mixed for smaller centres like Lethbridge and Medicine Hat with a decrease of less than 1 ppb and no significant change, respectively. This is likely due to station location and the relative contribution of emission sources at each site. There was also a smaller absolute decrease in vehicle counts in smaller urban centres compared to larger cities. The relationship between traffic volume and NO_2 concentration is complex, which leads to some study limitations. For example, by design ambient community monitoring stations in Alberta are sited away from roadways and change in vehicle use and emissions differ by type (i.e., passenger versus commercial or heavy duty) thus not all activities on neighborhood roads are represented. Future work is needed to examine the impacts on air quality from additional health measures, expand parameters and the time period investigated as well as the impacts of meteorology.

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

The 2017-2019 data were analyzed from the Calgary Central-Inglewood, the Calgary Southeast and the Lethbridge air monitoring stations as these stations triggered into a Level 3 during the current 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 $\mu g/m^3$ (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.

The seasonal $PM_{2.5}$ variation was similar for 2017-2019 between the Calgary Central-Inglewood, the Calgary Southeast and the Lethbridge stations. Although elevated concentrations may be observed throughout the year, such concentrations were more likely in the colder winter months (November through March) and least likely to be observed in the summer. 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. Boundary layer effects, detailed in previous management response reports, influence $PM_{2.5}$ concentrations and 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. These findings are similar to those reported in the previous management response reports.

Two studies have been initiated related to examining PM composition at stations in Calgary and Lethbridge. Long-term integrated PM sampling is collected by Environment and Climate Change Canada under the National Air Pollution Survey program at the Calgary Central-Inglewood and former Calgary Central stations. This data can provide information on the composition of $PM_{2.5}$ and link to possible emission source drivers based on chemical make-up of the collected samples. The data is currently undergoing analysis and processing using the U.S.EPA Positive Matrix Factorization model, which provides results in groups of species or "factors," that are representations for emission sources. The study goals are to understand PM composition, how the composition has changed over time and what likely emission sources are.

A focus study has also been initialized to examine $PM_{2.5}$ composition from the Lethbridge station, to better understand possible emission source drivers. Integrated particulate matter samples were collected in November 2020 through March 2021 and lab analyzed for ions, trace metals and elements to better understand $PM_{2.5}$ composition. Initial findings suggest the dominant known composition is ammonium nitrate, followed by ammonium sulfate during moderate to elevated $PM_{2.5}$ episodes. These particles are not directly emitted into the air but formed in the atmosphere through the interaction of precursor ammonia (NH_3), nitrogen oxides (NO_x) and sulphur dioxide (SO_2) substances. Agriculture, fertilizer, chemical industries, and transportation are common NH_3 emission sources. NO_x emissions are primarily resulting from fossil fuel combustion from transportation, building heating and industrial processes. SO_2 emissions are associated with combustion of sulphur contained in fossil fuels (coal, oil and fuel) in industrial and transportation source sectors. The contribution of ammonium nitrate to $PM_{2.5}$ peaks during the cooler months and is minimal during the summer (Jeong et al., 2016), while contribution from ammonium sulphate may be notable in both the winter and summer (Kim and Hopke, 2004). As a result, dominant ammonium nitrate was expected during the winter monitoring period. Data analysis continues through fall 2021.

Further findings will be reported in future reporting upon completion of the projects.

3.1.3 Ozone (O_3)

The 2017-2019 O_3 data were analyzed from the Airdrie, Lethbridge, and Medicine Hat air monitoring stations. 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 (produced in the presence of heat and sunlight as described in Section 1.2), it is expected that elevated concentrations are most often observed during the warmest part of the day, midafternoon. The analysis conducted confirms this pattern. Similarly, elevated O_3 concentrations occur most often during the warmer months of the year March through September, with a large proportion occurring in May through August. Overall, the elevated O_3 concentrations occur in the daily and seasonal warm periods as expected due to the nature of the formation of the substance.

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.

A focus study investigating O_3 characterization and potential drivers across the South Saskatchewan Region has been initiated. The time period studied is 2011-2018 with a primary focus on the summer months (April to September) when O_3 formation is most common. Data from the Calgary, Lethbridge and Medicine Hat monitoring stations are being analyzed. Analysis include investigation

into whether there are any changes in incoming solar radiation or temperature over the study time period, whether elevated O_3 episodes can be linked to transport from other parts of the province or outside of the province, and detailed analyses into conditions leading into elevated O_3 event days.

Initial findings suggest meteorology has a strong influence on elevated O_3 occurrence, specifically incoming solar radiation and low wind speeds. Findings also suggest that ozone likely flows from multiple regions within and outside of southern Alberta that contribute to peak O_3 days, although the occurrence of stagnant local conditions is more likely to result in elevated O_3 events. Additional findings from the focused investigation will be provided in future management response reporting.

3.1.4 Spatial Variability of Air Quality in CRAZ and PAS

Temporary, portable monitoring surveys are a common tool to provide additional snap shots of air quality in areas that do not have continuous air monitoring. To address some of the monitoring gaps identified by a regional monitoring network analysis, the Calgary Region Airshed Zone (CRAZ) initiated a 5 year Portable Air Monitoring Lab (PAML) project in 2018 where its PAML was deployed to four small communities within the CRAZ. The deployment schedule followed a seasonal rotation whereby the PAML cycled from sites in Cochrane, Foothills County, Canmore and Chestermere, monitoring at each location twice to capture monitoring during two different seasons. The monitoring objectives included investigating how the air quality in smaller CRAZ urban centers compare to Calgary and the Alberta's Ambient Air Quality Objectives (AAAQOs) as well as providing a snap shot of air quality and AQHI for additional CRAZ communities. The study is currently underway; however, findings from the first community were recently reported and are summarized as follows (CRAZ, 2021):

The CRAZ PAML was deployed twice at the Mitford Park, Cochrane location for the October 2018 to March 2019 and April 2020 to September 2020 monitoring periods, respectively. The Air Quality Health Index (AQHI) is a tool developed by health and environmental professionals to communicate the health risk posed by air pollution. During the monitoring period, the air quality in Cochrane was at low health risk the majority of the time (97.6%). Overall, concentrations of $PM_{2.5}$ and O_3 were similar to those measured at the Calgary monitoring stations. Average $PM_{2.5}$ and O_3 measured in Cochrane were most similar to those measured at the Calgary Varsity station, which has similar surrounding land use as the Cochrane site. NO_2 concentrations measured at the Cochrane PAML station were generally 5-10 µg/m^3 lower compared to the Calgary stations. This is expected due to the greater concentration of emission sources in the larger urban centre of Calgary. CRAZ will provide additional data summaries for the other three locations as the other monitoring surveys are completed.

The Palliser Airshed Society (PAS) also operates a portable ambient air monitoring station to augment the permanent monitoring network and provide additional spatial understanding of air quality in PAS. The PAS Airpointer was recently located at the Medicine Hat Trap Club 12 km northwest of the City of Medicine Hat. The Airpointer was deployed to the Trap Club location in October of 2018 and collected air quality measurements until May of 2021. Overall, the monitored annual average concentrations were lower at the Trap Club compared to the Crescent Heights station for NO_2 and O_3 and no discernable difference in annual $PM_{2.5}$ concentrations was determined between the two locations (PAS, 2021). The PAS airpointer was relocated to Taber in summer 2021 to provide a snap shot of air quality in an additional community as well as to provide AQHI reporting. PAS also acquired a second Airpointer on loan through collaboration with AEP, sited in Brooks for a temporary duration to fill an additional community monitoring gap. Monitoring was initiated in Brooks in summer of 2021.

3.1.5 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.

No further investigations for NO_2 were conducted specifically in the SSR for the current assessment period because all stations were below the trigger into Level 3. Previous analysis of NO_2 data indicates that seasonal variation in NO_2 concentration was similar between reporting stations. 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. AEP initiated a province-wide study to examine the impact of measures taken to reduce the spread of COVID-19 pandemic on air quality. Findings from the study indicate that mobility did change during the time period studied, with more Albertans spending time at home. On average 2020 NO_2 concentrations were lower at most sites, with the greatest change observed during the morning commute period. This implies that reduced traffic contributed to lower NO_2 concentrations, especially in large urban centres. Insight from these studies will inform future investigations on NO_2 conditions in the SSR and other regions.

Similar boundary layer effects are impacting $PM_{2.5}$ concentrations at the Calgary Central-Inglewood, Calgary Southeast, and Lethbridge monitoring stations. Traffic emissions could be a driver for elevated concentrations of $PM_{2.5}$ given the time of day they occur and the land uses around the stations. The seasonal variation was similar between the three monitoring stations. While elevated concentrations of $PM_{2.5}$ 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 $PM_{2.5}$ events. Two studies have been initiated related to examining PM composition at stations in Calgary and Lethbridge. PM composition identifies the chemical make-up of the $PM_{2.5}$, which can be linked to possible emission source drivers. Findings from these studies will be reported on in future management response reporting.

For the Airdrie, Lethbridge, and Medicine Hat stations, 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 NO_x and VOCs with sunlight. A more detailed investigation into the possible drivers for O_3 in the South Saskatchewan Region has been initiated. Initial findings indicate that meteorology has a strong influence on elevated O_3 occurrence, specifically incoming solar radiation and low wind speeds.

Local airshed organizations have deployed portable monitoring to augment the existing permanent monitoring network, provide snap shots of air quality and report on AQHI in additional communities in the South Saskatchewan Region. Information collected is compared to the long-term monitoring data and the AHQI is reported and accessible in real time.

Overall, the investigation findings to date suggest that effective management around South Saskatchewan Region reporting 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 finding.

3.2 Identification of Management Actions

Achieving the goal of the management actions within the South Saskatchewan Region requires a proactive and future focused approach. Management actions support, 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 include gathering baseline information, improving scientific understanding and knowledge and learning from other jurisdictions.

When identifying possible management actions, consideration needs to be given to the management intent associated with each trigger crossed or limit exceeded. The South Saskatchewan Region has frequently triggered into a Level 2, with occasional triggers into Level 3, thus management actions currently focus on improving our knowledge and assessing and planning potential management actions while implementing opportunities to reduce emissions when available.

A list of the management actions identified in this and previous years 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 additional years to be realized. For example, 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 the proactive management actions.

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

3.3 Oversight and Delivery of Management Actions

Management actions are categorized 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

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.	Ongoing	-During previous Status of the Management Response for Environmental Management Frameworks reports, analysis of ambient NO_2, $PM_{2.5}$ and O_3 data was presented. Presently the analysis was conducted for stations that triggered into a Level 3 during the current reporting period. The analyses indicate similar findings as in previous years (see Sections 3.1.1 through Section 3.1.3).
	-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.	In-Progress	-Analysis of existing PM composition data collected in Calgary and prioritization of potential future PM composition data collection locations has been initiated. Findings will be provided in future management response reporting.
	SSR Ozone: Investigation to characterize ozone concentrations across the South Saskatchewan Region	In-Progress	-Investigation into elevated O_3 in the SSR has been initiated. Impacts of solar radiation, long range transport and event days are being investigated. A summary of initial findings is included in Section 3.1.3.
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:		
	-Lethbridge $PM_{2.5}$ Composition Study	In-Progress	-Integrated particulate matter samples were collected in November 2020 through March 2021 and lab analyzed for ions, trace metals and elements to better understand PM composition. Initial findings are summarized in Section 3.1.2.
	-Palliser Airshed Society (PAS) mobile Airpointer ambient monitors sited temporarily at Taber and Brooks to assess air quality in PAS communities.	In-Progress	-The Palliser Airshed Society (PAS) mobile Airpointer relocated to Taber in spring 2021 to further augment the existing spatial understanding of air quality within PAS. PAS also acquired a second Airpointer on loan through collaboration with AEP, sited in Brooks for a temporary duration to fill a community monitoring gap.

Action	Description	Status	Progress Update
	-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.	In-Progress	-The CRAZ PAML was deployed in 4 different communities for two four month rotations starting in November 2018. Communities included in the rotation include Cochrane, Foothills County, Canmore and Chestermere. The PAML was located in Canmore in Summer 2021 and is scheduled to relocate to Foothills County in fall of 2021.
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 was 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 was completed in November 2019. -Since then, the toolbox has been further refined to include more examples of actions underway in Alberta and in other jurisdictions and to create a more user-friendly interface. The toolbox will continue to be refined over time and may be made public in the future.

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 of Alberta collaborated with industry, non-government organizations, and airsheds cross-provincially through the multi-stakeholder 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 is proceeding with additional	Ongoing	-The CASA report, Recommendations to Reduce Non-Point Source Air Emissions in Alberta (available at https://www.casahome.org/past-projects/non-point-source-project-team-37/), is helping to inform action on non-point sources. -A CASA ROVER III Project involving vehicle emissions testing, recommended by the CASA Non-Point Source Report,

Action	Description	Status	Progress Update
	non-point source work through CASA.		commenced in May 2018. However, the COVID-19 pandemic disrupted timelines as testing personnel and equipment are from the United States. In October 2020, the contractor completed a 1-week pilot project in Alberta to help inform site selection. In late summer 2021, roadside emissions testing of light-duty vehicles in Calgary, Red Deer, Edmonton, Fort McMurray, and Grande Prairie was conducted. Heavy duty vehicle testing is planned for Spring 2022. Data compilation is ongoing. Value-added activities included collaboration with the University of Alberta (U of A) including testing of U of A fleet vehicles, and co-located ambient air monitoring by AEP staff. Light-duty vehicle emissions testing took place in 2021 and heavy duty vehicle emissions testing is intended for 2022. -A CASA project, Impacts of Reduced Transportation on Air Quality in Alberta Associated with COVID-19 (IRTAQ), began in Summer 2021 to collaboratively develop messaging that links changes in air quality associated with measures undertaken to reduce the spread of COVID-19. -After the CASA IRTAQ work is completed, a CASA working group is expected to be formed for a Best Practices Guide for Dust Management in Alberta. This project, informed by the CASA Non-Point Source Report, would involve developing and helping to disseminate a best practices guide that applies to multiple sectors.
	-The Government of Alberta has been taking steps to manage non-point source emissions such as through funding to help reduce transportation emissions.	Ongoing	-Funding examples have included $1.2 million for the Peaks to Prairies Southern Electric Charging Network and $1.53 billion for the Calgary Green Line LRT. -The Municipal Climate Change Action Centre (MCCAC) is funded through grants from AEP and other organizations. Through the MCCAC Electric Vehicles for Municipalities Program (https://mccac.ca/programs/electric-vehicles-for-municipalities-program/), municipalities within Alberta are eligible to

Action	Description	Status	Progress Update
			receive funding for charging stations and multiple electric vehicles, to transition fleet vehicles towards more fuel-efficient options such as battery electric vehicles and plug-in hybrid electric vehicles.
	-The Government of Alberta collaborated federal/provincial/territorial jurisdictions on actions to help reduce transportation emissions.	Complete	-Alberta worked with other jurisdictions on the Canadian Council of Ministers of the Environment (CCME) Mobile Sources Working group for information sharing and developing resources to inform transportation emissions management actions in Alberta.
Establish provincial air emission policy, including defining standards / tools to apply to reduce emissions in air zones that require management based on environmental framework trigger crossings.	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.	Complete	The International Review of Non-Attainment Area Air Quality Management Tools and Techniques Report is available at: https://open.alberta.ca/publications/9781460130148. See "Alberta Air Quality Management Action Toolbox" under Knowledge Improvement Actions and "CASA Working Group on CAAQS in Alberta Workshop and Report" under Engagement Actions for details on ongoing work resulting from this action.
Establish and update source standards for both industrial sectors and equipment to reduce emissions.	Environment and Parks is updating NO_X emissions standards for natural-gas-fired turbines and reciprocating engines for use in new electricity generators.	In-Progress	In order to streamline and reduce wait times on approvals by improving regulatory clarity, and reduce NO_X emissions to meet the 2025 CAAQS for NO_2, Environment and Parks is working to release the new source standards by March 2022. This work builds upon discussions at the CASA Electricity Framework Review, and will include appropriate stakeholder engagement.
	Environment and Parks is working on the development of more stringent equipment standards for new boilers and heaters.	In-Progress	These standards are undergoing internal review.
Update Alberta Ambient Air Quality Objectives	Alberta's Ambient Air Quality Objectives (AAQOs) 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. Environment and Parks has been reviewing these objectives through multi-stakeholder consultation since 2000. Alberta now has air quality	Ongoing	The multi-stakeholder Clean Air Strategic Alliance AAQO project team provided their final report in April 2021. AEP is currently in the process of finalizing the total reduced sulphur Guideline, and posted the draft revised nitrogen dioxide and sulphur dioxide Objectives for public comment up to November 22, 2021. The final CASA report is available here: https://www.casahome.org/past-

Action	Description	Status	Progress Update
	objectives for more than 30 substances that could be released to the atmosphere.		projects/ambient-air-quality-objectives-project-team-52/
Update approaches to management of emissions from electricity generation	Originally developed in 2002, the third five-year review of the CASA Emissions Management Framework for the Alberta Electricity Sector was initiated in 2018.	In-Progress/ Ongoing	The project team completed the third five-year review, with the final project report submitted to the CASA Board on April 13, 2021. The next five year review is scheduled to occur in 2023. One of the non-consensus items, emissions standards for new natural gas fired generation, is a work item for Environment and Parks under updating source standards to reduce emissions.
Review EPEA codes of practice for needed updates	For less complex industrial operations, registrations under codes of practice are used as a regulatory tool in place of site-specific approvals and do not expire. Codes of practice for designated activities provide province-wide environmental requirements for consistency across a sector.	Ongoing	Various codes of practice are being considered for review and updating. A review and update of the Code of Practice for Asphalt Paving Plants has been initiated to modernize requirements to achieve environmental outcomes, and align with red tape reduction considerations.
Update Acid Deposition Management Framework (ADMF)	Modernization of the ADMF improves certainty for stakeholders and investors, and ensures policy alignment with neighboring jurisdictions and the Government of Canada. As acid deposition is caused mainly by emissions of SO_2 and NO_X, emission reductions to improve outcomes for acid deposition are likely to have co-benefits in achieving the CAAQS for SO_2 and NO_2.	In-Progress	Environment and Parks is preparing to post the updated Acid Deposition Management Framework in fall 2021.

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
Improving industrial emissions reporting	Since many large industrial sources are monitored by Continuous Emissions Monitoring Systems (CEMS), updating the CEMS Code will improve accuracy of emissions reporting, and enable the Government of Alberta to develop more effective management tools.	Complete	The revised CEMS code was released in April 2021, and will take effect on January 1, 2022. More information can be found at https://www.alberta.ca/continuous-emissions-monitoring.aspx.

	As of 2019, the Annual Emissions Inventory Reporting (AEIR) program has required industrial facilities to carry out an inventory of their sources and air emissions. This improves knowledge of environmental loading of ecosystems and consumption of the assimilative capacity of airsheds enabling the development of better tools to achieve CAAQS. Additionally, industrial facilities are able to access better data for air dispersion modelling.	Ongoing	Results of the AEIR Program for the 2018 inventory year, including data sets are available at https://www.alberta.ca/air-emissions-inventory.aspx. Annual reporting is ongoing, and future results will also be posted.
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.
Update Alberta Air Quality Model Guideline (AQMG)	Results from air dispersion modelling are used to predict if an air pollutant source is in compliance with ambient air quality objectives. Environment and Parks is updating the current 2013 AQMG.	Complete	Environment and Parks posted the updated Alberta Air Quality Model Guideline in September 2021. The Guideline is available at: https://open.alberta.ca/publications/air-quality-model-guideline-2021

Engagement Actions

Air quality management is multi-faceted, requiring the participation of numerous affected people, industries, and agencies. Engagement Actions involve working with stakeholders in the region to clearly define air quality challenges and identify management opportunities and educating the public on the state of air quality, how it impacts them, and what they can do to help.

Action	Description	Status	Progress Update
Develop and implement a provincial air literacy program.	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	Environment and Parks' Engagement and Education Branch recently developed an Air Literacy Strategy for the province. The air literacy strategy strives for the following goals: -Ultimate or long term goal: 5+ years: Albertans have awareness, understanding, ability, and motivation to take action themselves and to support action by others to improve air quality where they live, work and play. -Medium-term goal: 2-5 years: AEP works with partners and GoA to influence attitudes and develop skills needed for target audiences to take action to mitigate the human impacts on air quality.

Action	Description	Status	Progress Update
			-Short-term goal: 1-2 years: AEP works with partners and GoA to develop tools that increase the knowledge of target audiences on air, the air management system, and the effect of human activities on air quality.
Collaborate with existing stakeholder connections and support management actions underway.	Environment and Parks collaborates with stakeholders through the Calgary Region Airshed Zone (CRAZ), Palliser Airshed Society (PAS) and directly with stakeholders not currently involved in these organizations. This includes:		
	-Reaching out to stakeholders one-on-one to understand initiatives that are already underway in the SSR that address air quality or have air quality co-benefits.	Ongoing	-In the summer of 2018, 2020, and 2021, Environment and Parks reached out to area stakeholders to develop an inventory of management actions already underway in the SSR. This inventory is a living document that is very helpful for understanding what area stakeholders are doing to contribute to air quality management. Environment and Parks appreciates the support of area stakeholders in developing and maintaining this inventory.
	-Hosting 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. The next forum is currently being planned for 2022.
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. The most recent review and plan update was undertaken by CRAZ throughout 2018 and 2019. Environment and Parks will continue to support the implementation of the CRAZ Air Quality Management Plan by a multi-stakeholder group for the Calgary Region.

Action	Description	Status	Progress Update
CASA Working Group on CAAQS in Alberta Workshop and Report	The Government of Alberta is engaging with CASA members to garner stakeholder perspectives on solutions to address Alberta CAAQS air quality issues, on nitrogen dioxide specifically.	In-Progress	The first phase of this project is to document and confirm existing knowledge on air quality conditions, emissions and existing policies. The second phase aims to inform stakeholders with webinars about additional air quality topics. The hope is that stakeholders will be sufficiently informed to participate in a series of workshops and propose recommendations for GOA to reduce NO_2 emissions. Workshop outcomes will be documented in a final report.

4.0 Next Steps for Air Quality

Environment and Parks will continue to oversee the delivery of the identified management actions while also continuing the investigation into the trigger crossings, particularly at the stations triggering into Level 3. 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.

Although stations in the SSR recorded no higher than a Level 2 for NO_2 for the 2020 reporting period, with Alberta's adoption of the more stringent NO_2 CAAQS, in future reporting periods it is expected that higher management levels will be observed and will require continued management. In addition, NO_2 is an important contributor to the formation of both $PM_{2.5}$ and O_3. Further work is planned to gain a better understanding of the NO_2 emission source sectors, such as upstream oil and gas and transportation, which modelling has shown are possible significant contributors to NO_2 concentrations across the South Saskatchewan Region. AEP is also participating and engaging with CASA members on the *Approaches and Solutions for Canadian Ambient Air Quality Standards (CAAQS) Achievement in Alberta* project, both broadly and on NO_2 specifically, to confirm existing knowledge on emissions and exceedances and develop approaches to reduce emissions.

$PM_{2.5}$ variations observed for the Calgary Central-Inglewood, the Calgary Southeast and the Lethbridge monitoring stations were similar to those reported in previous management response reports. Briefly, elevated concentrations are typically observed in the colder winter months and during lower wind speed conditions. The time of day when elevated concentrations are occurring implies that motor vehicle traffic emissions could be a notable contributor to measured elevated concentrations. Two studies have been initiated related to examining PM composition at stations in Calgary and Lethbridge.

For O_3, South Saskatchewan Region stations have lingered at or just below the trigger into Level 3 in recent years and for the past two reporting periods O_3 reached a Level 3 at the Calgary (previous reporting period only), Lethbridge and Medicine Hat monitoring stations. A focus study to characterize ozone concentrations throughout the year as well as conditions that are conducive to elevated concentrations across the South Saskatchewan Region is underway. Initial findings suggest meteorology as a strong influence on elevated O_3 occurrence, specifically incoming solar radiation and low wind speeds.

Next steps will include completing the investigative focus studies underway, participating in the multi-stakeholder CASA *Approaches and Solutions for CAAQS Achievement in Alberta* project and collaborating within Environment and Parks on provincial management actions. Additionally, continuing to compile an inventory of possible management actions and identifying effective actions that are reasonable for implementation in the management response are also planned.

Environment and Parks will continue to work with specific stakeholders to inform the investigation and assist in improving the current environmental management system and 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 management response reports.

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Air Quality Glossary

Air Quality	The composition of air, with respect to quantities of substances therein, and/or a measure of the health-related and visual characteristics of the air used most frequently in connection with standards against which the contribution of the particular source can be compared.
Air Quality Objective	A numerical concentration, value or narrative statement which is intended to provide protection of the environment and human health to the extent that is technically and economically feasible, and is socially and politically acceptable.
Airshed Organization	Regional partnership associations that include government, industry, environmental groups and the public. These partnerships are responsible for air quality monitoring and, in some cases, air quality management for a specific region of Alberta. Alberta presently has nine local airshed organizations.
Air Zone	Air zones are geographic areas identified through the national Air Quality Management System to facilitate effective air quality management at a local scale. In Alberta, the air zones align with the regional Land-use Framework boundaries, with the exception of Peace Air Zone which includes both Upper Peace and Lower Peace Regions.
Alberta's Ambient Air Quality Data Warehouse	Alberta's central repository for ambient air quality data collected in the province, made available online to the public. Currently known as the air data warehouse.
Ambient Air	Outside air - any portion of the atmosphere not confined by walls and a roof to which the public has access.
Canadian Ambient Air Quality Standards (CAAQS)	Ambient air quality standards applied across Canada that are designed to provide a uniform measure of protection for human health and the environment.
Exceptional Events	Emission sources that influence ambient concentrations such as forest fires, grass fires or other non-controllable or accidental releases etc., that are outside the control of provinces or territories.
Fine Particulate Matter	Fine particulate matter refers to airborne solid or liquid particles that are 2.5 microns or less in diameter. It is either emitted directly (primary PM) or formed in the atmosphere from precursor emissions (secondary PM). Important precursors of secondary PM are nitrogen oxides, sulphur dioxide, ammonia, and volatile organic compounds. The chemical composition of particles can vary widely and depends on location, time of year, and weather.
Indicators	Parameters that are measured to provide information about environmental condition; metrics are applied to the measurements to compare with defined triggers and limits.
Limits	Numerical thresholds at which the risk of adverse effects on health or environmental quality is becoming unacceptable.
Metric	A procedure for processing monitoring data to determine an indicator value to compare to triggers and limits. In the AQMF, metrics specify the averaging periods and statistics applied to the ambient air quality data.

Nitrogen Dioxide (NO_2)	Toxic pungent reddish-brown gas formed by the reaction of atmospheric ozone with the nitric oxide produced from combustion.
Nitrogen Oxides (Oxides of Nitrogen, NO_x)	A general term pertaining to compounds of NO, NO_2, and other oxides of nitrogen. Nitrogen oxides are created during combustion processes and are major contributors to smog formation and acid deposition.
Ozone (O_3)	Ozone is a chemical whose effect on the environment is either beneficial or detrimental depending on where it occurs. Stratospheric ozone (the layer of the earth's atmosphere above the troposphere, extending to about 50km above the earth's surface) protects us from the sun's UV light, but tropospheric ozone (the lowest region of the atmosphere, extending from the earth's surface to a height of about 6-10km), can be toxic. Ozone is a highly reactive, colourless gas that is normally present in the troposphere as a result of naturally occurring photochemical and meteorological processes. It has a sharp, clean odour that can often be detected around running electric motors, after lightning storms, and around new mown hay.
Parameter	Chemical or physical characteristics of air that are measured as part of monitoring for air quality.
Primary pollutants	Primary pollutants are those, which are emitted directly from sources (e.g., sulphur dioxide emitted from a combustion process). Secondary pollutants are atmospheric contaminants, which form due to the reaction or transformation of primary pollutants and other atmospheric compounds in the atmosphere (e.g., ground-level ozone is formed through photochemical reactions of nitrogen dioxide and volatile organic compounds in the atmosphere).
Secondary pollutants	Secondary pollutants are atmospheric contaminants, which form due to the reaction or transformation of primary pollutants and other atmospheric compounds in the atmosphere (e.g., ground-level ozone is formed through photochemical reactions of nitrogen dioxide and volatile organic compounds in the atmosphere).
Source (of Emissions)	There are many sources of emissions, but these have generally been grouped into two categories: emissions from point and non-point sources. A point source is a stationary location or fixed facility from which substances are discharged; e.g., a smokestack. A non-point source is a pollution source that is not recognized to have a single point of origin. Common non-point emission sources are agriculture, forestry, urban, mining, construction, and city streets.
Sulphur Dioxide (SO_2)	A colourless gas that is formed primarily by the combustion of fossil fuels containing sulphur. Sour gas processing plants, oil sands processing plants and coal-fired power generating plants are major sources of SO_2.
Transboundary (Transport)	The long-range movement of emissions and substances across political or pre-determined spatial borders. Transboundary pollution refers to substances that originate in one jurisdiction, but have adverse effects in another area/jurisdiction at such a distance that it is not generally possible to distinguish the contribution of individual emission sources or groups of sources.
Triggers	Numerical thresholds set in advance of limits as early warning signals for evaluation and proactive management.

Part 2: Surface Water Quality

5.0 Introduction to Surface Water Quality

Under the *South Saskatchewan Regional Plan* (GoA, 2018) a management response is initiated when the Minister of Environment and Parks determines the condition of one of the 15 primary indicators (Table A1) has crossed a trigger or exceeded a limit as identified in the South Saskatchewan Region Surface Water Quality Management Framework: for the mainstem Bow, Milk, Oldman and South Saskatchewan Rivers (Alberta); (SSR SWQMF) (AESRD, 2014). Management responses may also be undertaken for secondary indicators (Table A1) that exceed relevant surface water quality guidelines (AEP, 2018a) as identified in the SWQMF. The SSR SWQMF triggers and limits apply to nine stations in the region (Figure 2); however, additional stations may be used to support a management response. The framework follows the water year, with assessments completed each year for the open water season (April to October) and winter season (November to March).

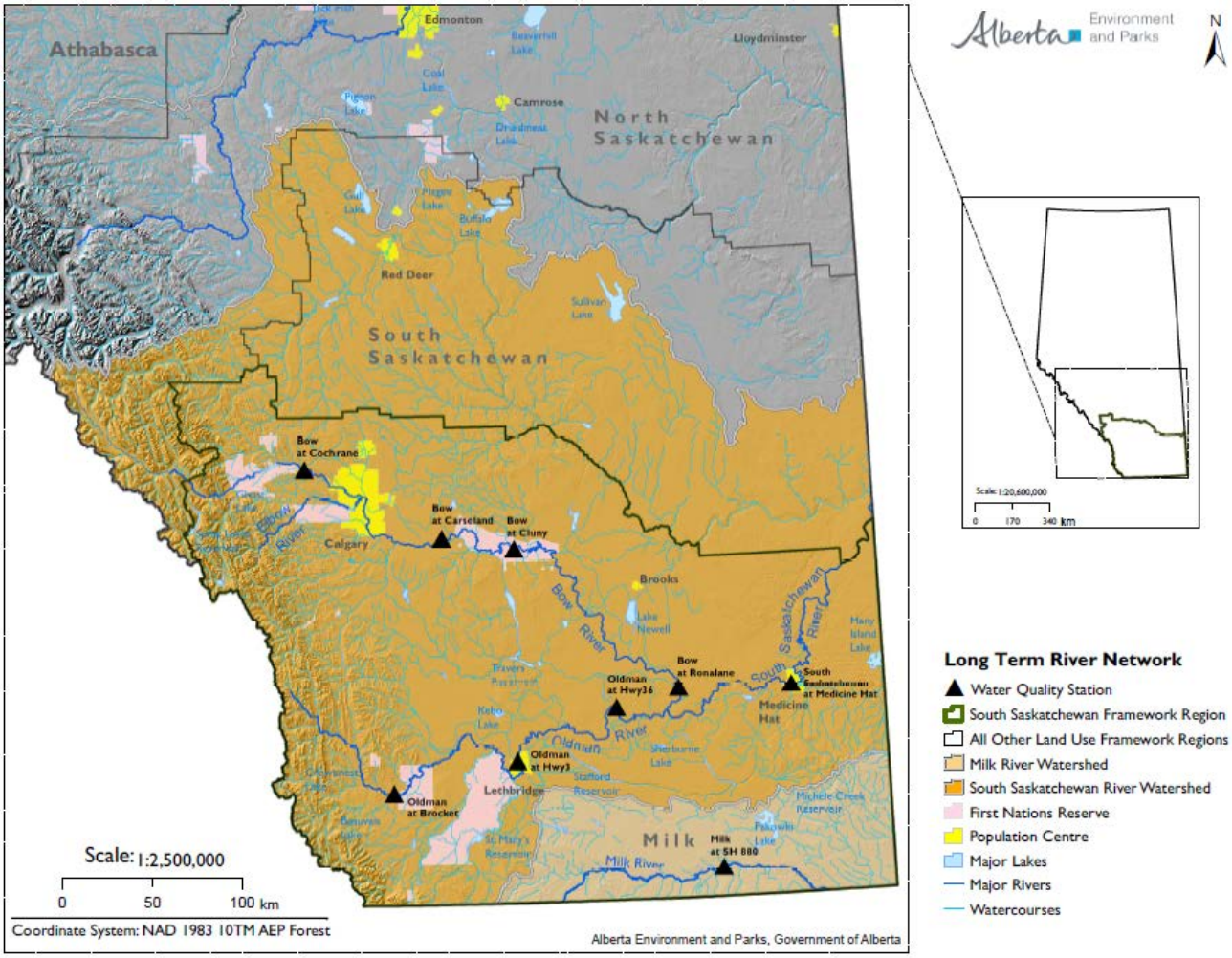

Figure 2: Map of surface water quality monitoring stations used in the 2019/2020 SSR SWQMF assessment.

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 identify and implement a management response.

A management response was initiated for the SSR after triggers were crossed for total nitrogen, nitrate, chloride, sulphate, total dissolved solids, specific conductance, sodium adsorption ratio (SAR), *Escherichia coli*, pH during 2020/2021 (Laceby et.al, 2022). As each annual report on status of conditions becomes available (AEP, 2017b; Kerr et al., 2018a; Kerr et al., 2018b; Chung et al., 2019; Taube and Kerr, 2020; Chung et al, 2020; Laceby et al., 2022), 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 (AEP, 2021). This is the sixth status report produced since the SSR SWQMF came into effect in September 2014 (AEP, 2017a; AEP, 2018b; AEP, 2020a; AEP, 2020b; AEP, 2021).

A full description of the management response can be found in the SSR SWQMF (AESRD, 2014). Initial steps include preliminary assessment, to determine the need for investigation and management actions. These steps are taken, in full or in part, when a surface water quality threshold is exceeded.

Part of the management response is determining the need for management action(s). The management response for surface water quality may 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 variability in time, assessment of the potential impact on the aquatic environment or water uses, and any additional influences or sources that lead to a deterioration. As the status of condition report becomes available, the management response is re-evaluated and updated based on new information.

The framework, as well as all condition and management response reports are available at https://www.alberta.ca/south-saskatchewan-regional-planning.aspx and on the Open Government Portal: https://open.alberta.ca/publications.

Steps of the management response

6.0 Summary of Trigger Crossings and Limit Exceedances

6.1 Minister's Determination

The Minister's Determination for 2020/2021 confirmed that monitoring detected trigger crossings for chloride (Bow River at Carseland, and Ronalane; Milk River at Hwy 880), nitrate (Bow River at Cluny), total nitrogen (Bow River at Cochrane), sulphate (Bow River at Cochrane and Carseland; Milk River at Hwy 880), specific conductance (Milk River at Hwy 880), total dissolved solids (Bow River at Cochrane, Carseland; Milk River at Hwy 880), sodium adsorption ratio (SAR) (Milk River at Hwy 880), *Escherichia coli* (South Saskatchewan River at Hwy 1) and pH (Milk River at Hwy 880) in the SSR. A limit exceedance was detected for total dissolved solids (during the winter) and *Escherichia coli* (during the open water season) in the Milk River at Hwy 880 (Table 4). There were no exceedances of guideline values for secondary indicators (Laceby et.al, 2022).

Exceedances from previous assessment periods are summarized in Table A2 of the Appendix.

TABLE 4: THRESHOLD EXCEEDANCES FOR SURFACE WATER QUALITY IN THE SOUTH SASKATCHEWAN REGION FOR 2020/2021 BASED ON TRIGGERS AND LIMITS ESTABLISHED IN THE FRAMEWORK.

Parameter	Station	Trigger Crossing		Limit Exceedance	
		Open Water	Winter	Open Water	Winter
Chloride	Bow River (Carseland)	Peak	Peak	-	-
	Bow River (Ronalane)	Peak	Peak	-	-
	Milk River (Hwy 880)	Peak	Peak	-	-
Nitrate	Bow River (Cluny)	Median	Median	-	-
Total Nitrogen	Bow River (Cochrane)		Median		
Sulphate	Bow River (Cochrane)	Peak	Peak	-	-
	Bow River (Carseland)	Median/Peak	Median/Peak	-	-
	Milk River (Hwy 880)	Peak	Peak	-	-
Specific Conductance	Milk River (Hwy 880)	Peak	Peak	-	-
Total Dissolved Solids	Bow River (Cochrane)	Median/Peak	Median/Peak	-	-
	Bow River (Carseland)	Peak	Peak	-	-
	Milk River (Hwy 880)	Peak	Peak	-	Median
Sodium Adsorption Ratio (SAR)	Milk River (Hwy 880)	Peak	Peak	-	-
Escherichia coli	South Saskatchewan River (Medicine Hat-Hwy 1)	-	Peak	-	-
	Milk River (Hwy 880)	-	-	Median	-
pH	Milk River (Hwy 880)	Peak	Peak	-	-

7.0 Preliminary Assessment for Surface Water Quality

Once trigger crossings have been identified, a preliminary assessment is undertaken to determine whether the exceedances represent changing ambient conditions, or are within the expected range of variability. This may include understanding if the exceedances are representative of change in an undesirable direction or if they can be attributed to rare events or natural circumstances. Comparison with historical data sets, the use of various trend assessments and evaluating the influence of flow are some approaches that may be used to make this distinction and understand the environmental significance of the exceedance. Preliminary assessments include trend analyses on unadjusted, seasonally-adjusted and flow-adjusted data to survey for undesirable trends in water quality. If the preliminary assessment identifies that the trigger crossing is indicative of changing ambient conditions, the indicator is placed in Level 2 (Table 5) of the management response and an investigation into cause is initiated.

The recently updated results of the preliminary assessment for indicators crossing a trigger, exceeding a limit, or exceeding a guideline previously identified in 2018/2019 are reported in Appendix C (Table A3). Further trend analysis is underway for pH in the Oldman at Brocket (identified in 2014/2015) to help determine the need for investigation and management actions. The available results of the preliminary assessment for all indicators crossing a trigger, exceeding a limit, or exceeding a guideline previously identified in 2019/2020 are available as Table A6 in AEP, 2021.

The recently available results of the preliminary assessment for all indicators crossing a trigger, exceeding a limit, or exceeding a guideline in 2020/2021 are reported in Appendix C (Table A4) and data visualizations (box plots) are in Appendix D (Figures A1 to A17). Flow-adjusted trend assessments on the indicators with trigger crossings in 2019/2020 and 2020/2021 will commence once validated flow data are available. On May 17, 2020 there was a failure of the diversion structure which normally moves water from the St Mary River to the Milk River. This failure prevented normal flows from materializing in the Milk River, until October 2020

when the structure was repaired. It is expected that this rare event may affect some remaining investigative and preliminary assessments (statistical analyses) for some exceedances in the Milk River. An update will be included in the next management response report.

The following exceedances remain in preliminary assessment for continued analysis to determine the need for investigation (Table A2).

- Oldman River at Brocket pH Further Analysis

Based on the results of preliminary assessment to date, management responses have been closed for the following exceedances (Table A2).

- Oldman River at Hwy 3 *E.coli*
- Oldman River at Hwy 3 Sulphate
- Oldman River at Hwy 3 Sodium Adsorption Ratio (SAR)
- Oldman River at Hwy 36 Specific Conductance
- Oldman River at Hwy 36 Total Selenium
- South Saskatchewan River at Medicine Hat - Hwy 1 Specific Conductance
- South Saskatchewan River at Medicine Hat - Hwy 1 Total Selenium
- Milk River at Hwy 880 Total Selenium

Indicators that have been moved into investigation are discussed in Section 8.1 and listed in Tables 6 and A2.

8.0 Status of Management Response for Surface Water Quality

The management response is a set of steps taken, in full or in part, when an ambient trigger is crossed or limit is exceeded. The management response will support the management intent associated with each level (Table 5). Levels are set through evaluation of indicator once a threshold has been exceeded, limit exceedances move parameters directly to investigation, whereas trigger crossings are evaluated through preliminary assessment prior to a decision on setting a level. A full description of the management system is found in the South Saskatchewan Region Surface Water Quality Management Framework (AESRD, 2014). The status of management response is reported on a regular basis and may be supported by supplemental technical reports (e.g. Gaas and Kromrey, 2021).

This section of the report summarizes progress made on the management response, including an update on the investigation and identification of potential mitigative management actions.

TABLE 5: SURFACE WATER QUALITY LEVELS – DESCRIPTION AND MANAGEMENT INTENT.

Level	Description	Management Intent
3	Indicator seasonal median values exceed water quality limits.	Management actions required to improve ambient water quality to below limits.
Limit Exceedance		
2	Indicator seasonal median and/or peak values statistically higher than trigger values.	Management response and determination of risk and urgency for management action to maintain water quality below limits. Investigation of cause and effects; evaluation and implementation of management actions.
Trigger Crossing		
1	Median and peak water quality conditions at or better than historical water quality conditions.	Apply standard regulatory and non-regulatory approaches to manage water quality

8.1 Investigation

The purpose of investigation is to determine factors likely influencing a water quality indicator (i.e. source identification) and inform decisions about management actions. The scale of the investigation depends on the management level as well as the complexity of the issue. Investigation may include considering the number and location of monitoring stations where exceedances were reported or guidelines crossed, trends in the data for multiple timeframes to understand changes over time, the potential impact of the exceedances to the aquatic environment or water uses, and any additional potential influences (natural or human-caused) including the influence of flow.

An investigation was initiated for TDS and specific conductance in the Milk River at Hwy 880 due to their winter limit exceedances (management level 3) in current and past years. The investigation of cause (source identification) has been completed (Gaas and Kromrey, 2021) and the findings suggest that groundwater is likely the primary source of TDS to the Milk River in the winter, the lower TDS values in the open-water season compared to the winter season are primarily due to the addition of relatively low TDS water from the St. Mary River during the summer months and 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 salt ions into the remaining flowing water. A determination of risk and urgency as well as an evaluation of possible management actions was also completed. The findings of the risk assessment are documented later in this report. An investigation has been initiated (management level 2) to address the multiple TDS, specific conductance, sulphate, chloride, pH, nitrate and total nitrogen trigger crossings reported among the one South Saskatchewan River station and the four Bow River stations since 2014 (Table 6). This includes source identification and a determination of risk and urgency may follow. An investigation in the Milk River at Hwy 880 has been initiated to address the open water *E.coli* limit exceedance in 2020/2021. The May 2020 St Mary River diversion structure failure rare event will likely play a role in this exceedance. Further details on these investigations are provided in Appendix E.

TABLE 6: LOCATION AND MANAGEMENT LEVELS FOR INDICATORS UNDER INVESTIGATION AND MANAGEMENT INTENT FOR THE ASSOCIATED PARAMETERS.

Location	Indicator	Management Level	Management Intent
Milk River	TDS	Level 3	Management Actions
Milk River	specific conductance	Level 3	Management Actions
Milk River	*E.coli*	Level 3	Under investigation
Bow River	TDS	Level 2	Under investigation
Bow River	specific conductance	Level 2	Under investigation
Bow River	sulphate	Level 2	Under investigation
Bow River	chloride	Level 2	Under investigation
Bow River	nitrate	Level 2	Under investigation
Bow River	pH	Level 2	Under investigation
Bow River	total nitrogen	Level 2	Under investigation
South Sask River	chloride	Level 2	Under investigation

8.2 Identification of Management Actions

Once there was adequate understanding of the various influences on total dissolved solids and specific conductance from the investigation in the Milk River, the first management action undertaken was to assess the risk to the various water uses. That **risk assessment**, was led by AEP with input from the Milk River Watershed Council of Canada and other stakeholders, and was used to determine future management actions needed to maintain and protect water uses now and in the future in the Milk River.

Since the limits for TDS and specific conductance that have been exceeded in the Milk River are based on irrigation guidelines but the exceedances have occurred during the winter period only, the anticipated risk was low. Nevertheless, a risk assessment was completed to ensure that all potential risks were adequately assessed and to establish a process for conducting risk assessments in response to future trigger crossings and limit exceedances that may occur under the SSR SWQMF.

The process that was used to conduct the risk assessment for the Milk River was based on the ISO 31000 risk management framework and the Government of Alberta's Common Risk Management Framework (CRMF) (IRMS Secretariat, 2019).

The risk assessment has been completed and AEP has sought input from area stakeholders to ensure the adequacy of the results. Below is a summary of the work to date.

A source-receptor conceptual model was developed to identify the potential risks that could result from high salinity in the Milk River. A total of 16 risks were identified using this conceptual model. The risks considered in the risk assessment included the following:

- Human health risks resulting from the consumption of treated and untreated water;
- Infrastructure risks resulting from scaling and corrosion in the distribution system and in homes;
- Animal health risks resulting from consumption of water by pets and livestock;
- Risks to vegetation and soils resulting from the use of water for irrigation of field crops, greenhouse crops, or aesthetic grasses;
- Risks to environmental receptors including riparian vegetation, benthic invertebrates, fish and wildlife, and;
- Risks to water uses by industrial operations in the area.

Each identified risk was analyzed against standard risk criteria.

The results of the risk assessment indicate that, in general, risks to various uses resulting from using water in winter from the Milk River are low. However the high salinity of Milk River water may cause scaling in water treatment and distribution systems and in homes. The large difference in salinity levels during the winter compared to when the U.S. St. Mary Diversion Canal is operating could also result in effects to benthic invertebrates and fish. However, there are no agreed-upon guidelines for TDS and specific conductance for the aquatic environment so any effects are uncertain. Since the large variability in salinity values have likely been present since the U.S. St. Mary Canal began operating in the early 1900's, it is most likely that the largest instream effects (e.g impacts to aquatic life) occurred decades ago, before the SWQMF came into effect, and the ecosystem has adjusted.

Although the focus of the risk assessment was on TDS and specific conductance exceedances in the mainstem Milk River, tributaries were also considered to ensure that all risks were adequately assessed. The tributaries that were included in the risk assessment are: Verdigris Coulee, Red Creek, Miners Coulee, Lodge Creek, Middle Creek and Battle Creek.

The risk assessment results for the tributaries indicate the following:

- Unlike the Milk River, where higher concentrations of TDS and specific conductance are recorded only during winter or during open water periods when the U.S St. Mary Diversion Canal is not diverting water into the Milk River, some of the tributaries naturally have high concentrations most of the time.

- The water from Verdigris Coulee and Red Creek could potentially have an unpleasant taste due to high concentrations of TDS, sulphate and sodium. Concentrations of sulphate in Red Creek are frequently above the aesthetic objective of 500 mg/L, which can sometimes lead to physiological effects such as intestinal discomfort or diarrhea among individuals unaccustomed to high sulphate water

- The high TDS values in Verdigris Coulee and Red Creek could result in physical damage to crops or reduced crop yield if used for irrigation of crops. This occurred in the 1980's when the St. Mary River Irrigation District released water into Verdigris Coulee for irrigators there, and the practice was stopped.

- The water from Verdigris Coulee could result in physical damage to grasses if used to irrigate, for example, golf courses, campgrounds, parks and lawns.

- The high salinity of water in Verdigris Coulee, and Red Creek likely influences the community structure and richness of their aquatic ecosystems.

The results of the risk assessment are being used to identify management actions for implementation in collaboration with stakeholders. Since the investigation identified the TDS and specific conductance exceedances in the Milk River were attributed to natural variation, mandatory actions were not required, but some were still identified. When identifying management actions, it is important to note that the results of the investigation into high TDS and specific conductance in the Milk River indicate that the salinity values originate from groundwater, the seasonal pausing of diverted water from the St Mary River, and ice formation processes in winter (which cannot be directly controlled). Therefore, management actions are limited to actions that mitigate impacts from water use as opposed to actions that prevent salinity in the river.

Some **management actions** that have been identified for implementation in response to the findings of the risk assessment include:

- Developing a fact sheet or other communication material to promote testing of water and point-of-use treatment to prevent aesthetic issues, potential physiological effects and scaling and corrosion in homes.

- Preparing a fact sheet communicating water quality limitations in some tributaries for irrigation purposes to the community and decision-makers. It is worth noting that due to a lack of water supply, no new water license allocations for irrigation purposes have been authorized from the Milk River or its tributaries for over two decades.

Additional actions are being considered to support future assessments of trigger crossings and limit exceedances for TDS and specific conductance in the Milk River under the SSR SWQMF. These include:

- Considering adjusting the seasons used in the framework at the Milk River at Hwy 880 station, to reflect the timing of water diverted from the St Mary River, when the framework is updated.

- Removing the TDS and specific conductance limits for the winter season for the Milk River at Hwy 880 station. Changes over time would still be monitored for, evaluated and reported against based on the trigger values and assessments of increasing trends over time.

Progress on the identified management actions will be reported on in subsequent Status of the Management Response Reports.

Ongoing discussions and additional investigations and studies will continue to inform and establish necessary and appropriate mitigative actions for other trigger crossings and limit exceedances under the SSR SWQMF as needed.

8.3 Oversight/Delivery of Management Actions

Management actions support, rather than replace existing policies and regulations. 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 additional years to be realized.

8.3.1 Summary of Management Actions Underway

AEP will continue to use the results of the risk assessment to focus on the delivery of the identified management actions, working with partners such as the Milk River Watershed Council of Canada. Progress on these actions, and any new actions identified, will be reported on in subsequent Status of the Management Response Reports.

9.0 Next Steps for Surface Water Quality

Alberta Environment and Parks will conduct the preliminary assessment for all indicators crossing a trigger or exceeding a limit in 2020/2021 and in previous reporting periods. This includes:

- further analysis on pH in the Oldman at Brocket (2014/2015) to help determine the need for investigation and management actions; and

- flow-adjusted trend assessments on the indicators with trigger crossings in 2019/2020 and 2020/2021, at the stations where the crossing occurred.

The following indicators are in the investigation phase:

- TDS, specific conductance, sulphate, chloride, pH, nitrate and total nitrogen among the four Bow River stations, due to trigger crossings reported since 2014;

- Chloride at the South Saskatchewan River - Hwy 1 at Medicine Hat station due to trigger crossings in 2018/2019 and 2019/2020; and

- *E.coli* in the Milk River at Hwy 880 for the limit exceedance in the open water season (2020/2021).

Next steps in the investigation for triggers crossed in the Bow and South Saskatchewan Rivers will focus on source identification and understanding current conditions and implications for aquatic life and other uses. Recommended steps include:

- An in-depth literature review
- Potential additional data gathering and analysis of surface water quality including tributary inputs, groundwater water, water flow influences and effluent discharged to the Bow River may follow.
- An investigation of cause (source identification), and
- Determination of recommendations for future steps

The Milk River TDS and specific conductance risk assessment has been completed. Management actions to be implemented are anticipated to include the following:

- Developing a fact sheet or other communication material to promote testing of water and point-of-use treatment to prevent aesthetic issues, potential physiological effects and scaling and corrosion in homes.

- Preparing a fact sheet communicating water quality limitations in some tributaries for irrigation purposes to the community and decision makers. It is worth noting that due to a lack of water supply, no new water license allocations for irrigation purposes have been authorized from the Milk River or its tributaries for over two decades.

Additional actions are also being considered that would help with the assessment of future trigger crossings and limit exceedances for TDS and specific conductance in the Milk River under the SSR SWQMF. These actions may be taken when the framework is updated and include:

- Adjusting the seasons used in the framework at the Milk River at Hwy 880 station, to reflect the timing of water diverted from the St Mary River, and

- Removing the TDS and specific conductance limits for the winter season for the Milk River at Hwy 880 station. Changes over time would still be monitored for, evaluated and reported against based on the trigger values and assessments of increasing trends over time.

AEP will continue to oversee the implementation of identified management actions, while also continuing preliminary assessment and investigation work. AEP will work with specific stakeholders and Indigenous Peoples, as appropriate, to inform the investigation and assist in improving the current management system and identifying management actions that may be necessary to address factors influencing surface water quality. Progress updates on the work outlined in this report will be communicated to the public in subsequent Status of the Management Response Reports.

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Surface Water Quality Glossary

Contaminant/ Pollutant	A substance in a concentration or amount that adversely alters the physical, chemical, or biological properties of the natural environment
Ecosystem Health	A healthy aquatic ecosystem is an aquatic environment that sustains its ecological structure, processes, functions, and resilience within its range of natural variability.
Indicator	Parameters that are measured to provide information about environmental condition; metrics are applied to the measurements to compare with defined triggers and limits.
Limits	Numerical thresholds at which the risk of adverse effects on health or environmental quality is becoming unacceptable.
Metric	A procedure for processing monitoring data to determine an indicator value to compare to triggers and limits. In the SWQualMF, metrics summarize parameter measurements over a specific timeframe at a specific location.
mg/L	milligrams per liter
Non-point Source Pollutant	Pollution that enters a water body from diffuse or undefined sources and is usually carried by runoff.
Parameter	Chemical, physical, or biological characteristics of water that are measured as part of monitoring for water quality.
Point Source Pollution	Pollution that originates from an identifiable cause or location, such as a sewage treatment plant.
Substance	From the framework, a 'substance' is defined as: i) Any matter that: a. Is capable of becoming dispersed in the environment, or b. Is capable of being transformed in the environment into matter refered to in a., ii) Any sound, vibration, heat, radiation or other form of energy, and iii) Any combination of things referred to in i) and ii).
TDS	total dissolved solids
Toxicity	The adverse effect on the growth, reproduction, or survival of an organism.
Triggers	Numerical thresholds set in advance of limits as early warning signals for evaluation and proactive management.
Wastewater	The liquid waste generated through various industrial and municipal processes.
Water Uses	For the purpose of the framework these include: protection of aquatic life, drinking water, recreation and aesthetics, agricultural, and industrial.
µS/cm	microsiemens per centimeter

Appendices for Surface Water Quality

Appendix A: Surface Water Quality Indicators for the South Saskatchewan Region

TABLE A1: LIST OF PRIMARY AND SECONDARY INDICATORS FOR THE SOUTH SASKATCHEWAN REGION SURFACE WATER QUALITY MANAGEMENT FRAMEWORK.

Primary Indicators	
Total Ammonia	Specific Conductance
Chloride	Total Dissolved Solids
Nitrate	Total Organic Carbon
Total Nitrogen	Total Suspended Solids
Total Dissolved Phosphorus	Turbidity
Total Phosphorus	pH
Sulphate	*Escherichia coli*
Sodium Adsorption Ratio (SAR)	
Secondary Indicators	
Mercury	Dicamba
Selenium	Methylchlorophenoxyacetic acid (MCPA)
2,4-Dichlorophenoxyacetic acid (2,4-D)	Mecoprop (MCPP)

Appendix B: History of Exceedances

TABLE A2: HISTORY OF MEDIAN AND PEAK GUIDELINE, TRIGGER CROSSINGS, OR LIMIT EXCEEDANCES AND STAGE OF MANAGEMENT RESPONSE.

Crossing or Exceedance	2014/2015		2015/2016		2016/2017		2017/2018		2018/2019		2019/2020		2020/2021		Next Steps/Stage of Management Response
	OW	W	OW	W	OW	W	OW	W	OW	W	OW	W	OW	W	
Bow River at Cochrane Total Nitrogen		M		M										M	Investigation
Bow River at Cochrane Nitrate												P			Investigation
Bow River at Cochrane Sulphate					P	P	P	P	P	P	P	P	P	P	Investigation
Bow River at Cochrane Specific Conductance											P	P			Investigation
Bow River at Cochrane Total Dissolved Solids (TDS)												M	M/P	M/P	Investigation
Bow River at Carseland Specific Conductance	P	P							P	P	M/P	M/P			Investigation
Bow River at Carseland Sulphate					P	P					P	P	M/P	M/P	Investigation
Bow River at Carseland Nitrate							P	P	M	M	M	M			Investigation
Bow River at Carseland Total Dissolved Solids (TDS)											M/P	M/P	P	P	Investigation
Bow River at Carseland Chloride									P	P	M/P	M/P	P	P	Investigation
Bow River at Cluny Total Dissolved Solids (TDS)					M	M									Investigation
Bow River at Cluny Specific Conductance											P	P			Investigation
Bow River at Cluny Chloride											P	P			Investigation
Bow River at Cluny pH									M	M					Investigation
Bow River at Cluny Nitrate							P	P	M	M			M	M	Investigation
Bow River at Ronalane Total Nitrogen			M	M					M	M					Investigation
Bow River at Ronalane Nitrate			M	M					M	M					Investigation
Bow River at Ronalane Specific Conductance							P	P			M/P	M/P			Investigation

TABLE A2. CON'T

Crossing or Exceedance	2014/2015		2015/2016		2016/2017		2017/2018		2018/2019		2019/2020		2020/2021		Next Steps/Stage of Management Response
	OW	W	OW	W	OW	W	OW	W	OW	W	OW	W	OW	W	
Bow River at Ronalane Total Dissolved Solids (TDS)							P	P			P	P			Investigation
Bow River at Ronalane Chloride									M/P	M/P	P	M/P	P	P	Investigation
Oldman River at Brocket pH	P	P													Further Analysis
Oldman River at Hwy 3 Sodium Adsorption Ratio (SAR)			M	M											Close Management Response
Oldman River at Hwy 3 *E.coli*										M/P					Close Management Response
Oldman River at Hwy 3 Sulphate									M	M					Close Management Response
Oldman River at Hwy 36 Specific Conductance	M	M													Close Management Response
Oldman River at Hwy 36 Total Selenium				G											Close Management Response
South Saskatchewan River at Medicine Hat - Hwy 1 Specific Conductance							M	M							Close Management Response
South Saskatchewan River at Medicine Hat - Hwy 1 Total Selenium								G*							Close Management Response
South Saskatchewan River at Medicine Hat - Hwy 1 Chloride									M/P	M/P	P	P			Investigation
South Saskatchewan River at Medicine Hat - Hwy 1 *E.coli*														P	Further Analysis*^
Milk River at Hwy 880 Specific Conductance								ML		ML			P	P	Management Actions<
Milk River at Hwy 880 Total Dissolved Solids (TDS)				ML		ML		ML		ML			P	PL	Management Actions<
Milk River at Hwy 880 Chloride													P	P	Further Analysis*^
Milk River at Hwy 880 Sulphate													P	P	Further Analysis*^
Milk River at Hwy 880 Sodium Adsorption Ratio (SAR)													P	P	Further Analysis*^
Milk River at Hwy 880 pH													P	P	Further Analysis*^
Milk River at Hwy 880 Total Selenium								G		G					Close Management Response

Milk River at Hwy 880 *E.coli*													L		Investigation

* 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.

< Source attribution for specific conductance and TDS limit exceedances at Milk River Hwy 880 completed as part of investigation. Risk assessment and need for management actions currently underway.

OW = Open Water, W = Winter, M = Median, P = Peak, L = Limit

Appendix C: Preliminary Assessment Technical Information

Trend assessments

The results of the preliminary assessment (trends) for indicators crossing a trigger, exceeding a limit, or exceeding a guideline in 2014/2015 and 2015/2016 are available as Tables 8 and 9 in AEP 2020a and Table A3 in AEP 2021. Respective results are available for 2016/2017 (Table A4) and 2017/2018 (Table A5) in AEP 2021 and as Table A3 below for 2018/2019. The available results of the initial (unadjusted and seasonally-adjusted) trend assessments for indicators crossing a trigger, exceeding a limit, or exceeding a guideline in 2019/2020 are available as Table A6 in AEP 2021 and as Table A4 below for 2020/2021. Flow-adjusted trend assessments on the indicators with trigger crossings in 2019/2020 and 2020/2021 will commence once validated flow data are available.

TABLE A3. STATUS OF TREND ASSESSMENTS FOR 2018/2019.

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 2018/2019 Trend Results

	Season	Flow-adjusted Trend	Unadjusted Trend	Action
Exceedance		**2009-2019**	**2009-2019**	**2009-2019**
Trigger Crossings				
Chloride Median & Peak SSR Hwy 1	Open Water	NT	NT	Investigation
	Winter	+	+	
Sulphate Peak Bow Cochrane	Open Water	NT	+	Investigation Continued
	Winter	+	+	
Nitrate Median Bow Carseland	Open Water	NT	NT	Investigation Continued
	Winter	+	+	
Chloride Peak Bow Carseland	Open Water	NT	NT	Investigation
	Winter	+	NT	
Specific Conductance Peak Bow Carseland	Open Water	NT	NT	Investigation Continued
	Winter	+	+	
Nitrate Median Bow Cluny	Open Water	NT	NT	Investigation Continued
	Winter	+	+	
pH Median Bow Cluny	Open Water	+	+	Investigation
	Winter	NT	NT	
Nitrate Median Bow Ronalane	Open Water	NT	-	Investigation Continued
	Winter	+	+	
Total Nitrogen Median Bow Ronalane	Open Water	NT	NT	Investigation Continued
	Winter	+	NT	
	Open Water	+	NT	Investigation

Chloride Median & Peak Bow Ronalane	Winter	+	+	
Sulphate Median Oldman Hwy 3	Open Water	NT	NT	Close Management Response
	Winter	NT	NT	
E.coli (Winter only) Median & Peak Oldman Hwy 3	Open Water			Close Management Response
	Winter	NT	NT	
Limit Exceedances				
Specific Conductance Limit (Winter only) Milk Hwy 880	Open Water			Investigation Closed~ Moved to Management Actions
	Winter	NT	NT	
Total Dissolved Solids Limit (Winter only) Milk Hwy 880	Open Water			Investigation Closed~ Moved to Management Actions
	Winter	NT	NT	
Guideline Exceedances				
Total Selenium Guideline Alert Concentration (Winter only) Milk Hwy 880	Open Water			Close Management Response
	Winter	NT	NT	

^ Some datasets that have different timeframes (e.g. Milk Hwy 880 TDS 2003-2016, Selenium 2004-2016).
~ Investigation due to winter median exceeding the Limit

TABLE A4. STATUS OF TREND ASSESSMENTS FOR 2020/2021.

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 2020/2021 Trend Results

	Season	**Unadjusted Trend**	**Seasonally Adjusted Trend**	**Flow-adjusted Trend**
Exceedance		**2009-2021**	**2009-2021**	**2009-2021**
Trigger Crossings				
Escherichia coli Peak (Winter only) SSR Hwy 1	Open Water	NT	NT	Underway
	Winter	+		
Sulphate Peak Bow Cochrane	Open Water	+	+	Underway
	Winter	+		
Total Dissolved Solids Median & Peak Bow Cochrane	Open Water	NT	+	Underway
	Winter	+		
Total Nitrogen Median (Winter only) Bow Cochrane	Open Water	NT	NT	Underway
	Winter	NT		
	Open Water	NT	+	Underway

Sulphate Median & Peak Bow Carseland	Winter	+		
Chloride Peak Bow Carseland	Open Water	NT	NT	Underway
	Winter	+		
Total Dissolved Solids Peak Bow Carseland	Open Water	NT	+	Underway
	Winter	+		
Nitrate Median Bow Cluny	Open Water	NT	+	Underway
	Winter	+		
Chloride Peak Bow Ronalane	Open Water	NT	+	Underway
	Winter	+		
Chloride Peak Milk Hwy 880	Open Water	NT	NT	Underway
	Winter	NT		
Sulphate Peak Milk Hwy 880	Open Water	NT	NT	Underway
	Winter	NT		
pH Peak Milk Hwy 880	Open Water	NT	NT	Underway
	Winter	NT		
Sodium Adsorption Ratio (SAR) Peak Milk Hwy 880	Open Water	NT	NT	Underway
	Winter	NT		
Specific Conductance Peak Milk Hwy 880	Open Water	NT	NT	Underway
	Winter	NT		
Total Dissolved Solids Peak Milk Hwy 880	Open Water	NT	NT	Underway
	Winter	NT		
Limit Exceedances				
Total Dissolved Solids Limit (Winter only) Milk Hwy 880	Open Water	NT	NT	Underway
	Winter	NT		
Escherichia coli Limit (Open Water season only) Milk Hwy 880	Open Water	NT	NT	Underway
	Winter	NT		
Guideline Exceedances				
None				

Appendix D: Box Plots of 2020/2021 Exceeded Indicators

South Saskatchewan River at Medicine Hat - Hwy 1 – *Escherichia coli* Winter Peak Trigger Crossings

Examination of the dataset revealed that the winter 2020/2021 90th percentile value is not the highest observed in the dataset at this station (Figure A1) and no samples exceeded the limit value.

Overall, the ***Escherichia coli*** concentrations in the South Saskatchewan River at Medicine Hat are similar to the nearest upstream stations on the Bow River at Ronalane and the Oldman River at Hwy 36. Further data analysis is needed to determine what influence river flow has on ***Escherichia coli*** concentrations.

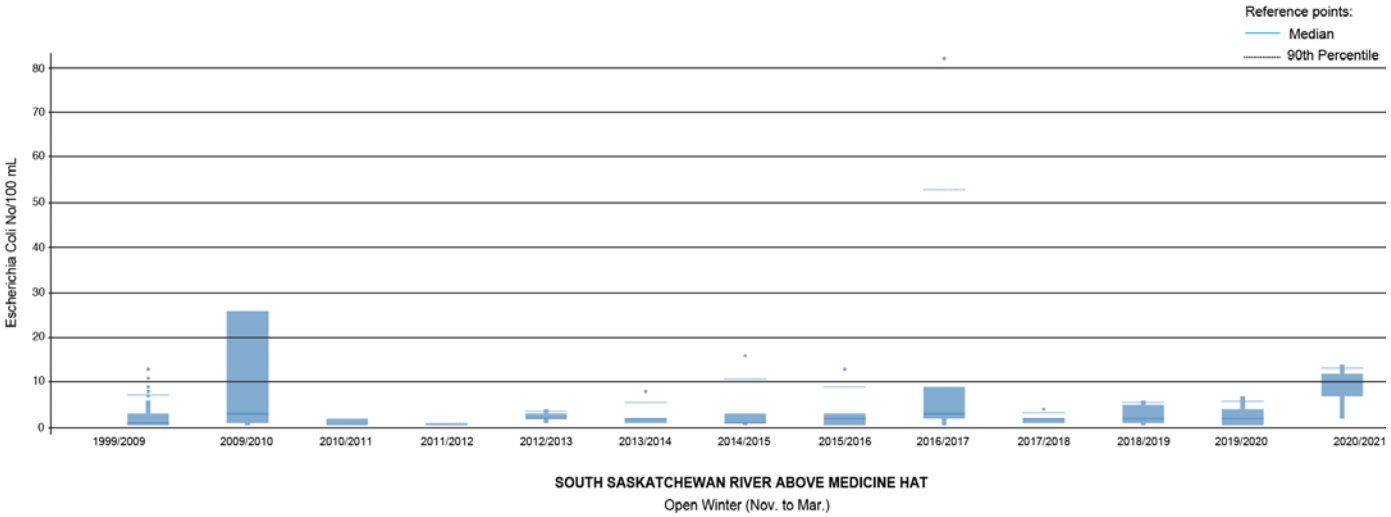

*Figure A1: Box plots of the **Escherichia coli** data in the South Saskatchewan River at Medicine Hat – Hwy 1 station during open water and winter from April 1999 to March 2021.*

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

Examination of the dataset revealed that although the 2020/2021 open water 90th percentile values (but not winter) are the highest observed in the dataset at this station (Figure A2), no samples exceeded the calculated limit value (based on hardness).

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

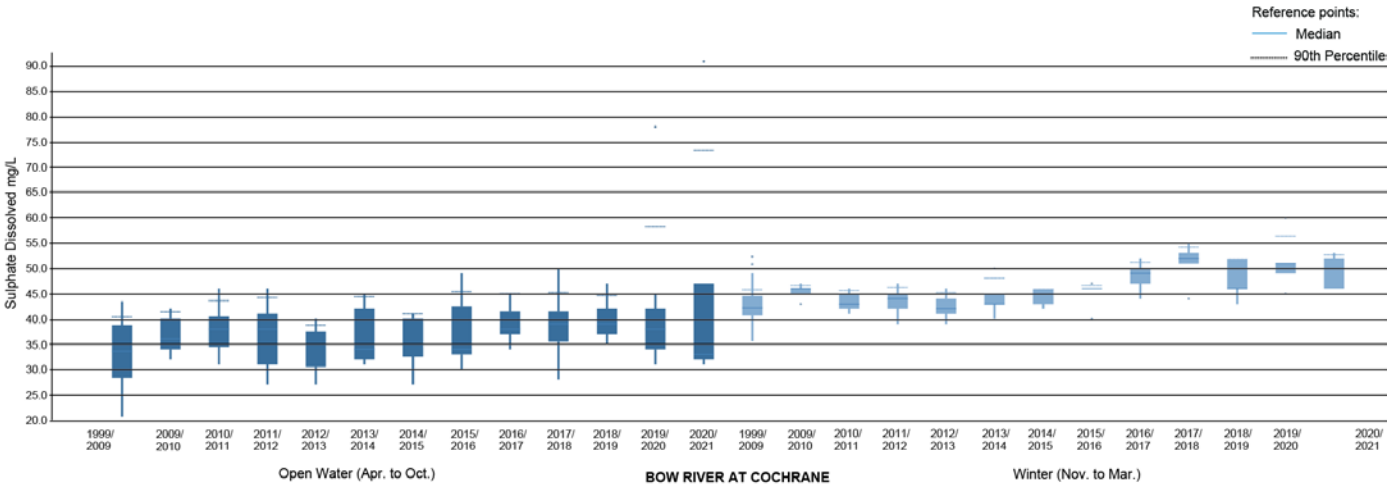

Figure A2: Box plots of the sulphate data in the Bow River at Cochrane station during winter from April 1999 to March 2021.

Bow River at Cochrane – Total Nitrogen Winter Median Trigger Crossing

Examination of the dataset revealed that the 2020/2021 winter median value is not the highest observed in the dataset at this station (Figure A3).

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

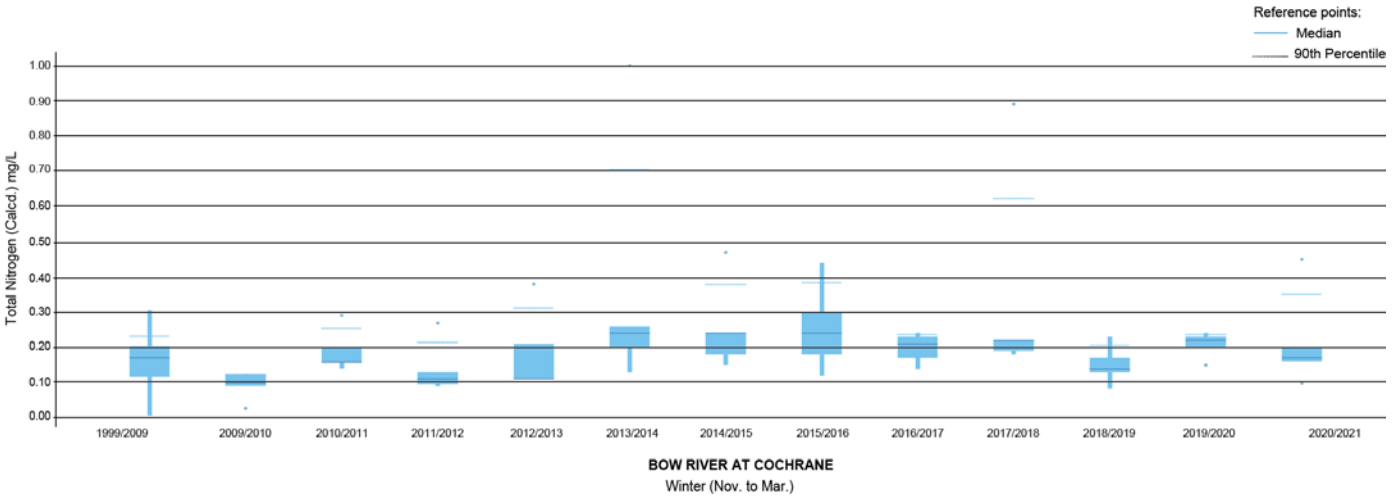

Figure A3: Box plots of the total nitrogen data in the Bow River at Cochrane station during winter from November 1999 to March 2021.

Bow River at Cochrane – Total Dissolved Solids Open Water and Winter, Median and Peak Trigger Crossing

Examination of the dataset revealed that the 2020/2021 open water (but not winter) peak value is the highest, but median values are not the highest, observed in the dataset at this station (Figure A4).

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

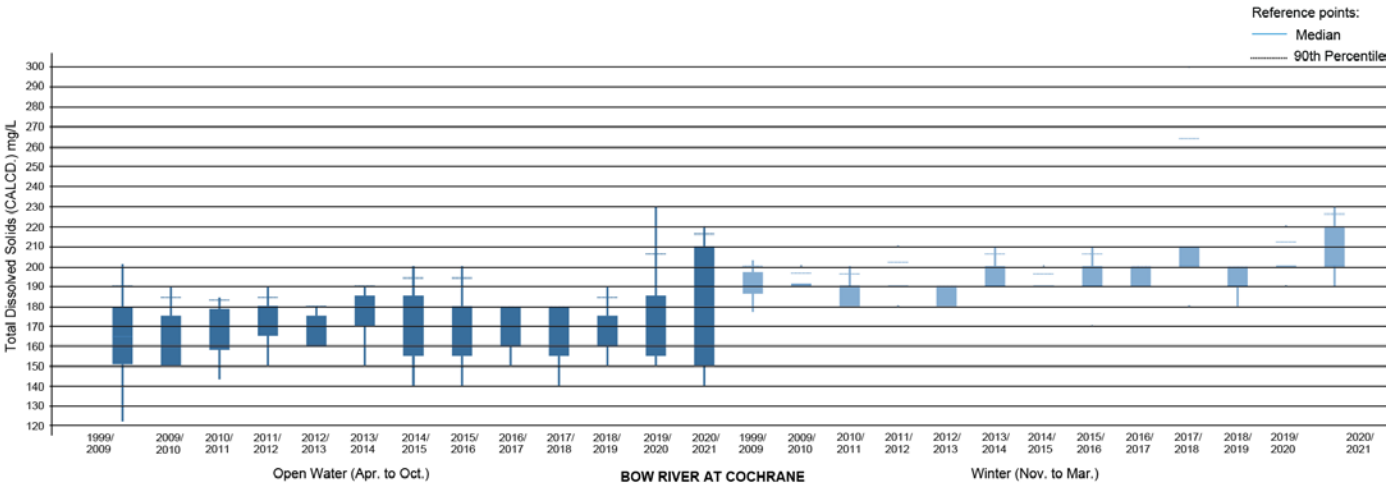

Figure A4: Box plots of the total dissolved solids data in the Bow River at Cochrane station during winter from November 1999 to March 2021.

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

Examination of the dataset revealed that the 2020/2021 median and peak values are not the highest observed in the dataset at this station (Figure A5) and no samples exceeded the calculated limit value (based on hardness).

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

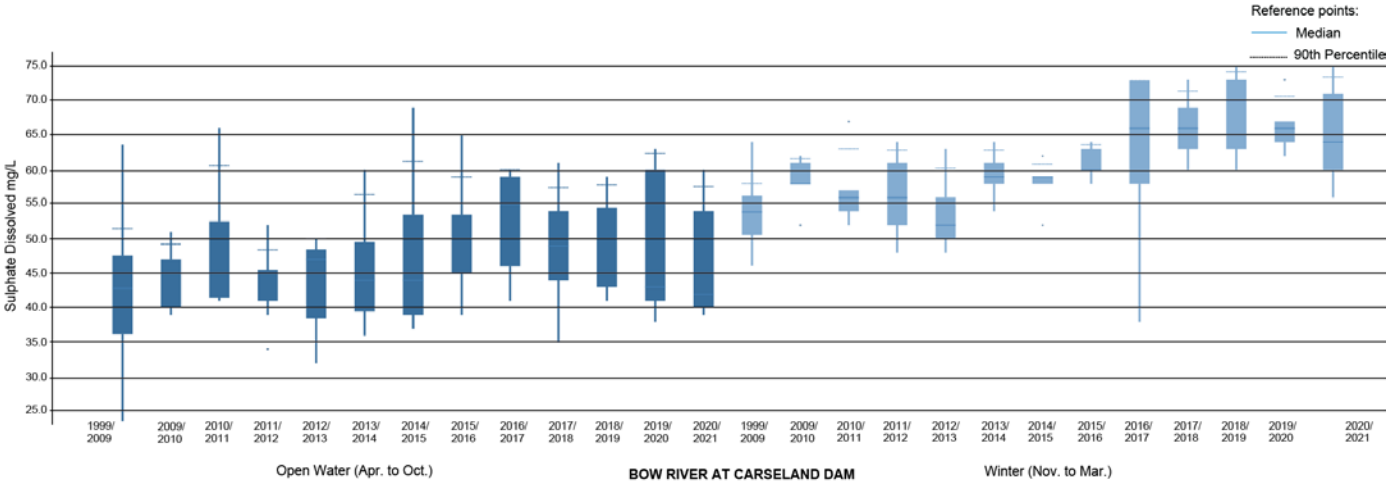

Figure A5: Box plots of the sulphate data in the Bow River at Carseland station during open water and winter from April 1999 to March 2021.

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

Examination of the dataset revealed that the 2020/2021 90th percentile values are not the highest observed in the dataset at this station (Figure A6).

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

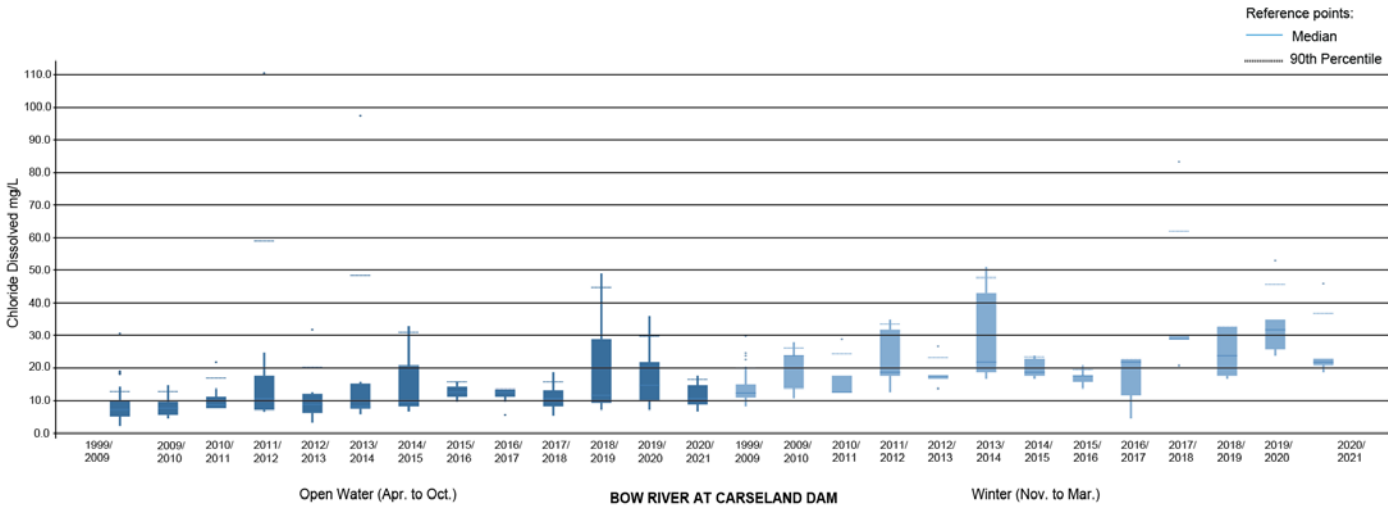

Figure A6: Box plots of the chloride data in the Bow River at Carseland station during open water and winter from April 1999 to March 2021.

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

Examination of the dataset revealed that the 2020/2021 90th percentile values are not the highest observed in the dataset at this station (Figure A7).

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

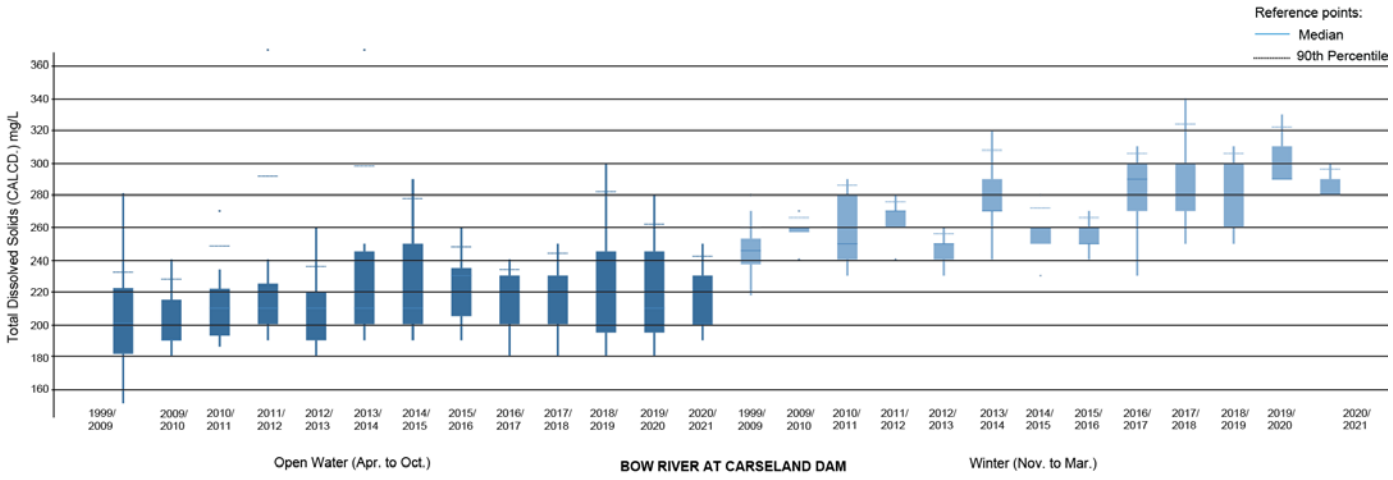

Figure A7: Box plots of the total dissolved solids data in the Bow River at Carseland station during open water and winter from April 1999 to March 2021.

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

Examination of the dataset revealed that the 2020/2021 median values are not the highest observed in the dataset at this station (Figure A8).

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

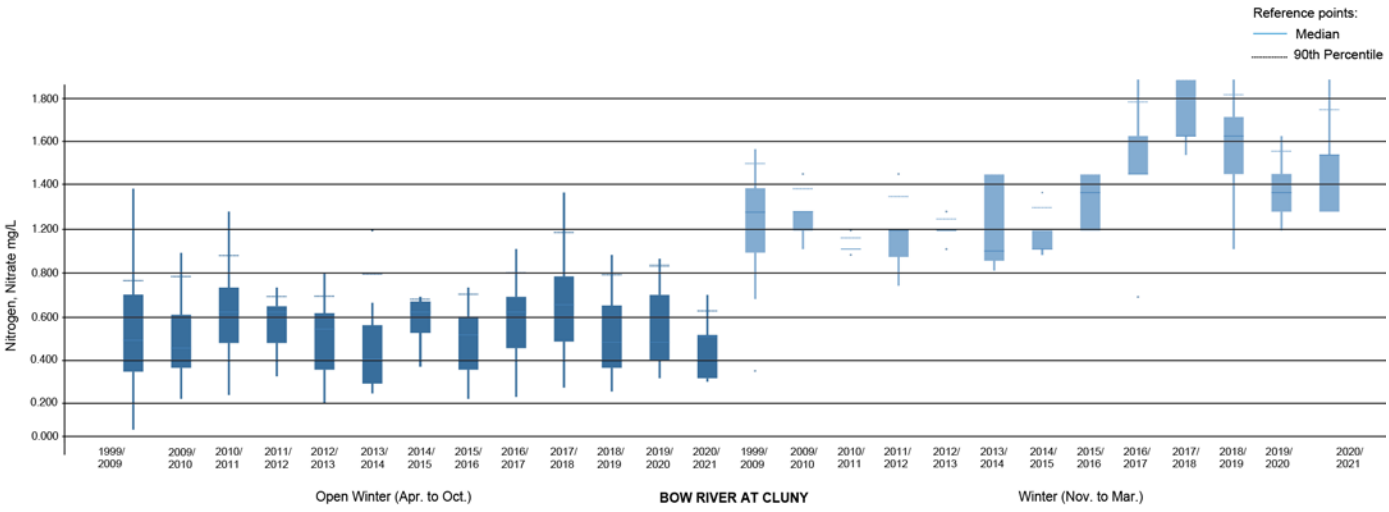

Figure A8: Box plots of the nitrate data in the Bow River at Cluny station during open water and winter from April 1999 to March 2021.

Bow River at Ronalane – Chloride Open Water and Winter Peak Trigger Crossings

Examination of the dataset revealed that the 2020/2021 90th percentile values are not the highest observed in the dataset at this station (Figure A9).

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

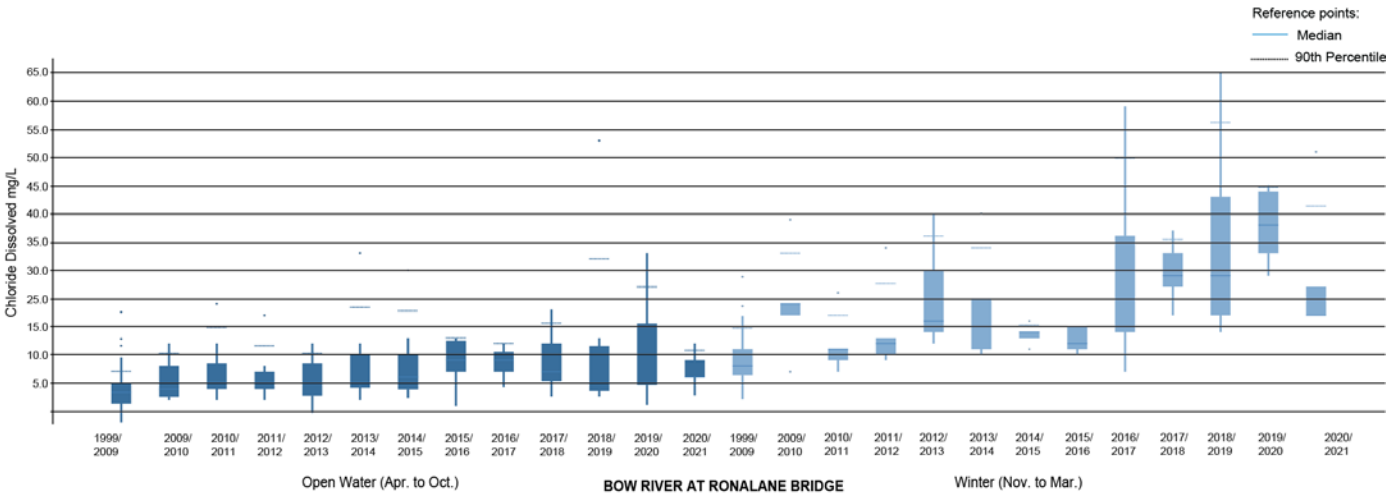

Figure A9: Box plots of the chloride data in the Bow River at Ronalane station during open water and winter from April 1999 to March 2021.

Milk River at Hwy 880 – Chloride Open Water and Winter Peak Trigger Crossings

Examination of the dataset revealed that the 2020/2021 90th percentile values are not the highest observed in the dataset at this station (Figure A10).

Overall, the Chloride concentrations in the Milk River at Hwy 880 are higher than those concentrations seen in the Oldman, but are lower than those observed in the lower Bow or South Saskatchewan Rivers. Further data analysis is needed to determine what influence river flow has on Chloride concentrations.

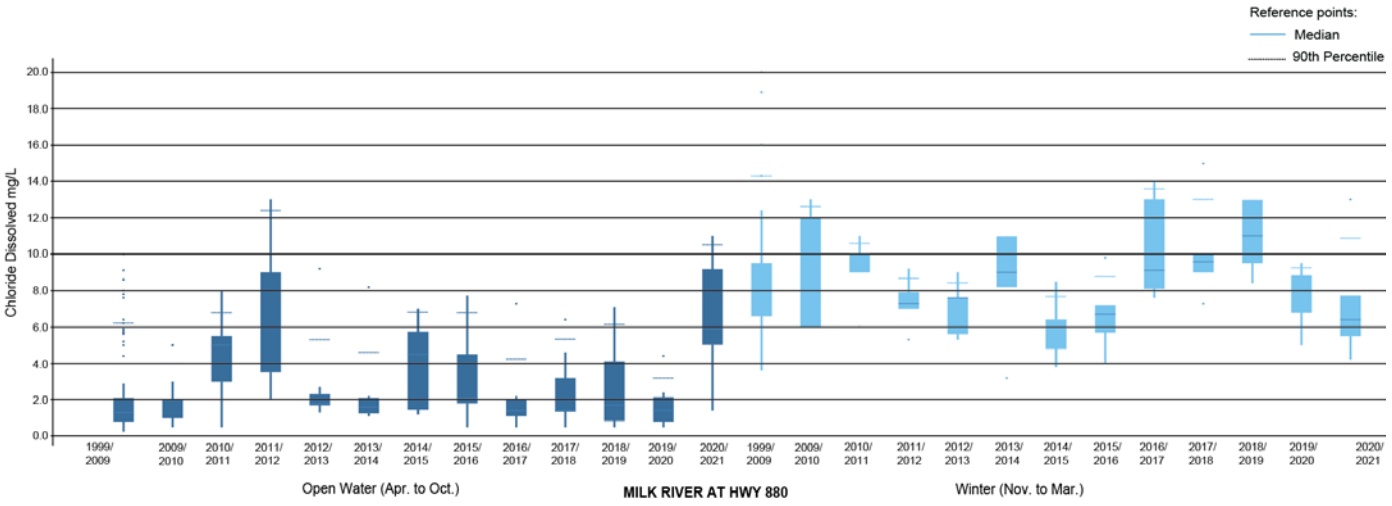

Figure A10: Box plots of the chloride data in the Milk River at Hwy 880 station during winter from November 2003 to March 2021

Milk River at Hwy 880 – Sulphate Open Water and Winter Peak Trigger Crossings

Examination of the dataset revealed that the 2020/2021 90th percentile values are not the highest observed in the dataset at this station (Figure A11).

Overall, the sulphate concentrations in the Milk River at Hwy 880 are higher than those concentrations seen in the Oldman, Bow or South Saskatchewan Rivers. Further data analysis is needed to determine what influence river flow has on sulphate concentrations.

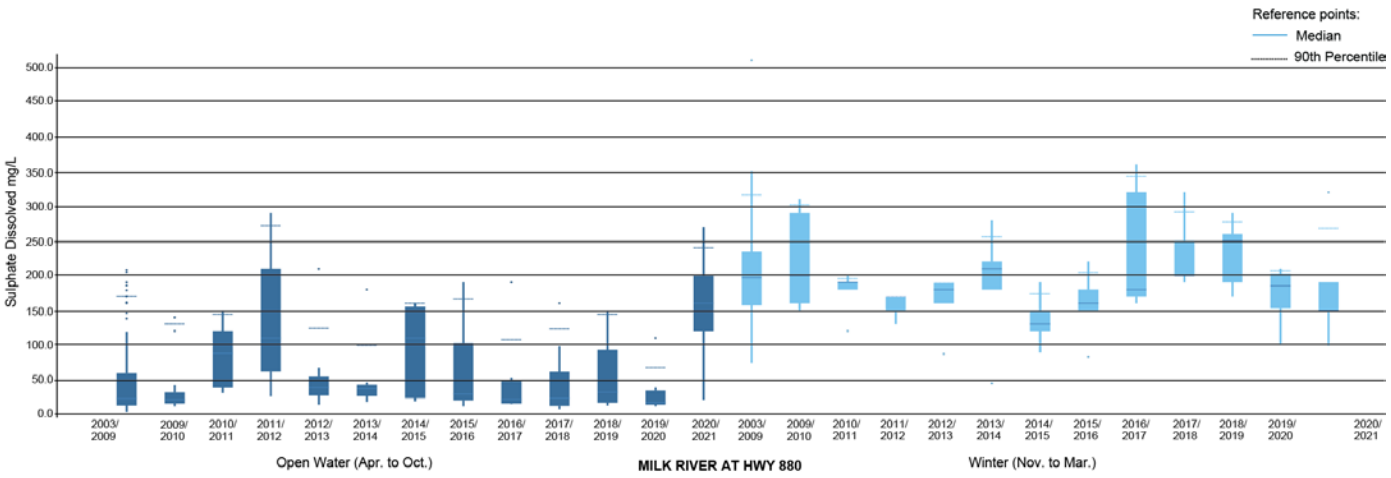

Figure A11: Box plots of the sulphate data in the Milk River at Hwy 880 station during winter from November 2003 to March 2021

Milk River at Hwy 880 – pH Open Water and Winter Peak Trigger Crossings

Examination of the dataset revealed that the 2020/2021 90th percentile values are not the highest observed in the dataset at this station (Figure A12).

Overall, the pH values in the Milk River at Hwy 880 are similar to those seen in the Oldman, Bow or South Saskatchewan Rivers. Further data analysis is needed to determine what influence river flow has on pH.

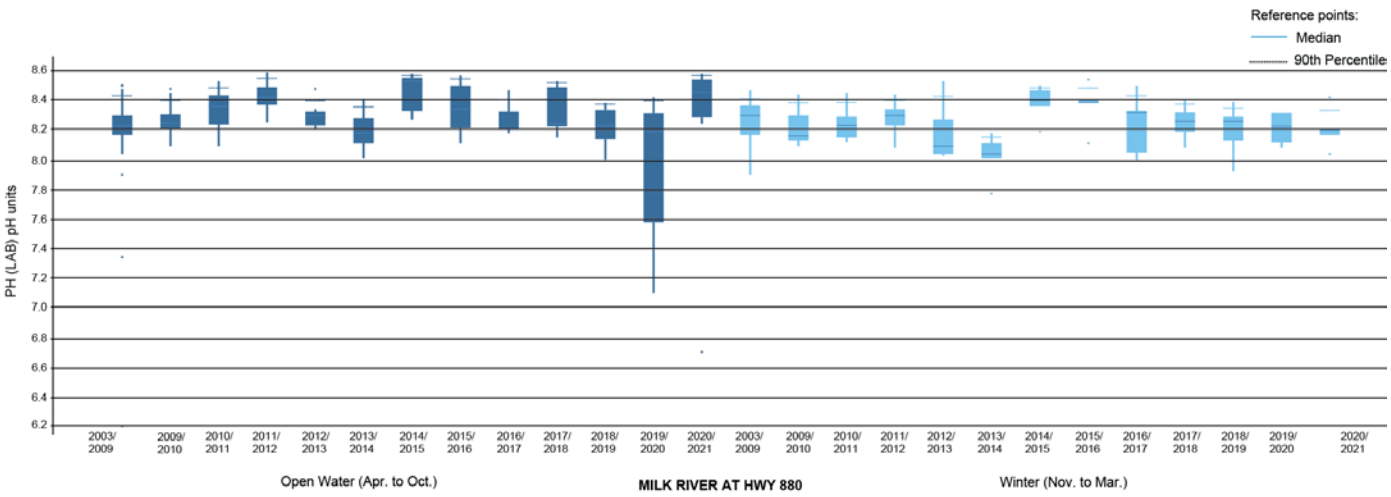

Figure A12: Box plots of the pH data in the Milk River at Hwy 880 station during winter from November 2003 to March 2021

Milk River at Hwy 880 – Sodium Adsorption Ration (SAR) Open Water and Winter Peak Trigger Crossings

Examination of the dataset revealed that the 2020/2021 90th percentile values are the highest observed (in the open water but not winter) in the dataset at this station (Figure A13).

Overall, the SAR values in the Milk River at Hwy 880 are higher than those seen in the Oldman, Bow or South Saskatchewan Rivers. Further data analysis is needed to determine what influence river flow has on SAR values.

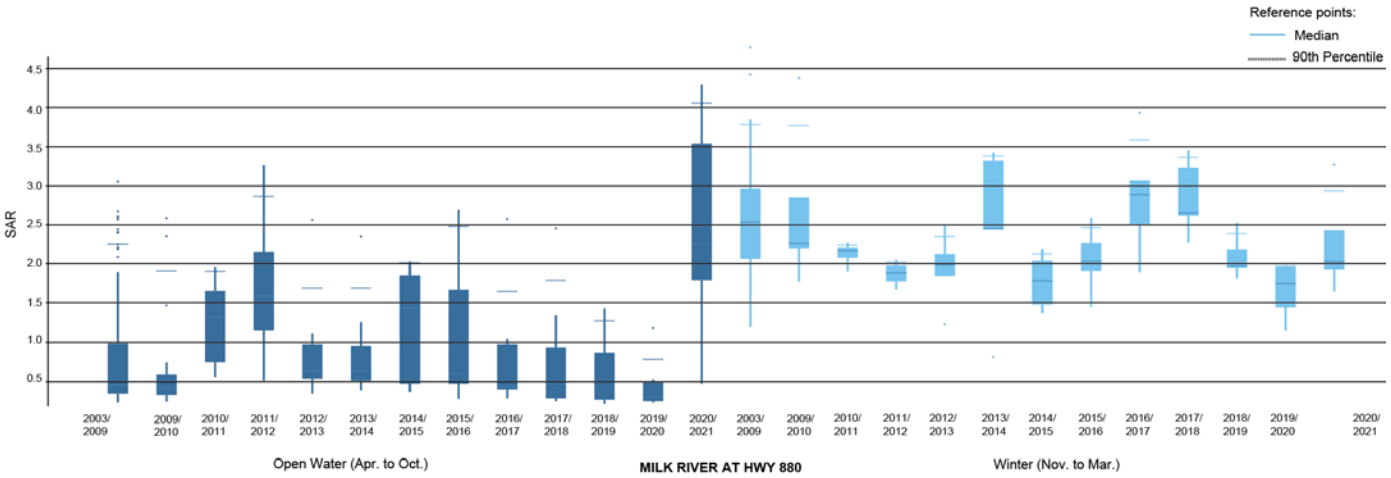

Figure A13: Box plots of the sodium adsorption ratio (SAR) data in the Milk River at Hwy 880 station during winter from November 2003 to March 2021

Milk River at Hwy 880 – Specific Conductance Open Water and Winter Peak Trigger Crossings

Examination of the dataset revealed that the 2020/2021 90th percentile values are not the highest observed in the dataset at this station (Figure A14).

Overall, the specific conductance values in the Milk River at Hwy 880 are higher than those seen in the Oldman, Bow or South Saskatchewan Rivers. Further data analysis is needed to determine what influence river flow has on specific conductance.

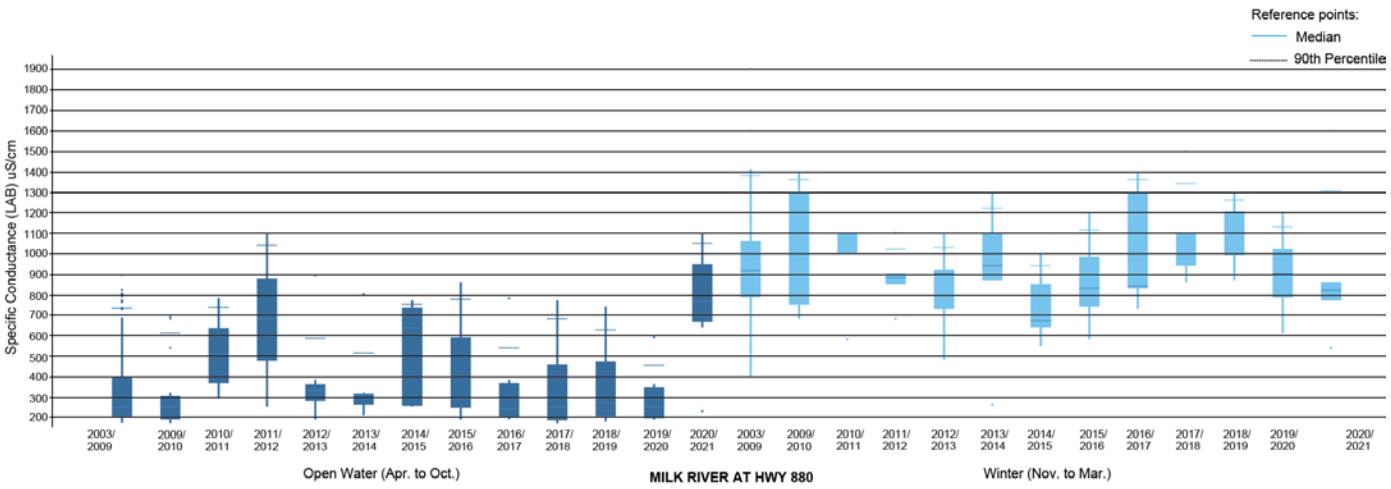

Figure A14: Box plots of the specific conductance data in the Milk River at Hwy 880 station during winter from November 2003 to March 2021

Milk River at Hwy 880 – Total Dissolved Solids Open Water and Winter Peak Trigger Crossings

Examination of the dataset revealed that the 2020/2021 90th percentile values are not the highest observed in the dataset at this station (Figure A15).

Overall, the TDS concentrations in the Milk River at Hwy 880 are higher than those concentrations seen in the Oldman, Bow or South Saskatchewan Rivers. Further data analysis is needed to determine what influence river flow has on TDS concentrations.

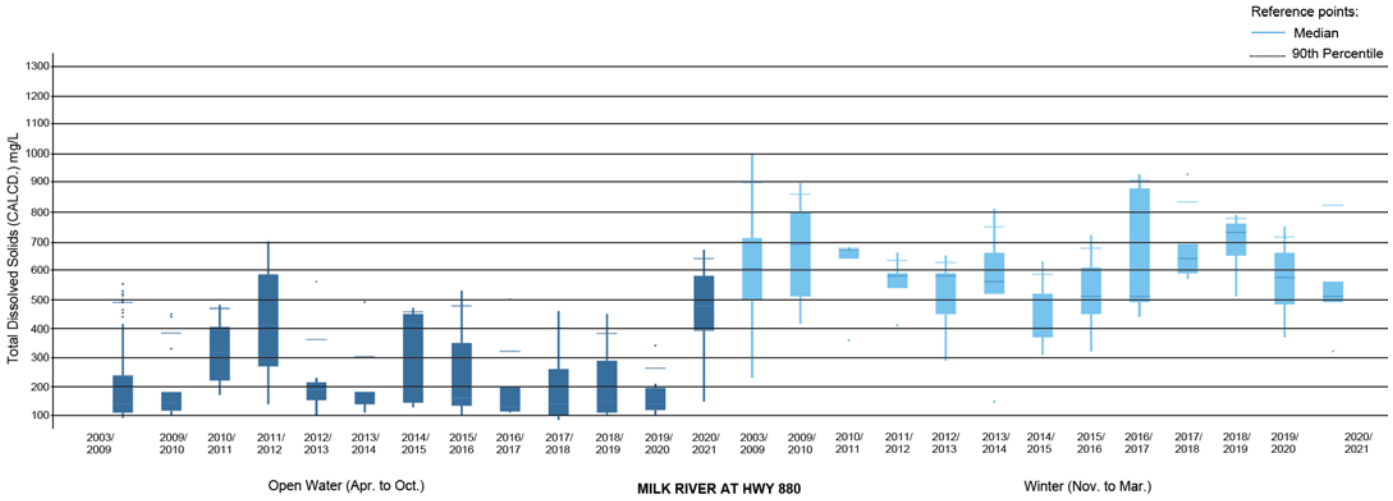

Figure A15: Box plots of the total dissolved solids data in the Milk River at Hwy 880 station during winter from November 2003 to March 2021

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

Examination of the dataset revealed that while the 2020/2021 winter median value is below the winter median trigger value of 606 mg/L and is not the highest observed in the dataset at this station, it is above the 500 mg/L winter median limit value (Figure A16).

Overall, the TDS concentrations in the Milk River at Hwy 880 are higher than those concentrations seen in the Oldman, Bow or South Saskatchewan Rivers. Further data analysis is needed to determine what influence river flow has on TDS concentrations.

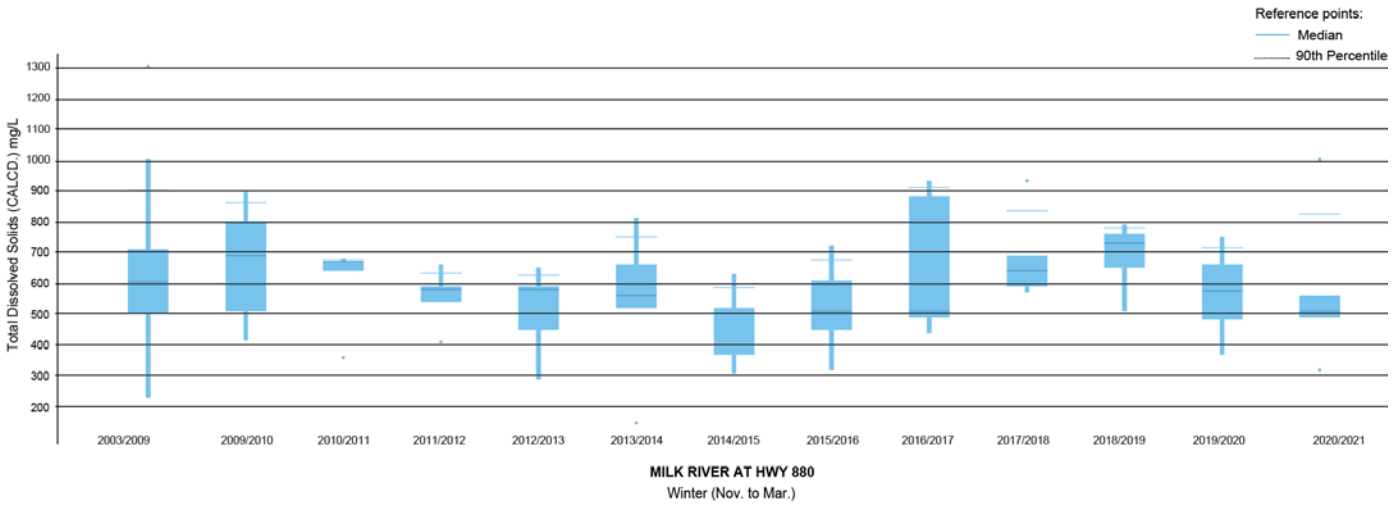

Figure A16: Box plots of the total dissolved solids data in the Milk River at Hwy 880 station during winter from November 2003 to March 2021.

Milk River at Hwy 880 – *Escherichia coli* Open Water Median Limit Exceedance

Examination of the dataset revealed that the 2020/2021 open water median value is the highest observed in the dataset at this station (Figure A17).

Overall, the open water *E coli* concentrations in the Milk River at Hwy 880 are similar to those concentrations seen in the lower Oldman, lower Bow or South Saskatchewan Rivers. Further data analysis is needed to determine what influence river flow has on *E coli* concentrations.

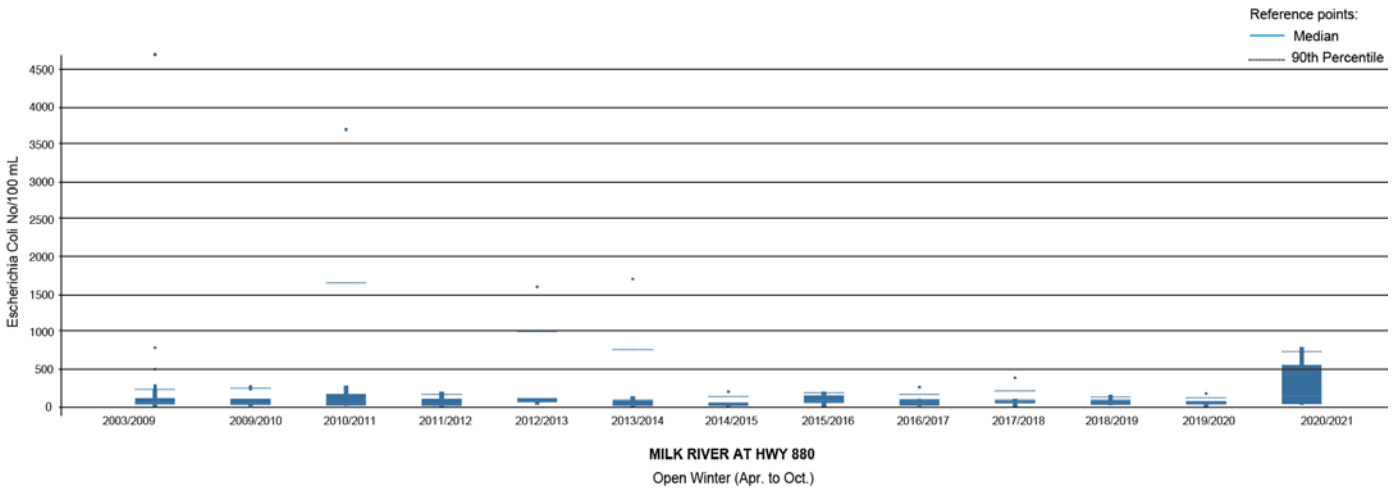

Figure A17: Box plots of the Escherichia coli data in the Milk River at Hwy 880 station during open water from April 2003 to March 2021.

Appendix E: Investigation Technical Information

Limit exceedances – TDS, Specific Conductance and *E coli* at Milk River Hwy 880

The framework limits for TDS and specific conductance are set at 500 mg/L and 1000 µS/cm respectively (AESRD, 2014). The seasonal medians exceeded the limit for TDS in the winter (November to March) in 2015/2016, 2016/2017, 2017/2018, 2018/2019, 2019/2020 and 2020/2021 as well as specific conductance in the winter in 2017/2018 and 2018/2019 (Kerr et al., 2018a; Kerr et al., 2018b; Chung et al., 2019; Taube and Kerr, 2020; Chung et al., 2020; Laceby et. al, 2022). As a management response, an investigation was initiated which included a literature review and analysis on surface water, groundwater water and water quantity (flow) data. The results of the investigation are provided in a separate report (Gaas and Kromrey, 2021). The report suggests that the winter exceedances are primarily controlled by the lack of dilution water from the St. Mary River which is diverted into the Milk River during the open water months, and that salinity to the Milk River in the winter is likely due to groundwater input and ice exclusion processes. Since the source has been identified an evaluation of possible management actions is underway as the next step in the management response process.

The limit for *E coli* is 100 cfu/100 mL (AESRD 2014). The seasonal median exceeded the limit for *E coli* in the open water season (April –October) in 2020/2021. An analysis of surface water data will be conducted. The results of the investigation will be included in the next management response report. The May 2020 diversion structure failure rare event will likely play a role in the investigation of this exceedance.

Trigger crossings – Bow and South Saskatchewan Rivers

An investigation in the Bow watershed has been initiated to address the TDS, specific conductance, sulphate, chloride, pH, nitrate and total nitrogen exceedances reported among the one South Saskatchewan River station and the four Bow River stations since 2014 (Table A2). The investigation will focus on the objectives of: source tracking (i.e. determining the cause of trigger crossings), determining a need for management actions and, recommendations for management actions (if needed). The initial focus will be

on the first objective, starting with an in-depth literature review. Additional data gathering and initial analysis of surface water quality may include tributary inputs, groundwater water, water flow influences and effluent discharged to the Bow River.