MILK RIVER WATERSHED

WATER MONITORING REPORT 2017

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 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 2017, with reference to the results from the previous three years (i.e., 2014-2016). Comparisons are made to Water Quality Objectives that were developed as part of the Milk River Integrated Watershed Management Plan (PESL 2015) as well as relevant provincial guidelines (ESRD 2014; Alberta Agriculture 1983).

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**. Alberta Environment and Parks also collected monthly samples at the HWY 880 Bridge in 2014, 2015, 2016 and 2017 (AEP) and Environment Canada collects monthly samples at the Western and Eastern crossings (Figure 1). Data from Environment Canada was not included in this summary report. Data from Alberta Environment and Parks was integrated into the data set. In 2017, the MRWCC sampled the watershed in the weeks beginning April 3, April 17, May 1, May 15, June 5, June 19, July 10, August 14, September 11 and October 16. The St. Mary River diversion flow period was from March 22 to September 22.

Milk River tributaries were also monitored in 2017. The monitoring included three sites at Red Creek (i.e., Upstream, Middle and Downstream), Verdigris Coulee (not sampled: dry during the 2017 monitoring period), 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).

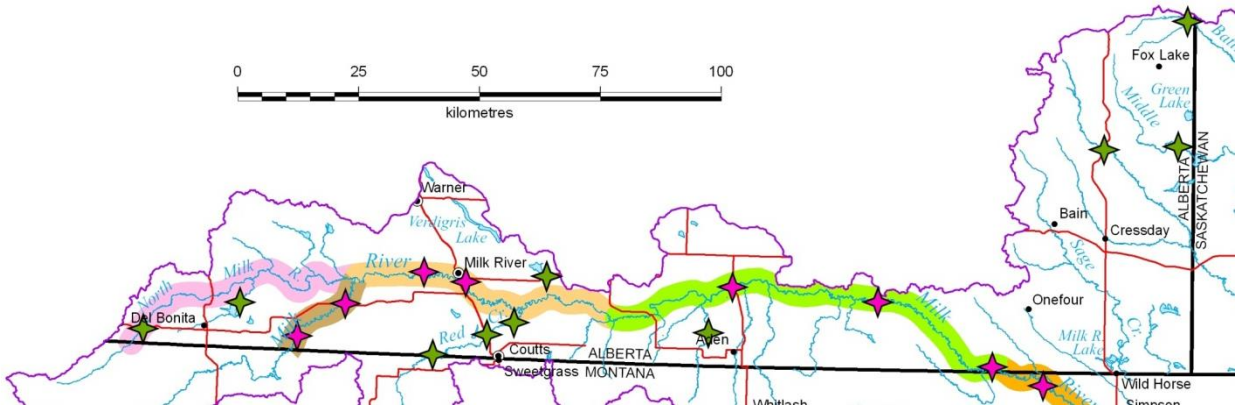


Figure 1 - Map showing water monitoring locations sampled in the Milk River watershed, 2016.

The MRWCC water monitoring program was conducted in collaboration with 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 Analytics 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 local Milk River Water Quality Objectives (WQO) that were established for the four main river reaches (i.e., North Fork Milk River, Mainstem Milk River, Milk River Gravel Bed and Milk River Sand Bed) within the Milk River Integrated Watershed Management Plan (IWMP) (PESL 2015) and to applicable provincial surface water quality guidelines (ESRD 2014). 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 2017 data set is the sixth year of data collected since the WQOs were established.

2.1 Missing Data

The following compromised samples or missing data for the 2017 water monitoring year was reported.

Site	Date	Measurement	Reason
Milk River: HWY 880 site	July 12	Total phosphorus (TP) and total dissolved phosphorus (TDP)	TDP result (0.53 mg/L) was 12 times greater than the TP result (0.044). TDP can only be equal to or less than the TP result. This data was collected by Alberta Environment and Parks (AEP) and was removed from the report as AEP was not able to determine if this was a transcription error (i.e., results reversed) or a measurement error.

[1] **CALA** – Canadian Association for Laboratory Accreditation Inc.
[2] **APHA** – American Public Health Association

3.0 RESULTS

3.1 Precipitation

Overall, total precipitation in the Milk River watershed in 2017 differed substantially across the watershed, ranging from 132.2 mm at Masinasin to 261.6 mm at Milk River (Tables 2, 3). June was generally the wettest month (mean= 50.8 mm) while August was the driest month (mean= 3.4 mm) (Table 2).

Table 2 – Total precipitation (mm) at five weather stations for the water monitoring April to October, 2017.

Month	Cardston	Del Bonita	Milk River	Masinasin	Onefour
April	45.4	39.6	58.4	25.5	28.1
May	45.8	37.2	43.0	31.4	29.2
June	43.0	64.1	93.1	5.8	48.0
July	9.7	8.4	41.3	9.1	4.0
August	0.8	3.0	0.0	3.8	9.4
September	4.2	1.9	0.7	37.9	13.5
October	35.5	21.7	25.1	18.7	7.8
Total	**184.4**	**175.9**	**261.6**	**132.2**	**140.0**
Data Source: Environment Canada - http://climate.weather.gc.ca/index_e.html and ACIS (2017)					

Comparing mean total precipitation for each year, 2017 was the driest of the six years reported (mean: 178.8 mm) (Table 4). The second driest year was recorded in 2015 (mean: 194.1 mm) with the wettest year occurring in 2014 (mean: 344.0 mm).

Table 3 - Historical total precipitation (mm) at five weather stations for the water monitoring period April to October.

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
Data Source: Environment and Climate Change Canada -http://climate.weather.gc.ca/index_e.html and ACIS (2017)						

3.2 Red Creek

3.2.1 General Water Chemistry

At Red Creek, the median water temperature in 2017 was similar to 2014 and 2016 at the upstream site (16.2°C) and middle site (14.3°C), but was cooler compared to the 2015 water temperature. Red Creek at the mouth had a median water temperature of 17.0°C, which was warmer than the median range from 2014 to 2016 (9.8 to 14.2°C) (Table 4). Lower than normal precipitation and warmer than average air temperatures probably resulted in higher water temperatures at the mouth. Maximum water temperatures at the three Red Creek sites occurred in June and July.

The median dissolved oxygen concentrations (range: 7.98 to 10.75 mg/L) met the acute (≥5.0 mg/L) and chronic (≥6.5 mg/L) guidelines at the three Red Creek sites in 2017. At the upstream site, samples on June 22nd and July 13th did not meet the acute guideline. The acute guideline was met for all samples at the middle and downstream sites (Table 5). From 2014 through 2017, all samples at the downstream site have met the acute guideline (Table 5). Compared to the previous three years, the median dissolved oxygen appears to be increasing at the middle site (Table 4). The compliance rate for the acute and chronic guideline appears to be high and stable at the downstream site (Table 5), whereas the other sites do not show a compliance trend.

The median pH (median range: 8.24 to 8.42) and all individual samples (range: 7.97 to 8.61) collected at three Red Creek sites met the pH guideline of 6.5 to 9.0 for aquatic life (Table 4). From 2014 to 2016, the median pH and all individual pH samples at the Red Creek three sites met the guideline.

Median specific conductivity was 2540 µS/cm at the upstream site, 2560 µS/cm at the middle site and 2630 µS/cm at the downstream site (Table 4). Similar to previous years, all samples collected at Red Creek exceeded the irrigation guideline of <1000 µS/cm for general crop irrigation (<700 µS/cm for sensitive crop irrigation) (Alberta Agriculture 1983; CCREM 1987).

3.2.2 Nutrients

Median total phosphorus concentration was lowest at the downstream site (0.036 mg/L) and highest at the middle site (0.098 mg/L) (Table 4). The maximum total phosphorus concentrations at the three sites occurred on June 22. The month of June was the wettest month (93.1 mm) at Red Creek based on the nearest weather station at Milk River (Table 2). Higher precipitation may have resulted in increased runoff containing phosphorus. Similarly, median total dissolved phosphorus was lowest at the downstream site (0.019 mg/L) and highest at the middle site (0.047 mg/L). In 2017, 55% of the total phosphorus at the three sites was present in the dissolved form. From 2014 to 2017, the median total phosphorus at the Red Creek middle site has been 1.5 to 5 times higher than the upstream and downstream sites.

Median total nitrogen concentration was lowest at the downstream site (1.070 mg/L) and highest at the upstream site (1.810 mg/L) (Table 4). In 2017 at the three Red Creek sites, most of the total nitrogen was present in the organic (TKN) form (88%) with a much smaller percentage (12%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen) (Table 4).

Table 4 - Median and range for water quality parameters at Red Creek, 2014-2017.

Parameter	Upstream				Middle				Downstream			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Water Temperature, °C	14.1 2.9-20.7	11.6 6.9-23.6	14.2 3.0-20.6	14.0 8.0-21.0	16.2 4.9-23.6	13.6 8.5-23	10.7 8.6-19.5	14.3 7.1-21.4	14.2 3.8-23.1	13.1 8.5-30.0	9.8 8.7-17.1	17.0 8.9-21.6
Dissolved Oxygen, mg/L	5.95 2.61-10.7	9.50 6.61-12.24	10.06 4.35-13.53	7.98 4.51-12.41	7.66 4.41-8.91	8.63 5.60-11.90	8.85 2.55-14.33	9.19 8.39-11.87	9.38 5.48-12.84	11.46 6.84-18.3	10.22 10.16-11.84	10.75 9.50-13.47
pH	8.22 8.11-8.42	8.28 7.95-8.37	8.15 7.69-8.58	8.24 7.98-8.34	8.33 8.26-8.64	8.39 7.89-8.67	8.45 7.98-8.92	8.42 8.18-8.61	8.34 8.24-8.58	8.41 8.33-8.52	8.39 8.29-8.43	8.35 7.97-8.50
Specific Conductivity, µS/cm	2415 1880-2760	2350 2030-2700	2610 2290-2790	2540 2130-2690	2590 2110-2880	2335 2040-3020	2870 2420-3450	2560 1610-3080	2620 2250-2830	2665 2440-2890	2615 2500-2880	2630 1530-2920
Total Phosphorus, mg/L	0.073 0.015-0.457	0.035 0.025-0.053	0.023 0.015-0.047	0.045 0.025-0.615	0.151 0.031-0.178	0.077 0.063-0.111	0.080 0.041-0.097	0.098 0.045-0.341	0.032 0.016-0.098	0.051 0.036-0.070	0.030 0.021-0.041	0.036 0.019-0.180
Total Dissolved Phosphorus, mg/L	0.030 0.006-0.426	0.017 0.010-0.031	0.016 0.012-0.033	0.021 0.008-0.447	0.048 0.019-0.139	0.038 0.021-0.053	0.047 0.026-0.077	0.047 0.024-0.310	0.009 0.005-0.048	0.019 0.012-0.031	0.018 0.014-0.029	0.019 0.007-0.160
Nitrate+Nitrite Nitrogen, mg/L	0.316 0.027-1.660	0.185 0.050-1.430	0.055 0.025-1.850	0.250 0.005-1.600	0.036 0.027-0.135	0.050 0.010-0.280	0.055 0.055-0.140	0.050 0.050-0.050	0.135 0.027-0.839	0.135 0.050-0.320	0.103 0.055-0.170	0.050 0.002-0.050
Total Kjeldahl Nitrogen, mg/L	0.985 0.570-1.710	0.850 0.100-1.100	0.925 0.580-1.100	1.000 0.840-2.120	1.310 0.460-1.560	0.880 0.310-1.530	1.270 0.790-1.950	1.280 1.080-1.890	0.79 0.530-1.590	0.815 0.520-2.760	0.730 0.590-0.960	1.020 0.510-1.300
Total Nitrogen, mg/L	1.638 0.787-2.230	0.985 0.380-2.390	1.100 0.635-2.810	1.810 0.850-2.540	1.367 0.487-1.695	0.930 0.320-1.580	1.325 0.845-2.005	1.330 1.130-1.940	1.230 0.717-1.725	1.015 0.640-2.930	0.823 0.685-1.110	1.070 0.510-1.300
Total Suspended Solids, mg/L	6 2-26	4 2-6	2 2-8	12 4-61	16 4-40	7 3-11	4 2-13	12 6-26	9 3-25	17 5-42	6 2-10	4 1-9
Fecal Coliform Bacteria, cfu/100 mL	46 1-900	122 1-900	47 1-8900	19 1-400	400 1-49000	49 1-192	21 0.5-1300	87 1-600	300 1-4600	315 9-6000	215 2-700	118 1-700

Table 5 - Summary of Red Creek water quality compliance with dissolved oxygen acute and chronic guidelines, 2014-2017 (ESRD 2014).

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
2014	70	40	67	67	100	89
2015	100	100	100	87	100	100
2016	89	100	83	67	100	100
2017	75	50	100	100	100	100
Trend	-	-	-	-	Stable	Stable

3.2.3 Total Suspended Solids

The downstream site had the lowest median total suspended solids concentration (4 mg/L) compared to the upstream (12 mg/L) and middle (12 mg/L) sites (Table 4). The median TSS at the upstream site was the highest of the four years (2014 to 2017) 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 was highest at the downstream site (118 cfu/100 mL), compared to the upstream site (19 cfu/100 mL) and middle site (87 mg/L) (Table 4). The median and range of fecal coliform bacteria counts were the lowest in 2017 at the upstream and downstream sites compare to the period 2014 to 2016. The median fecal coliform bacteria count at the downstream site (118 cfu/100 mL) did not meet the provincial guideline for irrigation (100 cfu/100 mL) (ESRD 2014). Fecal coliform bacteria counts appear to be highly variable from year to year at Red Creek (Table 4) and may be the result of fluctuating wildlife populations and usage near the creek, varied cattle grazing intensity and environmental bacteria (i.e., self-sustaining naturalized populations of coliform bacteria).

3.3 Eastern Tributaries

3.3.1 General Water Chemistry

Battle Creek – The median water temperature was 8.6^{o}C in 2017, and was similar to 2014 to 2016 (median range: 8.1 to 8.9^{o}C) (Table 6). The maximum water temperature reached 15.0^{o}C on July 13. Dissolved oxygen concentrations met the chronic (>6.5 mg/L) and acute (>5.0 mg/L) guidelines throughout 2017 with all concentrations greater than 8.81 mg/L and a median of 10.24 mg/L. Similarly, all pH values met the aquatic life guideline in 2017 (≥6.5 and ≤9.0). Median specific conductivity was 381 µS/cm and all samples were well below the irrigation guideline for sensitive crops (<700 µS/cm).

Middle Creek – The median water temperature was 13.2^{o}C in 2017, and was similar to 2014 to 2016 (median range: 13.6 to 15.3^{o}C) (Table 6). The maximum water temperature reached 21.5^{o}C on July 13. The median dissolved oxygen concentration (9.81 mg/L) met the acute and chronic guideline with oxygen concentrations ranging from 5.17 to 13.9 mg/L. Only 1 of 10 samples (10%) did not meet the chronic (>6.5 mg/L) guideline. All pH results met the aquatic life guideline in 2017 (≥6.5 and ≤9.0). The median specific conductivity (618 µS/cm) met the guideline for irrigation of sensitive crops (<700 µS/cm); however, 2 of 10 samples (20%) did not meet the irrigation guideline for sensitive crops, but all samples met the guideline for general crops (<1000 µS/cm). The two samples with conductivity >700 µS/cm occurred in May.

Lodge Creek – The median water temperature was 12.6^{o}C in 2017, and was similar to 2014 to 2016 (median range: 13.2 to 14.8^{o}C) (Table 6). Dissolved oxygen concentrations met the chronic (>6.5 mg/L) and acute (>5.0 mg/L) guidelines throughout 2016 with all concentrations greater than 10.30 mg/L with a median of 10.67 mg/L. Similarly, all pH values met the aquatic life guideline in 2017 (≥6.5 and ≤9.0) with a median of 8.37. The median specific conductivity (825 µS/cm) did not meet the guideline for irrigation of sensitive crops (700 µS/cm); 5 of 6 samples (83%) did not meet the irrigation guideline for sensitive crops, and 1 of 6 samples (17%) did not meet the guideline for irrigation of general crops

(<1000 µS/cm). The median specific conductivity at Lodge Creek has shown a decreasing trend from 2014 (1240 µS/cm) to 2017 (825 µS/cm).

3.3.2 Nutrients

Battle Creek – Median total phosphorus concentration was 0.017 mg/L in 2017, and was similar to 2014 to 2016 (median range: 0.017 to 0.020 mg/L) (Table 6). Total dissolved phosphorus concentration in 2017 was 0.011 mg/L, and was similar to 2014 to 2016 (median range: 0.009 to 0.015 mg/L). Seventy percent (70%) of the total phosphorus was present in the dissolved form. Median total nitrogen in 2017 (0.110 mg/L) was similar to 2014 and 2015 (0.127 and 0.110 mg/L, respectively), but lower than 2016 (0.168 mg/L); no trend was observed (Table 6). In 2017 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) (Table 6). Median nitrate+nitrite nitrogen in 2017 (0.010 mg/L) was at the low end of the range compared to the three previous monitoring years (median range: 0.010 to 0.027 mg/L); no trend was observed.

Middle Creek - Median total phosphorus concentration in 2017 (0.048 mg/L) was lower than the three previous monitoring years (median range: 0.104 to 0.123 mg/L) (Table 6). Median total dissolved phosphorus concentration in 2017 was 0.032 mg/L and lower than the three previous monitoring years (median range: 0.079 to 0.103 mg/L). In 2017, 63% of the total phosphorus was present in the dissolved form. Median total nitrogen in 2017 (0.595 mg/L) was similar to 2014 to 2016 (median range: 0.480 to 0.722 mg/L) and no trend was observed (Table 6). In 2017 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 6). Median nitrate+nitrite nitrogen in 2017 (0.010 mg/L) was at the low end of the range compared to the three previous monitoring years (median range: 0.010 to 0.027 mg/L); no trend was observed.

Lodge Creek - Median total phosphorus concentration in 2017 (0.053 mg/L) was 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 2017 (0.044 mg/L) was within the range of the three previous monitoring years (median range: 0.022 to 0.050 mg/L) but nearly double the 2014 and 2015 concentrations. In 2017, 78% of total phosphorus was present in the dissolved form. Median total nitrogen in 2017 (0.520 mg/L) was within the range of the three previous years (median range: 0.465 to 0.677 mg/L); no trend was observed (Table 6). In 2017 at Lodge Creek, most of the total nitrogen was present in the organic (TKN) form (96%) with a smaller percentage (4%) of the nitrogen present in soluble form (nitrate+nitrite nitrogen) (Table 6). Median nitrate+nitrite nitrogen in 2017 (0.010 mg/L) was at the low end of the range compared to the three previous monitoring years (median range: 0.010 to 0.027 mg/L); no trend was observed.

3.3.3 Total Suspended Solids

Battle Creek – The median total suspended solid concentration in 2017 (9 mg/L) was higher compared to the period 2014 to 2016 (median range: 2 to 6 mg/L) (Table 6). No trend in total suspended solids concentration was observed at Battle Creek from 2014 to 2017.

Middle Creek – The median total suspended solid concentration in 2017 (2 mg/L) was similar compared to 2014 to 2016 (2 to 4 mg/L, respectively) (Table 6). No trend in total suspended solids concentration was observed at Middle Creek from 2014 to 2017.

Lodge Creek – The median total suspended solid concentration in 2017 (7 mg/L) was similar compared to 2014 to 2016 (3 to 8 mg/L) (Table 6). No trend in total suspended solids concentration was observed at Lodge Creek from 2014 to 2017.

3.3.4 Fecal Coliform Bacteria

Battle Creek – The median fecal coliform bacteria count in 2017 (24 cfu/100 mL) was similar to 2014 to 2016 (median range: 10 to 26 cfu/100 mL) (Table 6). The median fecal bacteria count at Battle Creek has met the irrigation guideline (100 cfu/100 mL) from 2014 to 2017. In 2017, only 2 of the 10 samples exceeded 100 cfu/100 mL. No trend in fecal coliform bacteria counts was observed from 2014 to 2017 with median counts remaining low. However, maximum fecal coliform bacteria counts at Battle Creek in 2014 and 2015 were higher compared to 2016 and 2017.

Middle Creek – The median fecal coliform count in 2017 (7 cfu/100 mL) was similar to 2015 and 2016 (6 and 3 cfu/100 mL, respectively) (Table 6). The median fecal bacteria count at Middle Creek has met the irrigation guideline (100 cfu/100 mL) from 2014 to 2017. From 2015 to 2017, no individual sample exceeded the irrigation guideline. No trend in fecal coliform bacteria counts was observed from 2014 to 2017.

Lodge Creek – The median fecal coliform count in 2017 (3 cfu/100 mL) was lower compared to the period 2014 to 2016 (7 to 43 cfu/100 mL) (Table 6). Similarly, the maximum fecal bacteria count in 2017 (18 cfu/100 mL) was substantially lower compared to the previous three monitoring years (96 to 800 cfu/100 mL). The median fecal bacteria count at Lodge Creek has met the irrigation guideline (100 cfu/100 mL) from 2014 to 2017. In 2016 and 2017, no individual sample exceeded the irrigation guideline. No trend in fecal coliform bacteria counts was observed from 2014 to 2017.

Table 6 - Median and range for water quality parameters at the Eastern Tributaries (Battle Creek, Middle Creek and Lodge Creek), 2014-2017.

Parameter	Battle Creek				Middle Creek				Lodge Creek			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Water Temperature, °C	8.9 0.8-16.9	8.9 1.3-16.4	8.1 0.7-14.6	8.6 3.3-15.0	13.6 -4.0-19.8	15.3 5.7-21.2	15.0 4.5-21.8	13.2 6.7-21.5	13.2 3.6-20.8	14.8 5.8-21.7	14.2 1.6-22.6	12.6 6.5-20.0
Dissolved Oxygen, mg/L	8.26 6.48-9.30	10.23 8.53-12.08	10.49 8.49-12.03	10.24 8.81-11.72	7.00 0.42-9.25	12.10 9.42-14.39	10.57 5.6-14.3	9.81 5.17-13.19	8.38 6.67-9.59	11.77 10.37-15.90	12.22 10.18-14.02	10.67 10.30-10.96
pH	8.35 8.21-8.61	8.37 8.06-8.53	8.23 7.94-8.44	8.38 8.17-8.49	8.28 8.22-8.57	8.41 7.94-8.69	8.28 8.01-8.52	8.41 8.00-8.67	8.33 8.20-8.54	8.41 8.30-8.54	8.39 7.93-8.89	8.37 8.21-8.42
Specific Conductivity, µS/cm	369 338-410	376 199-392	391 353-425	381 338-399	687 380-947	694 549-745	699 584-828	618 519-897	1240 780-1630	1270 941-1540	965 645-1290	825 570-1170
Total Phosphorus, mg/L	0.017 0.012-0.041	0.018 0.014-0.023	0.020 0.013-0.036	0.017 0.010-0.034	0.116 0.055-0.293	0.104 0.013-0.327	0.123 0.027-0.256	0.048 0.023-0.122	0.060 0.013-0.106	0.049 0.040-0.084	0.067 0.026-0.210	0.053 0.028-0.103
Total Dissolved Phosphorus, mg/L	0.009 0.006-0.012	0.010 0.006-0.016	0.015 0.009-0.025	0.011 0.009-0.017	0.079 0.021-0.272	0.103 0.064-0.230	0.095 0.024-0.198	0.032 0.010-0.105	0.025 0.003-0.068	0.022 0.006-0.048	0.050 0.015-0.165	0.044 0.019-0.075
Nitrate+Nitrite Nitrogen, mg/L	0.027 0.027-0.077	0.010 0.010-0.240	0.025 0.025-0.110	0.010 0.010-0.010	0.027 0.027-0.175	0.010 0.010-0.010	0.025 0.025-0.025	0.010 0.010-0.010	0.027 0.027-0.175	0.010 0.010-0.050	0.025 0.025-0.100	0.010 0.010-0.050
Total Kjeldahl Nitrogen, mg/L	0.100 0.100-0.230	0.100 0.100-0.100	0.100 0.100-0.400	0.100 0.100-0.270	0.695 0.310-0.990	0.470 0.100-1.460	0.580 0.340-0.780	0.585 0.420-0.810	0.650 0.370-1.020	0.455 0.250-0.740	0.525 0.067-1.060	0.490 0.470-0.720
Total Nitrogen, mg/L	0.127 0.127-0.266	0.110 0.110-0.340	0.168 0.125-0.425	0.110 0.110-0.280	0.722 0.337-1.165	0.480 0.110-1.470	0.605 0.365-0.805	0.595 0.430-0.820	0.677 0.397-1.047	0.465 0.260-0.790	0.580 0.092-1.085	0.520 0.480-0.730
Total Suspended Solids, mg/L	6 2-19	2 2-17	5 2-10	9 2-33	4 2-17	4 2-14	2 2-7	2 2-10	8 2-16	6 3-23	3 2-17	7 4-9
Fecal Coliform Bacteria (cfu/100 mL)	10 1-500	26 1-390	23 1-102	24 1-159	36 1-214	6 1-51	3 1-12	7 1-73	9 1-300	43 6-800	7 1-96	3 2-18

3.4 Milk River

3.4.1 St. Mary/Milk River Diversion Operation

The St. Mary/Milk River Diversion was initiated on March 22 and was shut down on September 22, 2017. The initial flows on March 22nd were 1.4 m^3/s (50 ft^3/s); however, on March 25th the diversion was stopped due to concerns with flooding and reservoir levels in Montana. Diversion was resumed on April 10 at 1.4 m^3/s (50 ft^3/s), increasing to 2.8 m^3/s (100 ft^3/s) on April 11th and 5.7 m^3/s (200 ft^3/s) on April 13th. Diversion was further increased to 15.6 m^3/s (550 ft^3/s) on May 11th and 17 m^3/s (600 ft^3/s) on June 1. Diversion was reduced to 11.6 m^3/s (410 ft^3/s) on August 1st. Diversion flows were ramped down beginning September 12th and ended September 22nd (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 2017 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[a]	April 9	September 15
2013[b]	March 11	September 24
2014[c]	May 13	September 10
2015[d]	March 31	August 28
2016	March 22	September 10
2017[e]	March 22	September 22

[a]Start-up was April 9th and flows were ramped up until April 14th; shut-down started on September 11th and was ramped down to zero on September 15th.

[b]Note that the start date was March 11 with 1.4 m^3/s (50 cfs) of water, but flows were not substantial until about March 25 when flows reached about 11.3 m^3/s (400 cfs).

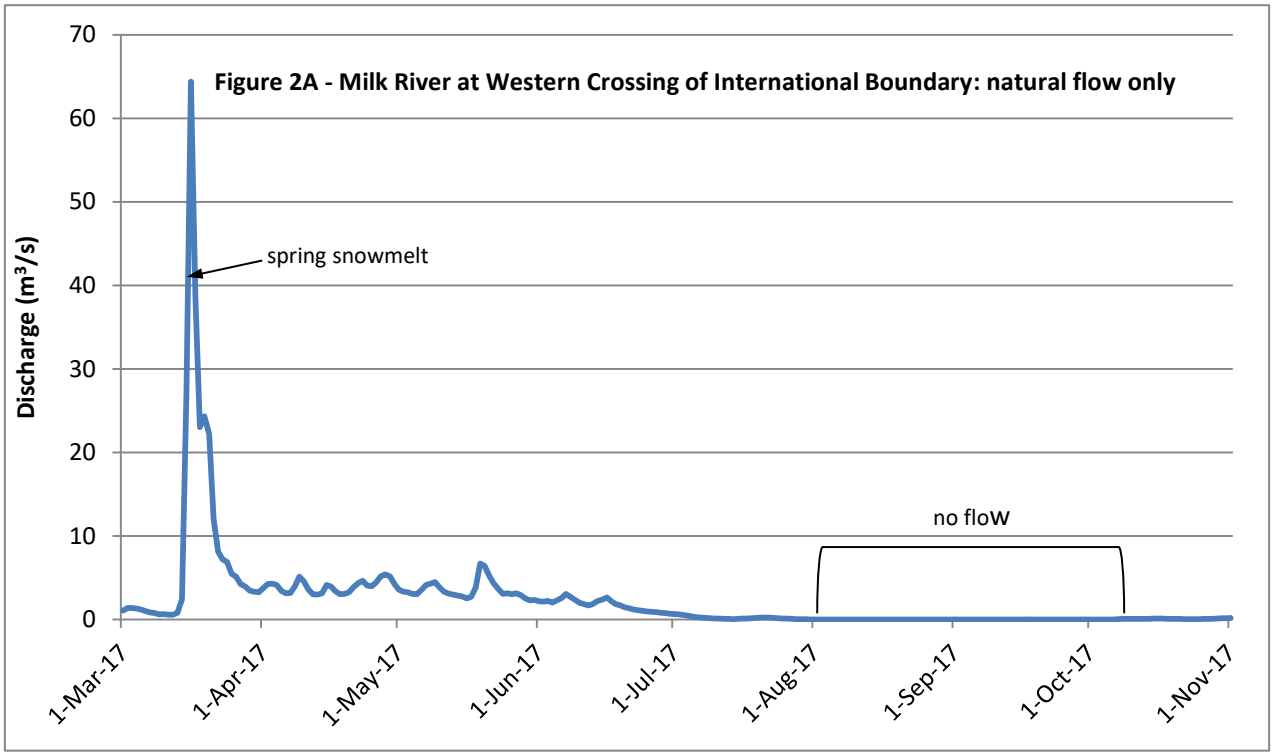
[c]Note that flow ramping began on May 13 increasing to 11.3 m^3/s (400 cfs) by May 20. Flow reductions began on September 3 with daily reductions of about 2.1 m^3/s (75 cfs) and complete shut-down by September 10.

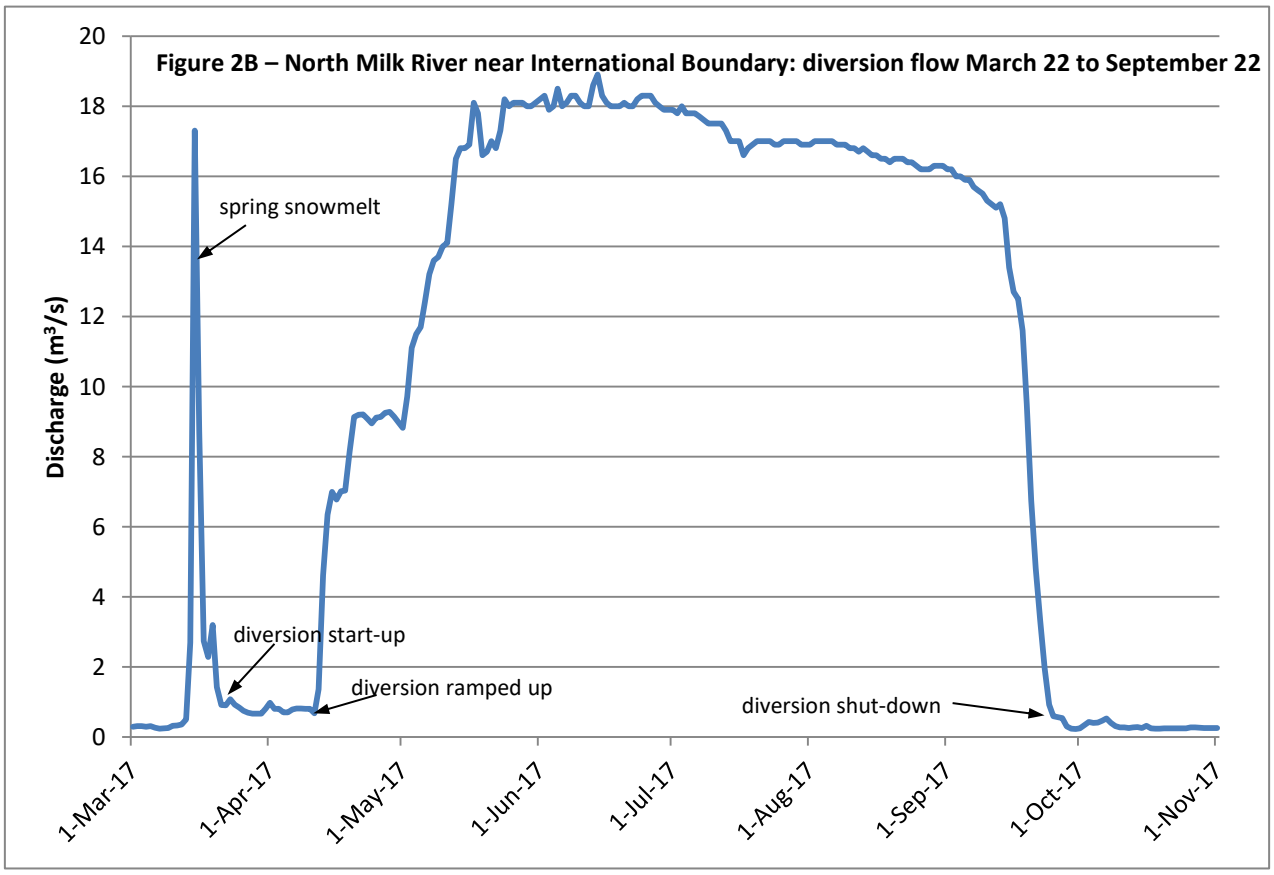
[d]Start-up was March 31st with 1.4 m^3/s (50 cfs) ramped over a week to 5.0 m^3/s (175 cfs), it was increased to 8.5 m^3/s (300 cfs) on May 4th.

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

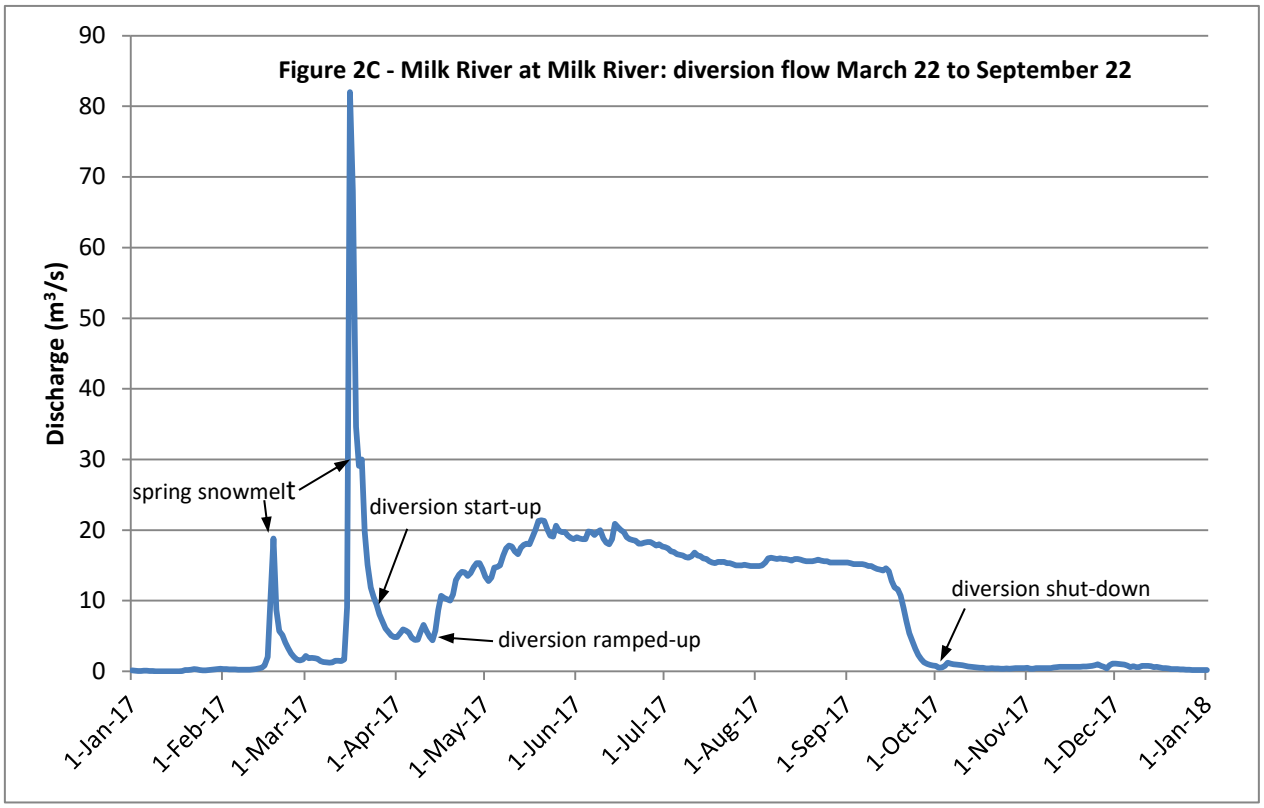
3.4.2 Streamflow

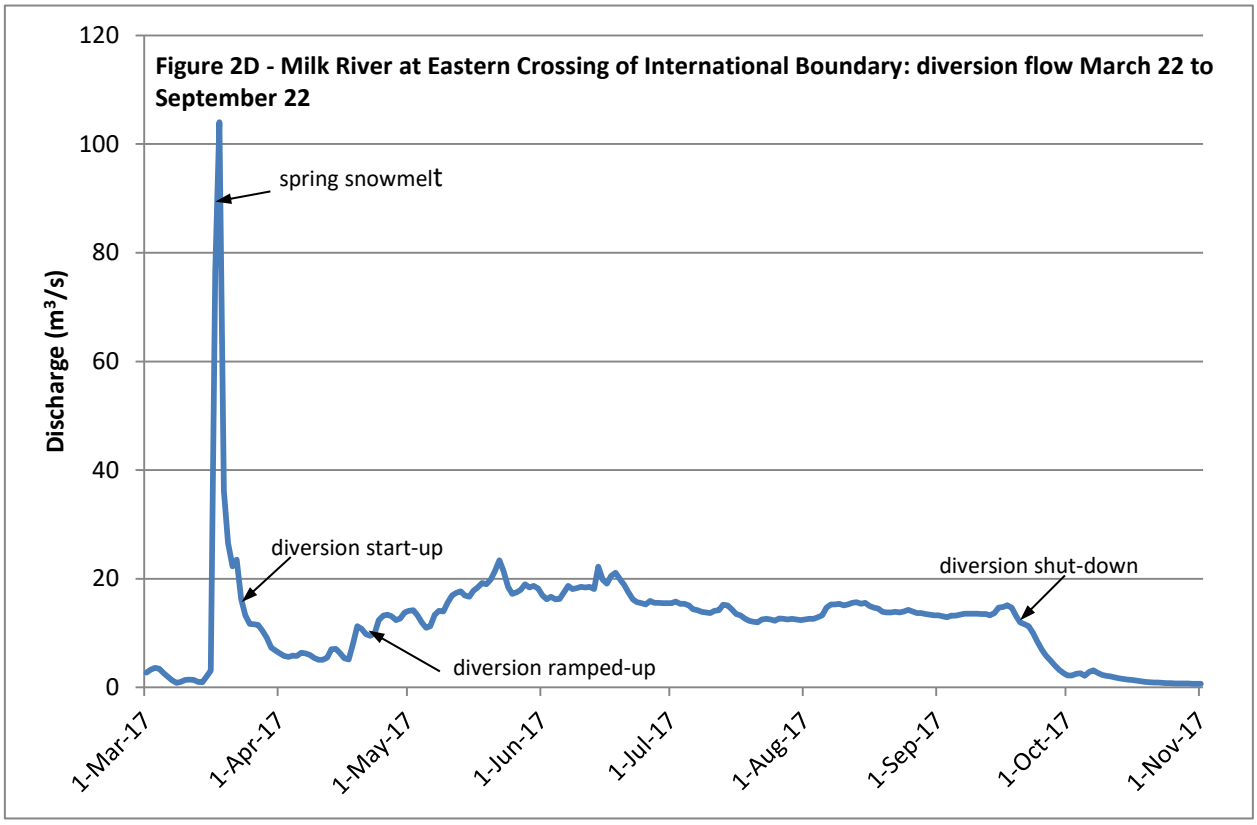
Mean daily streamflow data for 2017 is shown in Figures 2A to 2D at four Milk River sites (at Western Boundary, at North Milk River, at Milk River, and at Eastern Boundary). At 'Milk River at Western Crossing of International Boundary', the peak discharge occurred from March 15th to March 20th when flows ranged from 22.2 to 64.4 m^3/s during snowmelt (Figure 2A). From July 11th to October 31st, the recorded daily average flow was less than 0.1 m^3/s, with no flow from August 2nd to October 6th. Streamflow at the Milk River at 501 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, September or October 2017 due to an absence of visible flow (Figure 2A).





Figures 2A to 2D – Discharge data (m^3/s) at four Milk River sites during 2017. Raw data from Environment and Climate Change Canada (2017).





Figures 2A to 2D – cont'd

At 'North Milk River near International Boundary', the discharge during spring snowmelt from March 14th to March 20th ranged from 1.4 to 17.3 m^3/s (Figure 2B). The discharge at the North Milk River ranged between 1.36 and 18.9 m^3/s during diversion from March 22nd to September 22nd. Peak discharge occurred between May 13th and September 4th when flows were greater than 16.0 m^3/s. Natural flows after September 22nd (diversion shut-down) ranged from 0.233 to 0.598 m^3/s (Figure 2B).

At 'Milk River at Milk River', there were two spring snowmelt peaks: February 16th to 24th when discharge ranged between 2.03 to 18.8 m^3/s, and March 15th to 28th when discharge ranged between 6.08 to 82.0 m^3/s. The discharge at Milk River ranged between 4.42 and 21.4 m^3/s during diversion from March 22nd to September 22nd. Peak discharge occurred between May 17th and June 20th when flows ranged between 16.2 and 23.4 m^3/s. Natural flows after September 22nd (diversion shut-down) to December 31st ranged from 0.171 to 1.22 m^3/s (Figure 2C).

At 'Milk River at Eastern Crossing of International Boundary', the discharge during spring snowmelt from March 15th to March 31st 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 22nd to September 22nd. Peak discharge occurred between May 4th and September 15th when flows ranged between 14.2 and 21.4 m^3/s. Natural flows after September 22nd (diversion shut-down) ranged from 0.686 to 10 m^3/s (Figure 2D).

3.4.3 General Water Chemistry

Water chemistry parameters are presented in Table 8. Note that while water chemistry results from 2014 to 2016 are presented in the tables, they are generally not discussed in detail in the result summaries. In 2017, median water temperature ranged from 11.7°C at the N. Fork at 501 site to 15.1°C at the HWY 880 site. Median water temperatures at each site were within the range of median water temperatures from 2014 to 2016. The lowest (4.4°C on October 16) and highest (22.6°C on July 12) water temperature was recorded at the Pinhorn and HWY 880 sites, respectively.

Median dissolved oxygen concentration ranged from 9.47 mg/L at the Pinhorn site to 10.62 mg/L at the N. Fork at 501 site (Table 8). The lowest individual dissolved oxygen concentration occurred at the Pinhorn site (8.41 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 (ESRD 2014). In 2017, 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 (ESRD 2014). The median pH values (8.27 to 8.52) were within guideline for the protection of aquatic life at all Milk River sites in 2017. 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 (148 µS/cm) and highest at the Pinhorn site (246 µS/cm). During the natural flow period, median specific conductivity ranged from a low of 435 µS/cm at the North Fork at 501 site to a high of 678 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 2017 (Table 9).

The specific conductivity irrigation guideline is $\leq$700 µS/cm for sensitive crops (e.g., strawberries) and $\leq$1000 µS/cm for non-sensitive crops (cereals and forages) (Alberta Agriculture 1983, CCREM 1987). In 2017, all samples met the irrigation guideline for non-sensitive crops and one sample each exceeded the guideline for sensitive crops at the HWY 880 and Pinhorn sites in October during low, natural flow.

Table 8 - Summary (median and range) of general water quality parameters at the Milk River, 2014 to 2017.

Site	Water Temperature (°C)											
	2014			2015			2016			2017		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	9	12.1	4.3-18.2	9	9.8	3.6-18.6	9	12.4	1.9-18.2	10	11.7	5.2-19.2
Milk R. at 501	9	14.4	5.2-19.0	7	10.1	4.8-21.4	6	11.3	0.8-18.0	7	12.0	6.6-18.6
U/S Milk River	10	14.4	2.0-21.5	8	9.4	6.4-21.0	8	13.5	2.1-19.2	10	14.4	4.4-20.7
HWY 880	9	17.0	0.8-20.5	10	13.3	5.1-20.8	9	15.9	0.9-20.2	10	15.1	7.9-14.7
Pinhorn	9	15.6	0.1-20.7	10	14.1	5.5-20.5	9	15.4	0.6-20.4	10	14.4	7.5-20.5

Site	Dissolved Oxygen (mg/L)											
	2014			2015			2016			2017		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	9	7.70	7.03-9.29	9	10.26	8.92-11.61	9	10.12	8.71-11.76	10	10.62	8.92-12.45
Milk River at 501	9	7.14	6.72-8.56	7	10.27	8.93-11.47	6	9.88	8.97-12.2	7	10.39	8.36-11.88
U/S Milk River	10	7.69	6.51-9.87	9	9.91	8.19-11.31	8	10.35	8.80-12.80	10	9.62	8.62-12.52
HWY 880	9	7.44	6.37-10.82	10	10.60	8.83-11.50	9	10.28	8.64-13.48	10	10.10	9.07-12.48
Pinhorn	9	7.49	6.23-10.84	10	10.34	8.66-11.50	9	9.89	8.45-14.11	10	9.47	8.41-11.29

Site	pH											
	2014			2015			2016			2017		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	9	8.43	8.17-8.51	10	8.19	7.62-8.38	10	8.10	7.84-8.30	10	8.27	8.14-8.59
Milk R. at 501	10	8.49	8.32-8.57	8	8.52	8.30-8.59	7	8.46	8.33-8.60	7	8.52	8.40-8.59
U/S Milk River	10	8.40	8.28-8.60	10	8.35	7.91-8.54	10	8.24	8.08-8.41	10	8.31	8.17-8.47
HWY 880	9	8.36	8.28-8.61	10	8.41	7.76-8.53	10	8.28	8.05-8.44	10	8.34	8.19-8.49
Pinhorn	9	8.36	8.30-8.63	10	8.41	7.95-8.57	10	8.24	8.13-8.48	10	8.37	8.13-8.49

Table 9 - Summary of specific conductivity (µS/cm) at the Milk River, 2014 to 2017.

Site	Flow Period	WQO		2014				2015				2016				2017			
		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	4	149	165	139-172	6	154	159	145-161	8	155	183	136-195	8	148	183	130-183
	Natural	445	512	5	454	473	427-474	4	300	427	190-448	2	350	-	276-423	2	435	-	430-440
Milk R. at 501	April-Oct	510	882	10	489	579	354-588	8	489	696	461-863	7	530	1140	486-1900	7	456	492	423-492
U/S Milk River	Diversion	210	398	5	208	317	170-383	6	198	224	152-225	8	209	295	148-364	8	203	299	150-299
	Natural	570	674	5	492	580	458-606	4	423	539	308-567	2	407	-	248-566	2	470	-	470-470
HWY 880	Diversion	250	540	5	245	382	210-460	6	237	265	181-273	8	251	396	179-420	8	236	386	117-386
	Natural	727	936	4	654	735	477-759	4	522	707	391-766	2	601	-	342-859	2	664	-	599-728
Pinhorn	Diversion	250	540	5	261	404	223-481	6	212	286	116-296	8	273	421	189-428	8	246	423	188-423
	Natural	727	936	4	696	759	482-785	4	591	739	440-791	2	582	-	316-847	2	678	-	623-733

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**).

3.4.4 Nutrients

Total Phosphorus

In general, total phosphorus in the Milk River tends to increase in the downstream direction. During the diversion period, median total phosphorus concentration was 0.017 mg/L at the North Fork at 501 site, 0.062 mg/L at the U/S Milk River site and 0.176 mg/L at the Pinhorn site (Table 10). During the natural flow period, median total phosphorus was 0.010 mg/L at the North Fork at 501 site, 0.013 mg/L at the U/S Milk River site and 0.043 mg/L at the Pinhorn site. The lowest total phosphorus concentration (0.004 mg/L) occurred at the North Fork at 501 and U/S Milk River sites on October 17 during the natural flow period. The highest total phosphorus concentration (0.254 mg/L) occurred at the Pinhorn site on June 22 during the diversion period (Table 10). In 2017, total phosphorus ranged from 0.008 to 0.027 mg/L (median: 0.015 mg/L) at the Milk River at 501 site (April-October, natural flow only) (Table 10) and was the second lowest median of the four monitoring years.

During the diversion period, median total phosphorus concentration did not meet the WQO-50 objective at the N. Fork at 501 site, U/S Milk River and Pinhorn sites. During the natural flow period, the WQO-50 was not met at the HWY 880 and Pinhorn sites (Table 10).

The WQO-90 for total phosphorus was not met at the N. Fork at 501 or Pinhorn sites during the diversion period in 2017 (Table 10) as both sites were in the cautionary range. It was not possible to calculate a 90^{th} percentile for the natural flow period due to the small sample (N=2) except at the Milk River at 501 site (N=7) which met the WQO-90.

Total Dissolved Phosphorus

In general, total dissolved phosphorus concentrations are similar at all Milk River sites with only a small increase in the downstream direction. During the diversion period, median total dissolved phosphorus concentration ranged from 0.003 mg/L at the North Fork at 501 site to 0.006 mg/L at the Pinhorn site (Table 11). During the natural flow period, median total dissolved phosphorus ranged from 0.004 mg/L at the North Fork at 501 site to 0.010 mg/L at the Pinhorn site (Table 11). In 2017, total dissolved phosphorus ranged from 0.002 to 0.008 mg/L (median: 0.005 mg/L) at the Milk River at 501 site (April-October, natural flow only) (Table 11) and was the second lowest of the four monitoring years.

Median total dissolved phosphorus concentrations met the WQO-50 objective at all sites during the diversion period except at the Pinhorn site. Similarly, during the natural flow period, the WQO-50 was met at all sites except the Pinhorn site (Table 11). The total dissolved phosphorus WQO-90 was met at all sites in 2017 during the diversion and natural flow periods (Table 11).

Table 10 - Summary of total phosphorus concentrations (mg/L) at the Milk River, 2014 to 2017.

Site	Flow Period	WQO		2014				2015				2016				2017			
		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	5	0.013	0.029	0.008-0.033	6	0.016	0.022	0.010-0.023	8	0.014	0.037	0.010-0.080	8	0.017	0.041	0.005-0.041
	Natural	0.012	0.100	5	0.013	0.022	0.003-0.027	4	0.010	0.015	0.007-0.016	2	0.008	-	0.006-0.010	2	0.010	-	0.004-0.015
Milk R. at 501	April-Oct	0.019	0.186	10	0.021	0.089	0.008-0.098	8	0.014	0.020	0.010-0.021	7	0.023	0.050	0.016-0.063	7	0.015	0.027	0.008-0.027
U/S Milk River	Diversion	0.044	0.148	5	0.050	0.232	0.039-0.255	6	0.079	0.148	0.036-0.183	8	0.049	0.108	0.028-0.169	8	0.062	0.139	0.014-0.139
	Natural	0.013	0.504	5	0.029	0.134	0.009-0.202	4	0.013	0.024	0.008-0.028	2	0.013	-	0.008-0.017	2	0.013	-	0.004-0.022
HWY 880	Diversion	0.088	0.220	5	0.089	0.311	0.076-0.325	6	0.141	0.197	0.066-0.204	8	0.071	0.145	0.019-0.254	7	0.064	0.160	0.015-0.194
	Natural	0.013	0.086	4	0.029	0.202	0.007-0.270	4	0.021	0.040	0.007-0.045	2	0.011	-	0.009-0.013	2	0.026	-	0.005-0.047
Pinhorn	Diversion	0.088	0.220	5	0.190	0.436	0.133-0.446	6	0.156	0.245	0.107-0.284	8	0.155	0.179	0.034-0.196	8	0.176	0.254	0.078-0.254
	Natural	0.013	0.086	4	0.048	0.210	0.009-0.271	4	0.033	0.066	0.009-0.072	2	0.030	-	0.024-0.036	2	0.043	-	0.010-0.076

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, 2014 to 2017.

Site	Flow Period	WQO		2014				2015				2016				2017			
		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	4	0.003	0.003	0.003-0.003	6	0.003	0.003	0.003-0.003	8	0.004	0.012	0.003-0.018	8	0.003	0.007	0.002-0.007
	Natural	0.005	0.066	5	0.006	0.007	0.003-0.007	4	0.003	0.005	0.003-0.006	2	0.003	-	0.003-0.003	2	0.004	-	0.002-0.007
Milk R. at 501	Apr-Oct	0.006	0.015	10	0.004	0.008	0.003-0.022	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
U/S Milk River	Diversion	0.003	0.010	5	0.003	0.024	0.003-0.039	6	0.003	0.006	0.003-0.006	8	0.006	0.012	0.003-0.013	8	0.003	0.007	0.002-0.007
	Natural	0.005	0.173	5	0.007	0.021	0.003-0.030	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
HWY 880	Diversion	0.004	0.011	5	0.006	0.028	0.003-0.043	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
	Natural	0.004	0.021	4	0.005	0.007	0.003-0.008	4	0.006	0.006	0.003-0.007	2	0.004	-	0.003-0.006	2	0.005	-	0.002-0.008
Pinhorn	Diversion	0.004	0.011	5	0.006	0.022	0.003-0.033	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
	Natural	0.004	0.021	4	0.004	0.007	0.003-0.007	4	0.003	0.006	0.003-0.007	2	0.005	-	0.003-0.007	2	0.010	-	0.010-0.010

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 general, total nitrogen at the Milk River increases in concentration in the downstream direction. During the diversion period, median total nitrogen concentration ranged from a low of 0.126 mg/L at the North Fork at 501 site to 0.470 mg/L at the Pinhorn site (Table 12). During the natural flow period, total nitrogen ranged from 0.250 mg/L at the U/S Milk River site to 0.365 mg/L at the Pinhorn site. In 2017, total nitrogen ranged from 0.260 to 0.390 mg/L (median: 0.330 mg/L) at the Milk River at 501 site (April-October, natural flow only) (Table 12).

During the diversion period, total nitrogen concentration met the WQO-50 objective at all sites except the Pinhorn site which exceeded the objective by more than 20%. During the natural flow period, total nitrogen concentration met the WQO-50 objective at all sites except the Pinhorn site. The WQO-90 objective for total nitrogen was met at all sites in 2017 during the diversion period (Table 12).

3.4.5 Total Suspended Solids

During the diversion period, median total suspended solids concentrations ranged from 20 mg/L at the North Fork at 501 site to 194 mg/L at the Pinhorn site (Table 13). During the natural flow period, median total suspended solids ranged from 3 mg/L at the North Fork at 501 site to 37 mg/L at the Pinhorn site (Table 13). Total suspended solids concentration ranged from 6 to 33 mg/L (median: 11 mg/L) at the Milk River at 501 site in 2017 (April-October, natural flow only).

During the diversion period, the total suspended solids concentration did not meet the WQO-50 objective at the N. Fork at 501, U/S Milk River and the Pinhorn sites, exceeding the objective by more than 20%. During the natural flow period, the WQO-50 objective was not met at the HWY 880 and Pinhorn sites. The WQO-90 objective was met at all sites in 2017 during the diversion period (Table 13).

3.4.6 Fecal Coliform Bacteria

During the diversion period, median fecal coliform bacteria counts ranged from 30 cfu/100 mL at the N. Milk River at 501 site to 109 cfu/100 mL at the Pinhorn site (Table 14). During the natural flow period, median fecal coliform bacteria counts were low and ranged from 2 cfu/100 mL at the N. Milk River at 501 site to 18 cfu/100 mL at the Pinhorn site. At the Milk River at 501 site in 2017 (April-October, natural flow only), fecal coliform bacteria counts ranged from 1 to 5000 cfu/100 mL and the median (44 cfu/100 mL) was the lowest of the four monitoring years.

The median fecal coliform bacteria counts met the WQO-50 objective at all the sites during the diversion period except at the Pinhorn site (Table 14). During the natural flow period, the WQO-50 was met at all of the sites (Table 14). The WQO-90 objective was only met at the U/S Milk River site during the diversion period (Table 14). In 2017 at the Milk River at 501 site, the WQO-50 was met but the WQO-90 objective was not met.

Table 12 - Summary of total nitrogen concentrations (mg/L) at Milk River, 2014 to 2017.

Site	Flow Period	WQO		2014				2015				2016				2017			
		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	5	0.176	0.274	0.100-0.320	6	0.146	0.155	0.110-0.157	8	0.134	0.191	0.125-0.345	8	0.126	0.295	0.026-0.295
	Natural	0.900	1.578	5	0.289	0.516	0.202-0.576	4	0.225	0.316	0.121-0.338	2	0.311	-	0.145-0.477	2	0.313	-	0.220-0.405
Milk R. at 501	April-October	0.600	1.360	10	0.347	0.552	0.277-0.596	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
U/S Milk River	Diversion	0.325	0.667	5	0.307	0.624	0.127-0.717	6	0.264	0.315	0.110-0.317	8	0.222	0.451	0.110-0.629	8	0.275	0.508	0.110-0.508
	Natural	0.680	1.637	5	0.486	1.036	0.297-1.070	4	0.214	0.327	0.110-0.352	2	0.275	-	0.125-0.425	2	0.250	-	0.160-0.340
HWY 880	Diversion	0.365	0.668	5	0.367	0.859	0.277-0.880	6	0.315	0.463	0.122-0.466	8	0.295	0.593	0.125-0.845	8	0.309	0.531	0.170-0.531
	Natural	0.320	1.400	5	0.486	0.966	0.036-1.106	4	0.225	0.354	0.110-0.403	2	0.301	-	0.154-0.448	2	0.335	-	0.200-0.470
Pinhorn	Diversion	0.365	0.668	5	0.487	1.043	0.297-1.101	6	0.319	0.522	0.129-0.525	8	0.385	0.615	0.125-0.670	8	0.470	0.550	0.240-0.550
	Natural	0.320	1.400	5	0.227	0.931	0.036-1.222	4	0.301	0.609	0.110-0.660	2	0.416	-	0.142-0.690	2	0.365	-	0.220-0.510

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, 2014 to 2017.

Site	Flow Period	WQO		2014				2015				2016				2017			
		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	15	30	7.9-34.6	4	11	21	1.5-22	8	12	45	2-99	8	20	50	4-50
	Natural	5	55	5	2	6	1.5-9.3	6	5	11	1.5-12	2	3	-	1.5-4.7	2	3	-	1-6
Milk R. at 501	April-October	14	247	10	15	99	1.5-112	8	6	7	1.5-7.3	7	11	47	7-84	7	11	33	6-33
U/S Milk River	Diversion	56	282	5	78	239	47.7-267	6	88	160	15.3-175	8	52	134	21-212	8	83	351	18-351
	Natural	7	267	5	18	88	1.5-132	4	4	22	1.5-28	2	2	-	1.5-1.5	2	7	-	1-13
HWY 880	Diversion	131	384	5	151	387	87.6-388	6	154	212	36.7-250	8	89	174	14-259	8	78	236	57-236
	Natural	13	228	4	21	226	1.5-306	4	11	39	1.5-47.3	2	5	-	3.3-6	2	24	-	10-38
Pinhorn	Diversion	131	384	5	213	488	137-540	6	185	292	113-293	8	169	193	23-202	8	194	313	7-313
	Natural	13	228	4	37	195	3.8-251	4	20	58	1.5-67	2	14	-	8.7-18.7	2	37	65	8-65

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, 2014 to 2017.

Site	Flow Period	WQO		2014				2015				2016				2017			
		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	5	138	201	56-226	6	90	133	44-138	8	51	441	6-1100	8	30	283	6-283
	Natural	55	668	5	11	46	5-53	4	78	160	3-164	2	154	-	8-300	2	2	-	1-2
Milk R. at 501	April-October	77	619	10	104	2030	4-3200	8	86	462	4-900	7	122	2080	1-3400	7	44	5000	1-5000
U/S Milk River	Diversion	68	272	5	158	289	89-360	6	176	193	104-194	8	38	491	7-1300	8	53	191	1-191
	Natural	49	522	5	5	91	2-142	4	8	46	1-62	2	39	-	7-71	2	3	-	1-5
HWY 880	Diversion	78	280	5	142	206	70-210	6	156	741	84-1100	8	43	530	1-600	8	69	530	6-530
	Natural	29	163	4	6	42	1-57	4	20	57	1-65	2	34	-	5-62	2	17	-	1-32
Pinhorn	Diversion	78	280	5	128	189	48-229	6	157	277	115-366	8	85	216	18-318	8	109	468	12-468
	Natural	29	163	4	13	33	2-38	4	39	46	8-45	2	47	-	37-56	2	18	-	9-27

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 2017 differed substantially across the watershed, ranging from 132.2 mm at Masinasin to 261.6 mm at Milk River. June was generally the wettest month (mean = 50.8 mm) while August was the driest month (mean = 3.4 mm). At the three Milk River sites augmented by the St. Mary diversion, flow generally ranged from 15 to 20 m^3/s during normal diversion operation and was reduced to 0.25 to 2.20 m^3/s within a week of diversion shut-down.

Red Creek

- Median dissolved oxygen concentrations complied with acute and chronic guidelines in 2017 at the Red Creek sites; however, some individual samples did not meet the acute or chronic guideline at the upstream site.
- All pH values met the aquatic life guidelines at the three Red Creek sites in 2017.
- No individual specific conductivity sample (range: 1530 to 3080 µS/cm) or median conductivity values met irrigation guidelines at any of the three Red Creek sites in 2017.
- Median total phosphorus concentrations at the three Red Creek sites (range: 0.036 to 0.098 mg/L) were within the range of the three previous years.
- Median TSS concentrations (range: 4 to 12 mg/L) were low at Red Creek in 2017; although, the maximum TSS concentration reached 61 mg/L at the upstream site. No TSS trends are apparent from 2014 to 2017.
- Median fecal coliform bacteria counts at Red Creek met the irrigation guideline at the two upstream sites, but exceeded the guideline at the downstream site in 2017. Median fecal coliform bacteria counts at the downstream site have not met irrigation guidelines from 2014 to 2017. The maximum count of individual samples at each site in 2017 ranged from 400 to 700 cfu/100 mL.

Eastern Tributaries

- Median dissolved oxygen concentrations were compliant with acute and chronic guidelines in 2017 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 2017.
- The median specific conductivity met irrigation guidelines at Battle and Middle creeks; however, at Lodge Creek median specific conductivity did not meet the guideline for sensitive crops.
- Median total phosphorus concentrations at Battle Creek (0.017 mg/L) and Lodge Creek (0.053 mg/L) were within the range of the three previous years. Median total phosphorus at Middle Creek (0.048 mg/L) was substantially lower in 2017 compared to the three previous years (range: 0.104 to 0.123 mg/L).
- Median TSS concentrations (range: 2 to 9 mg/L) were low at the Eastern tributaries in 2017 and no TSS trends are apparent from 2014 to 2017.
- Median fecal coliform concentrations (range: 3 to 24 cfu/100 mL) were low at the Eastern tributaries in 2017 and median fecal coliform concentrations have met the irrigation guideline from 2014 to 2017.

Milk River Mainstem

- Milk River Water Quality Objectives (WQOs) were used to determine water quality at sites in 2017 (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 2017.
- Conductivity (salts) met the median WQO-50 and WQO-90 at all Milk River sites. The median conductivity also met the guideline for irrigation of sensitive crops at all Milk River sites.
- Total phosphorus exceeded the median WQO-50 at the N. Fork at 501, U/S Milk River and Pinhorn sites during the diversion flow period, and at the HWY 880 and Pinhorn sites during natural flow. The WQO-90 for total phosphorus was not met at the N. Fork at 501 or Pinhorn sites during the diversion period
- Total nitrogen met the WQO-50 and WQO-90 at all Milk River sites with the exception of the median objective at the Pinhorn site for the diversion and natural flow periods.
- Total suspended solids did not meet the WQO-50 during the diversion period at N. Fork at 501, U/S Milk River and Pinhorn sites, and during the natural flow period at HWY 880 and Pinhorn sites. The WQO-90 was not met at the HWY 880 site during the diversion period.
- Fecal coliform bacteria exceeded the WQO-50 during the diversion flow period at the N. Fork at 501 and the Pinhorn sites. The WQO-90 objective was exceeded at N. Fork at 501, HWY 880 and Pinhorn sites during the diversion flow period, and at Milk River at 501 site during the natural flow period.

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*), in particular, 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 excessive 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 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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