MILK RIVER WATERSHED

WATER MONITORING REPORT 2019

Prepared for: Milk River Watershed Council Canada

Prepared by: Palliser Environmental Services Ltd.

August 2020

Acknowledgements

Thank you to Cardston County, County of Warner and Cypress County for providing staff and vehicles required to undertake the surface water monitoring program. Thank you to Alberta Environment and Parks for their continued support.

The following individuals contributed to the successful completion of the 2019 monitoring year:

James Wills, County of Warner
Kennedy Fandrick, Cypress County
Lisa Sulz, Cypress County
Stephen Bevans, Cardston County
Mary Lupwayi, Milk River Watershed Council Canada
Kandra Forbes, Milk River Watershed Council Canada
Tim Romanow, Milk River Watershed Council Canada
Ryan Martin, Alberta Environment and Parks
Wendell Koning, Alberta Environment and Parks

Cover Photo of the Milk River at Writing-on-Stone Provincial Park:

Sandi Riemersma, Palliser Environmental Services Ltd.

TABLE OF CONTENTS

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 2019, with reference to the results from the previous three years (i.e., 2016-2018) (Palliser Environmental 2017 to 2019). 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 approximately every two weeks (April-June) and monthly (July-October) from five sites: 1) **North Fork at 501**, 2) **Milk River at 501**, 3) **Upstream of the Town of Milk River** (U/S Milk River), 4) at **HWY 880** Bridge, and 5) at the **Pinhorn Ranch**.

Milk River tributaries were also monitored in 2019. The monitoring included three sites at Red Creek (i.e., Upstream, Middle and Downstream) and three tributaries known as the "Eastern Tributaries" (i.e., Battle Creek, Middle Creek and Lodge Creek). The Eastern tributaries flow east to Saskatchewan and contribute flows to the Frenchman River (a tributary of the Milk River in Montana). Verdigris Coulee and Miners Coulee, two ephemeral tributaries to the Milk River which have been dry in past years were also sampled in 2018 and 2019.

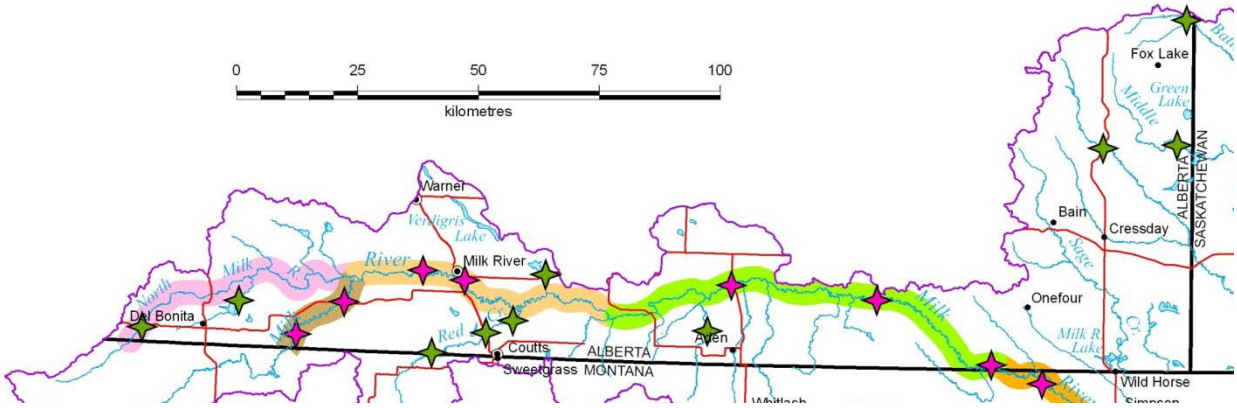


Figure 1 - Map showing water monitoring locations sampled in the Milk River watershed, 2018.

The MRWCC water monitoring program was conducted in collaboration with staff from Cardston County, County of Warner, Cypress County and Alberta Environment and Parks. 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., triple rinsing and 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**[2] approved methods for general parameters (e.g., pH, specific conductivity), nutrients (total phosphorus (TP), total dissolved phosphorus (TDP), nitrate+nitrite nitrogen (NO_3+NO_2-N), total kjeldahl nitrogen (TKN) and total nitrogen [TN; calculated]), total suspended solids (TSS) and fecal coliform bacteria (FCB).

Water monitoring results were compared to Milk River Water Quality Objectives (WQO) that were established at four main river reaches (i.e., North Fork Milk River, Mainstem Milk River, Milk River Gravel Bed and Milk River Sand Bed) in the Milk River IWMP (PESL 2015) and to applicable provincial surface water quality guidelines (GoA 2018). 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 2019 data set is the eighth year of data collected since the WQOs were established.

3.0 RESULTS

3.1 Precipitation

Overall, total precipitation in the Milk River watershed in 2019 differed across the watershed, ranging from 250.2 mm at Onefour to 369.2 mm at Cardston (Tables 1 and 2). June was the wettest month (mean= 78.2 mm) while October was the driest month (mean= 22.0 mm) (Table 1).

Table 1 – Total precipitation (mm) at five weather stations for the water monitoring April to October, 2019.

Month	Cardston	Del Bonita	Milk River	Masinasin	Onefour
April	46.8	34.8	35.7	33.3	27.4
May	70.7	66.4	55.2	51.6	46.8
June	89.3	87.6	79.8	70.9	63.2
July	40.9	39.6	35.0	33.0	32.6
August	43.9	41.1	37.2	35.0	33.0
September	47.8	41.0	36.1	35.3	30.4
October	29.8	23.8	20.4	19.4	16.8
Total	**369.2**	**334.3**	**299.4**	**278.5**	**250.2**
Data Source: Environment Canada - http://climate.weather.gc.ca/index_e.html					

Comparing mean total precipitation for each year, 2019 was the fourth wettest of the eight years reported (mean: 306.3 mm) (Table 2). The driest year was recorded in 2017 (mean: 178.8 mm) with the wettest year occurring in 2014 (mean: 344.0 mm) a difference of 165.2 mm of precipitation between the wettest and driest years.

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

[2] **APHA** – American Public Health Association

Table 2 - Historical total precipitation (mm) at five weather stations for the water monitoring period April to October, 2012 to 2019.

Year	Cardston	Del Bonita	Milk River	Masinasin	Onefour	Mean
2012	282.5	266.8	326.8	216.1	272.6	273.0
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
Data Source: Environment and Climate Change Canada - http://agriculture.alberta.ca/acis/weather-data-viewer.jsp						

3.2 Red Creek

3.2.1 General Water Chemistry

At Red Creek in 2019, the median water temperature at the upstream site (12.8°C) was lower than 2016 to 2018 (13.0 to 14.2°C). The median water temperature at the middle site (13.3°C) and downstream site (14.4°C) was within the range of 2016 to 2018 (Table 3). Maximum water temperatures at the upstream (17.6°C), middle (18.3°C) and downstream (22.0°C) sites occurred during July. At the middle Red Creek site the channel was dry during the last three sampling dates from August 15th to October 10th.

The median dissolved oxygen concentration at the upstream (8.28 mg/L), middle (8.06 mg/L) and downstream (10.60 mg/L) Red Creek sites met the acute (≥5.0 mg/L) and chronic (≥6.5 mg/L) guideline in 2019. A sample on August 15th (5.53 mg/L) at the upstream site and at the middle site on June 6th (6.49 mg/L) did not meet the chronic guideline. From 2016 to 2019, the median dissolved oxygen at the upstream and middle sites met the acute and chronic guidelines; although, there was some exceedances of individual samples from both sites. From 2016 through 2019, 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), whereas the upstream and middle sites do not show a compliance trend (Table 4).

In 2019, the median pH at the upstream (8.19), middle (8.33) and downstream (8.24) Red Creek sites and all individual samples (range: 7.71 to 8.48) met the pH guideline of 6.5 to 9.0 for aquatic life (Table 3). From 2016 to 2019, the median pH and all individual pH samples at Red Creek met the pH guideline.

Median specific conductivity at the upstream (2690 µS/cm), middle (2390 µS/cm) and downstream (2585 µS/cm) Red Creek sites exceeded the safe irrigation guideline (≤1000 µS/cm) and would be considered unsuitable for irrigation (≥2000 µS/cm) (GoA 2018).

3.2.2 Nutrients

In 2019, the median total phosphorus concentration at the upstream site (0.053 mg/L) was the second highest of the four monitoring years and the maximum total phosphorus (0.212 mg/L) was the third lowest of the four years. In 2019, the median total phosphorus concentration at the middle (0.075 mg/L) and downstream (0.026 mg/L) sites were the lowest of the four monitoring years and the maximum total phosphorus at the middles and downstream sites was the second lowest of the four years. The maximum total phosphorus concentration at the three sites occurred on April 4 and was likely due to snowmelt and runoff containing phosphorus. In 2019, an average of 50% of the total phosphorus at the three sites was present in the dissolved form. From 2016 to 2019, the median total phosphorus at the Red Creek middle site has been 1.4 to 3.5 times higher than the upstream site and 2.7 to 6.8 times higher than the downstream site.

The median total nitrogen concentration in 2019 at the upstream Red Creek site (2.052 mg/L) was the highest of the four monitoring years from 2016 to 2019. In 2019, the median total nitrogen concentration at the middle (1.080 mg/L) and downstream (0.814 mg/L) was the lowest of the four monitoring years from 2016 to 2019 (Table 3). In 2019 at the three Red Creek sites, most of the total nitrogen was present in the organic (TKN) form (80%) with a smaller percentage (20%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen) (Table 3).

3.2.3 Total Suspended Solids

In 2019 at Red Creek, the median total suspended solids concentration at the upstream, middle and downstream sites was 12, 9 and 4.8 mg/L, respectively and were within the range of the previous three years. The maximum TSS at the upstream site (106 mg/L) was the highest of the four years and the maximum TSS at the middle site (12 mg/L) was the lowest of the four years. The maximum total suspended solids concentrations at Red Creek has typically occurred during the April and May sampling which was likely the result of increased stream flows (i.e., increased runoff or bank erosion) from higher precipitation and/or snow melt runoff.

3.2.4 Fecal Coliform Bacteria

The median fecal coliform bacteria count at the upstream, middle and downstream Red Creek sites was 4, 2 and 121 cfu/100 mL, respectively. The upstream and middle sites had the lowest median of the four monitoring years while the downstream site had the second highest of the four years (Table 3). The maximum fecal coliform bacteria count at the upstream and middle Red Creek sites (300 cfu/100 mL at each site) was the second lowest of the four monitoring years while the downstream site had the second highest (2000 cfu/100 mL) of the four years (Table 3). The median fecal coliform bacteria count at the upstream and middle sites met the provincial guideline for irrigation (100 cfu/100 mL) (GoA 2018). Three (3) of 10 samples (30%) from upstream Red Creek and one (1) of seven samples (14%) from middle Red Creek were greater than the irrigation guideline. The median fecal coliform bacteria count at the downstream Red Creek site (121 cfu/100 mL) did not meet the provincial guideline for irrigation (100 cfu/100 mL) and four (4) of eight samples (50%) were greater than the irrigation guideline. 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).

Table 3 - Median and range for water quality parameters at Red Creek, 2016-2019.

Parameter	Upstream				Middle				Downstream			
	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
Water Temperature, °C	14.2 3.0-20.6	14.0 8.0-21.0	13.0 0.2-20.9	12.8 1.4-17.6	10.7 8.6-19.5	14.3 7.1-21.4	15.4 0.1-18.9	13.3 5.3-18.3	9.8 8.7-17.1	17.0 8.9-21.6	15.0 0.1-22.1	14.4 4.9-22.0
Dissolved Oxygen, mg/L	10.06 4.35-13.53	7.98 4.51-12.41	9.09 5.68-12.62	8.28 5.53-13.01	8.85 2.55-14.33	9.19 8.39-11.87	8.00 4.07-10.92	8.06 6.49-9.98	10.22 10.16-11.84	10.75 9.50-13.47	10.64 10.18-11.58	10.60 9.62-11.26
pH	8.15 7.69-8.58	8.24 7.98-8.34	8.44 7.99-8.55	8.19 7.99-8.33	8.45 7.98-8.92	8.42 8.18-8.61	8.49 8.12-8.64	8.33 7.94-8.40	8.39 8.29-8.43	8.35 7.97-8.50	8.17 8.06-8.56	8.24 7.71-8.48
Specific Conductivity, µS/cm	2610 2290-2790	2540 2130-2690	2345 506 to 2796	2690 1920-3140	2870 2420-3450	2560 1610-3080	2115 426-2440	2390 1580-2580	2615 2500-2880	2630 1530-2920	2489 510-2796	2585 1560-2880
Total Phosphorus, mg/L	0.023 0.015-0.047	0.045 0.025-0.615	0.081 0.012-0.488	0.053 0.016-0.212	0.080 0.041-0.097	0.098 0.045-0.341	0.177 0.056-0.362	0.075 0.072-0.172	0.030 0.021-0.041	0.036 0.019-0.180	0.026 0.009-0.400	0.026 0.011-0.121
Total Dissolved Phosphorus, mg/L	0.016 0.012-0.033	0.021 0.008-0.447	0.067 0.003-0.413	0.017 0.008-0.111	0.047 0.026-0.077	0.047 0.024-0.310	0.081 0.036-0.174	0.045 0.039-0.094	0.018 0.014-0.029	0.019 0.007-0.160	0.020 0.003-0.320	0.011 0.007-0.068
Nitrate+Nitrite Nitrogen, mg/L	0.055 0.025-1.850	0.250 0.005-1.600	0.482 0.050-4.190	0.064 0.050-2.680	0.055 0.055-0.140	0.050 0.050-0.050	0.053 0.050-0.495	0.055 0.050-0.870	0.103 0.055-0.170	0.050 0.002-0.050	0.039 0.025-0.850	0.096 0.055-0.920
Total Kjeldahl Nitrogen, mg/L	0.925 0.580-1.100	1.000 0.840-2.120	1.330 0.730-1.680	1.165 0.670-3.010	1.270 0.790-1.950	1.280 1.080-1.890	1.180 0.600-1.580	0.920 0.650-1.640	0.730 0.590-0.960	1.020 0.510-1.300	0.820 0.250-1.400	0.710 0.44-1.55
Total Nitrogen, mg/L	1.100 0.635-2.810	1.810 0.850-2.540	1.957 0.850-5.740	2.052 0.725-4.100	1.325 0.845-2.005	1.330 1.130-1.940	1.275 0.650-1.815	1.080 0.705-2.510	0.823 0.685-1.110	1.070 0.510-1.300	1.050 0.640-2.040	0.814 0.534-2.470
Total Suspended Solids, mg/L	2 2-8	12 4-61	9.15 1.5-33.3	12 5-106	4 2-13	12 6-26	14.0 3.7-91.3	9 7-12	6 2-10	4 1-9	1.60 0.5-135	4.8 1.2-16
Fecal Coliform Bacteria, cfu/100 mL	47 1-8900	19 1-400	61 1-204	4 1-300	21 0.5-1300	87 1-600	57 1-83	2 1-300	215 2-700	118 1-700	100 6-3600	121 1-2000

Table 4 - Summary of Red Creek water quality compliance with dissolved oxygen acute and chronic guidelines, 2015-2019 (GoA 2018).

Year	Compliance: Dissolved Oxygen					
	Upstream		Middle		Downstream	
	Acute >5.0 mg/L	Chronic >6.5 mg/L	Acute >5.0 mg/L	Chronic >6.5 mg/L	Acute >5.0 mg/L	Chronic >6.5 mg/L
2015	100	100	100	87	100	100
2016	89	100	83	67	100	100
2017	75	50	100	100	100	100
2018	100	100	88	88	100	100
2019	100	88	100	80	100	100
Trend	No Trend	No Trend	No Trend	No Trend	Stable	Stable

3.3 Eastern Tributaries

3.3.1 General Water Chemistry

Battle Creek – The median water temperature at Battle Creek was 10.2°C in 2019, and was the second highest median water temperature of the four monitoring years (Table 5). The maximum water temperature reached 16.6°C on July 18. Dissolved oxygen concentrations met the chronic (>6.5 mg/L) and acute (>5.0 mg/L) guidelines throughout 2019 with all concentrations greater than 7.17 mg/L and a median of 10.08 mg/L. Similarly, all pH values met the aquatic life guideline in 2019 (≥6.5 and ≤9.0). Median specific conductivity was 362 µS/cm and all samples were well below the safe irrigation guideline (≤1000 µS/cm) and all of the individual samples (N=10) were less than 1000 µS/cm.

Middle Creek – The median water temperature at Middle Creek was 12.5°C in 2019, and was lower compared to 2016 to 2018 (median range: 13.2 to 15.0°C) (Table 5). The maximum water temperature reached 17.6°C on August 15. The median dissolved oxygen concentration (8.20 mg/L) met the acute and chronic guideline with oxygen concentrations ranging from 5.66 to 12.38 mg/L. Two (2) of 10 samples (10%) did not meet the chronic (>6.5 mg/L) guideline. All pH results met the aquatic life guideline in 2019 (≥6.5 and ≤9.0). The median specific conductivity (614 µS/cm) met the guideline for safe irrigation (≤1000 µS/cm) and all of the individual samples (N=10) were less than 1000 µS/cm.

Lodge Creek – The median water temperature at Lodge Creek was 10.0°C in 2019, and was lower compared to 2016 to 2018 (median range: 12.6 to 14.6°C) (Table 5). Dissolved oxygen concentrations met the chronic (>6.5 mg/L) and acute (>5.0 mg/L) guidelines throughout 2019 with all concentrations greater than 9.65 mg/L with a median of 9.82 mg/L. Similarly, all pH values met the aquatic life guideline in 2019 (≥6.5 and ≤9.0) with a median of 8.37. The median specific conductivity (857 µS/cm) met the guideline for safe irrigation (≤1000 µS/cm) (GoA 2018). Four (4) of 6 samples (67%) were 'safe' for irrigation (<1000 µS/cm), and 2 of 6 samples (33%) were 'possibly safe' for irrigation (>1000 to < 2000 µS/cm).

3.3.2 Nutrients

Battle Creek – Median total phosphorus concentration was 0.012 mg/L in 2019, and was lower than 2016 to 2018 (median range: 0.017 to 0.024 mg/L) (Table 5). Total dissolved phosphorus concentration in 2019 was 0.010 mg/L, and was similar to 2016 to 2018 (median range: 0.010 to 0.015 mg/L). Seventy-five percent (75%) of the total phosphorus was present in the dissolved form. Median total nitrogen in 2019 (0.176 mg/L) was higher than 2016 to 2018 (0.110 to 0.168 mg/L). No total nitrogen trends were observed (Table 5). In 2019 at Battle Creek, most of the total nitrogen was present in the organic (TKN) form (92%) with a small percentage (8%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen). Median nitrate+nitrite nitrogen in 2019 (0.011 mg/L) was similar to 2017 and 2018 (median range: 0.010 and 0.010 mg/L) but lower than 2016 (0.025 mg/L). No nitrate+nitrite nitrogen trends were observed.

Middle Creek – Median total phosphorus concentration in 2019 (0.066 mg/L) was within the median range of the three previous monitoring years (median range: 0.048 to 0.123 mg/L) (Table 5). Median total dissolved phosphorus concentration in 2019 was 0.045 mg/L and was also within the median range of the three previous monitoring years (median range: 0.032 to 0.095 mg/L). In 2019, 73% of the total phosphorus was present in the dissolved form. Median total nitrogen in 2019 (0.721 mg/L) was within the median range of the three previous monitoring years (median range: 0.595 to 0.880 mg/L) and no trend was observed (Table 5). In 2019 at Middle Creek, most of the total nitrogen was present in the

organic (TKN) form (97%) with a much smaller percentage (3%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen) (Table 5). Median nitrate+nitrite nitrogen in 2019 (0.011 mg/L) was similar to 2017 and 2018 (median range: 0.010 and 0.010 mg/L) but lower than 2016 (0.025 mg/L). No nitrate+nitrite nitrogen trends were observed.

Lodge Creek – Median total phosphorus concentration in 2019 (0.030 mg/L) was lower than the three previous monitoring years (median range: 0.052 to 0.067 mg/L) (Table 6). Median total dissolved phosphorus concentration in 2019 (0.022 mg/L) was lower than the three previous monitoring years (median range: 0.034 to 0.050 mg/L). In 2019, 73% of total phosphorus was present in the dissolved form. Median total nitrogen in 2019 (0.568 mg/L) was within the range of the three previous years (median range: 0.520 to 0.580 mg/L) and no trend was observed (Table 5). In 2019 at Lodge Creek, most of the total nitrogen was present in the organic (TKN) form (92%) with a smaller percentage (8%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen) (Table 5). Median nitrate+nitrite nitrogen in 2019 (0.024 mg/L) was within the median range of the three previous monitoring years (median range: 0.010 to 0.050 mg/L) and no trend was observed.

3.3.3 Total Suspended Solids

Battle Creek – The median total suspended solid concentration in 2019 (7 mg/L) was within the range of the previous three years (5 to 11 mg/L) (Table 5). The maximum TSS in 2019 at Battle Creek (12 mg/L) was the second lowest of the four monitoring years. No trend in total suspended solids concentration was observed at Battle Creek from 2016 to 2019.

Middle Creek – The median total suspended solid concentration in 2019 (5 mg/L) was within the range of the three previous years (2 to 9.3 mg/L) (Table 5). The maximum TSS in 2019 at Middle Creek (28 mg/L) was the second highest of the four monitoring years. No trend in total suspended solids concentration was observed at Middle Creek from 2016 to 2019.

Lodge Creek – The median total suspended solid concentration in 2019 (5 mg/L) was within the range of the three previous years (3 to 7 mg/L) (Table 5). The maximum TSS in 2019 at Lodge Creek (28 mg/L) was the second highest of the four monitoring years. No trend in total suspended solids concentration was observed at Lodge Creek from 2016 to 2019.

3.3.4 Fecal Coliform Bacteria

Battle Creek – The median fecal coliform bacteria count in 2019 (14 cfu/100 mL) was the lowest of the four monitoring years; although, the maximum median fecal coliform bacteria count was the highest of the four years (Table 5). The median fecal bacteria count at Battle Creek has met the irrigation guideline (100 cfu/100 mL) from 2016 to 2019; although, individual samples exceeded the irrigation guideline in each year. In 2019, 2 of the 10 (20%) individual samples exceeded 100 cfu/100 mL. There has been a trend for decreasing median fecal coliform bacteria counts from 2016 to 2019 (23 to 14 cfu/100 mL); however, there has been a trend for increasing maximum fecal coliform bacteria counts from 2016 to 2019 (102 to 300 cfu/100 mL).

Middle Creek – The median fecal coliform count in 2019 at Middle Creek (1 cfu/100 mL) was the lowest of the four monitoring years. The maximum fecal coliform count in 2019 (212 cfu/100 mL) was the second highest of the four monitoring years (Table 5). The median fecal bacteria count at Middle Creek has met the irrigation guideline (100 cfu/100 mL) from 2016 to 2019. From 2016 to 2017, no individual

sample exceeded the irrigation guideline. In 2019, 1 of 10 (10%) samples exceeded the irrigation guideline. No trend in fecal coliform bacteria counts was observed from 2016 to 2019.

Lodge Creek – The median fecal coliform count in 2019 (3 cfu/100 mL) was the lowest of the four monitoring years (Table 5). The maximum fecal coliform count in 2019 (118 cfu/100 mL) was the second highest of the four monitoring years (Table 5). The median fecal bacteria count at Lodge Creek has met the irrigation guideline (100 cfu/100 mL) from 2016 to 2019. In 2016 and 2017, no individual sample exceeded the irrigation guideline. In 2019, 1 of 6 (17%) samples exceeded the irrigation guideline. No trend in fecal coliform bacteria counts was observed from 2016 to 2019.

Table 5 - Median and range for water quality parameters at the Eastern Tributaries (Battle Creek, Middle Creek and Lodge Creek), 2016-2019.

Parameter	Battle Creek				Middle Creek				Lodge Creek			
	2016	2017	2018	2019	2016	2017	2018	2019	2016	2017	2018	2019
Water Temperature, °C	8.1 0.7-14.6	8.6 3.3-15.0	11.4 2.4-19.1	10.2 0.4-16.6	15.0 4.5-21.8	13.2 6.7-21.5	15.0 5.3-20.9	12.5 2.1-17.6	14.2 1.6-22.6	12.6 6.5-20.0	14.6 6.7-19.3	10.0 5.6-18.7
Dissolved Oxygen, mg/L	10.49 8.49-12.03	10.24 8.81-11.72	8.78 7.25-10.93	10.08 7.17-11.03	10.57 5.60-14.30	9.81 5.17-13.19	7.51 5.60-10.08	8.20 5.66-12.38	12.22 10.18-14.02	10.67 10.30-10.96	9.30 8.23-9.93	9.82 9.65-10.68
pH	8.23 7.94-8.44	8.38 8.17-8.49	8.33 8.22-8.55	8.39 8.30-8.55	8.28 8.01-8.52	8.41 8.00-8.67	8.45 8.01-8.57	8.31 8.14-8.55	8.39 7.93-8.89	8.37 8.21-8.42	8.44 8.23-8.57	8.37 8.33-8.48
Specific Conductivity, µS/cm	391 353-425	381 338-399	382 297-415	362 355-677	699 584-828	618 519-897	599 302-712	614 418-751	965 645-1290	825 570-1170	1160 499-1240	857 707-1340
Total Phosphorus, mg/L	0.020 0.013-0.036	0.017 0.010-0.034	0.024 0.086-0.470	0.012 0.007-0.163	0.123 0.027-0.256	0.048 0.023-0.122	0.048 0.022-0.249	0.066 0.015-0.239	0.067 0.026-0.210	0.053 0.028-0.103	0.052 0.022-0.160	0.030 0.021-0.121
Total Dissolved Phosphorus, mg/L	0.015 0.009-0.025	0.011 0.009-0.017	0.010 0.003-0.027	0.010 0.006-0.142	0.095 0.024-0.198	0.032 0.010-0.105	0.046 0.015-0.170	0.045 0.008-0.199	0.050 0.015-0.165	0.044 0.019-0.075	0.034 0.010-0.022	0.022 0.005-0.087
Nitrate+Nitrite Nitrogen, mg/L	0.025 0.025-0.110	0.010 0.010-0.010	0.010 0.003-0.760	0.011 0.011-0.024	0.025 0.025-0.025	0.010 0.010-0.010	0.010 0.003-0.093	0.011 0.011-0.034	0.025 0.025-0.100	0.010 0.010-0.050	0.050 0.010-0.055	0.024 0.011-0.200
Total Kjeldahl Nitrogen, mg/L	0.100 0.100-0.400	0.100 0.100-0.270	0.100 0.100-0.390	0.165 0.100-0.290	0.580 0.340-0.780	0.585 0.420-0.810	0.870 0.340-14.10	0.705 0.100-1.290	0.525 0.067-1.060	0.490 0.470-0.720	0.560 0.340-0.920	0.525 0.330-0.970
Total Nitrogen, mg/L	0.168 0.125-0.425	0.110 0.110-0.280	0.110 0.103-0.466	0.176 0.111-0.301	0.605 0.365-0.805	0.595 0.430-0.820	0.880 0.350-14.19	0.721 0.111-1.301	0.580 0.092-1.085	0.520 0.480-0.730	0.570 0.390-0.975	0.568 0.341-1.007
Total Suspended Solids, mg/L	5 2-10	9 2-33	11 1.5-26.0	7 2-12	2 2-7	2 2-10	9.3 1.5-54.3	5 3-28	3 2-17	7 4-9	4 1.5-33.0	5 2-28
Fecal Coliform Bacteria (cfu/100 mL)	23 1-102	24 1-159	18 1-189	14 1-300	3 1-12	7 1-73	50 1-300	1 1-212	7 1-96	3 2-18	12 4-218	3 1-118

3.4 Ephemeral Tributaries

Miners Coulee contributed minor flow to the Milk River in 2019. During eight site visits between March 11 and October 8, flowing water was only observed on May 14. In 2018, flow was only observed on April 23 and May 22. Verdigris Coulee contributed minor flow to the Milk River in 2019. During eight site visits between March 11 and October 8, flowing water was observed on October 8. In 2018, flow at Verdigris Coulee was observed on April 23, May 22, June 19 and July 16.

3.4.1 General Water Chemistry

Miners Coulee – The dissolved oxygen concentration was 8.12 mg/L on May 14 at Miners Coulee in 2019 and met the acute (>5.0 mg/L) and chronic (>6.5 mg/L) guidelines. In 2018, one of 2 (50%) samples did not meet the chronic guideline. The pH (7.67) at Miners Coulee in 2019 met the aquatic life guideline (≥6.5 and ≤9.0). Both pH values met the aquatic life guideline in 2018 (Table 6). Specific conductivity at Miners Coulee in 2019 was 994 µS/cm and met the safe irrigation guideline (≤1000 µS/cm). In 2018 both samples met the irrigation guideline.

Verdigris Coulee – The October 8 dissolved oxygen concentration (8.41 mg/L) in 2019 at Verdigris Coulee met the aquatic life guidelines. In 2018, three of the 4 samples (75%) did not meet the chronic or acute oxygen guidelines. All pH results in 2019 and 2018 met the aquatic life guideline (≥6.5 and ≤9.0) at Verdigris Coulee. In 2019, the specific conductivity on October 8 (277 µS/cm) met the guideline for safe irrigation (≤1000 µS/cm). In 2018, the median specific conductivity (2562 µS/cm) was considered unsuitable for irrigation (≥2000 µS/cm) at Verdigris Coulee (GoA 2018).

3.4.2 Nutrients

Miners Coulee – In 2019, the total phosphorus concentration on May 14 at Miners Coulee was 0.043 and lower than the two samples from 2018 (0.096 and 0.160 mg/L) (Table 6). In 2019, the total dissolved phosphorus concentration on May 14 at Miners Coulee was 0.027 and lower than the two samples from 2018 (0.082 and 0.150 mg/L) (Table 6). In 2019, total nitrogen on May 14 was 0.88 mg/L and similar to 2018 (0.90 and 0.92 mg/L (Table 6). In 2019 at Miners Coulee, almost all of the total nitrogen was present in the organic (TKN) form with a small percentage of the nitrogen present in soluble form (nitrate+nitrite nitrogen). The nitrate+nitrite nitrogen concentration in 2019 (0.01 mg/L) was higher than 2018 (<0.0042 and 0.0079 mg/L) (Table 6).

Verdigris Coulee – In 2019, the total phosphorus at Verdigris Coulee was 0.190 mg/L on October 8 and was within the range of total phosphorus in 2018 (0.044 to 0.350 mg/L) (Table 6). In 2019, the total dissolved phosphorus at Verdigris Coulee was 0.140 mg/L on October 8 and was within the range of total dissolved phosphorus in 2018 (0.031 to 0.280 mg/L) (Table 6). Approximately 73% of total phosphorus in 2019 was present in the dissolved form. The total nitrogen in 2019 was 1.20 mg/L and was within the range of total nitrogen in 2018 (0.037 to 3.8 mg/L). Approximately 59% of the total nitrogen was present in the organic (TKN) form with the remaining 41% nitrogen present in soluble form (nitrate+nitrite nitrogen) (Table 6). The nitrate+nitrite nitrogen concentration in 2019 was 0.45 mg/L at Verdigris Coulee.

3.4.3 Total Suspended Solids

Miners Coulee – The total suspended solid concentration in 2019 at Miners Coulee was 2.2 mg/L for the May 14 sample (Table 6). Both TSS samples at Miners Coulee in 2018 were less than 1 mg/L.

Verdigris Coulee – The total suspended solid concentration in 2019 at Verdigris Coulee was 6.5 mg/L on October 8 (Table 6). In 2018, the median TSS at Verdigris Coulee was 9.65 mg/L (N=4).

3.4.4 Fecal Coliform Bacteria

Miners Coulee – The fecal coliform bacteria count in 2019 at Miners Coulee was 173 cfu/100 mL (Table 6). The fecal bacteria count on May 14 did not meet the irrigation guideline (100 cfu/100 mL).

Verdigris Coulee – The fecal coliform count in 2019 on October 8 (220 cfu/100 mL) at Verdigris Coulee did not meet the irrigation guideline (100 cfu/100 mL) (Table 6).

Table 6 - Median and range for water quality parameters at the ephemeral tributaries (Miners Coulee and Verdigris Coulee), 2018 and 2019.

Parameter	Miners Coulee		Verdigris Coulee	
	2018 (N=2)	2019 (N=1)	2018 (N=4)	2019 (N=1)
Water Temperature, °C	7.05 - 15.7	15.78	16.4 1.47 - 17.9	3.02
Dissolved Oxygen, mg/L	5.22 - 10.78	8.12	4.57 2.14 - 11.06	8.41
pH	7.90 - 8.13	7.67	8.42 7.53 - 9.29	7.19
Specific Conductivity, µS/cm	583 - 905	994	2562 83 - 4414	277
Total Phosphorus, mg/L	0.096 - 0.160	0.043	0.109 0.044 - 0.350	0.190
Total Dissolved Phosphorus, mg/L	0.082 - 0.150	0.027	0.054 0.031 - 0.280	0.140
Nitrate+Nitrite Nitrogen, mg/L	<0.004 - 0.008	0.01	0.007 <0.004 - 0.024	0.45
Total Kjeldahl Nitrogen, mg/L	0.900 - 0.910	0.87	1.93 0.340 - 3.8	0.71
Total Nitrogen, mg/L	0.900 - 0.920	0.88	1.93 0.370 - 3.8	1.2
Total Suspended Solids, mg/L	<1	2.2	9.65 1.3 - 45	6.5
Fecal Coliform Bacteria (cfu/100 mL)	20 - 310	173	360 1 - 900	220
Sample Dates	Apr 23, May 22	May 14	Apr 23, May 22, Jun 19, Jul 16	Oct 8

3.5 Milk River

3.5.1 St. Mary/Milk River Diversion Operation

The St. Mary/Milk River Diversion was initiated on April 8 and was shut down on September 27, 2019. The initial flows on April 8 were 1.4 m^3/s (50 ft^3/s), increasing to 5.7 m^3/s (200 ft^3/s) on April 11 and 7.1 m^3/s (250 ft^3/s) on April 12. Diversion was further increased to 9.9 m^3/s (350 ft^3/s) on April 16. Diversion was ramped up from 12.7 m^3/s (450 ft^3/s) on April 17 to 14.3 m^3/s (505 ft^3/s) on April 29. The diversion was ramped down to 11.3 m^3/s (400 ft^3/s) beginning April 30 and continued ramping down to 5.7 m^3/s (200 ft^3/s) on May 16. Diversion was increased to 8.5 m^3/s (300 ft^3/s) on May 22 with further increased diversion to 17.0 m^3/s (600 ft^3/s) on May 31. The diversion was held between 16.6 and 17.0 m^3/s (585 to 600 ft^3/s) from May 31 to September 9. Diversion flows were ramped down beginning September 10 at 14.2 m^3/s (500 ft^3/s) and ended September 27 (0 m^3/s: 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 2018 monitoring period.

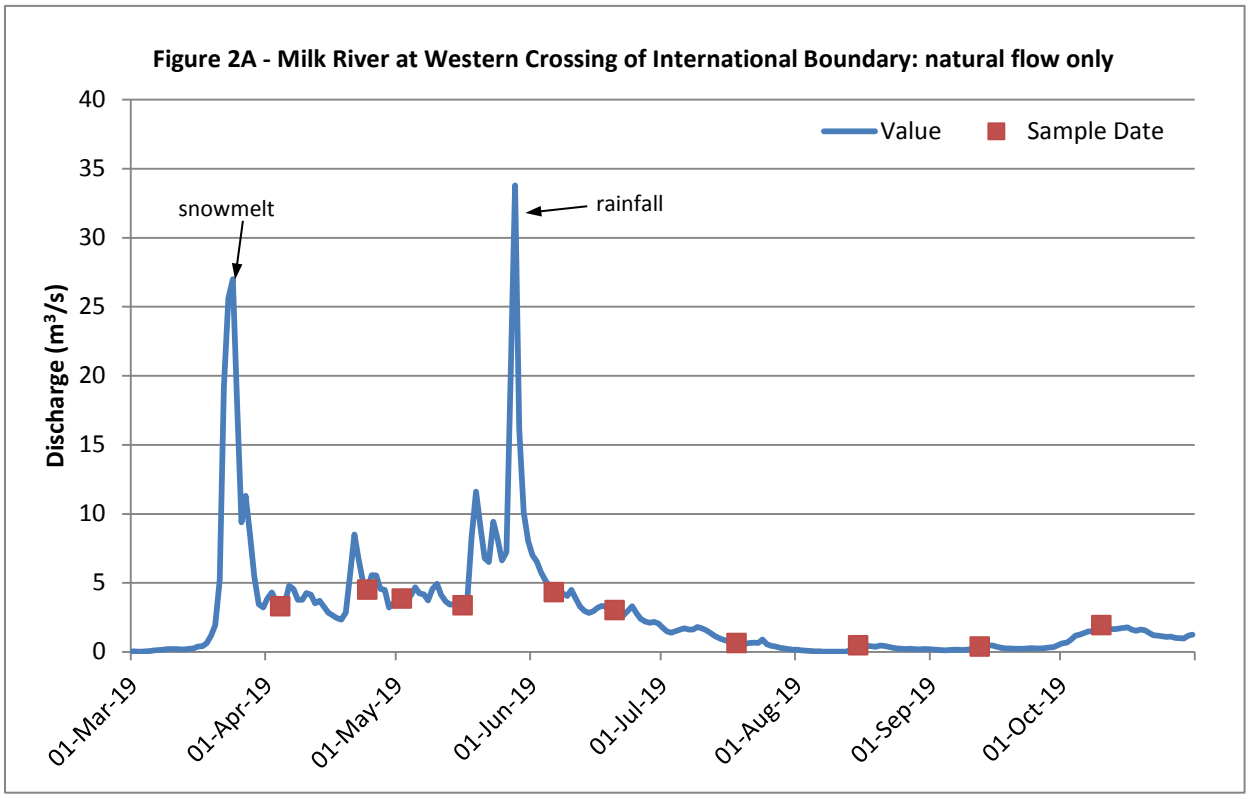
Year	Start Date	End Date
2006	March 05	September 24
2007	March 07	September 03
2008	March 17	September 12
2009	March 16	September 24
2010	March 21	September 03
2011	July 24	October 06
2012	April 9	September 15
2013	March 11	September 24
2014	May 13	September 10
2015[a]	March 31	August 28
2016	March 22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

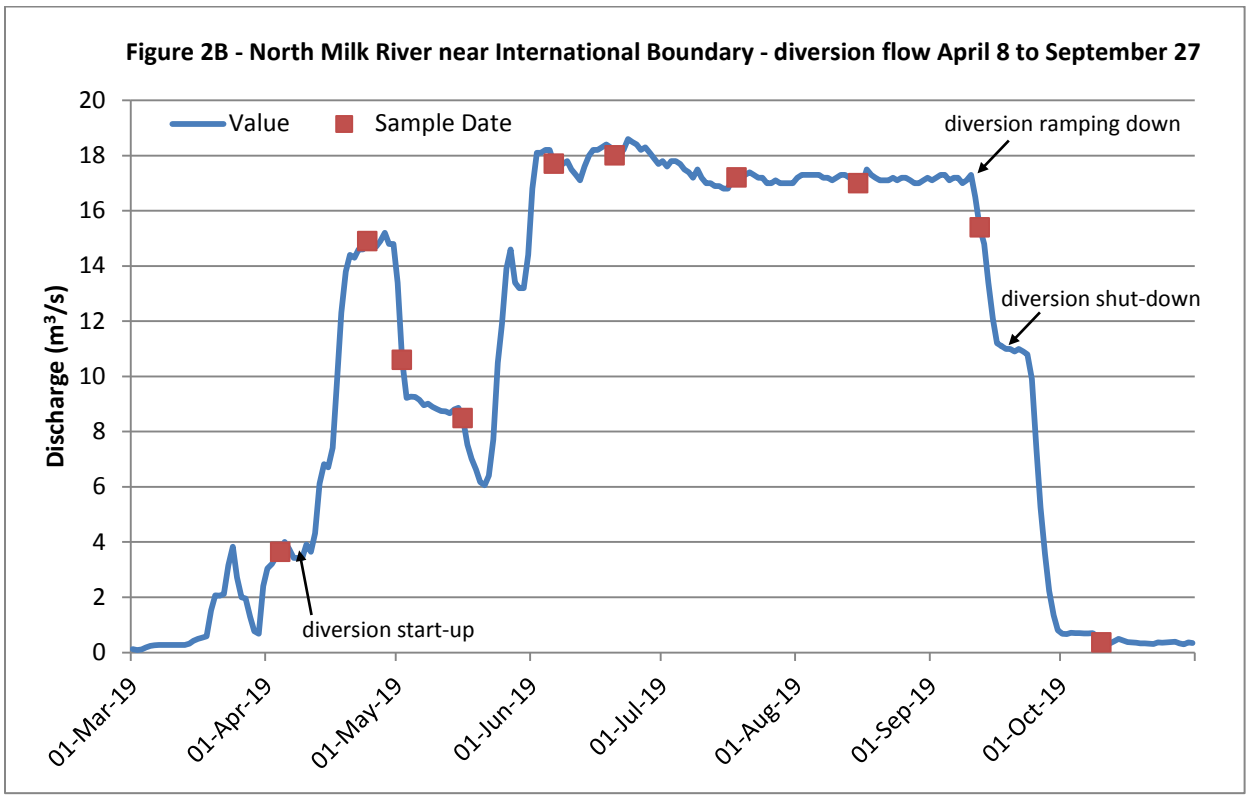
[a]Start-up was March 31 with 1.4 m^3/s (50 cfs) ramped over a week to 5.0 m^3/s (175 cfs), it was increased to 8.5 m^3/s (300 cfs) on May 4.

[b]Start-up was March 22 but diversion flow was minor until about April 10 when diversion flow was substantially increased.

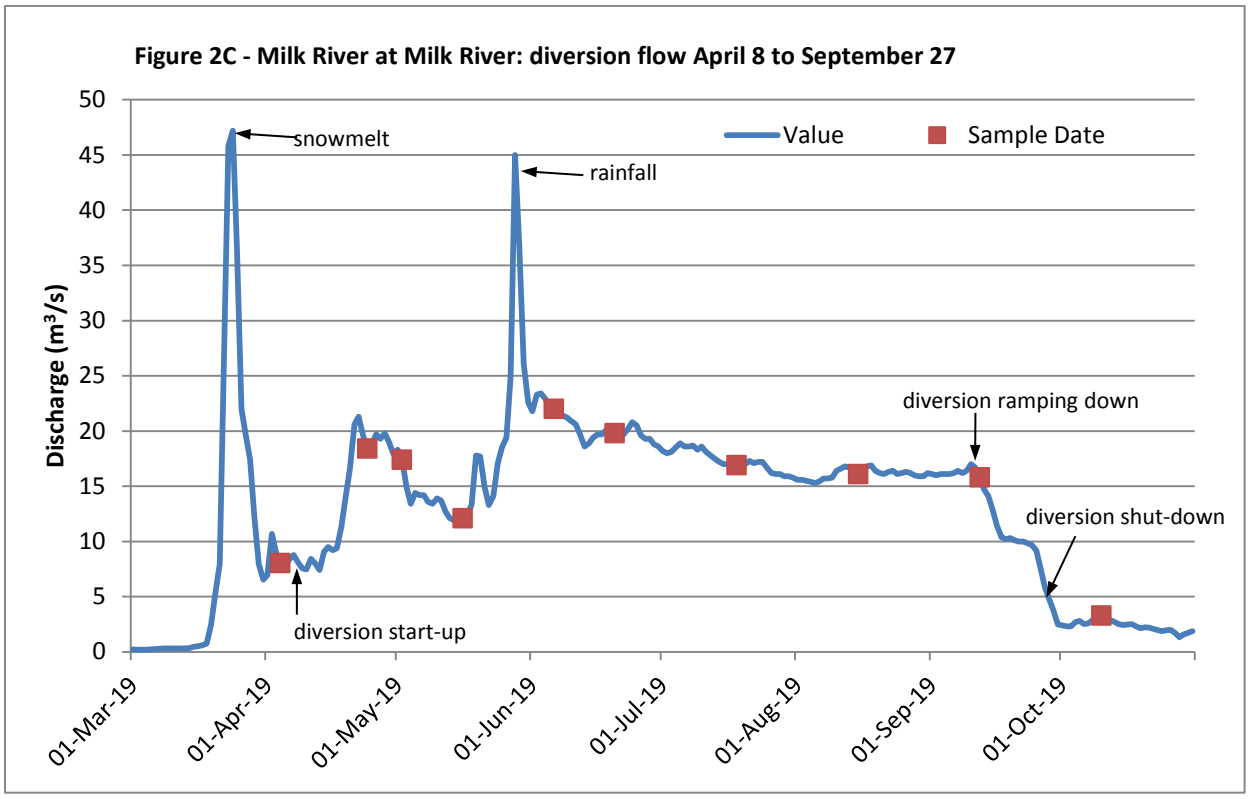
3.5.2 Streamflow

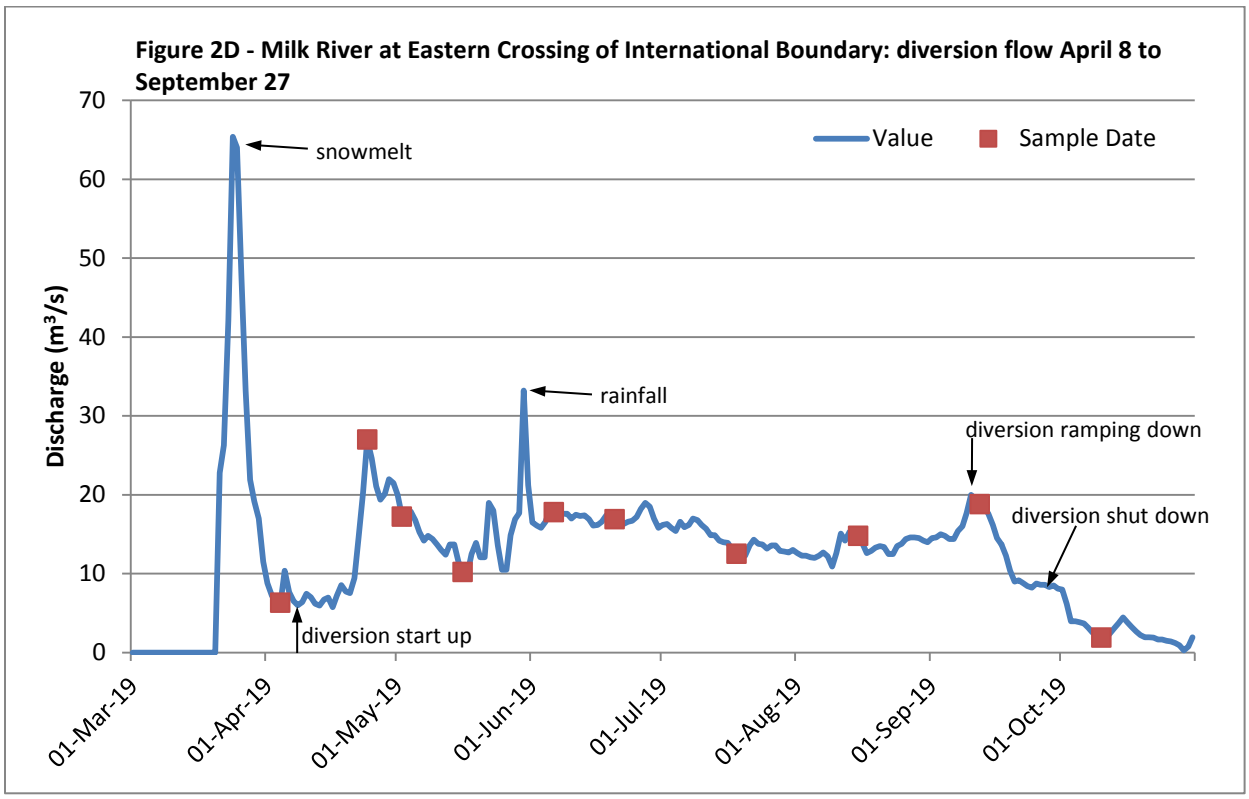
Mean daily streamflow data for 2019 is shown in Figures 2A to 2D at four Milk River sites (at Western Boundary, at North Milk River, at Milk River, and at Eastern Boundary). At 'Milk River at Western Crossing of International Boundary', the early spring discharge from March 1 to March 21 ranged from 0.03 to 1.9 m^3/s (median: 0.2 m^3/s) (Figure 2A). The peak discharge occurred from March 21 to May 31 when flows ranged from 2.4 to 33.8 m^3/s (median: 4.5 m^3/s), with peak discharges occurring on March 24 (27.0 m^3/s: snowmelt) and May 28 (33.8 m^3/s: rainfall) (Figure 2A). From June 1 to October 31, the daily median flow was 0.7 m^3/s (range: 0.01 to 7.0 m^3/s), with flows less than 0.1 m^3/s recorded from August 3 to August 13. Streamflow at the Milk River at Western Boundary site is not augmented by the St. Mary diversion; therefore, flows are always natural (Figure 2A).





Figures 2A to 2D – Discharge data (m^3/s) at four Milk River sites during the open water season, 2019.
Raw data from Environment and Climate Change Canada (2019).





Figures 2A to 2D – cont'd

At 'North Milk River near International Boundary', the discharge during early spring from March 1 to April 17 ranged from 0.1 to 4.0 m^3/s (median: 0.7 m^3/s) (Figure 2B). The discharge at the North Milk River ranged between 3.4 and 18.6 m^3/s (median: 17.0 m^3/s) during diversion from April 8 to September 27. Peak discharge occurred between June 1 and September 11 when flows were greater than 16.0 m^3/s. Natural flows after diversion shut-down from September 28 to October 31 ranged from 0.3 to 2.2 m^3/s (median: 0.38 m^3/s) (Figure 2B).

At 'Milk River at Milk River', the discharge during early spring from March 1 to April 7 ranged from 0.2 to 47.2 m^3/s (median: 3.8 m^3/s) (Figure 2C). The peak discharge of 47.2 m^3/s occurred on March 24 during snowmelt. The discharge at Milk River ranged between 5.8 and 45.0 m^3/s (median: 16.4 m^3/s) during diversion from April 8 to September 27. The peak discharge (45.0 m^3/s) occurred on May 28 during a period of rainfall. Natural flows (after diversion shut-down) from September 28 to October 31 ranged from 1.3 to 4.8 m^3/s (median: 2.4 m^3/s) (Figure 2C).

At 'Milk River at Eastern Crossing of International Boundary', the discharge during early spring from March 20 to April 7 ranged from 6.3 to 65.4 m^3/s (median: 18.1 m^3/s). The peak discharge of 65.4 m^3/s occurred on March 24 during snowmelt (Figure 2D).The discharge ranged between 5.8 and 33.2 m^3/s (median: 14.5 m^3/s) during diversion from April 8 to September 27. The peak discharge (33.2 m^3/s) occurred on May 30 during a period of rainfall. Natural flows (after diversion shut-down) from September 28 to October 31 ranged from 0.3 to 8.5 m^3/s (median: 2.5 m^3/s) (Figure 2D).

3.5.3 General Water Chemistry

Water chemistry parameters are presented in Table 8. Note that while water chemistry results from 2016 to 2018 are presented in the tables, they are generally not discussed in detail in the result summaries. In 2019, median water temperature ranged from 12.1°C at the North Fork at 501 site to 14.8°C at the U/S Milk River site. Median water temperatures at each site were within the range of median water temperatures from 2016 to 2018 with the exception of the U/S Milk River site which in 2019 had the warmest median water temperature of the four years. The warmest water temperature (21.4°C on July 24) was recorded at the U/S Milk River site.

Median dissolved oxygen concentration ranged from 9.06 mg/L at the U/S Milk River site to 11.25 mg/L at the HWY 880 site (Table 8). The lowest individual dissolved oxygen concentration occurred at the U/S Milk River site (8.00 mg/L). 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 2019, 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 $\geq$6.5 and $\leq$9.0 (GoA 2018). The median pH values (8.23 to 8.42) were within guideline for the protection of aquatic life at all Milk River sites in 2019. No individual sample exceeded the guideline (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 (158 µS/cm) and highest at the Pinhorn site (277 µS/cm). During the natural flow period, median specific conductivity ranged from a low of 324 µS/cm at the North Fork at 501 site to a high of 527 µS/cm at the HWY 880 site (Table 9). The WQO-50 and WQO-90 objectives for specific conductivity were met at all sites in 2019 with the exception of the median specific conductivity at the Pinhorn site during diversion which was in the cautionary range (Table 9). In 2019, all samples at the Milk River sites also met the provincial guideline for safe irrigation (≤1000 µS/cm).

Table 8 - Summary (median and range) of general water quality parameters at the Milk River, 2016 to 2019.

Site	Water Temperature (°C)											
	2016			2017			2018			2019		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	9	12.4	1.9-18.2	10	11.7	5.2-19.2	10	12.0	-0.4-17.9	10	12.1	0.4-16.4
Milk R. at 501	6	11.3	0.8-18.0	7	12.0	6.6-18.6	8	13.0	0.03-18.8	10	12.4	0.0-17.8
U/S Milk River	8	13.5	2.1-19.2	10	14.4	4.4-20.7	10	13.7	0.4-20.7	10	14.8	4.1-21.4
HWY 880	9	15.9	0.9-20.2	10	15.1	7.9-14.7	10	14.6	3.8-19.4	10	14.2	5.3-21.3
Pinhorn	9	15.4	0.6-20.4	10	14.4	7.5-20.5	9	17.6	4.4-21.3	10	12.8	0.3-18.4

Site	Dissolved Oxygen (mg/L)											
	2016			2017			2018			2019		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	9	10.12	8.71-11.76	10	10.62	8.92-12.45	10	10.10	8.7-12.9	10	9.69	8.84-12.38
Milk River at 501	6	9.88	8.97-12.2	7	10.39	8.36-11.88	8	9.76	8.3-12.4	10	9.36	8.46-12.50
U/S Milk River	8	10.35	8.80-12.80	10	9.62	8.62-12.52	10	9.15	8.6-12.8	10	9.06	8.00-11.24
HWY 880	9	10.28	8.64-13.48	10	10.10	9.07-12.48	10	9.28	8.5-12.3	10	11.25	8.06-12.06
Pinhorn	9	9.89	8.45-14.11	10	9.47	8.41-11.29	9	9.70	8.3-11.9	10	9.89	8.65-13.37

Site	pH											
	2016			2017			2018			2019		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	8.10	7.84-8.30	10	8.27	8.14-8.59	10	8.39	7.99-8.50	10	8.23	8.02-8.53
Milk R. at 501	7	8.46	8.33-8.60	7	8.52	8.40-8.59	8	8.47	8.24-8.63	10	8.42	8.29-8.79
U/S Milk River	10	8.24	8.08-8.41	10	8.31	8.17-8.47	10	8.33	8.02-8.48	10	8.25	8.10-8.41
HWY 880	10	8.28	8.05-8.44	10	8.34	8.19-8.49	11	8.27	8.09-8.51	10	8.35	8.10-8.41
Pinhorn	10	8.24	8.13-8.48	10	8.37	8.13-8.49	10	8.36	7.99-8.57	10	8.32	8.11-8.44

Table 9 - Summary of specific conductivity (µS/cm) at the Milk River, 2016 to 2019.

Site	Flow Period	WQO		2016				2017				2018				2019			
		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	165	246	8	155	183	136-195	8	148	182	130-183	74	147	269	129-427	8	158	182	137-185
	Natural	445	512	2	350	-	276-423	2	435	-	430-440	3	329	426	234-449	2	324	-	237-411
Milk R. at 501	Natural	510	882	7	530	1140	486-1900	7	456	490	423-492	8	419	546	309-603	10	436	595	252-600
U/S Milk River	Diversion	210	398	8	209	295	148-364	8	203	286	150-299	7	214	322	147-387	8	227	278	157-296
	Natural	570	674	2	407	-	248-566	2	470	-	470-470	3	341	510	306-552	2	394	-	350-437
HWY 880	Diversion	250	540	8	251	396	179-420	8	236	383	117-386	7	259	418	175-498	8	258	318	184-354
	Natural	727	936	2	601	-	342-859	2	664	-	599-728	4	473	660	447-729	2	527	-	504-549
Pinhorn	Diversion	250	540	8	273	421	189-428	8	246	416	188-423	7	266	457	196-523	8	277	333	200-392
	Natural	727	936	2	582	-	316-847	2	678	-	623-733	3	500	677	479-721	2	513	-	480-546

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**).

3.5.4 Nutrients

Total Phosphorus

In 2019, compliance with the WQO-50 and WQO-90 objectives for total phosphorus was the third lowest of the four monitoring years from 2016 to 2019. Total phosphorus concentrations were higher during natural flow compared to the diversion period. In general, total phosphorus in the Milk River tends to increase in the downstream direction during both natural and diversion flow.

During the diversion in 2019, median total phosphorus concentration ranged from a low of 0.013 mg/L at the North Fork at 501 site to 0.124 mg/L at the Pinhorn site (Table 12). During diversion, median total phosphorus concentration did not meet the WQO-50 objective at the Pinhorn site. In 2019, the WQO-90 for total phosphorus was not met at the HWY 880 site during the diversion period and the Pinhorn site was in the cautionary range (Table 10).

During natural flow, median total phosphorus ranged from 0.026 mg/L at the Milk River at 501 site to 0.194 mg/L at the HWY880 site (Table 12). During natural flow, the WQO-50 was not met at any Milk River site (Table 10). The WQO-90 for total phosphorus was met at the Milk River at 501 site during natural flow in 2019.

Total Dissolved Phosphorus

In 2019, compliance with the WQO-50 and WQO-90 objectives for total dissolved phosphorus was the second highest of the four monitoring years from 2016 to 2019. Total dissolved phosphorus concentrations were higher during natural flow compared to the diversion period.

In general, total dissolved phosphorus concentrations are similar at all Milk River sites with only a small increase in the downstream direction during diversion. During diversion, median total dissolved phosphorus concentration ranged from 0.002 mg/L at the Nork Fork at 501 site to 0.007 mg/L at the Pinhorn site (Table 11). During natural flow, median total dissolved phosphorus ranged from 0.006 mg/L at the Milk R. at 501 site to 0.121 mg/L at the HWY 880 site (Table 11).

In 2019, median total dissolved phosphorus concentrations did not met the WQO-50 objective at the Pinhorn site during the diversion period. Only the Milk River at 501 site met the WQO-50 for dissolved phosphorus during natural flow (Table 11). The total dissolved phosphorus WQO-90 was met at all sites in 2019 during diversion and at Milk River at 501 during natural flow (Table 11).

Table 10 - Summary of total phosphorus concentrations (mg/L) at the Milk River, 2016 to 2019.

Site	Flow Period	WQO		2016				2017				2018				2019			
		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	0.014	0.037	8	0.014	0.037	0.010-0.080	8	0.017	0.038	0.005-0.041	7	0.010	0.051	0.006-0.077	8	0.013	0.023	0.005-0.033
	Natural	0.012	0.100	2	0.008	-	0.006-0.010	2	0.010	-	0.004-0.015	3	0.081	0.367	0.004-0.438	2	0.036	-	0.032-0.041
Milk R. at 501	Natural	0.019	0.186	7	0.023	0.050	0.016-0.063	7	0.015	0.026	0.008-0.027	8	0.066	0.371	0.006-0.442	10	0.026	0.070	0.008-0.076
U/S Milk River	Diversion	0.044	0.148	8	0.049	0.108	0.028-0.169	8	0.062	0.101	0.014-0.139	7	0.059	0.107	0.012-0.120	8	0.045	0.149	0.014-0.170
	Natural	0.013	0.504	2	0.013	-	0.008-0.017	2	0.013	-	0.004-0.022	3	0.464	0.653	0.006-0.700	2	0.063	-	0.028-0.098
HWY 880	Diversion	0.088	0.220	8	0.071	0.145	0.019-0.254	7	0.064	0.155	0.015-0.194	7	0.090	0.194	0.350-0.260	8	0.075	0.285	0.034-0.570
	Natural	0.013	0.086	2	0.011	-	0.009-0.013	2	0.026	-	0.005-0.047	3	0.640	0.688	0.004-0.700	2	0.194	-	0.016-0.372
Pinhorn	Diversion	0.088	0.220	8	0.155	0.179	0.034-0.196	8	0.176	0.243	0.078-0.254	7	0.133	0.161	0.058-0.185	8	0.124	0.259	0.058-0.387
	Natural	0.013	0.086	2	0.030	-	0.024-0.036	2	0.043	-	0.010-0.076	3	0.437	0.911	0.009-1.030	2	0.137	-	0.025-0.249

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, 2016 to 2019.

Site	Flow Period	WQO		2016				2017				2018				2019			
		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	0.003	0.007	8	0.004	0.012	0.003-0.018	8	0.003	0.005	0.002-0.007	7	0.007	0.014	0.002-0.020	8	0.002	0.004	0.002-0.006
	Natural	0.005	0.066	2	0.003	-	0.003-0.003	2	0.004	-	0.002-0.007	3	0.056	0.155	0.002-0.180	2	0.016	-	0.010-0.022
Milk R. at 501	Natural	0.006	0.015	7	0.009	0.021	0.005-0.036	7	0.005	0.008	0.002-0.008	8	0.010	0.069	0.002-0.072	10	0.006	0.010	0.002-0.027
U/S Milk River	Diversion	0.003	0.010	8	0.006	0.012	0.003-0.013	8	0.003	0.005	0.002-0.007	7	0.002	0.010	0.002-0.010	8	0.003	0.005	0.002-0.005
	Natural	0.005	0.173	2	0.005	-	0.003-0.008	2	0.005	-	0.002-0.009	3	0.043	0.084	0.004-0.094	2	0.015	-	0.003-0.027
HWY 880	Diversion	0.004	0.011	8	0.004	0.010	0.003-0.011	7	0.003	0.006	0.002-0.530	7	0.004	0.014	0.002-0.020	8	0.004	0.007	0.002-0.007
	Natural	0.004	0.021	2	0.004	-	0.003-0.006	2	0.005	-	0.002-0.008	3	0.032	0.077	0.003-0.088	2	0.121	-	0.004-0.239
Pinhorn	Diversion	0.004	0.011	8	0.007	0.020	0.003-0.041	8	0.006	0.010	0.003-0.010	7	0.010	0.040	0.003-0.071	8	0.007	0.009	0.003-0.011
	Natural	0.004	0.021	2	0.005	-	0.003-0.007	2	0.010	-	0.010-0.010	3	0.028	0.042	0.003-0.045	2	0.023	-	0.003-0.044

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**).

Total Nitrogen

In 2019, compliance with the WQO-50 and WQO-90 objectives for total nitrogen was the third lowest of the four monitoring years from 2016 to 2019. In general, total nitrogen at the Milk River increases in concentration in the downstream direction.

During the diversion period in 2019, median total nitrogen concentration ranged from a low of 0.160 mg/L at the North Fork at 501 site to 0.448 mg/L at the Pinhorn site (Table 12). During diversion in 2019, total nitrogen concentrations met the WQO-50 objective at all sites except at the Pinhorn site. During the diversion period, total nitrogen concentration met the WQO-90 objective at the North Fork at 501 and Milk River at 501 sites and was in the cautionary range at the HWY 880 and Pinhorn sites (Table 12).

During natural flow, median total nitrogen ranged from 0.441 mg/L at the Milk R. at 501 site to 1.003 mg/L at the HWY 880 site (Table 12). During the natural flow period, total nitrogen concentration did not meet the WQO-50 objective at the HWY 880 or Pinhorn sites.

3.5.5 Total Suspended Solids

In 2019, compliance with the WQO-50 and WQO-90 objectives for TSS was the second lowest of the four monitoring years from 2016 to 2019.

During the diversion period, median total suspended solids concentrations ranged from 17 mg/L at the North Fork at 501 site to 197 mg/L at the Pinhorn site (Table 13). During the diversion period, the total suspended solids concentration did not meet the WQO-50 objective at the U/S Milk River and Pinhorn sites. During diversion the WQO-90 was met at all sites.

During natural flow, median total suspended solids ranged from 15 mg/L at the North Fork at 501 site to 191 mg/L at the HWY 880 site (Table 13). During natural flow, the WQO-50 objective was not met at any site (Table 13).

3.5.6 Fecal Coliform Bacteria

In 2019, compliance with the WQO-50 and WQO-90 objectives for fecal coliform bacteria was the highest of the four monitoring years from 2016 to 2019.

During the diversion period, median fecal coliform bacteria counts ranged from 28 cfu/100 mL at the North Fork at 501 site to 71 cfu/100 mL at the U/S Milk River site (Table 14). The median fecal coliform bacteria counts met the WQO-50 objective at all sites during the diversion period (Table 14). During the diversion period, the 90th percentile fecal coliform bacteria counts ranged from 46 cfu/100 mL at the N. Fork at 501 site to 469 cfu/100 mL at the U/S Milk River site. The WQO-90 was not met at the U/S Milk River site during the diversion period (Table 14) and the Pinhorn site was within the cautionary range.

During natural flow, median fecal coliform bacteria counts ranged from 1 cfu/100 mL at the Pinhorn site to 73 cfu/100 mL at the Milk River at 501 site. During natural flow, the WQO-50 was met at all sites (Table 14). During natural flow, the 90th percentile fecal coliform bacteria count was 720 cfu/100 mL at the Milk River at 501 site and within the cautionary range.

Table 12 - Summary of total nitrogen concentrations (mg/L) at Milk River, 2016 to 2019.

Site	Flow Period	WQO		2016				2017				2018				2019			
		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	0.134	0.191	0.125-0.345	8	0.126	0.264	0.026-0.295	7	0.143	0.456	0.097-0.643	8	0.160	0.224	0.110-0.232
	Natural	0.900	1.578	2	0.311	-	0.145-0.477	2	0.313	-	0.220-0.405	3	0.646	2.127	0.320-2.497	2	0.665	-	0.439-0.890
Milk R. at 501	Natural	0.600	1.360	7	0.405	0.695	0.295-1.070	7	0.330	0.390	0.260-0.390	8	0.516	1.355	0.110-1.826	10	0.441	0.629	0.320-0.976
U/S Milk River	Diversion	0.325	0.667	8	0.222	0.451	0.110-0.629	8	0.275	0.474	0.110-0.508	7	0.207	0.514	0.110-0.610	8	0.261	0.394	0.150-0.570
	Natural	0.680	1.637	2	0.275	-	0.125-0.425	2	0.250	-	0.160-0.340	3	1.500	1.709	0.240-1.761	2	0.610	-	0.320-0.899
HWY 880	Diversion	0.365	0.668	8	0.295	0.593	0.125-0.845	8	0.309	0.418	0.170-0.531	7	0.284	0.610	0.064-0.640	8	0.305	0.800	0.240-1.300
	Natural	0.320	1.400	2	0.301	-	0.154-0.448	2	0.335	-	0.200-0.470	3	1.700	2.430	0.112-2.612	2	1.003	-	0.230-1.776
Pinhorn	Diversion	0.365	0.668	8	0.385	0.615	0.125-0.670	8	0.470	0.527	0.240-0.550	7	0.380	0.954	0.220-1.750	8	0.448	0.770	0.152-1.172
	Natural	0.320	1.400	2	0.416	-	0.142-0.690	2	0.365	-	0.220-0.510	3	1.26	2.34	0.370-2.620	2	0.968	-	0.151-1.785

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, 2016 to 2019.

Site	Flow Period	WQO		2016				2017				2018				2019			
		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	12	45	2-99	8	20	40	4-50	7	8.3	68	2.9-120	8	17	34	5-51
	Natural	5	55	2	3	-	1.5-4.7	2	3	-	1-6	3	7.7	161	2.1-199	2	15	-	9-20
Milk R. at 501	Natural	14	247	7	11	47	7-84	7	11	22	6-33	8	69	469	0.5-560	10	28	69	4-160
U/S Milk River	Diversion	56	282	8	52	134	21-212	8	83	203	18-351	7	91.3	144	22-150	8	82	239	14-260
	Natural	7	267	2	2	-	1.5-1.5	2	7	-	1-13	3	486	737	1.3-800	2	90	-	54-125
HWY 880	Diversion	131	384	8	89	174	14-259	8	78	188	57-236	7	141	288	41-360	8	140	403	55-810
	Natural	13	228	2	5	-	3.3-6	2	24	-	10-38	3	630	696	2.7-712	2	191	-	14-368
Pinhorn	Diversion	131	384	8	169	193	23-202	8	194	272	7-313	7	190	528	75.7-994	8	197	386	101-608
	Natural	13	228	2	14	-	8.7-18.7	2	37	-	8-65	3	502	1908	3.7-2260	2	136	-	31-240

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 14 - Summary of fecal coliform bacteria counts (cfu/100 mL) at Milk River, 2016 to 2019.

Site	Flow Period	WQO		2016				2017				2018				2019			
		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	51	441	6-1100	8	30	168	6-283	7	46	109	9-180	8	28	46	1-69
	Natural	55	668	2	154	-	8-300	2	2	-	1-2	3	4	353	4-440	2	27	-	2-52
Milk R. at 501	Natural	77	619	7	122	2080	1-3400	7	44	2076	1-5000	8	86	841	7-1730	10	73	720	1-4500
U/S Milk River	Diversion	68	272	8	38	491	7-1300	8	53	191	1-191	7	56	121	13-164	8	71	469	2-490
	Natural	49	522	2	39	-	7-71	2	3	-	1-5	3	284	325	2-335	2	14	-	4-24
HWY 880	Diversion	78	280	8	43	530	1-600	8	69	272	6-530	7	36	134	26-171	8	51	161	4-240
	Natural	29	163	2	34	-	5-62	2	17	-	1-32	3	51	406	36-495	2	28	-	2-54
Pinhorn	Diversion	78	280	8	85	216	18-318	8	109	359	12-468	7	95	222	36-254	8	50	330	9-400
	Natural	29	163	2	47	-	37-56	2	18	-	9-27	3	70	90	1-95	2	1	-	1

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 2019 differed substantially across the Milk River watershed, ranging from 250.2 mm at Onefour to 362.9 mm at Cardston. June was the wettest month (mean = 78.2 mm) while October was the driest month (mean = 22.0 mm). At the three Milk River sites augmented by the St. Mary diversion, flow generally ranged from a median of 14.5 to 17.0 m^3/s during normal diversion operation and was reduced to a median of 0.4 to 2.5 m^3/s after diversion shut-down.

Red Creek

- Median dissolved oxygen concentrations complied with acute and chronic guidelines in 2019 at the Red Creek sites; however, an individual sample did not meet the chronic guideline at the upstream and middle site.
- All pH values met the aquatic life guidelines at the two Red Creek sites in 2019.
- The median conductivity (range: 2390 to 2690 µS/cm) did not meet safe irrigation guidelines at the two Red Creek sites in 2019 and would be considered unsuitable for irrigation.
- The median total phosphorus concentrations at the Red Creek upstream site (0.053 mg/L) was the second highest of the four monitoring years. The median total phosphorus concentration at the Red Creek middle site (0.075 mg/L) was the lowest of the four monitoring years.
- Median TSS concentrations (range: 9 to 12 mg/L) were low at Red Creek in 2019; although, the maximum TSS concentration at the upstream site (106 mg/L) was the highest of the four monitoring years. No TSS trends are apparent from 2016 to 2019.
- Median fecal coliform bacteria counts at Red Creek met the irrigation guideline at the two Red Creek sites in 2019. Median fecal coliform bacteria counts at the upstream and middle sites have met the irrigation guideline from 2016 to 2019, whereas the downstream site did not meet the irrigation guideline in two of three years (2016 to 2018).

Eastern Tributaries

- Median dissolved oxygen concentrations were compliant with acute and chronic guidelines in 2019 at the Eastern Tributaries; however, two samples did not meet the chronic guideline at Middle Creek.
- All pH values met the aquatic life guidelines at the Eastern tributaries in 2019.
- The median specific conductivity met safe irrigation guidelines (≤1000 µS/cm) at Battle, Middle and Lodge creeks; however, at Lodge Creek 2 of 6 samples (33%) were 'possibly safe' for irrigation (>1000 to ≤2000 µS/cm)
- In 2019, the median total phosphorus concentration at Battle Creek (0.012 mg/L) and Lodge Creek (0.030 mg/L) was the lowest of the four monitoring years. The median total phosphorus at Middle Creek (0.066 mg/L) was the second highest of the four years and was within the median range of the three previous years (0.048 to 0.123 mg/L).
- Median (range: 5 to 7 mg/L) and maximum TSS concentrations (12 to 28 mg/L) were low at the Eastern tributaries in 2019 and no TSS trends are apparent from 2016 to 2019.
- Median fecal coliform concentrations (range: 1 to 14 cfu/100 mL) were low at the Eastern tributaries in 2019 and median fecal coliform concentrations have also met the irrigation guideline from 2016 to 2018.

Ephemeral Tributaries

- A single sample was collected at each of Miners Coulee and Verdigris Coulee in 2019.
- The dissolved oxygen concentration was 8.12 mg/L at Miners Coulee in 2019. The dissolved oxygen concentration at Verdigris Coulee in 2019 was 8.41 mg/L. Both samples met the acute and chronic guidelines for protection of aquatic life.
- Both pH values met the aquatic life guidelines at Miners Coulee and Verdigris Coulee in 2019.
- At Miners Coulee and Verdigris Coulee, the two samples met the specific conductivity objective for safe irrigation.
- Total phosphorus concentrations at Miners Coulee and Verdigris Coulee in 2019 were 0.043 and 0.190 mg/L, respectively.
- The TSS concentrations in 2019 at Miners Coulee and Verdigris Coulee were 2.2 and 6.5 mg/L, respectively.
- The two samples at Miners Coulee and Verdigris Coulee in 2019 had fecal coliform counts of 173 and 220 cfu/100 mL, respectively, 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 2019 (i.e., WQO-50 [50th percentile or median] and WQO-90 [90th percentile]).
- Median pH and dissolved oxygen met aquatic life guidelines at all Milk River sites in 2019.
- Conductivity (salts) met the median WQO-50 and WQO-90 at all Milk River sites. The median conductivity also met the provincial guideline for safe irrigation at all Milk River sites in 2019.
- In 2019, compliance with total phosphorus objectives was the third lowest at the Milk River sites from 2016 to 2019. Median total phosphorus exceeded the WQO-50 at the Pinhorn site during diversion and at all sites during natural flow. The WQO-90 for total phosphorus was not met at the HWY 880 site during diversion and was in the cautionary range at the Pinhorn site.
- In 2019, compliance with total nitrogen objectives was the third lowest at the Milk River sites from 2016 to 2019. The Pinhorn site did not meet the total nitrogen WQO-50 during diversion, and during natural flow the HWY 880 and Pinhorn sites did not meet the WQO-50. During diversion, the HWY 880 and Pinhorn sites were in the cautionary range of the WQO-90 and during natural flow the Milk River at 501 site met the WQO-90.
- In 2019, compliance with TSS objectives was the second lowest at the Milk River sites from 2016 to 2019. During diversion, the WQO-50 was not met at the U/S Milk River or Pinhorn sites. Total suspended solids did not meet the WQO-50 during the natural flow period at any of the Milk River sites. The WQO-90 was met at all sites during the diversion and natural flow periods.
- In 2019, compliance with fecal coliform objectives was the highest at the Milk River sites from 2016 to 2019. During diversion and natural flow, the fecal coliform WQO-50 was met at all sites. Fecal coliform bacteria exceeded the WQO-90 during the diversion flow period at the U/S Milk River site and was within the cautionary range at the Pinhorn site. The Milk River at 501 site was in the cautionary range of the WQO-90 during natural flow.

5.0 RECOMMENDATIONS

Red Creek

- Historically, there have been landowner concerns regarding water quality at Red Creek. The main concerns are related to potential pesticide use and their impact on amphibians, as well as heavy metals (e.g., mercury, cadmium and lead) and their potential impact on livestock health.

Landowners have noted that they have not observed the same abundance of the Northern Leopard Frog (*Rana pipiens*) at the creek.

To support the Red Creek Watershed Group, a scoping study could be undertaken to better understand pesticides and heavy metals at Red Creek. Further, a better understanding of land use, occurrence of streambank erosion and riparian health could help to better interpret water quality results. There may be potential for source-tracking fecal coliform bacteria at Red Creek. Further discussions could be held with landowners who may observe changes in activity or land management in the area (e.g., livestock, wildlife).

Eastern Tributaries

- The water monitoring program at the Eastern Tributaries should continue to maintain an understanding of environmental condition at Battle, Middle and Lodge creeks for state of the watershed reporting. This monitoring would also support future stewardship work in this area of the watershed.
- Water Quality Objectives should be determined using the data collected by the Milk River Watershed Council Canada. Future water quality data should 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 site downstream of the Milk River wastewater treatment lagoons should be re-initiated.
- 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.
- Water withdrawals on the Milk River (South Fork) should be investigated to determine if the zero flow is natural or due to water withdrawal upstream of the Canadian border.

Shared Water Monitoring Program (MRWCC-AEP)

- In 2016, AEP initiated a monthly water monitoring program in the Milk River at the same sites that have been traditionally monitored by the MRWCC. From 2017 to 2019 the MRWCC worked with AEP to share field work (i.e., sample collection) where sites were duplicated to minimize redundancy and reduce overall program costs. While this collaboration is worthy, additional steps should be taken to strengthen the partnership:
    - AEP should review and provide results of the monthly data to MRWCC as soon as they become available. This would allow the MRWCC to compile and review the results in a timely way. Any concerns with the data may be identified and addressed before sample/data integrity is compromised.

6.0 LITERATURE CITED

Agroclimatic Information Service (ACIS). 2019. Current and Historical Alberta Weather Station Data Viewer. Alberta Agriculture and Food, Edmonton, AB. Website. (http://agriculture.alberta.ca/acis/alberta-weather-data-viewer.jsp)

Environment and Climate Change Canada. 2019. 2019 Streamflow Data for Stations 11AA001, 11AA005, 11AA025, and 11AA031. Raw data provided by National Hydrological Services: Engineering Services, Calgary, AB.

Government of Alberta (GoA). 2018. Environmental Quality Guidelines for Alberta Surface Waters. Water Policy Branch, Alberta Environment and Parks. Edmonton, Alberta

Palliser Environmental Services Ltd. 2015. Milk River Integrated Watershed Management Plan. Milk River Watershed Council Canada, Milk River, Alberta.

Palliser Environmental Services Ltd. 2017. Milk River Watershed Water Monitoring Report 2016. Prepared for the Milk River Watershed Council Canada, Milk River, Alberta. 23 pp.

Palliser Environmental Services Ltd. 2018. Milk River Watershed Water Monitoring Report 2017. Prepared for the Milk River Watershed Council Canada, Milk River, Alberta. 23 pp.

Palliser Environmental Services Ltd. 2019. Milk River Watershed Water Monitoring Report 2018. Prepared for the Milk River Watershed Council Canada, Milk River, Alberta. 26 pp.