

MILK RIVER WATERSHED WATER MONITORING REPORT 2022



Prepared for: Milk River Watershed Council Canada

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Cover Photo: The Milk River at the Pinhorn site (April 7, 2022)



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1.0 INTRODUCTION

The Milk River is the most southern major river system in Alberta and the only river in the province that flows to the Gulf of Mexico. The headwaters of the Milk River originate in Montana, and the river flows eastward through Alberta for about 288 km. The mainstem of the Milk River is prairie fed and is often referred to as the South Fork of the Milk River. Flows in the North Fork of the Milk River are augmented by water from the St. Mary River (i.e., the St. Mary River Diversion) as part of the 1909 Boundary Waters Treaty.

The Milk River Watershed Council Canada (MRWCC) has monitored the Milk River and some of its tributaries since 2006. This report is a compilation of water monitoring data collected in 2022, with reference to the results from the previous three years (i.e., 2019-2021) (Palliser Environmental 2020 to 2022). Comparisons are made to Water Quality Objectives that were developed as part of the Milk River Integrated Watershed Management Plan (IWMP) (PESL 2015) and relevant provincial guidelines (GoA 2018).

2.0 METHODS

Grab samples were collected twice monthly (April-June) and monthly (July-October) (N=10) from five sites: **North Fork at 501, Milk River at 501, Upstream of the Town of Milk River (U/S Milk River), HWY 880 Bridge** and the **Pinhorn** site (Figure 1). Staff from the MRWCC collected the water samples at the North Fork at 501, Milk River at 501, U/S Milk River and Pinhorn sites. The HWY 880 site was sampled by MRWCC staff (3 samples) and staff from Alberta Environment and Protected Areas (EPA) (7 samples).

Red Creek 'downstream' was monitored in 2022 by EPA. Monitoring in previous years at Red Creek included an upstream and middle site sampled by the MRWCC; however, these sites have not been sampled since 2019. The MRWCC Research and Monitoring Team determined sufficient data has been collected to understand the trends and conditions on Red Creek and a summary report was completed in 2020. Verdigris Coulee and Miners Coulee, two ephemeral tributaries to the Milk River, have been sampled intermittently since 2018. In 2022, a single sample was collected at Miners Coulee in June and no samples were collected at Verdigris Coulee.

Samples were only collected when flows could be visually detected. Sample bottles were submersed to mid-depth by hand or using a sample pole (with sample bottle attached) when the water was deep or fast-flowing. Each sample container was prepared using standard protocols (e.g., sample preservation, where required). Sterile sample containers were provided by the analytical laboratory. The water samples were kept on ice in coolers and transported to ALS Laboratories in Calgary. ALS Laboratories is **CALA**¹ accredited for criteria and standards established by the Association under their Certificate of Laboratory Proficiency.

Samples were analysed using APHA approved methods for general parameters (e.g., pH, specific conductivity), nutrients (total phosphorus (TP), total dissolved phosphorus (TDP), nitrate+nitrite nitrogen (NO₃+NO₂-N), total kjeldahl nitrogen (TKN) and total nitrogen [TN; calculated]), total suspended solids (TSS) and fecal coliform bacteria (FCB).

¹ **CALA** – Canadian Association for Laboratory Accreditation Inc.

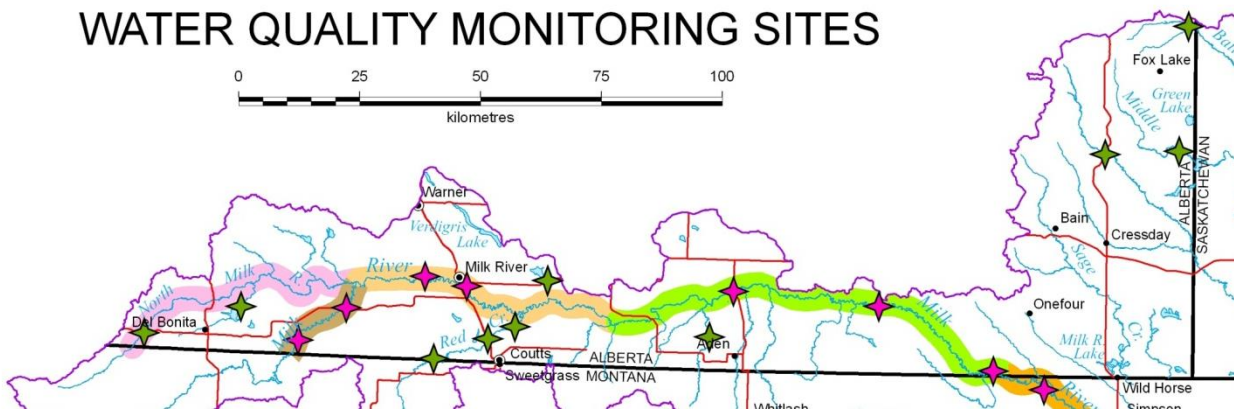


Figure 1 - Map showing water monitoring locations sampled in the Milk River watershed, 2022.

Water monitoring results were compared to Milk River Water Quality Objectives (WQO) and to applicable provincial surface water quality guidelines (GoA 2018). The WQO were established using data from 2006 to 2011 at four main river reaches (i.e., North Fork Milk River, Mainstem Milk River, Milk River Gravel Bed and Milk River Sand Bed) (PESL 2015). The Milk River IWMP Implementation Strategy suggests that water quality data should be compared to the WQOs annually with a trend analysis completed every five years. The current 2022 data set is the tenth year of data collected since the WQOs were established.

3.0 RESULTS

3.1 Precipitation

Overall, total precipitation (April-October) in the Milk River watershed in 2022 varied moderately across the watershed, ranging from 241.2 mm at Onefour to 288.5 mm at Del Bonita (Tables 1 and 2). June was the wettest month (mean = 104.9 mm) while April was the driest month (mean = 6.6 mm) (Table 1). Comparing mean total precipitation for each year, 2022 was the fifth driest of the ten years (mean: 264.8 mm) (Table 2). The driest year was recorded in 2017 (mean: 178.8 mm) and the wettest year occurred in 2014 (mean: 344.0 mm) a difference of 165.2 mm of precipitation between the wettest and driest years. Based on ten-year averages, the weather station Cardston is the wettest (average: 294.2 mm) while the weather station Masinasin (average: 234.0 mm) is the driest.

Comparing the 2022 precipitation data to 2021, the weather stations Cardston and Del Bonita had similar precipitation; however, the weather stations Milk River, Masinasin and Onefour had substantially more precipitation in 2022 compared to 2021 (Table 2). In 2022, the weather station Cardston had the third lowest precipitation of ten years.

Table 1 – Total precipitation (mm) at five weather stations, April to October, 2022.

Month	Cardston	Del Bonita	Milk River	Masinasin	Onefour
April	4.2	7.4	10.3	4.3	6.8
May	35.2	23.8	30.4	23.4	14.1
June	62.6	131.0	115.6	123.4	91.9
July	40.8	30.5	39.9	54.4	69.1
August	65.5	36.0	12.3	16.1	15.2
September	27.7	34.5	17.8	13.2	4.8
October	22.0	25.3	39.6	36.8	39.3
Total	258.0	288.5	264.9	271.6	241.2

Data Source: Environment Canada - http://climate.weather.gc.ca/index_e.html (Note: April data for Milk River is from ACIS viewer: <http://agriculture.alberta.ca/acis/alberta-weather-data-viewer.jsp>)

Table 2 - Historical total precipitation (mm) at five weather stations for the water monitoring period April to October, 2012 to 2022.

Year	Cardston	Del Bonita	Milk River	Masinasin	Onefour	average
2013	323.1	245.1	347.5	256.8	408.6	316.2
2014	376.8	404.7	290.1	333.7	314.7	344.0
2015	256.3	192.6	199.6	123.5	198.6	194.1
2016	304.0	309.3	315.5	323.1	319.1	314.2
2017	184.4	175.9	261.6	132.2	140.0	178.8
2018	303.9	251.9	195.4	180.0	154.0	217.0
2019	369.2	334.3	299.4	278.5	250.2	306.3
2020	272.5	246.5	294.3	283.0	232.3	265.7
2021	294.1	224.3	160.2	157.1	139.9	195.1
2022	258.0	288.5	264.9	271.6	241.2	264.8
average	294.2	267.3	262.9	234.0	239.9	

Data Source: Environment and Climate Change Canada - http://climate.weather.gc.ca/index_e.html

3.2 Red Creek (downstream site)

3.2.1 General Water Chemistry

In 2022, five water samples (N=5) were collected at the downstream Red Creek 'downstream' site: one in each month from March to July. Red Creek did not have any flow during the August to October site visits.

At Red Creek in 2022, the median water temperature (14.7°C) was within the range of previous years and the maximum water temperature (22.8°C) was the highest from 2017 to 2022 (Table 3). The maximum water temperature at Red Creek occurred in July.

The median dissolved oxygen concentration at the Red Creek site (11.83 mg/L) met the acute (≥ 5.0 mg/L) and chronic (≥ 6.5 mg/L) guideline in 2022. All samples at the downstream Red Creek site were in compliance in 2022. From 2017 through 2022, the median dissolved oxygen and all samples at the

downstream site have met the acute and chronic dissolved oxygen guidelines. The compliance rate for the acute and chronic guideline is high (100%) and stable at the downstream site (Table 4).

Table 3 - Median and range of water quality at Red Creek, downstream site, 2017-2022.

Parameter	Red Creek - downstream					
	2017	2018	2019	2020	2021	2022
Water Temperature, °C	17.0 8.9-21.6	15.0 0.1-22.1	14.4 4.9-22.0	20.0 3.1-22.5	12.1 0.5-20.8	14.7 -0.03-22.8
Dissolved Oxygen, mg/L	10.75 9.50-13.47	10.64 10.18-11.58	10.60 9.62-11.26	12.64 10.31-15.10	13.03 12.77-14.23	11.83 7.80-12.54
pH	8.35 7.97-8.50	8.17 8.06-8.56	8.24 7.71-8.48	8.29 8.19-8.39	8.28 7.94-8.43	7.88 7.76-8.06
Specific Conductivity, µS/cm	2,630 1,530-2,920	2,489 510-2,796	2,585 1,560-2,880	2,700 2,500-3,000	2,550 1,200-2,800	2,650 2,200-2,685
Total Phosphorus, mg/L	0.036 0.019-0.180	0.026 0.009-0.400	0.026 0.011-0.121	0.006 0.004-0.017	0.019 0.017-0.070	0.036 0.002-0.053
Total Dissolved Phosphorus, mg/L	0.019 0.007-0.160	0.020 0.003-0.320	0.011 0.007-0.068	0.003 0.002-0.009	0.009 0.006-0.051	0.004 0.002-0.013
Nitrate+Nitrite Nitrogen, mg/L	0.050 0.002-0.050	0.039 0.025-0.850	0.096 0.055-0.920	0.260 0.210-1.500	0.185 0.019-0.330	0.110 0.009-0.280
Total Kjeldahl Nitrogen, mg/L	1.02 0.51-1.30	0.82 0.25-1.40	0.71 0.44-1.55	0.63 0.49-0.97	0.78 0.57-1.30	0.85 0.45-1.1
Total Nitrogen, mg/L	1.07 0.51-1.30	1.05 0.64-2.04	0.81 0.53-2.47	1.06 0.71-1.99	0.89 0.80-1.60	0.96 0.45-1.4
Total Suspended Solids, mg/L	4 1-9	1.60 0.5-135	4.8 1.2-16	4.3 2.7-7.9	4.6 2.2-7.3	2.4 0.5-18
Fecal Coliform Bacteria, cfu/100 mL	118 1-700	100 6-3,600	121 1-2,000	20 6-1,091	5 1-1,364	39 8 - >60,000

Table 4 - Summary of Red Creek water quality compliance (%) with dissolved oxygen acute and chronic guidelines, 2015-2022 (GoA 2018).

Year	Red Creek - downstream	
	Acute: >5.0 mg/L	Chronic: >6.5 mg/L
2015	100	100
2016	100	100
2017	100	100
2018	100	100
2019	100	100
2020	100	100
2021	100	100
2022	100	100
Trend	stable	stable

In 2022, the median pH at the downstream Red Creek site (7.88) and all individual pH samples (range: 7.76 to 8.06) met the pH guideline of 6.5 to 9.0 for aquatic life (Table 3). From 2017 to 2022, the median pH and all individual pH samples at Red Creek met the pH guideline.

Median specific conductivity at the downstream Red Creek site in 2022 (2,650 µS/cm) exceeded the safe irrigation guideline ($\leq 1,000$ µS/cm) and would be considered unsuitable for irrigation ($\geq 2,000$ µS/cm) (GoA 2018). The specific conductivity results in 2022 at the downstream site were similar to previous years (2017-2021) (Table 3).

3.2.2 Nutrients

In 2022 at Red Creek, the median total phosphorus (0.036 mg/L) was the highest of the six years (2017 also had the same median) whereas the maximum total phosphorus (0.053 mg/L) was the second lowest of the six years (Table 3). The maximum total phosphorus concentration at Red Creek occurred in June and was likely due to increased runoff and sediment containing phosphorus during “heavy rain”. In 2022, an average of 28% of the total phosphorus at the downstream site was present in the dissolved form.

The median total nitrogen concentration in 2022 at Red Creek (0.96 mg/L) was similar to and within the range of previous years. In 2022 at Red Creek, 88% of the total nitrogen was present in the organic (TKN) form and 12% of the total nitrogen present was in the soluble form (nitrate+nitrite nitrogen) (Table 3).

3.2.3 Total Suspended Solids

In 2022 at Red Creek, the median total suspended solids (TSS) concentration at the downstream site was 2.4 mg/L and was within the range of previous years. The maximum TSS at the downstream site (18 mg/L) was the second highest of the six years and occurred in June (Table 3). The maximum total suspended solids concentrations at Red Creek have typically occurred during the spring and was likely the result of increased stream flows from snow melt runoff and/or higher precipitation.

3.2.4 Fecal Coliform Bacteria

In 2022, the median fecal coliform bacteria count at the Red Creek site was 39 cfu/100 mL and within the range of previous years (Table 3). The median fecal coliform bacteria count at Red Creek met the provincial guideline for irrigation (100 cfu/100 mL) (GoA 2018). Two of five samples (40%) from Red Creek were greater than the irrigation guideline. The maximum fecal coliform bacteria counts were >60,000 cfu/100 mL (May 24) and >10,000 cfu/100 mL (June 20) and were the highest of the six years (Table 3). The elevated count during May occurred when observations from the site visit indicated there was “Lots of cattle at site and in stream. Very low flow” and the June observations stated “heavy rain.”

Fecal coliform bacteria counts appear to be highly variable from year to year at Red Creek (Table 3) and may be the result of fluctuating wildlife populations and usage near the creek, varied cattle grazing intensity and environmental bacteria (i.e., self-sustaining naturalized populations of coliform bacteria).

3.2.5 Other Parameters

A review of a 5-year dataset of historical water quality data for lower Red Creek from 2016 to 2020 (PESL 2021b) indicated some exceedances for livestock, irrigation and protection of aquatic life (PAL). The data from 2022 was reviewed and the following observations were made:

- Livestock Water Guidelines: From 2006 to 2020 (10-year dataset), sulphate sometimes exceeded the guideline (1,000 mg/L). In 2022, sulphate ranged from 840 to 1,200 mg/L (N=5) and two samples exceeded the livestock water guideline. In 2021, sulphate ranged from 400 to 1,100 mg/L (N=4) and one sample exceeded the livestock water guideline.
- Irrigation Guidelines: From 2016 to 2020 (5-year dataset), total boron occasionally exceeded the guideline (500 µg/L). In 2022, total boron ranged from 227 to 457 µg/L (N=5) and none of the samples exceeded the irrigation guideline. Similarly in 2021, total boron ranged from 81.5 to 128 µg/L (N=4) and no sample exceeded the irrigation guideline.
- Protection of Aquatic Life Guidelines:

- From 2016 to 2020 (5-year dataset), total arsenic occasionally exceeded the chronic guideline (5 µg/L). In 2022, total arsenic ranged from 0.96 to 2.04 µg/L (N=5) and none of the samples exceeded the PAL guideline. Similarly in 2021, total arsenic ranged from 1.33 to 2.92 µg/L (N=4) and no sample exceeded the PAL guideline.
- From 2016 to 2020, total copper rarely exceeded the chronic guideline (7 µg/L). In 2022, total copper ranged from 0.27 to 0.88 µg/L (N=5) and none of the samples exceeded the PAL guideline. Similarly in 2021, total copper ranged from 0.29 to 1.31 µg/L (N=4) and no sample exceeded the PAL guideline.
- From 2016 to 2020, total mercury rarely exceeded the chronic guideline (5 ng/L). In 2022, total mercury ranged from 0.87 to 2.87 ng/L (N=5) and none of the samples exceeded the PAL guideline. Similarly in 2021, total mercury ranged from 0.86 to 2.27 ng/L (N=4) and no sample exceeded the PAL guideline.
- From 2016 to 2020, total selenium almost always exceeded the chronic guideline (2 µg/L). In 2022, total selenium ranged from 3.2 to 9.7 µg/L (median: 5.2 µg/L) and all of the samples (N=5) exceeded the PAL guideline by a factor ranging from 1.6 to 4.9 times. These results are similar to 2021 when total selenium ranged from 2.7 to 10.4 µg/L (median: 4.7 µg/L) and all of the samples (N=4) exceeded the PAL guideline by a factor ranging from 1.4 to 5.2 times.

3.3 Ephemeral Tributaries

Miners Coulee contributed minor flow to the Milk River in 2022. During eight monthly site visits between March 14 and October 12, flowing water was observed on June 20 with the June visit noting 'heavy rain' and 'moderate flow'. Verdigris Coulee contributed little to no flow to the Milk River in 2022. During eight site visits between March 14 and October 12, no flowing water was observed at Verdigris Coulee and no water samples were collected at Verdigris Coulee in 2022 (Table 6).

3.3.1 General Water Chemistry

Miners Coulee – The dissolved oxygen concentration was 6.48 mg/L at Miners Coulee on June 20 and was within the range of previous years (4.32 to 12.21 mg/L). The dissolved oxygen at Miners Coulee met the acute (5.0 mg/L) and chronic (6.5 mg/L) guideline. The pH (7.56) at Miners Coulee on June 20 met the aquatic life guideline (≥ 6.5 and ≤ 9.0) and was the lowest since 2018 (2018 to 2021 range: 7.67 to 8.28). The specific conductivity at Miners Coulee on June 20 was 658 µS/cm and was within the range of previous years (583 to 1,100 µS/cm). The June 20 specific conductivity (590 µS/cm) was considered 'safe' for irrigation (GoA 2018) (Table 6).

3.3.2 Nutrients

Miners Coulee – Total phosphorus at Miners Coulee was 0.096 mg/L on June 20 and was within the range of previous years (0.020 to 0.160 mg/L) (Table 6). The total dissolved phosphorus concentration at Miners Coulee was 0.097 mg/L on June 20 and was within the range of previous years (0.011 to 0.150 mg/L) (Table 6). In 2022, the total nitrogen at Miners Coulee was 0.88 mg/L on June 20 and was within the range of previous years (0.61 to 1.0 mg/L) (Table 6). Almost all of the total nitrogen was present in the organic (TKN) form (~95%) with a small percentage (~4%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen). The median nitrate+nitrite nitrogen concentration on June 20 was 0.039 mg/L and was the highest concentration compared to previous years (range: <0.004 to 0.019 mg/L) (Table 6).

3.3.3 Total Suspended Solids

Miners Coulee – The total suspended solids concentration on June 20 at Miners Coulee was low at <1 mg/L and was within the range of previous years (<1 to 4.8 mg/L) (Table 6).

3.3.4 Fecal Coliform Bacteria

Miners Coulee – The fecal coliform bacteria count in 2022 at Miners Coulee was 590 cfu/100 mL on June 20 and was the third highest fecal coliform bacteria count since 2018 (N=10) but was within the range of previous years (<2 to 1,091 cfu/100 mL) (Table 6). The fecal coliform bacteria count on June 20 did not meet the irrigation guideline (100 cfu/100 mL).

Table 6 - Median and range for water quality parameters at the ephemeral tributaries (Miners Coulee and Verdigris Coulee), 2018 to 2022.

Parameter	Miners Coulee					Verdigris Coulee				
	2018 (N=2)	2019 (N=1)	2020 (N=2)	2021 (N=4)	2022 (N=1)	2018 (N=4)	2019 (N=1)	2020 (N=0)	2021 (N=0)	2022 (N=0)
Water Temperature, °C	7.1 - 15.7	15.78	18.8 - 19.6	10.1 1.6 - 17.4	15.7	16.4 1.47 - 17.9	3.02	No samples collected due to Covid-19 restrictions (March to May) and lack of flow (Jun 23, Jul 21, Aug 17, Sep 21, Oct 20)	No samples collected due to lack of flow (Mar 16, Apr 19, May 17, Jun 21, Aug 16, Oct 6)	No samples collected due to lack of flow (Mar 14, Apr 19, May 24, Jun 20, Jul 18, Aug 24, Sep 15) or lack of water (Oct 12)
Dissolved Oxygen, mg/L	5.22 - 10.78	8.12	4.32 - 9.75	10.40 9.07 - 12.21	6.48	4.57 2.14 - 11.06	8.41			
pH	7.90 - 8.13	7.67	8.22 - 8.28	8.25 8.08 - 8.27	7.56	8.42 7.53 - 9.29	7.19			
Specific Conductivity, µS/cm	583 - 905	994	590 - 650	925 780 - 1,100	658	2,562 83 - 4,414	277			
Total Phosphorus, mg/L	0.096 - 0.160	0.043	0.061 - 0.072	0.034 0.020 - 0.054	0.096	0.109 0.044 - 0.350	0.190			
Total Dissolved Phosphorus, mg/L	0.082 - 0.150	0.027	0.047 - 0.067	0.024 0.011 - 0.045	0.097	0.054 0.031 - 0.280	0.140			
Nitrate+Nitrite Nitrogen, mg/L	<0.004 - 0.008	0.01	0.0021	0.008 <0.004 - 0.019	0.039	0.007 <0.004 - 0.024	0.45			
Total Kjeldahl Nitrogen, mg/L	0.90 - 0.91	0.87	0.80 - 0.81	0.66 0.60 - 1.0	0.84	1.93 0.340 - 3.8	0.71			
Total Nitrogen, mg/L	0.90 - 0.92	0.88	0.80 - 0.81	0.67 0.61 - 1.0	0.88	1.93 0.370 - 3.8	1.2			
Total Suspended Solids, mg/L	<1	2.2	2.2 - 4.8	3.6 1.7 - 4.4	<1	9.65 1.3 - 45	6.5			
Fecal Coliform Bacteria (cfu/100 mL)	20 - 310	173	900 - 1,091	75 <2 - 220	590	360 1 - 900	220			
Sample Dates	Apr 23, May 22	May 14	Jun 23, Jul 21	Mar 16, Apr 19, May 17, Jun 21	Jun 20	Apr 23, May 22, Jun 19, Jul 16	Oct 8			

3.4 Milk River

3.4.1 St. Mary/Milk River Diversion Operation

The St. Mary/Milk River Diversion was initiated on March 15 and shut down on September 30, 2022. Diversion to the St. Mary Canal was initially 1.4 m³/s (50 ft³/s) on March 15 which was ramped up to approximately 2.8 m³/s (100 ft³/s) on March 16, 5.7 m³/s (200 ft³/s) on March 18 and further increased to 8.5 m³/s (300 ft³/s) on March 21. Flow was further ramped up on March 22 to 11.3 m³/s (400 ft³/s), 14.2 m³/s (500 ft³/s) on March 23 and increased to 17.0 m³/s (600 ft³/s) on March 24. The diversion to the St. Mary Canal was maintained at approximately 17.0 m³/s (600 ft³/s) from March 24 to September 23.

Canal shutdown was initiated on September 24 when diversion was ramped down to 14.2 m³/s (500 ft³/s) and further decreased to 11.3 m³/s (400 ft³/s) on September 25 and decreased again to 8.5 m³/s (300 ft³/s) on September 26. On September 27, diversion was further reduced to 5.7 m³/s (200 ft³/s) and reduced again to 2.8 m³/s (100 ft³/s) on September 28. Diversion was reduced to 1.4 m³/s (50 ft³/s) on September 29 and reduced to 0 m³/s (0 ft³/s) on September 30 (shut-down complete). Table 7 shows the start-up and shut-down dates of the St. Mary/Milk River Diversion since 2006.

Table 7 - St. Mary/Milk River Diversion start-up and shut-down dates for the 2006 through 2022 monitoring period.

Year	Start Date	End Date
2006	March 05	September 24
2007	March 07	September 03
2008	March 17	September 12
2009	March 16	September 24
2010	March 21	September 03
2011	July 24	October 06
2012	April 9	September 15
2013	March 11	September 24
2014	May 13	September 10
2015	March 31	August 28
2016	March 22	September 10
2017	March 22	September 22
2018	May 9	September 28
2019	April 8	September 27
2020 ^a	March 31	October 31
2021	March 22	September 16
2022	March 15	September 30

^aDue to a drop structure failure, there was no diversion to the St. Mary Canal from May 17 to October 7, 2020.

3.4.2 Streamflow

Mean daily streamflow data for 2022 is shown in Figures 2A to 2D at four Milk River sites.

At 'Milk River at Western Crossing of International Boundary' the streamflow is not augmented by the St. Mary diversion; therefore, flows are always natural. The majority of streamflow occurred from March 19 to August 9 with typical flows between 1 and 2 m³/s and low flows ranging between 0.19 to 0.61 m³/s

(Figure 2A). Seven peak flow events occurred during this period with the largest occurring from June 20 to 24 when flows ranged between 5.17 to 17.9 m³/s. This peak flow event was due to 82 mm of rainfall from June 18 to 20 (Del Bonita AGDM weather station). Six smaller flows events between March 30 and July 6 had peaks flows between 2.84 and 4.55 m³/s and were due to snowmelt (March 30) or rainfall events (May to July). Late-summer to fall low flow occurred from August 10 to October 31 when typical flows ranged between 0.00 to 0.66 m³/s with a peak flow event of 3.23 m³/s on August 26 (rainfall event) (Figure 2A). Two days (August 22 and 23) had a recorded flow of 0.00 m³/s and 14 days had recorded flows between 0.002 and 0.009 m³/s (primarily in September). There was no flow data after October 31 as the streamflow gauging station stopped operation. The April to October total discharge in 2022 was 27,680 dam³, compared to 19,366 dam³ (2021), 52,423 dam³ (2020) and 47,458 dam³ (2019)². Total discharge in 2022 was the second lowest from 2019 to 2022.

At 'North Milk River near International Boundary', pre-diversion flow ranged between 0.28 m³/s to 0.63 m³/s from March 1 to March 18. The flow increased from 4.21 m³/s on March 19 to 15.6 m³/s by March 29 during the ramping up of diversion (Figure 2B). The flow generally ranged between 15.9 to 17.3 m³/s from March 30 to September 24. Peak flows occurred on June 20 and 21 when the flow was 19.7 and 19.4 m³/s, respectively. This peak flow event was due to 82 mm of rainfall from June 18 to 20 (Del Bonita AGDM weather station). The flow decreased from 15.5 m³/s on September 25 to 0.28 m³/s on October 6 during the ramping down of diversion flow (Figure 2B). The diversion to the St. Mary canal ended on September 30. From October 7 to October 31 the flow ranged from 0.26 to 0.41 m³/s. The April to October total discharge in 2022 was 259,900 dam³, compared to 236,044 dam³ (2021), 53,072 dam³ (2020) and 220,510 dam³ (2019). Total discharge in 2022 was the highest from 2019 to 2022. The low total discharge in 2020 was due to a drop structure failure resulting in no water diversion to the St. Mary Canal from May 17 to October 7, 2020.

At 'Milk River at Milk River', pre-diversion flow ranged between 0.03 m³/s to 4.47 m³/s from January 1 to March 17. The flow increased from 4.86 m³/s on March 18 to 15.8 m³/s by March 23 during the ramping up of diversion (Figure 2C). The flow generally ranged between 15.6 to 21.7 m³/s from March 24 to September 26. A total of 57 mm of rainfall on June 20 (Milk River weather station) resulted in peak flows on June 21 to 23 when the flow was between 31.3 and 36.5 m³/s. The flow decreased from 14.1 m³/s on September 27 to 1.57 m³/s on October 5 during the ramping down of diversion flow (Figure 2C). The diversion to the St. Mary canal ended on September 30. From October 6 to December 31 the flow ranged from 0.15 to 1.10 m³/s. The April to October total discharge in 2022 was 288,400 dam³, compared to 252,570 dam³ (2021), 106,158 dam³ (2020) and 259,300 dam³ (2019). Total discharge in 2022 was the highest from 2019 to 2022. The lower total discharge in 2020 was due to the drop structure failure.

At 'Milk River at Eastern Crossing of International Boundary', pre-diversion flow ranged between 0.96 m³/s to 1.00 m³/s from March 22 to March 24. The flow increased from 3.8 m³/s on March 25 to 22.6 m³/s by April 18 during the ramping up of diversion and spring runoff with a peak flow event on April 4 (18.3 m³/s: snowmelt) (Figure 2D). The flow generally ranged between 15 to 20 m³/s from April 19 to July 14 and between 12 to 15 m³/s from July 15 to September 29. Peak flow events occurred on June 15 (46.0 m³/s), June 24 (41.3 m³/s) and July 8 (36.8 m³/s) due to smaller rainfall events. The flow decreased from 13.7 m³/s on September 30 to 2.2 m³/s on October 10 during the ramping down of diversion flow (Figure 2D). The diversion to the St. Mary canal ended on September 30. During the fall low flow period between October 11 and 31, flow generally ranged from 1.1 to 1.9 m³/s with a peak flow of 4.9 m³/s (October 24).

² dam³ (cubic decameter): 1 dam³ = 1,000 m³ or 1,000,000 litres

Figure 2A: Milk River at Western Crossing of International Boundary - natural flow only

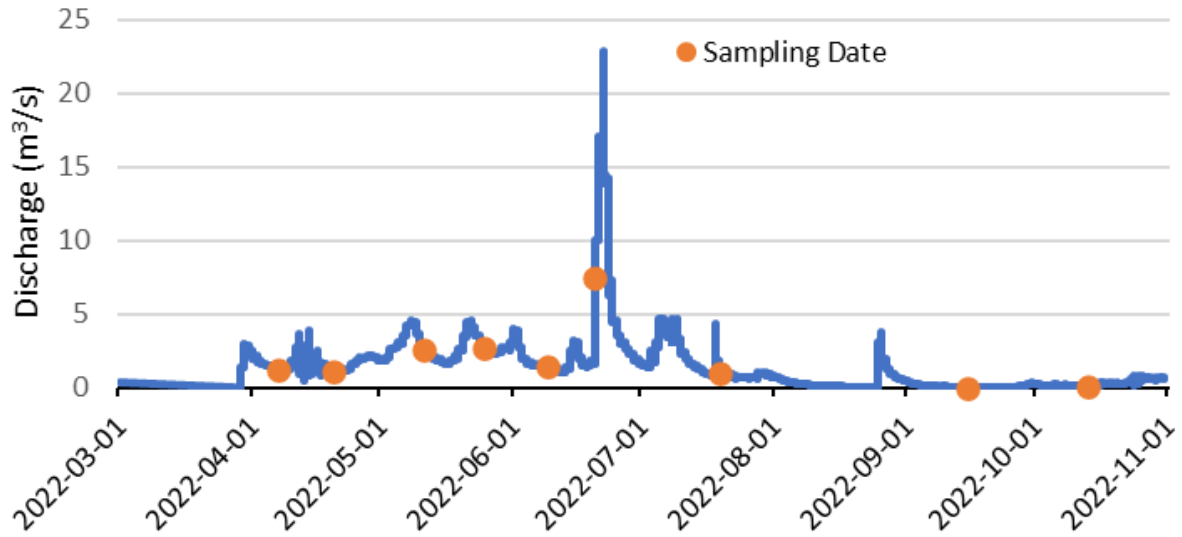
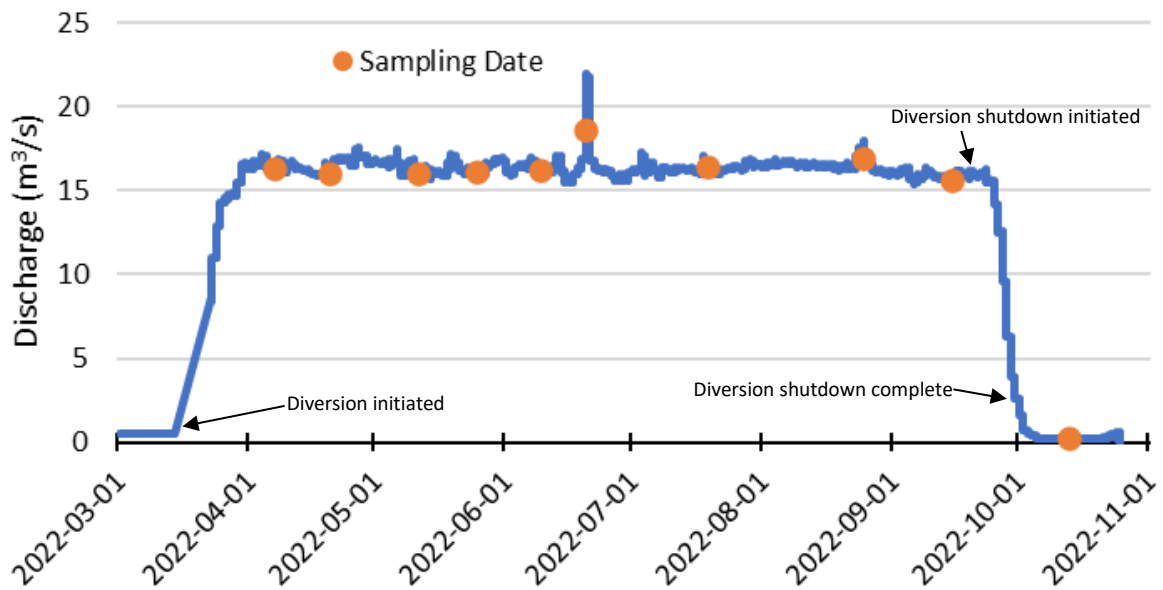
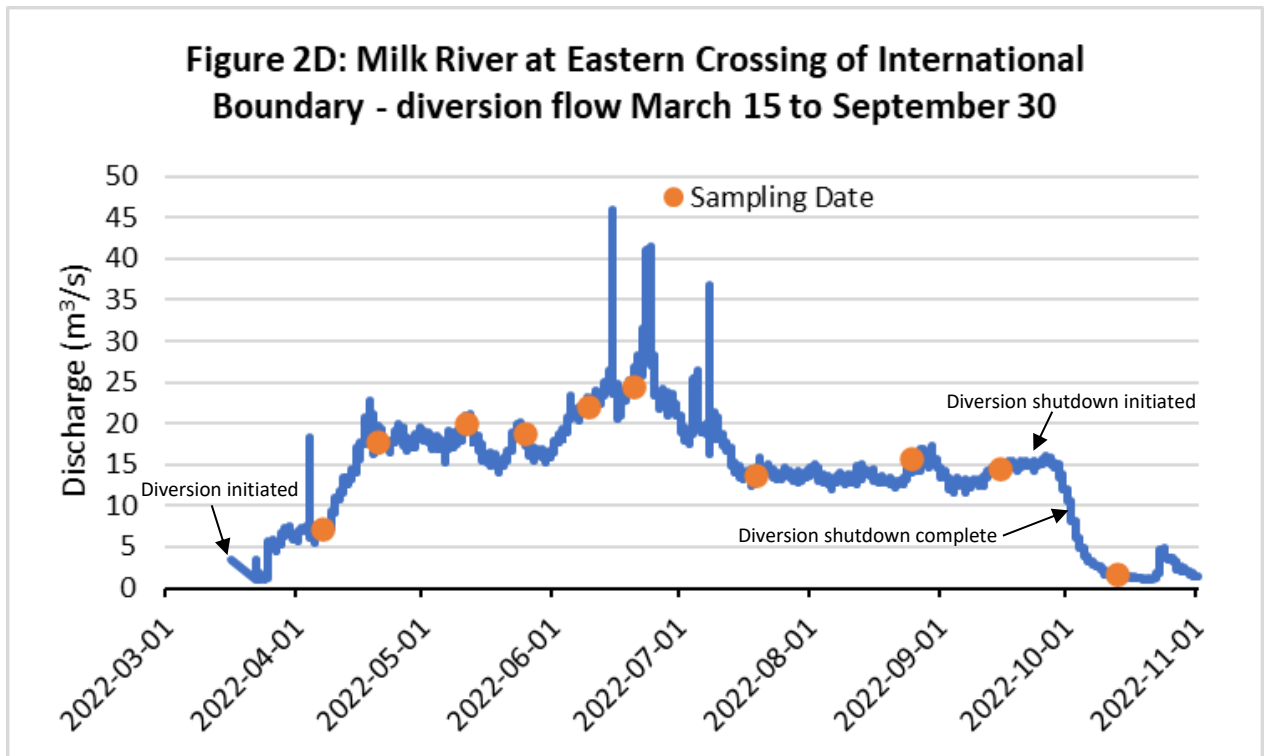
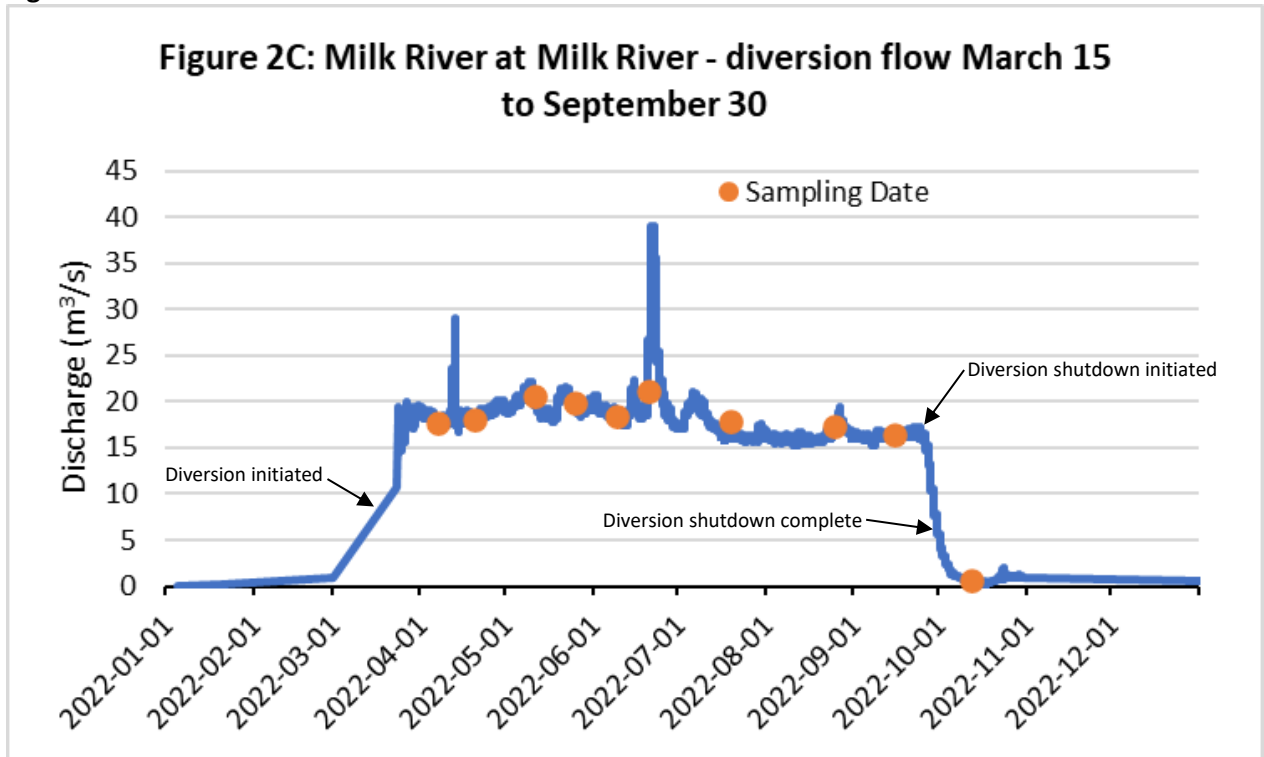


Figure 2B: North Milk River near International Boundary - diversion flow March 15 to September 30



Figures 2A to 2D – Discharge data (m^3/s) at four Milk River sites during the open water season, 2022.
Raw data from Environment and Climate Change Canada (2022).

Figures 2C to 2D – cont'd



3.4.3 General Water Chemistry

Water chemistry parameters are presented in Table 8. Note that while water chemistry results from 2019 to 2021 are presented in the tables, they are generally not discussed in detail in the result summaries. In 2022, median water temperature ranged from 11.2°C at the North Fork at 501 site to 13.0°C at the U/S Milk River site. Median water temperatures at North Fork at 501 were quite similar from 2019 to 2022 (Table 8). The warmest water temperature in 2022 (21.8°C on July 18) was recorded at the HWY 880 site.

Median dissolved oxygen concentration ranged from 11.00 mg/L at the HWY 880 site to 11.98 mg/L at the North Fork at 501 site (Table 8). The acute daily minimum dissolved oxygen concentration for the protection of aquatic life is ≥ 5.0 mg/L and the chronic, 7-day average concentration is ≥ 6.5 mg/L (GoA 2018). In 2022, all samples met the acute daily minimum guideline and the chronic guideline at all Milk River sites.

The pH guideline for the protection of aquatic life is ≥ 6.5 and ≤ 9.0 (GoA 2018). The median pH values (8.10 to 8.30) were within guideline for the protection of aquatic life at all Milk River sites in 2022. No individual sample exceeded the guideline (Table 8). Median pH values were similar at all Milk River sites from 2019 to 2022 (Table 8).

Specific conductivity was lowest during the diversion period. During the diversion period, median conductivity was lowest at the North Fork at 501 site (151 $\mu\text{S}/\text{cm}$) and highest at the Pinhorn site (236 $\mu\text{S}/\text{cm}$). During the natural flow period, median specific conductivity ranged from 422 $\mu\text{S}/\text{cm}$ at the North Fork at 501 site to 659 $\mu\text{S}/\text{cm}$ at the Pinhorn site (Table 9).

The WQO-50 and WQO-90 objectives for specific conductivity were met at all Milk River sites in 2022 during both natural and diversion flow periods (Table 9) and was the highest compliance from 2019 to 2022. In 2022, all of the samples from the Milk River sites met the provincial guideline for safe irrigation ($\leq 1,000$ $\mu\text{S}/\text{cm}$) with the exception of a sample at Milk River at 501 on October 13 (1,009 $\mu\text{S}/\text{cm}$) which minimally exceeded the guideline.

Table 8 - Summary (median and range) of general water quality parameters at the Milk River, 2019 to 2022.

Site	Water Temperature (°C)											
	2019			2020			2021			2022		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	12.1	0.4-16.4	10	11.3	3.0-18.9	10	11.7	0.4-18.1	10	11.2	2.8-17.9
Milk R. at 501	10	12.4	0.0-17.8	9	12.2	0.5-19.8	6	10.4	4.5-22.3	9	12.1	2.8-17.0
U/S Milk River	10	14.8	4.1-21.4	10	14.1	1.4-25.0	9	13.7	3.8-20.4	10	13.0	3.4-19.3
HWY 880	10	14.2	5.3-21.3	10	14.3	0.5-21.1	10	13.9	0.8-20.5	10	12.6	3.9-21.8
Pinhorn	10	12.8	0.3-18.4	-	--	--	8	14.5	0.6-20.3	10	12.4	2.9-21.5

Site	Dissolved Oxygen (mg/L)											
	2019			2020			2021			2022		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	9.69	8.84-12.38	10	9.54	8.35-11.57	10	10.41	9.47-14.07	9	11.98	10.64-15.50
Milk River at 501	10	9.36	8.46-12.50	9	9.59	8.69-12.47	6	10.00	9.33-13.10	9	11.45	9.39-14.96
U/S Milk River	10	9.06	8.00-11.24	10	9.71	7.52-13.63	9	9.59	8.21-12.90	9	11.16	9.37-13.47
HWY 880	10	11.25	8.06-12.06	10	9.71	8.41-13.38	10	9.65	8.14-12.97	10	11.00	9.27-13.93
Pinhorn	10	9.89	8.65-13.37	-	--	--	8	8.93	7.98-13.30	10	11.90	9.75-14.70

Site	pH											
	2019			2020			2021			2022		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	8.23	8.02-8.53	10	8.50	8.04-8.56	10	8.09	7.31-8.41	10	8.11	7.66-8.27
Milk R. at 501	10	8.42	8.29-8.79	9	8.48	8.14-8.58	6	8.34	8.12-8.64	9	8.30	8.17-8.58
U/S Milk River	10	8.25	8.10-8.41	10	8.54	8.21-8.59	10	8.25	7.42-8.38	10	8.04	7.82-8.28
HWY 880	10	8.35	8.10-8.41	10	8.53	8.24-8.50	10	8.10	7.51-8.49	10	8.10	7.74-8.49
Pinhorn	10	8.32	8.11-8.44	-	--	--	8	8.23	7.55-8.48	10	8.20	7.53-8.43

Table 9 - Summary of specific conductivity ($\mu\text{S}/\text{cm}$) at the Milk River, 2019 to 2022.

Site	Flow Period	WQO		2019				2020				2021				2022			
		WQO-50	WQO-90	N	50 th	90 th	Range	N	50 th	90 th	Range	N	50 th	90 th	Range	N	50 th	90 th	Range
N. Fork at 501	Diversion	165	246	8	158	182	137-185	3	173	237	139-254	9	161	176	136-180	9	151	172	136-176
	Natural	445	512	2	324	-	237-411	7	390	452	102-466	1	435	--	435	1	422	--	422
Milk R. at 501	Natural	510	882	10	436	595	252-600	9	435	880	277-1400	6	476	508	418-522	9	433	669	368-1,009
U/S Milk River	Diversion	210	398	8	227	278	157-296	3	289	365	171-384	9	223	262	152-350	9	193	211	150-223
	Natural	570	674	2	394	-	350-437	7	499	617	339-657	1	267	--	267	1	469	--	469
HWY 880	Diversion	250	540	8	258	318	184-354	3	416	433	235-437	9	214	254	176-270	9	215	244	179-248
	Natural	727	936	2	527	-	504-549	7	900	1128	336-1170	1	895	--	895	1	625	--	625
Pinhorn	Diversion	250	540	8	277	333	200-392	-	-	-	--	7	236	287	192-299	9	235	268	176-278
	Natural	727	936	2	513	-	480-546	-	-	-	--	1	873	--	873	1	659	--	659

If the measured 50th (median) or 90th percentile value is $\leq 10\%$ above the WQO it is considered to meet the WQO (**Green**); if the value is $>10\%$ but $\leq 20\%$ above the WQO, it is considered within the normal but cautionary range (**Orange**); if the measured value is $>20\%$ above the WQO, it exceeds the WQO (**Red**).

3.4.4 Nutrients

Total Phosphorus

In 2022, compliance with the WQO-50 and WQO-90 objectives for total phosphorus (TP) was the second highest of the four monitoring years from 2019 to 2022. Total phosphorus in the Milk River tends to increase in the downstream direction during diversion flow.

During the diversion in 2022, median total phosphorus concentration ranged from 0.012 mg/L at the North Fork at 501 site to 0.101 mg/L at the Pinhorn site (Table 10). During diversion, the median total phosphorus was in the cautionary range of the WQO-50 at the Pinhorn site. The WQO-90 was not met during diversion at the North Fork at 501 or Pinhorn sites.

During natural flow, median TP ranged from 0.005 mg/L at the North Fork at 501 site to 0.025 mg/L at the Milk River at 501 site. During natural flow, the WQO-50 was not met at the Milk River at 501 site (Table 10). During natural flow, a 90th percentile for total phosphorus could only be calculated at the Milk River at 501 site (N=9) as the other sites only had one sample collected during natural flow. During natural flow, the WQO-90 for TP was met at the Milk River at 501 site.

Total Dissolved Phosphorus

In 2022, compliance with the WQO-50 and WQO-90 objectives for total dissolved phosphorus (TDP) was the second highest of the four monitoring years from 2019 to 2022.

During diversion, median TDP concentration ranged from 0.002 mg/L at the Nork Fork at 501, U/S Milk River and HWY 880 sites to 0.011 mg/L at the Pinhorn site (Table 11). In 2022, total dissolved phosphorus did not meet the WQO-50 or WQO-90 at the Pinhorn site during diversion.

During natural flow, median TDP ranged from 0.002 to 0.007 mg/L at the Milk River sites (Table 11). The total dissolved phosphorus WQO-50 was not met at the Pinhorn site in 2022 during natural flow. The WQO-90 was met at Milk River at 501 for TDP during natural flow (Table 11).

Total Nitrogen

In 2022, compliance with the WQO-50 and WQO-90 for total nitrogen was the highest from 2019 to 2022 at the Milk River sites.

During the diversion period in 2022, median total nitrogen concentration ranged from 0.028 mg/L at the North Fork at 501 site to 4.231 mg/L at the Pinhorn site (Table 12). During diversion in 2022, total nitrogen was in the cautionary range of the WQO-50 at the Pinhorn site and the Pinhorn site did not meet the WQO-90 (Table 12).

During natural flow, median total nitrogen ranged from 0.054 to 0.760 mg/L at the Milk River at 501 site (Table 12). During the natural flow period, the WQO-50 for total nitrogen was met at all Milk River sites. During natural flow, a 90th percentile for total nitrogen could only be calculated at the Milk River at 501 site (N=9) as the other sites only had one sample collected during natural flow. During natural flow, the WQO-90 for total nitrogen was met at the Milk River at 501 site.

Table 10 - Summary of total phosphorus concentrations (mg/L) at the Milk River, 2019 to 2022.

Site	Flow Period	WQO		2019				2020				2021				2022			
		WQO-50 th	WQO-90 th	N	50 th	90 th	Range	N	50 th	90 th	Range	N	50 th	90 th	Range	N	50 th	90 th	Range
N. Fork at 501	Diversion	0.014	0.037	8	0.013	0.023	0.005-0.033	3	0.066	0.416	0.025-0.504	9	0.003	0.030	0.003-0.053	9	0.012	0.049	0.004-0.064
	Natural	0.012	0.100	2	0.036	-	0.032-0.041	7	0.006	0.016	0.003-0.007	1	0.003	--	0.003	1	0.005	--	0.005
Milk R. at 501	Natural	0.019	0.186	10	0.026	0.070	0.008-0.076	9	0.024	0.169	0.003-0.671	6	0.016	0.031	0.007-0.040	9	0.025	0.098	0.015-0.220
U/S Milk River	Diversion	0.044	0.148	8	0.045	0.149	0.014-0.170	3	0.163	0.212	0.038-0.224	9	0.023	0.112	0.011-0.214	9	0.034	0.094	0.015-0.130
	Natural	0.013	0.504	2	0.063	-	0.028-0.098	7	0.013	0.024	0.003-0.027	1	0.006	--	0.006	1	0.006	--	0.006
HWY 880	Diversion	0.088	0.220	8	0.075	0.285	0.034-0.570	3	0.071	0.255	0.053-0.301	9	0.063	0.176	0.005-0.322	9	0.075	0.134	0.048-0.160
	Natural	0.013	0.086	2	0.194	-	0.016-0.372	7	0.014	0.039	0.010-0.051	1	0.003	--	0.003	1	0.006	--	0.006
Pinhorn	Diversion	0.088	0.220	8	0.124	0.259	0.058-0.387	-	-	-	--	7	0.099	0.196	0.023-0.202	9	0.101	0.298	0.065-0.402
	Natural	0.013	0.086	2	0.137	-	0.025-0.249	-	-	-	--	1	0.003	--	0.003	1	0.008	--	0.008

If the measured 50th (median) or 90th percentile value is ≤10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but ≤20% above the WQO, it is considered within normal but cautionary range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

Table 11 - Summary of total dissolved phosphorus concentrations (mg/L) at the Milk River, 2019 to 2022.

Site	Flow Period	WQO		2019				2020				2021				2022			
		WQO-50 th	WQO-90 th	N	50 th	90 th	Range	N	50 th	90 th	Range	N	50 th	90 th	Range	N	50 th	90 th	Range
N. Fork at 501	Diversion	0.003	0.007	8	0.002	0.004	0.002-0.006	3	0.005	0.043	0.003-0.053	9	0.003	0.003	0.002-0.003	9	0.002	0.003	0.001-0.008
	Natural	0.005	0.066	2	0.016	-	0.010-0.022	7	0.003	0.006	0.003-0.006	1	0.003	--	0.003	1	0.004	--	0.004
Milk R. at 501	Natural	0.006	0.015	10	0.006	0.010	0.002-0.027	9	0.005	0.017	0.003-0.041	6	0.006	0.007	0.002-0.007	9	0.004	0.011	0.002-0.012
U/S Milk River	Diversion	0.003	0.010	8	0.003	0.005	0.002-0.005	3	0.007	0.027	0.006-0.031	9	0.003	0.004	0.002-0.008	9	0.002	0.004	0.001-0.008
	Natural	0.005	0.173	2	0.015	-	0.003-0.027	7	0.003	0.007	0.003-0.009	1	0.003	--	0.003	1	0.002	--	0.002
HWY 880	Diversion	0.004	0.011	8	0.004	0.007	0.002-0.007	3	0.013	0.031	0.010-0.036	9	0.003	0.006	0.002-0.009	9	0.002	0.006	0.001-0.013
	Natural	0.004	0.021	2	0.121	-	0.004-0.239	7	0.003	0.009	0.003-0.011	1	0.003	--	0.003	1	0.002	--	0.002
Pinhorn	Diversion	0.004	0.011	8	0.007	0.009	0.003-0.011	-	-	-	--	7	0.005	0.007	0.003-0.003	9	0.011	0.082	0.003-0.102
	Natural	0.004	0.021	2	0.023	-	0.003-0.044	-	-	-	--	1	0.003	--	0.003	1	0.007	--	0.007

If the measured 50th (median) or 90th percentile value is ≤10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but ≤20% above the WQO, it is considered within normal but cautionary range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

Table 12 - Summary of total nitrogen concentrations (mg/L) at Milk River, 2019 to 2022.

Site	Flow Period	WQO		2019				2020				2021				2022			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	0.240	0.468	8	0.160	0.224	0.110-0.232	3	0.305	2.379	0.111-2.897	9	0.122	0.303	0.024-0.353	9	0.150	0.338	0.028-0.370
	Natural	0.900	1.578	2	0.665	-	0.439-0.890	7	0.324	0.343	0.160-0.346	1	0.339	--	0.399	1	0.240	--	0.240
Milk R. at 501	Natural	0.600	1.360	10	0.441	0.629	0.320-0.976	9	0.361	1.132	0.321-2.742	6	0.201	0.428	0.111-0.491	9	0.463	0.728	0.054-0.760
U/S Milk River	Diversion	0.325	0.667	8	0.261	0.394	0.150-0.570	3	0.640	2.658	0.271-3.163	9	0.271	0.797	0.111-1.101	9	0.260	0.388	0.120-0.419
	Natural	0.680	1.637	2	0.610	-	0.320-0.899	7	0.331	0.507	0.221-0.561	1	0.111	--	0.111	1	0.210	--	0.210
HWY 880	Diversion	0.365	0.668	8	0.305	0.800	0.240-1.300	3	0.303	2.765	0.045-3.380	9	0.371	0.754	0.111-1.249	9	0.340	0.514	0.130-0.571
	Natural	0.320	1.400	2	1.003	-	0.230-1.776	7	0.350	0.476	0.231-0.570	1	0.490	--	0.490	1	0.190	--	0.190
Pinhorn	Diversion	0.365	0.668	8	0.448	0.770	0.152-1.172	-	-	-	--	7	0.421	0.579	0.111-0.685	9	0.437	1.764	0.213-4.231
	Natural	0.320	1.400	2	0.968	-	0.151-1.785	-	-	-	--	1	0.271	--	0.271	1	0.161	--	0.161

If the measured 50th (median) or 90th percentile value is ≤10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but ≤20% above the WQO, it is considered within the normal but cautionary range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

Table 13 - Summary of total suspended solids concentrations (mg/L) at Milk River, 2019 to 2022.

Site	Flow Period	WQO		2019				2020				2021				2022			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	16	59	8	17	34	5-51	3	38	492	28-605	9	13	58	3-162	9	17	101	5-144
	Natural	5	55	2	15	-	9-20	7	4	18	2-32	1	2	--	2	1	5	--	5
Milk R. at 501	Natural	14	247	10	28	69	4-160	9	16	310	2-1,040	6	17	50	6-61	9	24	142	3-330
U/S Milk River	Diversion	56	282	8	82	239	14-260	3	265	957	41-1,130	9	46	184	18-359	9	54	146	20-180
	Natural	7	267	2	90	-	54-125	7	8	23	2-25	1	2	--	2	1	1	--	1
HWY 880	Diversion	131	384	8	140	403	55-810	3	83	1,385	20-1,710	9	95	257	7-483	9	124	200	2-210
	Natural	13	228	2	191	-	14-368	7	10	63	2-111	1	2	--	2	1	2	--	2
Pinhorn	Diversion	131	384	8	197	386	101-608	-	-	-	--	7	136	297	45-335	9	149	473	89-657
	Natural	13	228	2	136	-	31-240	-	-	-	--	1	2	--	2	1	2	--	2

If the measured 50th (median) or 90th percentile value is ≤10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but ≤20% above the WQO, it is considered within the normal but cautionary range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

3.4.5 Total Suspended Solids

In 2022, total suspended solids (TSS) compliance with the WQO-50 and WQO-90 objectives was the second highest from 2019 to 2022. TSS at the Milk River sites in 2022 ranged between 1 and 657 mg/L.

During diversion, median TSS concentrations ranged from 17 mg/L at the North Fork at 501 site to 149 mg/L at the Pinhorn site (Table 13). During the diversion period, the WQO-50 was in the cautionary range at the Pinhorn site and the WQO-90 was not met at the North Fork at 501 or Pinhorn sites.

During natural flow, median TSS ranged from 1 mg/L at U/S Milk River to 24 mg/L at the Milk River at 501 site (Table 13). During natural flow, the WQO-50 for TSS was not met at the Milk River at 501 site (Table 13). During natural flow, a 90th percentile for TSS could only be calculated at the Milk River at 501 site (N=9) as the other sites only had one sample collected during natural flow. During natural flow, the WQO-90 for TSS was met at the Milk River at 501 site.

3.4.6 Fecal Coliform Bacteria

In 2022, fecal coliform bacteria (FCB) compliance with the WQO-50 and WQO-90 objectives was the second lowest from 2019 to 2022. The 2020 year had the lowest compliance with FCB objectives and 2021 the highest compliance. FCB at the Milk River sites in 2022 ranged between 2 and 5,400 cfu/100 mL.

During the diversion period, median FCB counts ranged from 10 cfu/100 mL at the Pinhorn site to 29 cfu/100 mL at the HWY 880 site (Table 14). The median FCB counts met the WQO-50 objective at all sites during the diversion period (Table 14). During the diversion period, the 90th percentile FCB counts ranged from 168 cfu/100 mL at HWY 880 to 655 cfu/100 mL at the North Fork at 501 site. The WQO-90 was not met at the North Fork at 501 and U/S Milk River sites during the diversion period (Table 14).

During natural flow, median FCB counts ranged from 3 cfu/100 mL at the Pinhorn site to 110 cfu/100 mL at the HWY 880 site. During natural flow, the FCB WQO-50 was not met at the HWY 880 site (Table 14). During natural flow, a 90th percentile FCB count could only be calculated at the Milk R. at 501 site (N=9) as the other sites only had one sample collected during natural flow. During natural flow, the WQO-90 was not met at the Milk River at 501 site.

All of the Milk River sites had a least one exceedance of the provincial irrigation guideline for FCB (100 cfu/100 mL) in 2022. The North Fork at 501, U/S Milk River, Milk R. at 501 and HWY 880 sites each had three exceedances and the Pinhorn site had one exceedance. The FCB exceedances occurred primarily in June with some exceedances in July and August.

Table 14 - Summary of fecal coliform bacteria counts (cfu/100 mL) at Milk River, 2019 to 2022.

Site	Flow Period	WQO		2019				2020				2021				2022			
		WQO-50	WQO-90	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	27	140	8	28	46	1-69	3	60	556	35-680	9	15	66	3-81	9	19	655	2-1,636
	Natural	55	668	2	27	-	2-52	7	92	149	6-208	1	3	--	3	1	7	--	7
Milk R. at 501	Natural	77	619	10	73	720	1-4,500	9	246	804	21-818	6	21	106	1-153	9	57	1,960	2-5,400
U/S Milk River	Diversion	68	272	8	71	469	2-490	3	85	497	10-600	9	24	119	5-204	9	15	485	4-1,545
	Natural	49	522	2	14	-	4-24	7	48	155	5-224	1	49	--	1	1	15	--	15
HWY 880	Diversion	78	280	8	51	161	4-240	3	20	324	3-400	9	48	136	9-187	9	29	168	4-280
	Natural	29	163	2	28	-	2-54	7	198	714	72-1,400	1	47	--	47	1	110	--	110
Pinhorn	Diversion	78	280	8	50	330	9-400	-	-	-	--	7	45	99	13-107	9	10	270	4-1,020
	Natural	29	163	2	1	-	1	-	-	-	--	1	12	--	12	1	3	--	3

If the measured 50th (median) or 90th percentile value is ≤10% above the WQO it is considered to meet the WQO (**Green**); if the value is >10% but ≤20% above the WQO, it is considered within the normal but cautionary range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

4.0 SUMMARY

Weather and Streamflow

- Overall, total precipitation in 2022 ranged from 241.2 mm at Onefour to 288.5 mm at Del Bonita (April to October). June was the wettest month (mean = 104.9 mm) while April was the driest month (mean = 6.6 mm). Based on mean precipitation, 2022 was the fifth driest year of 10 years (2013 to 2022) and would be considered an average precipitation year.
- The streamflow regime and volume discharge at the three Milk River sites in 2022 augmented by the St. Mary diversion were similar to the previous years 2019 and 2021. The flow regime in 2020 was substantially different compared to previous years due to a structural failure in Montana that resulted in no diversion to the Milk River for most of the 2020 irrigation season.

Red Creek (downstream site only)

- Only the downstream Red Creek site was sampled in 2022.
- The median dissolved oxygen concentration and all samples complied with acute and chronic guidelines in 2022.
- All pH samples and the median value (7.88) met the aquatic life guideline.
- The median conductivity (2,650 $\mu\text{S}/\text{cm}$) did not meet safe irrigation guideline and would be considered unsuitable for irrigation.
- The median total phosphorus concentration (0.036 mg/L) was the highest from 2017 to 2022 (the 2017 median was also 0.036 mg/L).
- In 2022, the median TSS concentration (2.4 mg/L) was low and similar to previous years. Median TSS concentrations have been stable since 2017 and have ranged between 1.6 and 4.8 mg/L.
- The median fecal coliform bacteria count (39 cfu/100mL) met the irrigation guideline in 2022 and was the third lowest since 2017. The maximum fecal coliform bacteria counts in 2022 at Red Creek were >60,000 cfu/100 mL (May 24) and >10,000 cfu/100 mL (June 20) and were the highest from 2017 to 2022.
- Similar to 2021, all total selenium samples in 2022 (N=5) exceeded the chronic guideline for the protection of aquatic life.

Miners Coulee

- One water sample was collected at Miners Coulee in 2022 (June 20).
- The dissolved oxygen concentration on June 20 was 6.48 mg/L at Miners Coulee. The oxygen samples met the acute and chronic guideline for protection of aquatic life.
- The pH sample (7.56) met the aquatic life guideline at Miners Coulee in 2022.
- At Miners Coulee, the specific conductivity sample was 658 $\mu\text{S}/\text{cm}$ and met the objective for safe irrigation.
- The total phosphorus concentration at Miners Coulee in 2022 was 0.096 mg/L and was within the range of previous years.
- The TSS concentration in 2022 at Miners Coulee was low at <1.0 mg/L and similar to previous years.
- Miners Coulee had a fecal coliform bacteria count of 590 cfu/100 mL and did not meet the irrigation guideline (≤ 100 cfu/100 mL).

Milk River Mainstem

- Milk River Water Quality Objectives (WQOs) were used to determine water quality at sites in 2022 (i.e., WQO-50 [50th percentile or median] and WQO-90 [90th percentile]).

- pH and dissolved oxygen (median and all samples) met aquatic life guidelines at Milk River sites.
- Overall, compliance with specific conductivity objectives in 2022 was the highest of four years. All WQOs were met during the diversion and natural flow period. Specific conductivity was lowest during the diversion period.
- Compliance with the water quality objectives for total phosphorus was the second highest of the four monitoring years from 2019 to 2022. The Pinhorn site was in the cautionary range of the WQO-50 for total phosphorus during diversion. The WQO-90 was not met at the North Fork at 501 or Pinhorn sites during diversion. During natural flow, the WQO-50 was not met at the Milk River at 501 site.
- In 2022, compliance with total nitrogen objectives was the highest from 2019 to 2022. During the diversion period, the Pinhorn site was in the cautionary range of the WQO-50 and did not meet the WQO-90.
- Compliance with TSS objectives was the second highest at the Milk River sites from 2019 to 2022. During diversion, the Pinhorn site was in the cautionary range of the WQO-50 and the WQO-90 was not met at the North Fork at 501 or Pinhorn sites. The WQO-50 was not met during natural flow at the Milk River at 501 site. The highest TSS concentrations occurred during diversion flow.
- Compliance with fecal coliform objectives was the second lowest at the Milk River sites from 2019 to 2022. During diversion, the fecal coliform WQO-90 was not met at the North Fork at 501 or U/S Milk River sites. During natural flow, the fecal coliform WQO-50 was not met at the HWY 880 site and the WQO-90 was not met at the Milk River at 501 site.

5.0 RECOMMENDATIONS

Red Creek

- Total selenium at the lower Red Creek site is chronically elevated and almost always exceeds the chronic guideline for the protection of aquatic life. The MRWCC may consider an expanded study of total selenium in Red Creek to determine spatial and temporal trends and to identify potential sources.
- Consider additional BMPs (e.g., offstream watering) at Red Creek to reduce time spent by cattle in the Creek.

Eastern Tributaries

- Monitoring at the Eastern Tributaries was not completed from 2020 to 2022.
- Water Quality Objectives could be determined using the historical data collected by the MRWCC. Future water quality data could be compared to the established five-year objectives and other relevant provincial guidelines.

Milk River

- Water quality sampling at the existing Milk River (mainstem) sites should continue.
- The MRWCC should continue to collect water quality data at HWY 880 for consistency with the overall Milk River water quality database. AEP could consider increasing their monitoring frequency at HWY 880 to coincide with MRWCC sampling dates.
- The Milk River experienced events that impacted streamflows and water quality in 2020 (e.g., the St. Mary River Diversion failure and a substantial rain event in late June). MRWCC staff noted sediment transport and deposition patterns not previously observed, particularly sediment deposition at the Hoyt Bridge. The MRWCC should consider the occurrence of potential future events (e.g., streamflow conditions, spill, fire) and develop a plan to monitor them to help interpret annual water quality results.

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