MILK RIVER WATERSHED

WATER MONITORING REPORT 2018

Prepared for: Milk River Watershed Council Canada

Prepared by: Palliser Environmental Services Ltd.

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Cover Photo of the Milk River:

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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 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 2018, with reference to the results from the previous three years (i.e., 2015-2017). 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 (March, 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**. Samples were also collected in November and December at the HWY 880 site.

Milk River tributaries were also monitored in 2018. 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.

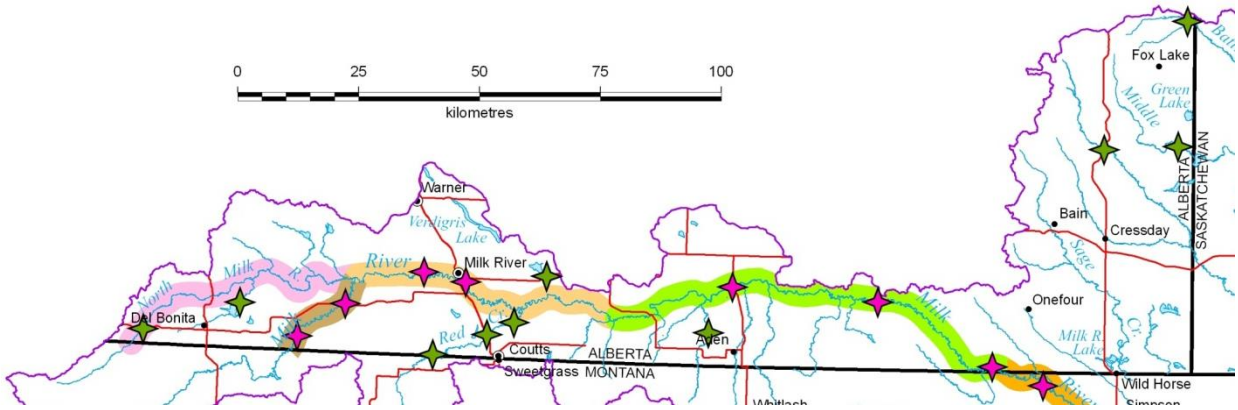


Figure 1 - Map showing water monitoring locations sampled in the Milk River watershed, 2018.

The MRWCC water monitoring program was conducted in collaboration with staff from Cardston County, County of Warner, County of Forty Mile, 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 2018 data set is the seventh year of data collected since the WQOs were established.

3.0 RESULTS

3.1 Precipitation

Overall, total precipitation in the Milk River watershed in 2018 differed substantially across the watershed, ranging from 154.0 mm at Onefour to 303.9 mm at Cardston (Tables 2, 3). June was generally the wettest month (mean= 58.6 mm) while August was the driest month (mean= 19.8 mm) (Table 1).

Table 1 – Total precipitation (mm) at five weather stations for the water monitoring April to October, 2018.

Month	Cardston	Del Bonita	Milk River	Masinasin	Onefour
April	36.4	28.8	21.7	16.6	11.8
May	42.5	32.7	50.0	41.0	40.0
June	47.3	89.4	56.0	47.3	52.8
July	63.8	20.5	11.8	25.5	7.3
August	46.9	29.4	30.7	16.0	9.5
September	28.0	20.5	11.7	16.7	22.0
October	39.0	30.6	13.5	16.9	10.6
Total	**303.9**	**251.9**	**195.4**	**180.0**	**154.0**
Data Source: Environment Canada - http://climate.weather.gc.ca/index_e.html					

Comparing mean total precipitation for each year, 2018 was the third driest of the seven years reported (mean: 217.0 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).

[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 2018.

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

3.2 Red Creek

3.2.1 General Water Chemistry

At Red Creek in 2018, the median water temperature at the upstream (13°C) and downstream (15°C) sites were within the median ranges from 2015 to 2017 (11.6 to 14°C and 13.1 to 17.0°C), respectively. The median water temperature at the middle site (15.4°C) was slightly warmer than the median range from 2015 to 2017 (10.7 to 14.3°C) (Table 3). Maximum water temperatures at the three Red Creek sites occurred in June and July.

The median dissolved oxygen concentrations (range: 8.00 to 10.64 mg/L) met the acute (≥5.0 mg/L) and chronic (≥6.5 mg/L) guidelines at the three Red Creek sites in 2018. At the middle site, a sample on August 23rd (4.07 mg/L) did not meet the acute or chronic guideline. The acute and chronic guideline was met for all samples at the upstream and downstream sites (Table 4). From 2015 through 2018, all samples at the downstream site have met the acute and chronic guidelines. The compliance rate for the acute and chronic guideline is high (100%) and stable at the downstream site (Table 4), whereas the other sites do not show a compliance trend.

The median pH (median range: 8.17 to 8.49) and all individual samples (range: 7.99 to 8.64) collected at three Red Creek sites in 2018 met the pH guideline of 6.5 to 9.0 for aquatic life (Table 3). From 2015 to 2017, the median pH and all individual pH samples at the Red Creek three sites met the pH guideline.

Median specific conductivity was 2345 µS/cm at the upstream site, 2115 µS/cm at the middle site and 2489 µS/cm at the downstream site in 2018 (Table 3). The median specific conductivity at the three Red Creek sites exceeded the safe irrigation guideline (≤1000 µS/cm) would be considered unsuitable for irrigation (≥2000 µS/cm) (GoA 2018).

3.2.2 Nutrients

In 2018, median total phosphorus concentration was lowest at the downstream site (0.026 mg/L) and highest at the middle site (0.177 mg/L) (Table 3). The maximum total phosphorus concentrations at the three sites occurred between April 12 and May 1. The months of May and June were the wettest months (50.0 and 56.0 mm, respectively) at Red Creek based on the nearest weather station at Milk River (Table 1). Higher precipitation may have resulted in increased runoff containing phosphorus.

Similarly, median total dissolved phosphorus was lowest at the downstream site (0.020 mg/L) and highest at the middle site (0.081 mg/L). In 2018, an average of 60% of the total phosphorus at the three sites was present in the dissolved form. From 2015 to 2018, the median total phosphorus at the Red Creek middle site has been 1.5 to 7 times higher than the upstream and downstream sites.

In 2018 at Red Creek, median total nitrogen concentration was lowest at the downstream site (1.050 mg/L) and highest at the upstream site (1.957 mg/L) (Table 3). In 2018 at the three Red Creek sites, most of the total nitrogen was present in the organic (TKN) form (77%) with a smaller percentage (23%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen) (Table 3).

3.2.3 Total Suspended Solids

In 2018 at Red Creek, the downstream site had the lowest median total suspended solids concentration (1.6 mg/L) compared to the upstream (9.15 mg/L) and middle (14.0 mg/L) sites (Table 3); although, the highest TSS in a sample was recorded at the downstream site (135 mg/L on April 12). The median TSS at the middle site was the highest of the four years (2015 to 2018) while the median TSS at the downstream site was the lowest of the four years. The maximum total suspended solids concentrations at Red Creek typically occurred during the April and May sampling which was likely the result of increased stream flows (i.e., increased bank erosion) from higher precipitation and/or snow melt runoff.

3.2.4 Fecal Coliform Bacteria

The median fecal coliform bacteria count at Red Creek was highest at the downstream site (100 cfu/100 mL), compared to the middle site (57 cfu/100 mL) and upstream site (61 mg/L) (Table 3) in 2018. The median fecal coliform bacteria count at the three Red Creek sites (57 to 100 cfu/100 mL) met the provincial guideline for irrigation (100 cfu/100 mL) (GoA 2018). The median and range of fecal coliform bacteria counts in 2018 at the three Red Creek sites were within the range of fecal coliform counts from 2015 to 2017. 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, 2015-2018.

Parameter	Upstream				Middle				Downstream			
	2015	2016	2017	2018	2015	2016	2017	2018	2015	2016	2017	2018
Water Temperature, °C	11.6 6.9-23.6	14.2 3.0-20.6	14.0 8.0-21.0	13.0 0.2-20.9	13.6 8.5-23	10.7 8.6-19.5	14.3 7.1-21.4	15.4 0.1-18.9	13.1 8.5-30.0	9.8 8.7-17.1	17.0 8.9-21.6	15.0 0.1-22.1
Dissolved Oxygen, mg/L	9.50 6.61-12.24	10.06 4.35-13.53	7.98 4.51-12.41	9.09 5.68-12.62	8.63 5.60-11.90	8.85 2.55-14.33	9.19 8.39-11.87	8.00 4.07-10.92	11.46 6.84-18.3	10.22 10.16-11.84	10.75 9.50-13.47	10.64 10.18-11.58
pH	8.28 7.95-8.37	8.15 7.69-8.58	8.24 7.98-8.34	8.44 7.99-8.55	8.39 7.89-8.67	8.45 7.98-8.92	8.42 8.18-8.61	8.49 8.12-8.64	8.41 8.33-8.52	8.39 8.29-8.43	8.35 7.97-8.50	8.17 8.06-8.56
Specific Conductivity, µS/cm	2350 2030-2700	2610 2290-2790	2540 2130-2690	2345 506 to 2796	2335 2040-3020	2870 2420-3450	2560 1610-3080	2115 426-2440	2665 2440-2890	2615 2500-2880	2630 1530-2920	2489 510-2796
Total Phosphorus, mg/L	0.035 0.025-0.053	0.023 0.015-0.047	0.045 0.025-0.615	0.081 0.012-0.488	0.077 0.063-0.111	0.080 0.041-0.097	0.098 0.045-0.341	0.177 0.056-0.362	0.051 0.036-0.070	0.030 0.021-0.041	0.036 0.019-0.180	0.026 0.009-0.400
Total Dissolved Phosphorus, mg/L	0.017 0.010-0.031	0.016 0.012-0.033	0.021 0.008-0.447	0.067 0.003-0.413	0.038 0.021-0.053	0.047 0.026-0.077	0.047 0.024-0.310	0.081 0.036-0.174	0.019 0.012-0.031	0.018 0.014-0.029	0.019 0.007-0.160	0.020 0.003-0.320
Nitrate+Nitrite Nitrogen, mg/L	0.185 0.050-1.430	0.055 0.025-1.850	0.250 0.005-1.600	0.482 0.050-4.19	0.050 0.010-0.280	0.055 0.055-0.140	0.050 0.050-0.050	0.053 0.050-0.495	0.135 0.050-0.320	0.103 0.055-0.170	0.050 0.002-0.050	0.039 0.025-0.850
Total Kjeldahl Nitrogen, mg/L	0.850 0.100-1.100	0.925 0.580-1.100	1.000 0.840-2.120	1.330 0.730-1.680	0.880 0.310-1.530	1.270 0.790-1.950	1.280 1.080-1.890	1.180 0.600-1.580	0.815 0.520-2.760	0.730 0.590-0.960	1.020 0.510-1.300	0.820 0.250-1.400
Total Nitrogen, mg/L	0.985 0.380-2.390	1.100 0.635-2.810	1.810 0.850-2.540	1.957 0.850-5.740	0.930 0.320-1.580	1.325 0.845-2.005	1.330 1.130-1.940	1.275 0.650-1.815	1.015 0.640-2.930	0.823 0.685-1.110	1.070 0.510-1.300	1.050 0.640-2.040
Total Suspended Solids, mg/L	4 2-6	2 2-8	12 4-61	9.15 1.5-33.3	7 3-11	4 2-13	12 6-26	14.0 3.7-91.3	17 5-42	6 2-10	4 1-9	1.60 0.5-135
Fecal Coliform Bacteria, cfu/100 mL	122 1-900	47 1-8900	19 1-400	61 1-204	49 1-192	21 0.5-1300	87 1-600	57 1-83	315 9-6000	215 2-700	118 1-700	100 6-3600

Table 4 - Summary of Red Creek water quality compliance with dissolved oxygen acute and chronic guidelines, 2015-2018 (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
Trend	-	-	-	-	Stable	Stable

3.3 Eastern Tributaries

3.3.1 General Water Chemistry

Battle Creek – The median water temperature at Battle Creek was 11.4°C in 2018, and was higher than 2015 to 2017 (median range: 8.1 to 8.9°C) (Table 5). The maximum water temperature reached 19.1°C on July 19. Dissolved oxygen concentrations met the chronic (>6.5 mg/L) and acute (>5.0 mg/L) guidelines throughout 2018 with all concentrations greater than 7.25 mg/L and a median of 8.78 mg/L. Similarly, all pH values met the aquatic life guideline in 2018 (≥6.5 and ≤9.0). Median specific conductivity was 382 µS/cm and all samples were well below the safe irrigation guideline (≤1000 µS/cm) and all of the individual samples (N=9) were less than 1000 µS/cm.

Middle Creek – The median water temperature at Middle Creek was 15.0°C in 2018, and was similar to 2015 to 2017 (median range: 13.2 to 15.3°C) (Table 5). The maximum water temperature reached 20.9°C on July 19. The median dissolved oxygen concentration (7.51 mg/L) met the acute and chronic guideline with oxygen concentrations ranging from 5.60 to 10.08 mg/L. Only 1 of 9 samples (11%) did not meet the chronic (>6.5 mg/L) guideline. All pH results met the aquatic life guideline in 2018 (≥6.5 and ≤9.0). The median specific conductivity (599 µS/cm) met the guideline for safe irrigation (≤1000 µS/cm) and all of the individual samples (N=9) were less than 1000 µS/cm.

Lodge Creek – The median water temperature at Lodge Creek was 14.6°C in 2018, and was similar to 2015 to 2017 (median range: 12.6 to 14.8°C) (Table 5). Dissolved oxygen concentrations met the chronic (>6.5 mg/L) and acute (>5.0 mg/L) guidelines throughout 2018 with all concentrations greater than 8.23 mg/L with a median of 9.30 mg/L. Similarly, all pH values met the aquatic life guideline in 2018 (≥6.5 and ≤9.0) with a median of 8.44. The median specific conductivity (1160 µS/cm) did not meet the guideline for safe irrigation (≤1000 µS/cm) and was in the cautionary range of the guideline (>1000 to < 2000 µS/cm: possibly safe[3]) (GoA 2018). Two (2) of 6 samples (33%) were <1000 µS/cm, and 4 of 6 samples (66%) were possibly safe for irrigation (>1000 to < 2000 µS/cm). The median specific conductivity at Lodge Creek had shown a decreasing trend from 2015 (1270 µS/cm) to 2017 (825 µS/cm) but increased to 1160 µS/cm in 2018.

3.3.2 Nutrients

Battle Creek – Median total phosphorus concentration was 0.024 mg/L in 2018, and was higher than 2015 to 2017 (median range: 0.017 to 0.020 mg/L) (Table 5). Total dissolved phosphorus concentration in 2018 was 0.010 mg/L, and was similar to 2015 to 2017 (median range: 0.010 to 0.015 mg/L). Fifty-two percent (52%) of the total phosphorus was present in the dissolved form. Median total nitrogen in 2018 (0.110 mg/L) was similar to 2015 and 2017 (0.110 and 0.110 mg/L, respectively), but lower than 2016 (0.168 mg/L). No total nitrogen trends were observed (Table 5). In 2018 at Battle Creek, most of the total nitrogen was present in the organic (TKN) form (91%) with a small percentage (9%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen). Median nitrate+nitrite nitrogen in 2018 (0.010 mg/L) was similar to 2015 and 2017 (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 2018 (0.048 mg/L) was similar to 2017 (0.048 mg/L) but lower than 2015 and 2016 (median range: 0.104 and 0.123 mg/L) (Table 5). Median total

[3] Saline-sodic irrigation water in the possibly safe range (>1000 to < 2000 µS/cm) may negatively affect structural stability of the soil and an irrigation specialist should be consulted (GoA 2018).

dissolved phosphorus concentration in 2018 was 0.046 mg/L and similar to 2017 (0.032 mg/L) but lower than 2015 and 2016 (median range: 0.103 and 0.095 mg/L). In 2018, 77% of the total phosphorus was present in the dissolved form. Median total nitrogen in 2018 (0.880 mg/L) was higher than 2015 to 2017 (median range: 0.480 to 0.605 mg/L) and no trend was observed (Table 5). The higher median total nitrogen in 2018 was partly due to the July 19 sample which had a very high total Kjeldahl nitrogen concentration of 14.1 mg/L. In 2018 at Middle Creek, most of the total nitrogen was present in the organic (TKN) form (98%) with a much smaller percentage (2%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen) (Table 5). Median nitrate+nitrite nitrogen in 2018 (0.010 mg/L) was similar to 2015 and 2017 (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 2018 (0.052 mg/L) was similar and within the range of the three previous monitoring years (median range: 0.049 to 0.067 mg/L) (Table 6). Total dissolved phosphorus concentration in 2018 (0.034 mg/L) was within the range of the three previous monitoring years (median range: 0.022 to 0.050 mg/L). In 2018, 58% of total phosphorus was present in the dissolved form. Median total nitrogen in 2018 (0.570 mg/L) was within the range of the three previous years (median range: 0.465 to 0.580 mg/L) and no trend was observed (Table 6). In 2018 at Lodge Creek, most of the total nitrogen was present in the organic (TKN) form (93%) with a smaller percentage (7%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen) (Table 6). Median nitrate+nitrite nitrogen in 2018 (0.050 mg/L) was higher than the three previous monitoring years (median range: 0.010 to 0.025 mg/L) and no trend was observed.

3.3.3 Total Suspended Solids

Battle Creek – The median total suspended solid concentration in 2018 (11.0 mg/L) was similar to 2017 (9 mg/L) and higher than 2015 and 2016 (2 and 5 mg/L) (Table 5). The maximum TSS from 2015 to 2018 followed a similar pattern as median TSS (i.e., similar in 2017 and 2018 but higher than 2015 and 2016) (Table 5). No trend in total suspended solids concentration was observed at Battle Creek from 2015 to 2018.

Middle Creek – The median total suspended solid concentration in 2018 (9.3 mg/L) was higher than 2015 to 2017 (2 to 4 mg/L) (Table 5). No trend in total suspended solids concentration was observed at Middle Creek from 2015 to 2018.

Lodge Creek – The median total suspended solid concentration in 2018 (12 mg/L) was higher than 2016 and 2017 (7 and 3 mg/L) but lower than 2015 (43 mg/L) (Table 5). No trend in total suspended solids concentration was observed at Lodge Creek from 2015 to 2018.

3.3.4 Fecal Coliform Bacteria

Battle Creek – The median fecal coliform bacteria count in 2018 (18 cfu/100 mL) was similar to 2015 to 2017 (median range: 23 to 26 cfu/100 mL) (Table 5). The median fecal bacteria count at Battle Creek has met the irrigation guideline (100 cfu/100 mL) from 2015 to 2018. In 2018, 3 of the 9 individual samples exceeded 100 cfu/100 mL. No trend in fecal coliform bacteria counts was observed from 2015 to 2018 with median counts remaining low.

Middle Creek – The median fecal coliform count in 2018 (50 cfu/100 mL) was higher than 2015 to 2017 (3 to 7 cfu/100 mL, Table 5). The median fecal bacteria count at Middle Creek has met the irrigation guideline (100 cfu/100 mL) from 2015 to 2018. From 2015 to 2017, no individual sample exceeded the

irrigation guideline; however, 2 of 9 samples exceeded the irrigation guideline in 2018. No trend in fecal coliform bacteria counts was observed from 2015 to 2018.

Lodge Creek – The median fecal coliform count in 2018 (12 cfu/100 mL) was slightly higher compared to 2016 and 2017 (3 and 7 cfu/100 mL) but lower compared to 2015 (43 cfu/100 mL) (Table 5). Similarly, the maximum fecal bacteria count in 2018 (218 cfu/100 mL) was higher compared to 2016 and 2017 (18 and 96 cfu/100 mL) but lower than 2015 (800 cfu/100 mL). The median fecal bacteria count at Lodge Creek has met the irrigation guideline (100 cfu/100 mL) from 2015 to 2018. In 2016 and 2017, no individual sample exceeded the irrigation guideline. No trend in fecal coliform bacteria counts was observed from 2015 to 2018.

Table 5 - Median and range for water quality parameters at the Eastern Tributaries (Battle Creek, Middle Creek and Lodge Creek), 2015-2018.

Parameter	Battle Creek				Middle Creek				Lodge Creek			
	2015	2016	2017	2018	2015	2016	2017	2018	2015	2016	2017	2018
Water Temperature, °C	8.9 1.3-16.4	8.1 0.7-14.6	8.6 3.3-15.0	11.4 2.4-19.1	15.3 5.7-21.2	15.0 4.5-21.8	13.2 6.7-21.5	15.0 5.3-20.9	14.8 5.8-21.7	14.2 1.6-22.6	12.6 6.5-20.0	14.6 6.7-19.3
Dissolved Oxygen, mg/L	10.23 8.53-12.08	10.49 8.49-12.03	10.24 8.81-11.72	8.78 7.25-10.93	12.10 9.42-14.39	10.57 5.60-14.30	9.81 5.17-13.19	7.51 5.60-10.08	11.77 10.37-15.90	12.22 10.18-14.02	10.67 10.30-10.96	9.30 8.23-9.93
pH	8.37 8.06-8.53	8.23 7.94-8.44	8.38 8.17-8.49	8.33 8.22-8.55	8.41 7.94-8.69	8.28 8.01-8.52	8.41 8.00-8.67	8.45 8.01-8.57	8.41 8.30-8.54	8.39 7.93-8.89	8.37 8.21-8.42	8.44 8.23-8.57
Specific Conductivity, µS/cm	376 199-392	391 353-425	381 338-399	382 297-415	694 549-745	699 584-828	618 519-897	599 302-712	1270 941-1540	965 645-1290	825 570-1170	1160 499-1240
Total Phosphorus, mg/L	0.018 0.014-0.023	0.020 0.013-0.036	0.017 0.010-0.034	0.024 0.086-0.470	0.104 0.013-0.327	0.123 0.027-0.256	0.048 0.023-0.122	0.048 0.022-0.249	0.049 0.040-0.084	0.067 0.026-0.210	0.053 0.028-0.103	0.052 0.022-0.160
Total Dissolved Phosphorus, mg/L	0.010 0.006-0.016	0.015 0.009-0.025	0.011 0.009-0.017	0.010 0.003-0.027	0.103 0.064-0.230	0.095 0.024-0.198	0.032 0.010-0.105	0.046 0.015-0.170	0.022 0.006-0.048	0.050 0.015-0.165	0.044 0.019-0.075	0.034 0.010-0.022
Nitrate+Nitrite Nitrogen, mg/L	0.010 0.010-0.240	0.025 0.025-0.110	0.010 0.010-0.010	0.010 0.003-0.760	0.010 0.010-0.010	0.025 0.025-0.025	0.010 0.010-0.010	0.010 0.003-0.093	0.010 0.010-0.050	0.025 0.025-0.100	0.010 0.010-0.050	0.050 0.010-0.055
Total Kjeldahl Nitrogen, mg/L	0.100 0.100-0.100	0.100 0.100-0.400	0.100 0.100-0.270	0.100 0.100-0.390	0.470 0.100-1.460	0.580 0.340-0.780	0.585 0.420-0.810	0.870 0.340-14.10	0.455 0.250-0.740	0.525 0.067-1.060	0.490 0.470-0.720	0.560 0.340-0.920
Total Nitrogen, mg/L	0.110 0.110-0.340	0.168 0.125-0.425	0.110 0.110-0.280	0.110 0.103-0.466	0.480 0.110-1.470	0.605 0.365-0.805	0.595 0.430-0.820	0.880 0.350-14.19	0.465 0.260-0.790	0.580 0.092-1.085	0.520 0.480-0.730	0.570 0.390-0.975
Total Suspended Solids, mg/L	2 2-17	5 2-10	9 2-33	11.0 1.5-26.0	4 2-14	2 2-7	2 2-10	9.3 1.5-54.3	6 3-23	3 2-17	7 4-9	4.0 1.5-33.0
Fecal Coliform Bacteria (cfu/100 mL)	26 1-390	23 1-102	24 1-159	18 1-189	6 1-51	3 1-12	7 1-73	50 1-300	43 6-800	7 1-96	3 2-18	12 4-218

3.4 Ephemeral Tributaries

Miners Coulee contributed minor flow to the Milk River in 2018. During eight site visits between March 20 and October 29, flowing water was only observed on April 23 and May 22. Verdigris Coulee contributed some flow to the Milk River in 2018. During eight site visits between March 20 and October 29, flowing water 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 5.22 and 10.78 mg/L at Miners Coulee in 2018. The May 22 oxygen concentration (5.22 mg/L) did not meet the chronic (>6.5 mg/L) guideline. Both pH values met the aquatic life guideline in 2018 (≥6.5 and ≤9.0) (Table 6). Specific conductivity at Miners Coulee in 2018 was 583 and 905 µS/cm and met the safe irrigation guideline (≤1000 µS/cm).

Verdigris Coulee – The median water temperature at Verdigris Coulee was 16.4^{o}C in 2018, and ranged between 1.47 and 17.9^{o}C (Table 6). The median dissolved oxygen concentration (4.57 mg/L) did not meet the acute and chronic guideline with oxygen concentrations ranging from 2.14 to 11.06 mg/L. Three of the 4 samples (75%) did not meet the chronic or acute guidelines. All pH results met the aquatic life guideline in 2018 (≥6.5 and ≤9.0). The median specific conductivity (2562 µS/cm) did not meet the guideline for safe irrigation (≤1000 µS/cm) or possibly safe irrigation (>1000 to < 2000 µS/cm) and was considered unsuitable for irrigation (≥2000 µS/cm) (GoA 2018). Two (2) of the 4 individual samples were considered unsuitable for irrigation and one sample was considered possibly safe for irrigation (GoA 2018). The April 23 sample had a low conductivity (83 µS/cm); however, sample observations indicate the environmental technician re-checked the result and the water quality meter provided conductivity results within expected ranges at other sites on the same date.

3.4.2 Nutrients

Miners Coulee – Total phosphorus concentrations at Miners Coulee in 2018 were 0.096 and 0.160 mg/L (Table 6). Total dissolved phosphorus concentrations in 2018 were 0.082 and 0.150 mg/L. Median total nitrogen in 2018 was similar at 0.900 and 0.920 mg/L (Table 6). In 2018 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). Median nitrate+nitrite nitrogen concentrations in 2018 were low at <0.0042 and 0.0079 mg/L (Table 6)

Verdigris Coulee – The median total phosphorus concentration in 2018 at Verdigris Coulee was 0.109 mg/L with a range of 0.044 to 0.350 mg/L (Table 6). The median total dissolved phosphorus concentration was 0.054 mg/L and approximately 50% of total phosphorus was present in the dissolved form. The median total nitrogen was 1.93 mg/L and 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) (Table 6). Median nitrate+nitrite nitrogen in 2018 was 0.007 mg/L at Verdigris Coulee.

3.4.3 Total Suspended Solids

Miners Coulee – The total suspended solid concentration in 2018 at Miners Coulee was < 1 mg/L for both samples (Table 6).

Verdigris Coulee – The median total suspended solid concentration in 2018 at Verdigris Coulee was 9.65 mg/L and ranged from 1.3 to 45 mg/L (Table 6). The highest TSS (45 mg/L) occurred on April 23 during spring melt and runoff.

3.4.4 Fecal Coliform Bacteria

Miners Coulee – The fecal coliform bacteria count in 2018 at Miners Coulee was 20 and 310 cfu/100 mL (Table 6). The fecal bacteria count on May 22 did not meet the irrigation guideline (100 cfu/100 mL).

Verdigris Coulee – The median fecal coliform count in 2018 (360 cfu/100 mL) at Verdigris Coulee did not meet the irrigation guideline (100 cfu/100 mL) (Table 6). In 2018, 3 of 4 samples exceeded the irrigation guideline.

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

Parameter	Miners Coulee (N=2)	Verdigris Coulee (N=4)
Water Temperature, °C	7.05 - 15.7	16.4 1.47 - 17.9
Dissolved Oxygen, mg/L	5.22 - 10.78	4.57 2.14 - 11.06
pH	7.90 - 8.13	8.42 7.53 - 9.29
Specific Conductivity, µS/cm	583 - 905	2562 83 - 4414
Total Phosphorus, mg/L	0.096 - 0.160	0.109 0.044 - 0.350
Total Dissolved Phosphorus, mg/L	0.082 - 0.150	0.054 0.031 - 0.280
Nitrate+Nitrite Nitrogen, mg/L	<0.004 - 0.008	0.007 <0.004 - 0.024
Total Kjeldahl Nitrogen, mg/L	0.900 - 0.910	1.93 0.340 - 3.8
Total Nitrogen, mg/L	0.900 - 0.920	1.93 0.370 - 3.8
Total Suspended Solids, mg/L	<1	9.65 1.3 - 45
Fecal Coliform Bacteria (cfu/100 mL)	20 - 310	360 1 - 900

3.5 Milk River

3.5.1 St. Mary/Milk River Diversion Operation

The St. Mary/Milk River Diversion was initiated on May 9 and was shut down on September 28, 2018. The initial flows on May 9 were 1.4 m^3/s (50 ft^3/s), increasing to 1.8 m^3/s (65 ft^3/s) on May 11 and 4.2 m^3/s (150 ft^3/s) on May 15. Diversion was further increased to 7.1 m^3/s (250 ft^3/s) on May 16 and 9.9 m^3/s (350 ft^3/s) on May 17. Diversion was further increased to 12.7 m^3/s (450 ft^3/s) on May 18 and 17.0 m^3/s (600 ft^3/s) on May 26. The diversion was steady at approximately 17.0 m^3/s (600 ft^3/s) until August 3 when the diversion was reduced to 16.7 m^3/s (590 ft^3/s). Diversion was reduced to 14.4 m^3/s (510 ft^3/s) on September 2 and again on September 19 to 12.7 m^3/s (450 ft^3/s). The diversion was further reduced to 11.3 m^3/s (400 ft^3/s) on September 21, reduced on September 24 to 7.8 m^3/s (275 ft^3/s) and again reduced to 5.0 m^3/s (175 ft^3/s) on September 25. Diversion flows were ramped down beginning September 25 and ended September 28 (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.

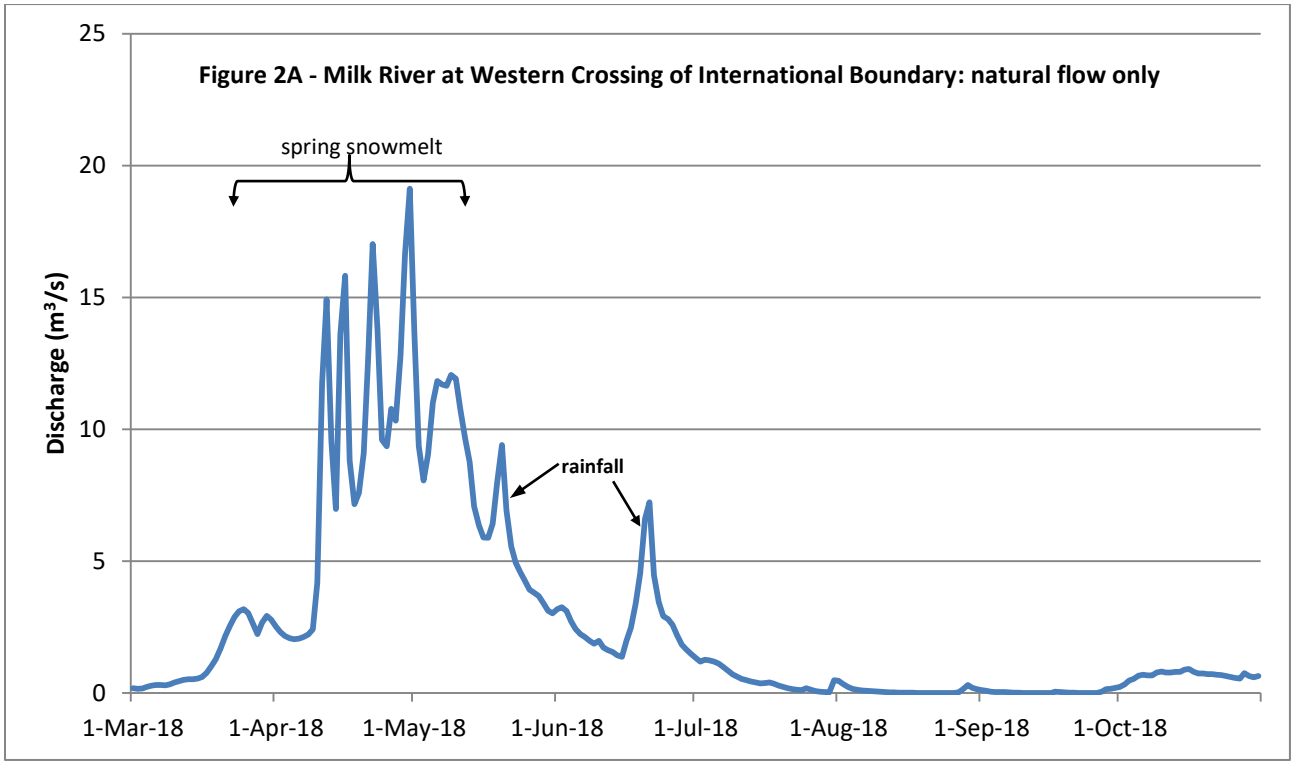
Year	Start Date	End Date
2006	March 05	September 24
2007	March 07	September 03
2008	March 17	September 12
2009	March 16	September 24
2010	March 21	September 03
2011	July 24	October 06
2012	April 9	September 15
2013	March 11	September 24
2014	May 13	September 10
2015[a]	March 31	August 28
2016	March 22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

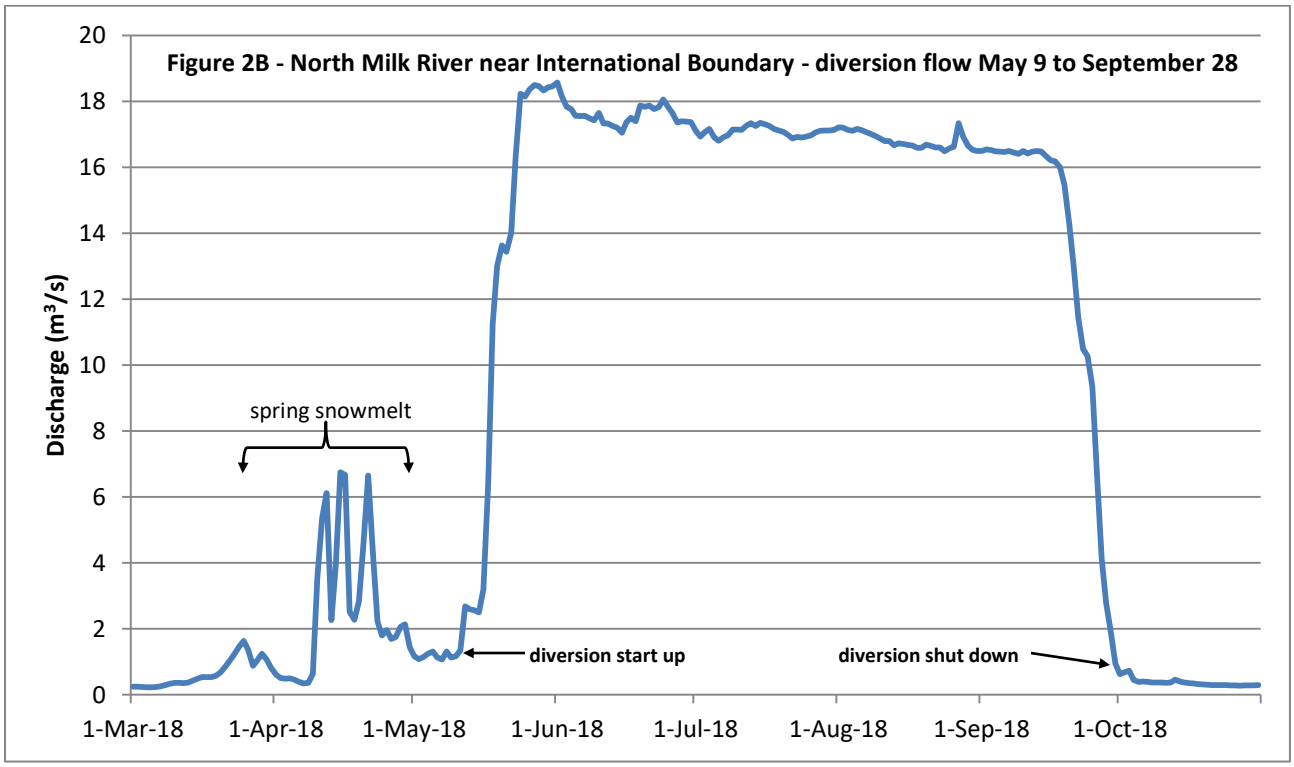
[a]Start-up was March 31 with 1.4 m^3/s (50 cfs) ramped over a week to 5.0 m^3/s (175 cfs), it was increased to 8.5 m^3/s (300 cfs) on May 4.

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

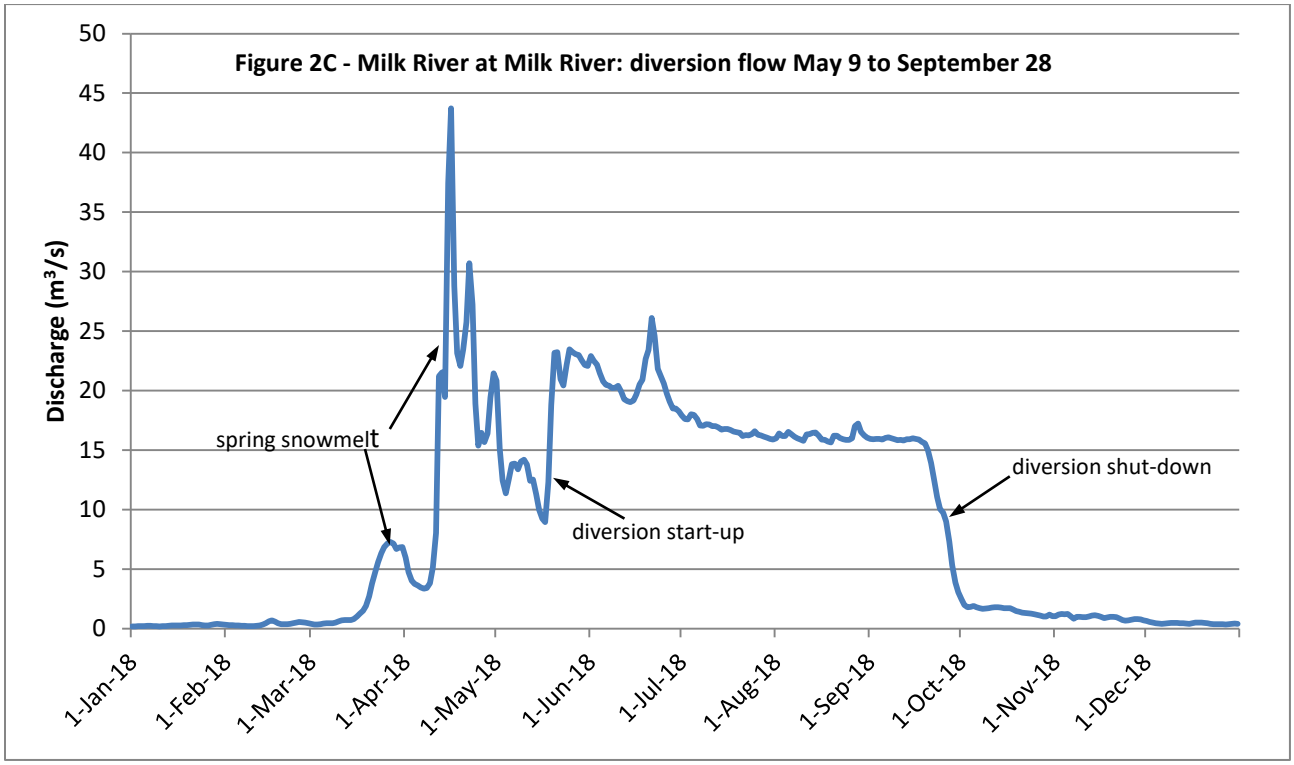
3.5.2 Streamflow

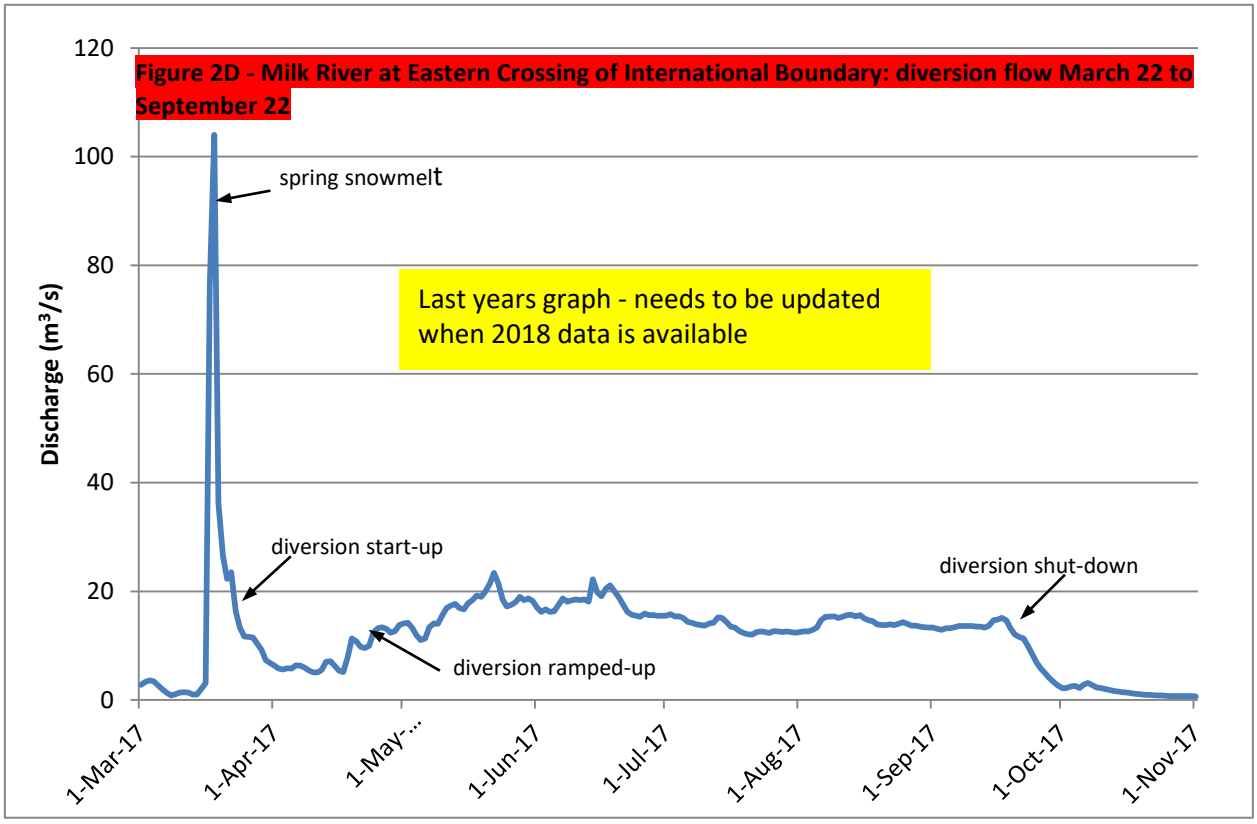
Mean daily streamflow data for 2018 is shown in Figures 2A to 2D at four Milk River sites (at Western Boundary, at North Milk River, at Milk River, and at Eastern Boundary). At 'Milk River at Western Crossing of International Boundary', the peak discharge occurred from April 11 to May 11 when flows ranged from 10.8 to 19.1 m^3/s during snowmelt and runoff (Figure 2A). From July 27 to September 27, the recorded daily average flow was typically less than 0.100 m^3/s, with no flow recorded on September 24. Streamflow at the Milk River at Western Boundary site is not augmented by the St. Mary diversion; therefore, flows are always natural. No samples were collected at the Milk River at 501 site in August or September 2018 due to an absence of visible flow (Figure 2A).





Figures 2A to 2D – Discharge data (m^3/s) at four Milk River sites during 2018. Raw data from Environment and Climate Change Canada (2018).





Figures 2A to 2D – cont'd

At 'North Milk River near International Boundary', the discharge during spring snowmelt from March 22 to April 22 ranged from 0.34 to 6.7 m^3/s (Figure 2B). The discharge at the North Milk River ranged between 1.13 and 18.57 m^3/s (median: 16.9 m^3/s) during diversion from May 9 to September 28. Peak discharge occurred between May 24 and June 2 when flows were greater than 18.0 m^3/s. Natural flows after September 28 (diversion shut-down) ranged from 0.28 to 1.9 m^3/s (Figure 2B).

At 'Milk River at Milk River', the discharge during spring snowmelt from March 16 to May 1 ranged from 1.03 to 20.8 m^3/s (Figure 2C). The discharge at Milk River ranged between 5.3 and 26.1 m^3/s (median: 16.3 m^3/s) during diversion from May 9 to September 28. Peak discharge occurred between May 19 and June 25 when flows were typically >20 m^3/s (maximum flow: 26.1 m^3/s). Natural flows after September 28 (diversion shut-down) to December 31st ranged from 0.37 to 3.08 m^3/s (Figure 2C).

At 'Milk River at Eastern Crossing of International Boundary', the discharge during spring snowmelt from March 15 to March 31 ranged from 2.02 to 104 m^3/s (Figure 2D). The discharge ranged between 5.07 and 23.5 m^3/s during diversion from March 22 to September 22. Peak discharge occurred between May 4 and September 15 when flows ranged between 14.2 and 21.4 m^3/s. Natural flows after September 22 (diversion shut-down) ranged from 0.686 to 10 m^3/s (Figure 2D). Needs to be updated with 2018 data

3.5.3 General Water Chemistry

Water chemistry parameters are presented in Table 8. Note that while water chemistry results from 2015 to 2017 are presented in the tables, they are generally not discussed in detail in the result summaries. In 2018, median water temperature ranged from 12.0°C at the N. Fork at 501 site to 17.6°C at the Pinhorn site. Median water temperatures at each site were within the range of median water temperatures from 2015 to 2017 with the exception of the Milk River at 501 and Pinhorn sites which in 2018 had the warmest median water temperature of the four years. The warmest water temperature (21.3°C on July 18) was recorded at the Pinhorn site.

Median dissolved oxygen concentration ranged from 9.15 mg/L at the U/S Milk River site to 10.10 mg/L at the N. Fork at 501 site (Table 8). The lowest individual dissolved oxygen concentration occurred at the Pinhorn site (8.27 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 2018, 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 (8.27 to 8.47) were within guideline for the protection of aquatic life at all Milk River sites in 2018. 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 N. Milk River at 501 site (147 µS/cm) and highest at the Pinhorn site (266 µS/cm). During the natural flow period, median specific conductivity ranged from a low of 329 µS/cm at the North Fork at 501 site to a high of 500 µS/cm at the Pinhorn site (Table 9). The WQO-50 and WQO-90 objectives for specific conductivity were met at all sites in 2018 (Table 9). In 2018, 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, 2015 to 2018.

Site	Water Temperature (°C)											
	2015			2016			2017			2018		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	9	9.8	3.6-18.6	9	12.4	1.9-18.2	10	11.7	5.2-19.2	10	12.0	-0.4-17.9
Milk R. at 501	7	10.1	4.8-21.4	6	11.3	0.8-18.0	7	12.0	6.6-18.6	8	13.0	0.03-18.8
U/S Milk River	8	9.4	6.4-21.0	8	13.5	2.1-19.2	10	14.4	4.4-20.7	10	13.7	0.4-20.7
HWY 880	10	13.3	5.1-20.8	9	15.9	0.9-20.2	10	15.1	7.9-14.7	10	14.6	3.8-19.4
Pinhorn	10	14.1	5.5-20.5	9	15.4	0.6-20.4	10	14.4	7.5-20.5	9	17.6	4.4-21.3

Site	Dissolved Oxygen (mg/L)											
	2015			2016			2017			2018		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	9	10.26	8.92-11.61	9	10.12	8.71-11.76	10	10.62	8.92-12.45	10	10.10	8.7-12.9
Milk River at 501	7	10.27	8.93-11.47	6	9.88	8.97-12.2	7	10.39	8.36-11.88	8	9.76	8.3-12.4
U/S Milk River	9	9.91	8.19-11.31	8	10.35	8.80-12.80	10	9.62	8.62-12.52	10	9.15	8.6-12.8
HWY 880	10	10.60	8.83-11.50	9	10.28	8.64-13.48	10	10.10	9.07-12.48	10	9.28	8.5-12.3
Pinhorn	10	10.34	8.66-11.50	9	9.89	8.45-14.11	10	9.47	8.41-11.29	9	9.70	8.3-11.9

Site	pH											
	2015			2016			2017			2018		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	8.19	7.62-8.38	10	8.10	7.84-8.30	10	8.27	8.14-8.59	10	8.39	7.99-8.50
Milk R. at 501	8	8.52	8.30-8.59	7	8.46	8.33-8.60	7	8.52	8.40-8.59	8	8.47	8.24-8.63
U/S Milk River	10	8.35	7.91-8.54	10	8.24	8.08-8.41	10	8.31	8.17-8.47	10	8.33	8.02-8.48
HWY 880	10	8.41	7.76-8.53	10	8.28	8.05-8.44	10	8.34	8.19-8.49	11	8.27	8.09-8.51
Pinhorn	10	8.41	7.95-8.57	10	8.24	8.13-8.48	10	8.37	8.13-8.49	10	8.36	7.99-8.57

Table 9 - Summary of specific conductivity (µS/cm) at the Milk River, 2015 to 2018.

Site	Flow Period	WQO		2015				2016				2017				2018			
		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	6	154	159	145-161	8	155	183	136-195	8	148	182	130-183	7	147	269	129-427
	Natural	445	512	4	300	427	190-448	2	350	-	276-423	2	435	-	430-440	3	329	426	234-449
Milk R. at 501	Natural	510	882	8	489	696	461-863	7	530	1140	486-1900	7	456	490	423-492	8	419	546	309-603
U/S Milk River	Diversion	210	398	6	198	224	152-225	8	209	295	148-364	8	203	286	150-299	7	214	322	147-387
	Natural	570	674	4	423	539	308-567	2	407	-	248-566	2	470	-	470-470	3	341	510	306-552
HWY 880	Diversion	250	540	6	237	265	181-273	8	251	396	179-420	8	236	383	117-386	7	259	418	175-498
	Natural	727	936	4	522	707	391-766	2	601	-	342-859	2	664	-	599-728	4	473	660	447-729
Pinhorn	Diversion	250	540	6	212	286	116-296	8	273	421	189-428	8	246	416	188-423	7	266	457	196-523
	Natural	727	936	4	591	739	440-791	2	582	-	316-847	2	678	-	623-733	3	500	677	479-721

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 range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

3.5.4 Nutrients

Total Phosphorus

In 2018, compliance with the WQO-50 and WQO-90 objectives for total phosphorus was the lowest of the four monitoring years from 2015 to 2018. 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 2018, median total phosphorus concentration ranged from a low of 0.010 mg/L at the North Fork at 501 site to 0.133 mg/L at the Pinhorn site (Table 12). During natural flow, median total phosphorus ranged from 0.065 mg/L at the Milk R. at 501 site site to 0.437 mg/L at the Pinhorn site (Table 12).

During diversion, median total phosphorus concentration did not meet the WQO-50 objective at the U/S Milk River and Pinhorn sites. During natural flow, the WQO-50 was not met at any Milk River site (Table 10).

The WQO-90 for total phosphorus was not met at the N. Fork at 501 site during the diversion period in 2018 (Table 10). The WQO-90 for total phosphorus was not met at any site during natural flow in 2018.

Total Dissolved Phosphorus

In 2018, compliance with the WQO-50 and WQO-90 objectives for total dissolved phosphorus was the lowest of the four monitoring years from 2015 to 2018. 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 U/S Milk River site to 0.010 mg/L at the Pinhorn site (Table 11). During natural flow, median total dissolved phosphorus ranged from 0.010 mg/L at the Milk R. at 501 site to 0.056 mg/L at the N. Fork at 501 site (Table 11).

Median total dissolved phosphorus concentrations did not met the WQO-50 objective at the N. Fork at 501 or Pinhorn sites during the diversion period. No sites met the WQO-50 during natural flow (Table 11). The total dissolved phosphorus WQO-90 was met at the U/S Milk River site in 2018 during the diversion and natural flow periods (Table 11). No other Milk River sites met the WQO-90 during diversion or natural flow periods (Table 11).

Table 10 - Summary of total phosphorus concentrations (mg/L) at the Milk River, 2015 to 2018.

Site	Flow Period	WQO		2015				2016				2017				2018			
		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	6	0.016	0.022	0.010-0.023	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
	Natural	0.012	0.100	4	0.010	0.015	0.007-0.016	2	0.008	-	0.006-0.010	2	0.010	-	0.004-0.015	3	0.081	0.367	0.004-0.438
Milk R. at 501	Natural	0.019	0.186	8	0.014	0.020	0.010-0.021	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
U/S Milk River	Diversion	0.044	0.148	6	0.079	0.148	0.036-0.183	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
	Natural	0.013	0.504	4	0.013	0.024	0.008-0.028	2	0.013	-	0.008-0.017	2	0.013	-	0.004-0.022	3	0.464	0.653	0.006-0.700
HWY 880	Diversion	0.088	0.220	6	0.141	0.197	0.066-0.204	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
	Natural	0.013	0.086	4	0.021	0.040	0.007-0.045	2	0.011	-	0.009-0.013	2	0.026	-	0.005-0.047	3	0.640	0.688	0.004-0.700
Pinhorn	Diversion	0.088	0.220	6	0.156	0.245	0.107-0.284	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
	Natural	0.013	0.086	4	0.033	0.066	0.009-0.072	2	0.030	-	0.024-0.036	2	0.043	-	0.010-0.076	3	0.437	0.911	0.009-1.030

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 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, 2015 to 2018.

Site	Flow Period	WQO		2015				2016				2017				2018			
		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	6	0.003	0.003	0.003-0.003	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
	Natural	0.005	0.066	4	0.003	0.005	0.003-0.006	2	0.003	-	0.003-0.003	2	0.004	-	0.002-0.007	3	0.056	0.155	0.002-0.180
Milk R. at 501	Natural	0.006	0.015	8	0.006	0.008	0.003-0.008	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
U/S Milk River	Diversion	0.003	0.010	6	0.003	0.006	0.003-0.006	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
	Natural	0.005	0.173	4	0.003	0.005	0.003-0.006	2	0.005	-	0.003-0.008	2	0.005	0.009	0.002-0.009	3	0.043	0.084	0.004-0.094
HWY 880	Diversion	0.004	0.011	6	0.007	0.015	0.003-0.020	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
	Natural	0.004	0.021	4	0.006	0.006	0.003-0.007	2	0.004	-	0.003-0.006	2	0.005	-	0.002-0.008	3	0.032	0.077	0.003-0.088
Pinhorn	Diversion	0.004	0.011	6	0.006	0.011	0.003-0.014	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
	Natural	0.004	0.021	4	0.003	0.006	0.003-0.007	2	0.005	-	0.003-0.007	2	0.010	-	0.010-0.010	3	0.028	0.042	0.003-0.045

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 range (**Orange**); if the measured value is >20% above the WQO, it exceeds the WQO (**Red**).

Total Nitrogen

In 2018, compliance with the WQO-50 and WQO-90 objectives for total nitrogen was the lowest of the four monitoring years from 2015 to 2018.

In general, total nitrogen at the Milk River increases in concentration in the downstream direction. During the diversion period in 2018, median total nitrogen concentration ranged from a low of 0.143 mg/L at the North Fork at 501 site to 0.380 mg/L at the Pinhorn site (Table 12). During natural flow, median total nitrogen ranged from 0.516 mg/L at the Milk R. at 501 site to 1.700 mg/L at the HWY 880 site (Table 12).

During diversion, total nitrogen concentrations met the WQO-50 objective at all sites in 2018. During the natural flow period, total nitrogen concentration did not meet the WQO-50 objective at the U/S Milk River, HWY 880 or Pinhorn sites. During the diversion period, total nitrogen concentration met the WQO-90 objective at all sites except the Pinhorn site (Table 12). During natural flow, total nitrogen concentration did not meet the WQO-90 objective at the N. Fork at 501, HWY 880 or Pinhorn sites.

3.5.5 Total Suspended Solids

In 2018, compliance with the WQO-50 and WQO-90 objectives for TSS was the lowest of the four monitoring years from 2015 to 2018.

During the diversion period, median total suspended solids concentrations ranged from 8.3 mg/L at the North Fork at 501 site to 190 mg/L at the Pinhorn site (Table 13). During natural flow, median total suspended solids ranged from 6.1 mg/L at the North Fork at 501 site to 630 mg/L at the HWY 880 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 natural flow, the WQO-50 objective was not met at any site. During diversion the WQO-90 was not met at the Pinhorn site and the N. Fork at 501 site was in the cautionary range of the WQO-90. During natural flow, WQO-90 objective was not met at any Milk River site (Table 13).

3.5.6 Fecal Coliform Bacteria

In 2018, compliance with the WQO-50 and WQO-90 objectives for fecal coliform bacteria was the second highest of the four monitoring years from 2015 to 2018.

During the diversion period, median fecal coliform bacteria counts ranged from 36 cfu/100 mL at the HWY 880 site to 95 cfu/100 mL at the Pinhorn site (Table 14). The median fecal coliform bacteria counts met the WQO-50 objective at all sites during the diversion period except the Pinhorn site (Table 14). The WQO-90 was met at all sites during the diversion period (Table 14).

During natural flow, median fecal coliform bacteria counts ranged from 4 cfu/100 mL at the N. Milk River at 501 site to 284 cfu/100 mL at the U/S Milk River site. During natural flow, the WQO-50 was not met at U/S Milk River or HWY 880 sites and was in the cautionary range at the Milk R. at 501 site (Table 14). The WQO-90 objective was not met at the Milk River at 501 site (841 cfu/100 mL) or HWY 880 site (406 cfu/100 mL) during natural flow.

Table 12 - Summary of total nitrogen concentrations (mg/L) at Milk River, 2015 to 2018.

Site	Flow Period	WQO		2015				2016				2017				2018			
		WQO-50	WQO-90	N	50th	N	N	N	N	90th	Range	N	50th	90th	Range	N	50th	90th	Range
N. Fork at 501	Diversion	0.240	0.468	6	0.146	0.155	0.110-0.157	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
	Natural	0.900	1.578	4	0.225	0.316	0.121-0.338	2	0.311	-	0.145-0.477	2	0.313	-	0.220-0.405	3	0.646	2.127	0.320-2.497
Milk R. at 501	Natural	0.600	1.360	8	0.110	0.283	0.110-0.290	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
U/S Milk River	Diversion	0.325	0.667	6	0.264	0.315	0.110-0.317	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
	Natural	0.680	1.637	4	0.214	0.327	0.110-0.352	2	0.275	-	0.125-0.425	2	0.250	-	0.160-0.340	3	1.500	1.709	0.240-1.761
HWY 880	Diversion	0.365	0.668	6	0.315	0.463	0.122-0.466	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
	Natural	0.320	1.400	4	0.225	0.354	0.110-0.403	2	0.301	-	0.154-0.448	2	0.335	-	0.200-0.470	3	1.700	2.430	0.112-2.612
Pinhorn	Diversion	0.365	0.668	6	0.319	0.522	0.129-0.525	8	0.385	0.615	0.125-0.670	8	0.470	0.527	0.240-0.550	7	0.380	0.954	0.220-1.75
	Natural	0.320	1.400	4	0.301	0.609	0.110-0.660	2	0.416	-	0.142-0.690	2	0.365	-	0.220-0.510	3	1.26	2.34	0.370-2.620

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 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, 2015 to 2018.

Site	Flow Period	WQO		2015				2016				2017				2018			
		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	4	11	21	1.5-22	8	12	45	2-99	8	20	40	4-50	7	8.3	68	2.9-120
	Natural	5	55	6	5	11	1.5-12	2	3	-	1.5-4.7	2	3	-	1-6	3	7.7	161	2.1-199
Milk R. at 501	Natural	14	247	8	6	7	1.5-7.3	7	11	47	7-84	7	11	22	6-33	8	69	469	0.5-560
U/S Milk River	Diversion	56	282	6	88	160	15.3-175	8	52	134	21-212	8	83	203	18-351	7	91.3	144	22-150
	Natural	7	267	4	4	22	1.5-28	2	2	-	1.5-1.5	2	7	-	1-13	3	486	737	1.3-800
HWY 880	Diversion	131	384	6	154	212	36.7-250	8	89	174	14-259	8	78	188	57-236	7	141	288	41-360
	Natural	13	228	4	11	39	1.5-47.3	2	5	-	3.3-6	2	24	-	10-38	3	630	696	2.7-712
Pinhorn	Diversion	131	384	6	185	292	113-293	8	169	193	23-202	8	194	272	7-313	7	190	528	75.7-994
	Natural	13	228	4	20	58	1.5-67	2	14	-	8.7-18.7	2	37	65	8-65	3	502	1908	3.7-2260

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 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, 2015 to 2018.

Site	Flow Period	WQO		2015				2016				2017				2018			
		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	6	90	133	44-138	8	51	441	6-1100	8	30	168	6-283	7	46	109	9-180
	Natural	55	668	4	78	160	3-164	2	154	-	8-300	2	2	-	1-2	3	4	353	4-440
Milk R. at 501	Natural	77	619	8	86	462	4-900	7	122	2080	1-3400	7	44	2076	1-5000	8	86	841	7-1730
U/S Milk River	Diversion	68	272	6	176	193	104-194	8	38	491	7-1300	8	53	191	1-191	7	56	121	13-164
	Natural	49	522	4	8	46	1-62	2	39	-	7-71	2	3	-	1-5	3	284	325	2-335
HWY 880	Diversion	78	280	6	156	741	84-1100	8	43	530	1-600	8	69	272	6-530	7	36	134	26-171
	Natural	29	163	4	20	57	1-65	2	34	-	5-62	2	17	-	1-32	3	51	406	36-495
Pinhorn	Diversion	78	280	6	157	277	115-366	8	85	216	18-318	8	109	359	12-468	7	95	222	36-254
	Natural	29	163	4	39	46	8-45	2	47	-	37-56	2	18	-	9-27	3	70	90	1-95

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 normal 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 the Milk River watershed in 2018 differed substantially across the watershed, ranging from 154.0 mm at Onefour to 303.9 mm at Cardston. June was generally the wettest month (mean = 58.6 mm) while August was the driest month (mean = 19.8 mm). At the three Milk River sites augmented by the St. Mary diversion, flow generally ranged from a median of 15 to 17 m^3/s during normal diversion operation and was reduced to 0.39 to 3.80 m^3/s within a week of diversion shut-down.

Red Creek

- Median dissolved oxygen concentrations complied with acute and chronic guidelines in 2018 at the Red Creek sites; however, an individual sample did not meet the acute or chronic guideline at the middle site.
- All pH values met the aquatic life guidelines at the three Red Creek sites in 2018.
- The median conductivity (range: 2115 to 2489 µS/cm) values did not meet safe irrigation guidelines at any of the three Red Creek sites in 2018 and were considered unsuitable for irrigation.
- The median total phosphorus concentrations at the Red Creek upstream and middle sites (0.081 and 0.177 mg/L) were the highest of the four monitoring years. The median total phosphorus concentration at the Red Creek downstream site (0.026 mg/L) was the lowest of the four monitoring years.
- Median TSS concentrations (range: 1.6 to 14 mg/L) were low at Red Creek in 2018; although, the maximum TSS concentrations at the middle and downstream sites (91.3 and 135 mg/L) were the highest of the four monitoring years. No TSS trends are apparent from 2015 to 2018.
- Median fecal coliform bacteria counts at Red Creek met the irrigation guideline at the three Red Creek sites in 2018. Median fecal coliform bacteria counts at the upstream and middle sites have generally met the irrigation guideline from 2015 to 2018, whereas the downstream site has not met the irrigation guideline in three of four years.

Eastern Tributaries

- Median dissolved oxygen concentrations were compliant with acute and chronic guidelines in 2018 at the Eastern Tributaries; however, one individual sample did not meet the chronic guideline at Middle Creek.
- All pH values met the aquatic life guidelines at the Eastern tributaries in 2018.
- The median specific conductivity met safe irrigation guidelines at Battle and Middle creeks; however, at Lodge Creek the median specific conductivity (1160 µS/cm) was considered possibly safe for irrigation.
- In 2018 the median total phosphorus concentration at Battle Creek (0.024 mg/L) was the highest of the four monitoring years and the median total phosphorus at Middle Creek (0.048 mg/L) was the lowest of the four years. Median total phosphorus at Lodge Creek (0.053 mg/L) was within the median range of the three previous years (0.049 to 0.067 mg/L).
- Median (range: 4 to 11 mg/L) and maximum TSS concentrations (26 to 54.3 mg/L) were low at the Eastern tributaries in 2018 and no TSS trends are apparent from 2015 to 2018.
- Median fecal coliform concentrations (range: 12 to 50 cfu/100 mL) were low at the Eastern tributaries in 2018 and median fecal coliform concentrations have met the irrigation guideline from 2015 to 2018.

Ephemeral Tributaries

- The dissolved oxygen concentration was 5.22 and 10.78 mg/L at Miners Coulee in 2018. The median dissolved oxygen concentration at Verdigris Coulee in 2018 was 4.57 mg/L and did not meet the acute or chronic guidelines for protection of aquatic life.
- All pH values met the aquatic life guidelines at Miners Coulee and Verdigris Coulee in 2018.
- At Miners Coulee, the two samples met the specific conductivity objective for safe irrigation. The median specific conductivity at Verdigris Coulee (2562 µS/cm) was considered unsuitable for irrigation.
- Total phosphorus concentrations at Miners Coulee in 2018 were 0.096 and 0.160 mg/L. In 2018 the median total phosphorus concentration at Verdigris Coulee was 0.109 mg/L.
- The TSS concentrations in 2018 at Miners Coulee was <1 mg/L during both sampling events. The median TSS concentration at Verdigris Coulee was 9.65 mg/L (range: 1.3 to 45 mg/L).
- Two samples at Miners Coulee in 2018 had a fecal coliform count of 20 and 310 cfu/100 mL. The median fecal coliform count (360 cfu/100 mL) at Verdigris Coulee in 2018 did not meet the irrigation guideline. Three of four samples at Verdigris Coulee exceeded the irrigation guideline.

Milk River Mainstem

- Milk River Water Quality Objectives (WQOs) were used to determine water quality at sites in 2018 (i.e., WQO-50 [50^{th} percentile or median] and WQO-90 [90^{th} percentile]).
- Median pH and dissolved oxygen met aquatic life guidelines at all Milk River sites in 2018.
- 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 2018.
- Compliance with total phosphorus objectives was low at the Milk River sites in 2018. Median total phosphorus exceeded the WQO-50 at the U/S Milk River and Pinhorn sites during diversion and at all sites during natural flow. The WQO-90 for total phosphorus was not met at the N. Fork at 501 during diversion and all of the sites exceeded the WQO-90 during natural flow.
- Compliance with total nitrogen objectives was low at the Milk River sites in 2018. All Milk River sites met the total nitrogen WQO-50 during diversion, but during natural flow the U/S Milk River, HWY 880 and Pinhorn sites did not meet the WQO-50. During diversion, the WQO-90 was met at all Milk River sites with the exception of the Pinhorn site, and during natural flow the N. Fork at 501, HWY 880 and Pinhorn sites did not meet the WQO-90.
- Compliance with TSS objectives was low at the Milk River sites in 2018. Total suspended solids did not meet the WQO-50 during the diversion period at the U/S Milk River and Pinhorn sites, and during natural flow at all of the sites. The WQO-90 was not met at the HWY 880 Pinhorn site during the diversion period and was in the cautionary range at the N. Fork at 501 site. During natural flow, none of the five Milk River sites met the WQO-90 objective.
- Fecal coliform bacteria exceeded the WQO-50 during the diversion flow period at the Pinhorn site and during the natural flow at U/S Milk River and HWY 880. The Milk R. at 501 site was in the cautionary range of the WQO-50 during natural flow. The WQO-90 was exceeded during natural flow at the Milk River at 501 and HWY 880 sites. During diversion, the fecal coliform WQO-90 was met at all sites.

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 work would also support future 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. In 2017 and 2018 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

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