MILK RIVER WATERSHED

WATER MONITORING REPORT 2016

Prepared for: Milk River Watershed Council Canada

Prepared by: Palliser Environmental Services Ltd.

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Palliser Environmental Services Ltd.

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Cover Photo:

Red Creek, by Tim Romanow

Table of Contents

1.0 INTRODUCTION

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

The Milk River Watershed Council Canada has monitored the Milk River and some of its tributaries since 2006. This report is a compilation of water monitoring data collected in 2016, with reference to the results from the previous three years (i.e., 2013-2015). 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 and 2016 (AEP) and Environment Canada collects monthly samples at the Western and Eastern crossings (Figure 1). Data from Alberta Environment and Parks and Environment Canada has not been included in this summary report. In 2016, the MRWCC sampled April 6, April 20, May 12, May 26, June 9, June 23, July 14, August 18, September 14 and October 13. The St. Mary River diversion flow period was from March 22 to September 10. A period of lower flow augmentation occurred from May 24 to June 6.

Milk River tributaries were also monitored in 2016. The monitoring included three sites at Red Creek (i.e., Upstream, Middle and Downstream), Verdigris Coulee (not sampled: dry during the 2016 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).

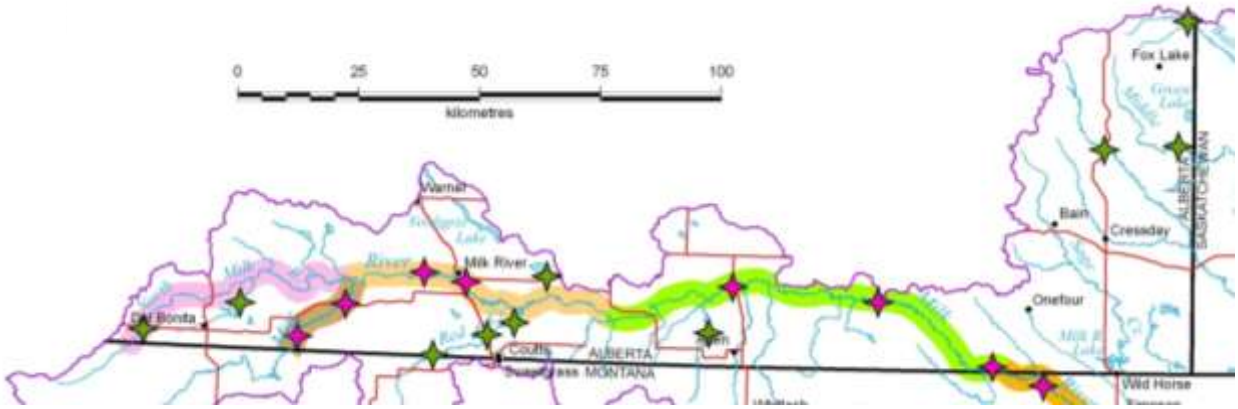


Figure 1 - Map showing water monitoring locations sampled in the Milk River watershed, 2016.

The MRWCC water monitoring program was conducted in collaboration with Cardston County, County of Warner, County of Forty Mile and Cypress County. 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 2016 data set is the fifth year of data collected since the WQOs were established.

2.1 Missing Data

Table 1 - Summary of compromised samples or missing data for the 2016 water monitoring year.

Site	Date	Measurement	Reason
Battle Creek	July 15	Fecal coliforms, NO_2+NO_3_N and TDS	Caution: Sampling was done on Friday causing delays in analysis until Monday. Laboratory received sample at a temperature of 19°C
Lodge Creek	July 15	Fecal coliforms, NO_2+NO_3_N and TDS	Caution: Sampling was done on Friday causing delays in analysis until Monday. Laboratory received sample at a temperature of 19°C
Middle Creek	July 15	Fecal coliforms, NO_2+NO_3_N and TDS	Caution: Sampling was done on Friday causing delays in analysis until Monday. Laboratory received sample at a temperature of 19°C
Red Creek at Upstream	April 20	Water temperature, dissolved oxygen	Meter not working.
Red Creek at Midstream	April 20	Water temperature, dissolved oxygen	Meter not working.
Red Creek at Mouth	April 20	Water temperature, dissolved oxygen	Meter not working.
North Fork at 501	April 20	Water temperature, dissolved oxygen	Meter not working.
Milk River at 501	April 20	Water temperature, dissolved oxygen	Meter not working
Upstream of Milk River	April 20	Water temperature, dissolved oxygen	Meter not working.
	June 9	Water temperature, dissolved oxygen	Meter not working.
Hwy 880	April 20	Water temperature, dissolved oxygen	Meter not working
Pinhorn Ranch	April 20	Water temperature, dissolved oxygen	Meter not working.

[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 2016 was quite similar, ranging from 304.0 mm at Cardston to 323.1 mm at Masinasin (Tables 2, 3). May was the wettest month (mean= 70.5 mm) while August was the driest month (mean= 30.7 mm) (Table 2).

Table 2 – Total precipitation (mm) at five weather stations for the water monitoring April to October, 2016.

Month	Cardston	Del Bonita	Milk River	Masinasin	Onefour
April	21.2	19.6	63.2	76.4	59.5
May	103.6	81.1	67.8	51.8	48.0
June	16.1	28.8	34.7	34.9	50.7
July	38.3	72.9	50.3	57.0	16.9
August	30.8	33.8	26.7	28.8	33.6
September	53.1	40.2	35.8	34.4	38.2
October	40.9	32.9	37.0	39.8	72.2
Total	**304.0**	**309.3**	**315.5**	**323.1**	**319.1**
Data Source: Environment Canada - http://climate.weather.gc.ca/index_e.html					

Comparing mean total precipitation for each year, 2016 was the third wettest with the wettest years occurring in 2013 and 2014 (Table 4). The year 2015 was the driest year (mean: 194.1 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
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 the median water temperatures were cooler at the middle and downstream sites compared to previous years (2013 to 2015); however, at the downstream site only three water temperatures were collected in April and May which would have underestimated the median water temperatures from April to October (Table 4). The maximum water temperature at the middle site (19.5^{o}C) was the lowest of the years 2013 to 2016 (Table 4) and the maximum water temperature at the upstream and middle sites occurred in June.

The median dissolved oxygen concentrations (9.8 to 14.2 mg/L) met the acute (≥5.0 mg/L) and chronic (≥6.5 mg/L) guidelines at all Red Creek sites in 2016. At the upstream site, one sample on August 18th was 4.35 mg/L and did not meet the acute guideline. Similarly at the middle site, one sample on July 14th was 2.55 mg/L and did not meet the acute guideline. In comparison to the previous three years, the median dissolved oxygen appears to be increasing at the middle site (Table 4). The compliance rate for the chronic guideline appears to be improving at the upstream site (Table 5) whereas the other sites do not show a compliance trend.

The median pH and all individual samples collected at Red Creek met the pH guideline of 6.5 to 9.0 for aquatic life. From 2013 to 2016, the median pH at the middle site has increased slightly from 8.29 to 8.45.

Median specific conductivity was 2610 µS/cm at the upstream site, 2870 µS/cm at the middle site and 2615 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). The median conductivity values at the upstream and middle site in 2016 were the highest of the four years (Table 4).

3.2.2 Nutrients

Median total phosphorus concentration was lowest at the upstream site (0.023 mg/L) and highest at the middle site (0.080 mg/L) (Table 4). The maximum total phosphorus concentrations (0.041 to 0.097 mg/L) occurred during May which was the wettest month in 2016. Higher precipitation would have resulted in increased runoff and increased TSS. Phosphorus tends to adsorb to sediment particles; therefore, the highest total phosphorus concentrations often occur when TSS concentrations are the highest. Similarly, median total dissolved phosphorus was lowest at the upstream site (0.016 mg/L) and highest at the middle site (0.047 mg/L). Median total dissolved phosphorus concentrations tend to be increasing at the downstream site (0.006 mg/L in 2013 and 0.018 mg/L in 2016).

Median total nitrogen concentration was lowest at the downstream site (0.823 mg/L) and highest at the middle site (1.325 mg/L) (Table 4). Total nitrogen concentration tends to be decreasing at the downstream site compared to previous years (1.244 mg/L in 2013 and 0.823 mg/L in 2016). In 2016, most of the total nitrogen was present in the organic (TKN) form (~90%) with a much smaller percentage (~10%) of the nitrogen present in soluble form (Nitrate+Nitrite Nitrogen) (Table 4).

Table 4 - Median and range for water quality parameters at Red Creek, 2013-2016.

Parameter	Upstream				Middle				Downstream			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
Water Temperature, °C	15.1 4.7-20.7	14.1 2.9-20.7	11.6 6.9-23.6	14.2 3.0-20.6	16.3 6.6-22.2	16.2 4.9-23.6	13.6 8.5-23	10.7 8.6-19.5	15.7 6.5-22.9	14.2 3.8-23.1	13.1 8.5-30.0	9.8 8.7-17.1
Dissolved Oxygen, mg/L	8.97 4.61-10.37	5.95 2.61-10.7	9.50 6.61-12.24	10.06 4.35-13.53	7.61 4.14-11.60	7.66 4.41-8.91	8.63 5.60-11.90	8.85 2.55-14.33	9.33 7.84-10.91	9.38 5.48-12.84	11.46 6.84-18.3	10.22 10.16-11.84
pH	8.24 7.94-8.32	8.22 8.11-8.42	8.28 7.95-8.37	8.15 7.69-8.58	8.29 8.01-8.79	8.33 8.26-8.64	8.39 7.89-8.67	8.45 7.98-8.92	8.29 8.04-8.40	8.34 8.24-8.58	8.41 8.33-8.52	8.39 8.29-8.43
Specific Conductivity, µS/cm	2550 2500-2700	2415 1880-2760	2350 2030-2700	2610 2290-2790	2665 2220-2860	2590 2110-2880	2335 2040-3020	2870 2420-3450	2500 2230-2960	2620 2250-2830	2665 2440-2890	2615 2500-2880
Total Phosphorus, mg/L	0.022 0.015-0.035	0.073 0.015-0.457	0.035 0.025-0.053	0.023 0.015-0.047	0.081 0.038-0.163	0.151 0.031-0.178	0.077 0.063-0.111	0.080 0.041-0.097	0.024 0.006-0.081	0.032 0.016-0.098	0.051 0.036-0.070	0.030 0.021-0.041
Total Dissolved Phosphorus, mg/L	0.007 0.003-0.014	0.030 0.006-0.426	0.017 0.010-0.031	0.016 0.012-0.033	0.030 0.010-0.047	0.048 0.019-0.139	0.038 0.021-0.053	0.047 0.026-0.077	0.006 0.003-0.011	0.009 0.005-0.048	0.019 0.012-0.031	0.018 0.014-0.029
Nitrate+Nitrite Nitrogen, mg/L	0.036 0.036-1.410	0.316 0.027-1.660	0.185 0.050-1.430	0.055 0.025-1.850	0.036 0.036-0.036	0.036 0.027-0.135	0.050 0.010-0.280	0.055 0.055-0.140	0.644 0.258-1.520	0.135 0.027-0.839	0.135 0.050-0.320	0.103 0.055-0.170
Total Kjeldahl Nitrogen, mg/L	0.760 0.690-1.080	0.985 0.570-1.710	0.850 0.100-1.100	0.925 0.580-1.100	1.215 0.880-1.420	1.310 0.460-1.560	0.880 0.310-1.530	1.270 0.790-1.950	0.655 0.380-2.480	0.79 0.530-1.590	0.815 0.520-2.760	0.730 0.590-0.960
Total Nitrogen, mg/L	1.066 0.746-2.100	1.638 0.787-2.230	0.985 0.380-2.390	1.100 0.635-2.810	1.251 0.916-1.456	1.367 0.487-1.695	0.930 0.320-1.580	1.325 0.845-2.005	1.244 0.898-3.780	1.230 0.717-1.725	1.015 0.640-2.930	0.823 0.685-1.110
Total Suspended Solids, mg/L	2 2-13	6 2-26	4 2-6	2 2-8	5 2-21	16 4-40	7 3-11	4 2-13	6 2-32	9 3-25	17 5-42	6 2-10
Fecal Coliform Bacteria, cfu/100 mL	18 1-400	46 1-900	122 1-900	47 1-8900	14 1-74	400 1-49000	49 1-192	21 0.5-1300	44 1-17800	300 1-4600	315 9-6000	215 2-700

Table 5 - Summary of Red Creek water quality compliance with dissolved oxygen acute and chronic guidelines, 2013-2016 (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
2013	89	67	90	70	100	100
2014	70	40	67	67	100	89
2015	100	100	100	87	100	100
2016	89	100	83	67	100	100
Trend	-	Improving	-	-	-	-

3.2.3 Total Suspended Solids

The downstream site had the highest median total suspended solids concentration (6 mg/L) compared to the upstream (2 mg/L) and middle (4 mg/L) sites (Table 4). The maximum total suspended solids concentrations (8 to 13 mg/L) occurred during the April 20 or May 12 sampling dates which were the two wettest months in 2016. Increased precipitation would cause more runoff and increased stream flows (i.e., increased bank erosion) resulting in higher instream TSS.

3.2.4 Fecal Coliform Bacteria

The median fecal coliform bacteria count was highest at the downstream site (215 mg/L), compared to the upstream site (47 mg/L) and middle site (21 mg/L) (Table 4). Fecal coliform bacteria counts appear to be highly variable from year to year (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 8.1°C in 2016, similar to 2014 and 2015 but cooler than 2013 (median: 10.6°C) (Table 6). The maximum water temperature reached 14.6°C on June 9. Dissolved oxygen concentrations met the chronic (>6.5 mg/L) and acute (>5.0 mg/L) guidelines throughout 2016 with all concentrations greater than 8.49 mg/L. Similarly, all pH values met the aquatic life guideline in 2016 (≥6.5 and ≤9.0). Median specific conductivity was 391 µS/cm and all samples were well below the irrigation guideline for sensitive crops (<700 µS/cm).

Middle Creek – The median water temperature was 15.0°C in 2016, similar to 2013 (15.0°C) and 2015 (15.3°C) but warmer than 2014 (13.6°C) (Table 6). The maximum water temperature reached 21.8°C on June 9. Dissolved oxygen concentrations met the acute (>5.0 mg/L) guideline throughout 2016 with oxygen concentrations ranging from 5.5 to 14.3 mg/L (median: 10.57 mg/L) and only 1 of 10 samples (10%) did not meet the chronic (>6.5 mg/L) guideline. All pH values met the aquatic life guideline in 2016 (≥6.5 and ≤9.0). Median specific conductivity was 699 µS/cm; 5 of 10 samples (40%) did not meet the irrigation guideline for sensitive crops (<700 µS/cm), but all samples met the guideline for general crops (<1000 µS/cm). The maximum conductivity was recorded at 828 µS/cm on April 20. A minor increasing trend for specific conductivity has occurred at Middle Creek from 2013 to 2016.

Lodge Creek – The median water temperature was 14.2°C in 2016 similar to 2015, slightly warmer than 2014 (13.2°C) and cooler compared to 2013 (15.8°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 10.18 mg/L. Similarly, all pH values met the aquatic life guideline in 2016 (≥6.5 and ≤9.0). Median specific conductivity was 965 µS/cm; 9 of 10 samples (90%) did not meet the irrigation guideline for sensitive crops (<700 µS/cm), and 4 of 10 samples (40%) did not meet the guideline for general crops (<1000 µS/cm). Maximum conductivity was 1290 µS/cm at Lodge Creek and occurred on May 12. The median specific conductivity at Lodge Creek in 2016 was the lowest from 2013 to 2016.

3.3.2 Nutrients

Battle Creek – Median total phosphorus concentration was 0.020 mg/L in 2016, similar to 2013 to 2015 (0.017 to 0.022 mg/L) (Table 6). Total dissolved phosphorus concentration was the highest in 2016 (0.015 mg/L) and an increasing trend is observed since 2013 (0.008 mg/L). About 50% of the total phosphorus was present in the dissolved form. Median total nitrogen in 2016 (0.168 mg/L) was the highest compared to the three previous monitoring years (0.110 to 0.136 mg/L) and no trend is observed (Table 6). Approximately 60% of the total nitrogen was comprised of total Kjeldahl nitrogen (organic nitrogen) which is lower than the previous years when it ranged from 74 to 91%. Median nitrate+nitrite nitrogen concentrations were decreasing from 2013 (0.036 mg/L) to 2015 (0.010 mg/L) but increased in 2016 (0.025 mg/L).

Middle Creek - Median total phosphorus concentration in 2016 (0.123 mg/L) was higher than the three previous monitoring years (0.075 to 0.116 mg/L) (Table 6). Total dissolved phosphorus concentration in 2016 was 0.095 mg/L and an increasing trend is observed since 2013 (0.055 mg/L). In 2016, a substantial portion of total phosphorus was present in the dissolved form. Median total nitrogen in 2016 (0.605 mg/L) was similar to 2013 (0.591 mg/L), higher than 2015 (0.480 mg/L), lower compared to 2014 (0.722 mg/L) and no trend was observed (Table 6). Approximately 96% of the total nitrogen was comprised of total Kjeldahl nitrogen which is similar to previous years when it ranged from 94 to 98%.

Median nitrate+nitrite nitrogen concentrations tended to decrease from 2013 (0.036 mg/L) to 2015 (0.010 mg/L) but increased in 2016 (0.025 mg/L).

Lodge Creek - Median total phosphorus concentration in 2016 (0.067 mg/L) was higher than the three previous monitoring years (0.047 to 0.060 mg/L) (Table 6). Total dissolved phosphorus concentration in 2016 (0.050 mg/L) was the highest of the three previous monitoring years (0.022 to 0.033 mg/L); however, no trend is apparent. In 2016, about 50% of total phosphorus was present in dissolved form. Median total nitrogen in 2016 (0.580 mg/L) was similar to 2013 (0.536 mg/L), higher than 2015 (0.465 mg/L), lower compared to 2014 (0.677 mg/L) and no trend was observed (Table 6). Approximately 91% of total nitrogen was comprised of total Kjeldahl nitrogen which is similar to previous years when it ranged from 93 to 98%. Median nitrate+nitrite nitrogen concentrations tended to decrease from 2013 (0.036 mg/L) to 2015 (0.010 mg/L) but increased in 2016 (0.025 mg/L).

3.3.3 Total Suspended Solids

Battle Creek – The median total suspended solid concentration in 2016 (5 mg/L) at Battle Creek was similar to 2013 (5 mg/L) and 2014 (6 mg/L) but higher than 2015 (2 mg/L) (Table 6). No trend in total suspended solids concentration was observed at Battle Creek from 2013 to 2016.

Middle Creek – The median total suspended solid concentration in 2016 (2 mg/L) was similar to 2013 (2 mg/L) and lower than 2014 (4 mg/L) and 2015 (4.4 mg/L) (Table 6). No trend in total suspended solids concentration was observed at Middle Creek from 2013 to 2016.

Lodge Creek – The median total suspended solid concentration in 2016 (3 mg/L) was similar to 2013 (3 mg/L) and lower compared to 2014 (8 mg/L) and 2015 (6.4 mg/L) (Table 6). No trend in total suspended solids concentration was observed at Lodge Creek from 2013 to 2016.

3.3.4 Fecal Coliform Bacteria

Battle Creek – The median fecal coliform count in 2016 (23 cfu/100 mL) was similar to 2013 (22 cfu/100 mL) and 2015 (26 cfu/100 mL) but higher compared to 2014 (10 cfu/100 mL) (Table 6). The maximum fecal bacteria count of 102 cfu/100 mL in 2016 was the lowest of the three previous monitoring years (191 to 500 cfu/100 mL). The median fecal bacteria count at Battle Creek has met the irrigation guideline (100 cfu/100 mL) from 2013 to 2016. No trend in fecal coliform bacteria counts was observed from 2013 to 2016.

Middle Creek – The median fecal coliform count in 2016 (3 cfu/100 mL) was the lowest compared to 2013 to 2015 (6 to 36 cfu/100 mL) (Table 6). Similarly, the maximum fecal bacteria count was lower in 2016 (12 cfu/100 mL) compared to the three previous monitoring years (51 to 264 cfu/100 mL). The median fecal bacteria count at Middle Creek has met the irrigation guideline (100 cfu/100 mL) from 2013 to 2016. No trend in fecal coliform bacteria counts was observed from 2013 to 2016.

Lodge Creek – The median fecal coliform count in 2016 (7 cfu/100 mL) was the lowest compared to 2013 to 2015 (9 to 43 cfu/100 mL) (Table 6). Similarly, the maximum fecal bacteria count in 2016 (96 cfu/100 mL) was substantially lower compared to the three previous monitoring years (300 to 800 cfu/100 mL). The median fecal bacteria count at Lodge Creek has met the irrigation guideline (100 cfu/100 mL) from 2013 to 2016. No trend in fecal coliform bacteria counts was observed from 2013 to 2016.

Table 6 - Median and range for water quality parameters at the Eastern Tributaries (Battle Creek, Middle Creek and Lodge Creek), 2013-2016.

Parameter	Battle Creek				Middle Creek				Lodge Creek			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
water temperature, °C	10.6 0.7-17.4	8.85 0.8-16.9	8.9 1.3-16.4	8.1 0.7-14.6	15.0 5.2-21.0	13.55 -4.0-19.8	15.25 5.7-21.2	15.0 4.5-21.8	15.8 5.2-22.1	13.20 3.6-20.8	14.8 5.8-21.7	14.2 1.6-22.6
dissolved oxygen, mg/L	7.67 6.34-9.93	8.26 6.48-9.30	10.23 8.53-12.08	10.49 8.49-12.03	6.99 2.59-9.27	7.00 0.42-9.25	12.10 9.42-14.39	10.57 5.6-14.3	8.52 4.88-9.56	8.38 6.67-9.59	11.77 10.37-15.90	12.22 10.18-14.02
pH	8.25 8.19-8.38	8.35 8.21-8.61	8.37 8.06-8.53	8.23 7.94-8.44	8.20 7.97-8.29	8.28 8.22-8.57	8.41 7.94-8.69	8.28 8.01-8.52	8.27 7.54-8.49	8.33 8.20-8.54	8.41 8.30-8.54	8.39 7.93-8.89
specific conductivity, µS/cm	380 313-397	369 338-410	376 199-392	391 353-425	681 516-740	687 380-947	694 549-745	699 584-828	1006 468-1480	1240 780-1630	1270 941-1540	965 645-1290
total phosphorus, mg/L	0.022 0.009-0.045	0.017 0.012-0.041	0.018 0.014-0.023	0.020 0.013-0.036	0.075 0.030-0.163	0.116 0.055-0.293	0.104 0.013-0.327	0.123 0.027-0.256	0.047 0.020-0.601	0.060 0.013-0.106	0.049 0.040-0.084	0.067 0.026-0.210
total dissolved phosphorus, mg/L	0.008 0.003-0.015	0.009 0.006-0.012	0.010 0.006-0.016	0.015 0.009-0.025	0.055 0.017-0.133	0.079 0.021-0.272	0.103 0.064-0.230	0.095 0.024-0.198	0.033 0.003-0.080	0.025 0.003-0.068	0.022 0.006-0.048	0.050 0.015-0.165
nitrate+nitrite nitrogen, mg/L	0.036 0.036-0.036	0.027 0.027-0.077	0.010 0.010-0.240	0.025 0.025-0.110	0.036 0.036-0.036	0.027 0.027-0.175	0.010 0.010-0.010	0.025 0.025-0.025	0.036 0.036-0.036	0.027 0.027-0.175	0.010 0.010-0.050	0.025 0.025-0.100
total Kjeldahl nitrogen, mg/L	0.100 0.100-0.100	0.100 0.100-0.230	0.100 0.100-0.100	0.100 0.100-0.400	0.555 0.440-0.750	0.695 0.310-0.990	0.470 0.100-1.460	0.580 0.340-0.780	0.500 0.440-1.840	0.650 0.370-1.020	0.455 0.250-0.740	0.525 0.067-1.060
total nitrogen, mg/L	0.136 0.136-0.136	0.127 0.127-0.266	0.110 0.110-0.340	0.168 0.125-0.425	0.591 0.476-0.789	0.722 0.337-1.165	0.480 0.110-1.470	0.605 0.365-0.805	0.536 0.476-1.876	0.677 0.397-1.047	0.465 0.260-0.790	0.580 0.092-1.085
total suspended solids, mg/L	5 2-13	6 2-19	2 2-17	5 2-10	2 2-2	4 2-17	4.4 1.5-14.0	2 2-7	3 2-30	8 2-16	6.4 3.3-22.7	3 2-17
fecal coliform bacteria (cfu/100 mL)	22 1-191	10 1-500	26 1-390	23 1-102	21 1-264	36 1-214	6 1-51	3 1-12	21 1-200	9 1-300	43 6-800	7 1-96

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 10, 2016. The initial flows on March 22nd were 1.4 m^3/s (50 ft^3/s) increasing to 5.7 m^3/s (200 ft^3/s) on March 29th. Diversion flow was reduced from 9.9 m^3/s (350 ft^3/s) to 5.7 m^3/s (200 ft^3/s) on May 24th due to concerns of flooding in Montana. On June 6th diversion flow was increased from 5.7 m^3/s (200 ft^3/s) to 8.5 m^3/s (300 ft^3/s) and on June 9th diversion was again increased to 12.7 m^3/s (450 ft^3/s). Table 5 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 2016 monitoring period.

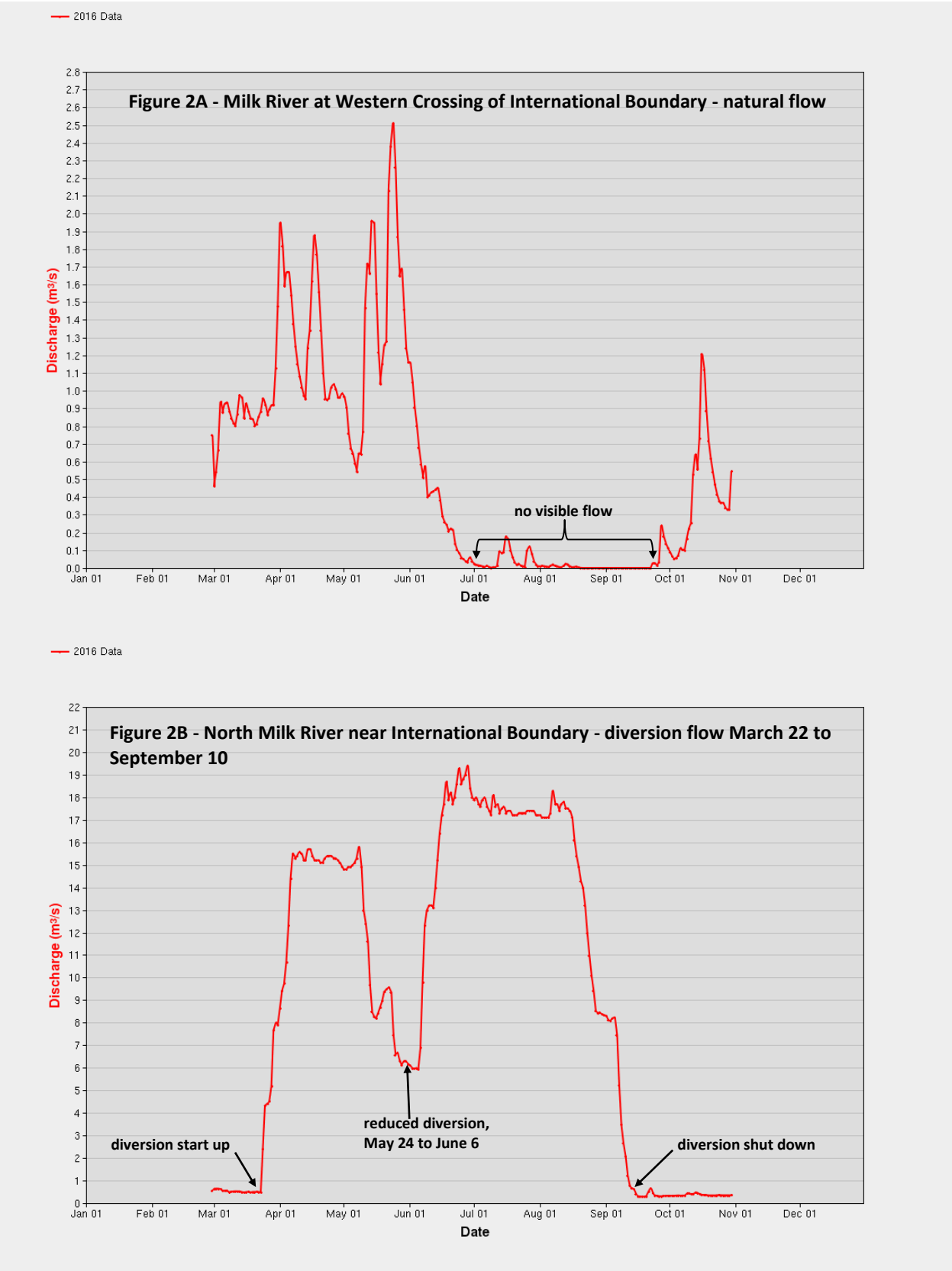
Year	Start Date	End Date
2006	March 05	September 24
2007	March 07	September 03
2008	March 17	September 12
2009	March 16	September 24
2010	March 21	September 03
2011	July 24	October 06
2012[a]	April 9	September 15
2013[b]	March 11	September 24
2014[c]	May 13	September 10
2015[d]	March 31	August 28
2016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

[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.

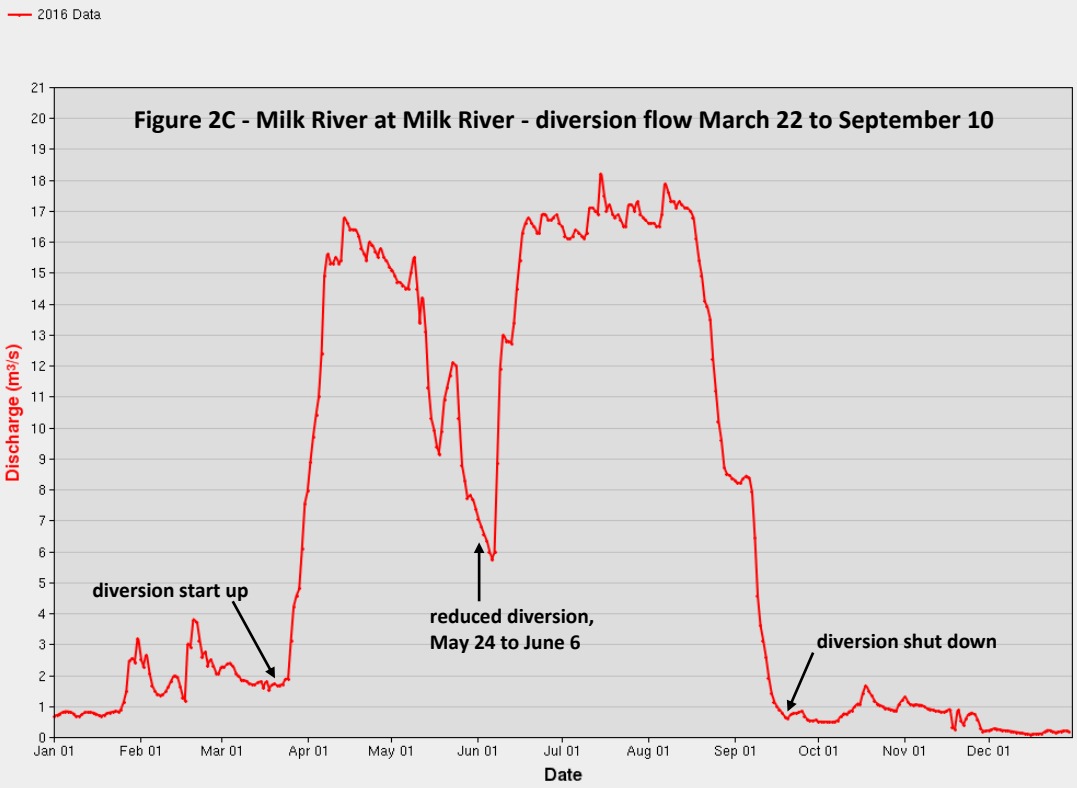
3.4.2 Streamflow

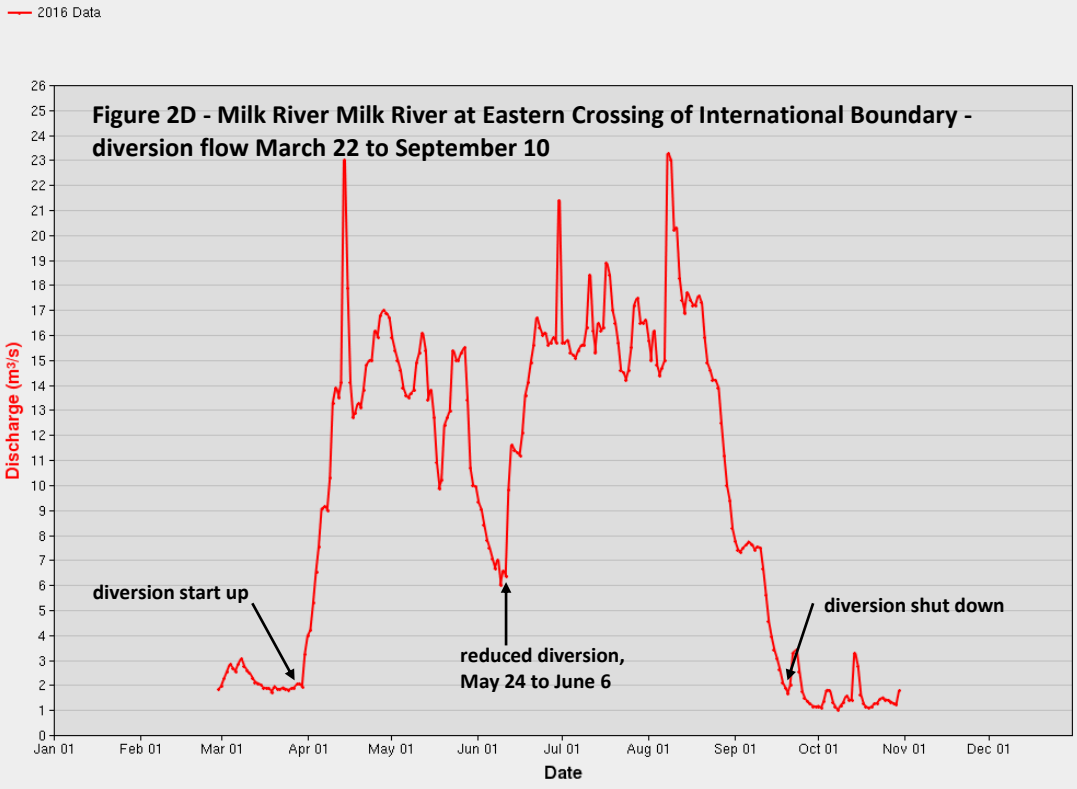
Mean daily streamflow data for 2016 is shown in Figures 2A to 2D at four Milk River sites (at Western Boundary, at North Milk River, at Milk River and at Eastern Boundary). There was zero flow recorded at the Milk River at the Western Crossing site for 10 days in August and 23 days in September (Environment Canada 2017: https://wateroffice.ec.gc.ca/report/historical_e.html). 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 July, August or September in 2016 due to an absence of visible flow (Figure 2A).

Flow at the three sites influenced by the St. Mary/Milk River Diversion generally ranged between 15 to 18 m^3/s (maximum: 23 m^3/s) during normal diversion operation but was reduced to between 6 and 7 m^3/s from May 24 to June 6 to alleviate flooding concerns in Montana (Figure 2B to 2D).



Figures 2A to 2D – Discharge data (m^3/s) at four Milk River sites, January to December 2016. Data from Environment and Climate Change Canada (https://wateroffice.ec.gc.ca/search/historical_e.html).





Figures 2A to 2D – cont'd

3.4.3 General Water Chemistry

Note that while water chemistry results from 2013 to 2015 are presented in the data tables for comparison, they are generally not discussed in the result summaries.

General water chemistry parameters are presented in Table 8. In 2016, median water temperature ranged from 11.3°C at the Milk River at 501 site to 15.9°C at the HWY 880 site. The lowest (0.6°C on October 13) and highest (20.4°C on June 19) water temperature was recorded at the Pinhorn site.

Median dissolved oxygen concentration ranged from 9.88 mg/L at the Milk River at 501 site to 10.35 mg/L at the Upstream of Milk River site (Table 8). The lowest and highest individual dissolved oxygen concentrations occurred at the Pinhorn site (8.45 and 14.11 mg/L, respectively). 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 2016, all samples met the acute daily minimum guideline and the chronic guideline at all Milk River sites.

The pH guidelines for the protection of aquatic life is $\geq$6.5 and $\leq$9.0 (ESRD 2014). The median pH was within guidelines for the protection of aquatic life at all Milk River sites in 2016 and 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 (155 µS/cm) and highest at the Pinhorn site (273 µS/cm). During the natural flow period, median specific conductivity ranged from a low of 350 µS/cm at the North Fork at 501 site to a high of 601 µS/cm at the HWY 880 site (Table 9). In 2016, specific conductivity ranged from 486 to 1900 µS/cm (median: 530 µS/cm) at the Milk River at 501 site (April-October, natural flow only) (Table 9). The specific conductivity irrigation guideline is $\leq$700 µS/cm for sensitive crops such as strawberries and $\leq$1000 µS/cm for non-sensitive crops like cereals and forages (Alberta Agriculture 1983, CCREM 1987). In 2016, all samples met the irrigation guideline for non-sensitive crops and one sample each exceeded the guideline for sensitive crops (700 µS/cm) at the Milk River at 501, the HWY 880 and Pinhorn sites on October 13th during low flow. The WQO-50 objective for specific conductivity were met at all sites in 2016 (Table 7) and all sites met the WQO-90 objective except the Milk River at 501 site (Table 9).

Table 8 - Summary (median and range) of general water quality parameters at the Milk River, 2013 to 2016.

Site	Water Temperature (°C)											
	2013			2014			2015			2016		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	12.1	3.2-18.5	9	12.1	4.3-18.2	9	9.8	3.6-18.6	9	12.4	1.9-18.2
Milk R. at 501	10	12.9	4.8-18.8	9	14.4	5.2-19.0	7	10.1	4.8-21.4	6	11.3	0.8-18.0
U/S Milk River	10	14.5	6.4-20.5	10	14.4	2.0-21.5	8	9.4	6.4-21.0	8	13.5	2.1-19.2
HWY 880	7	17.2	5.2-21.9	9	17.0	0.8-20.5	10	13.3	5.1-20.8	9	15.9	0.9-20.2
Pinhorn	10	15.4	4.3-21.2	9	15.6	0.1-20.7	10	14.1	5.5-20.5	9	15.4	0.6-20.4

Site	Dissolved Oxygen (mg/L)											
	2013			2014			2015			2016		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	7.57	6.79-9.58	9	7.70	7.03-9.29	9	10.26	8.92-11.61	9	10.12	8.71-11.76
Milk River at 501	10	7.37	6.94-9.47	9	7.14	6.72-8.56	7	10.27	8.93-11.47	6	9.88	8.97-12.2
U/S Milk River	10	7.37	6.84-9.36	10	7.69	6.51-9.87	9	9.91	8.19-11.31	8	10.35	8.80-12.80
HWY 880	7	8.70	7.87-12.50	9	7.44	6.37-10.82	10	10.60	8.83-11.50	9	10.28	8.64-13.48
Pinhorn	10	7.18	6.36-9.76	9	7.49	6.23-10.84	10	10.34	8.66-11.50	9	9.89	8.45-14.11

Site	pH											
	2013			2014			2015			2016		
	N	Median	Range	N	Median	Range	N	Median	Range	N	Median	Range
N. Fork at 501	10	8.21	7.84-8.37	9	8.43	8.17-8.51	10	8.19	7.62-8.38	10	8.10	7.84-8.30
Milk R. at 501	10	8.44	8.36-8.65	10	8.49	8.32-8.57	8	8.52	8.30-8.59	7	8.46	8.33-8.60
U/S Milk River	10	8.38	8.21-8.58	10	8.40	8.28-8.60	10	8.35	7.91-8.54	10	8.24	8.08-8.41
HWY 880	7	8.22	8.02-8.32	9	8.36	8.28-8.61	10	8.41	7.76-8.53	10	8.28	8.05-8.44
Pinhorn	10	8.34	8.19-8.49	9	8.36	8.30-8.63	10	8.41	7.95-8.57	10	8.24	8.13-8.48

Table 9 - Summary of specific conductivity (µS/cm) at the Milk River, 2013 to 2016.

Site	Flow Period	WQO		2013				2014				2015				2016			
		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	9	152	163	132-164	4	149	165	139-172	6	154	159	145-161	8	155	183	136-195
	Natural	445	512	1	399	-	-	5	454	473	427-474	4	300	427	190-448	2	350	-	276-423
Milk R. at 501	April-Oct	510	882	10	473	592	434-799	10	489	579	354-588	8	489	696	461-863	7	530	1140	486-1900
U/S Milk River	Diversion	210	398	9	218	247	161-265	5	208	317	170-383	6	198	224	152-225	8	209	295	148-364
	Natural	570	674	1	522	-	-	5	492	580	458-606	4	423	539	308-567	2	407	-	248-566
HWY 880	Diversion	250	540	6	***308***	321	206-322	5	245	382	210-460	6	237	265	181-273	8	251	396	179-420
	Natural	727	936	1	782	-	-	4	654	735	477-759	4	522	707	391-766	2	601	-	342-859
Pinhorn	Diversion	250	540	9	***311***	326	200-348	5	261	404	223-481	6	212	286	116-296	8	273	421	189-428
	Natural	727	936	1	691	-	-	4	696	759	482-785	4	591	739	440-791	2	582	-	316-847

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 (**Yellow**); 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 0.014 mg/L at the North Fork at 501 site, 0.049 mg/L at the U/S Milk River site and 0.155 mg/L at the Pinhorn site (Table 10). During the natural flow period, median total phosphorus was 0.008 mg/L at the North Fork at 501 site, 0.013 mg/L at the U/S Milk River site and 0.030 mg/L at the Pinhorn site. The lowest total phosphorus concentration (0.006 mg/L) occurred at the North Fork at 501 site on October 13 during the natural flow period and the highest total phosphorus concentration (0.254 mg/L) occurred at the HWY 880 site on April 6 during the diversion period (Table 10). In 2016, total phosphorus ranged from 0.016 to 0.063 mg/L (median: 0.023 mg/L) at the Milk River at 501 site (April-October, natural flow only) (Table 10).

During the diversion period, median total phosphorus concentration met the WQO-50 objective at all sites with the exception of the Pinhorn site. During the natural flow period, the WQO-50 was not met at the Milk River at 501 site and the Pinhorn site (Table 10).

The WQO-90 was met at all Milk River sites during the diversion periods in 2016 (Table 10). 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 which met the WQO-90.

Total Dissolved Phosphorus

In general, dissolved phosphorus concentrations are similar at all Milk River sites with only a slight increase in the downstream direction. During the diversion period, median total dissolved phosphorus concentration ranged from 0.004 mg/L at the North Fork at 501 site to 0.007 mg/L at the Pinhorn site (Table 11). During the natural flow period, median total dissolved phosphorus ranged from 0.003 mg/L at the North Fork at 501 site to 0.005 mg/L at the Upstream of Milk River and Pinhorn sites (Table 11). In 2016, total dissolved phosphorus ranged from 0.005 to 0.036 mg/L (median: 0.009 mg/L) at the Milk River at 501 site (April-October, natural flow only) (Table 11).

Median total dissolved phosphorus concentrations did not meet the WQO-50 objective at any site during the diversion period except at the HWY 880 site. During the natural flow period, the WQO-50 was exceeded at the Milk River at 501 site and the Pinhorn site (Table 11). The total dissolved phosphorus WQO-90 was not met at any sites in 2016 during the diversion and natural flow periods with the exception of the HWY 880 site during the diversion period (Table 11). The WQO-90 at the site Upstream of Milk River was in the cautionary range for dissolved phosphorus during the diversion period.

Table 10 - Summary of total phosphorus concentrations (mg/L) at the Milk River, 2013 to 2016.

Site	Flow Period	WQO		2013				2014				2015				2016			
		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	9	0.010	0.029	0.003-0.059	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
	Natural	0.012	0.100	1	0.003	-	-	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
Milk R. at 501	April-Oct	0.019	0.186	10	**0.021**	0.044	0.012-0.047	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
U/S Milk River	Diversion	0.044	0.148	9	0.035	0.061	0.012-0.083	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
	Natural	0.013	0.504	1	0.007	-	-	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
HWY 880	Diversion	0.088	0.220	6	0.099	0.260	0.033-0.410	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
	Natural	0.013	0.086	1	0.005	-	-	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
Pinhorn	Diversion	0.088	0.220	9	0.120	0.246	0.061-0.352	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
	Natural	0.013	0.086	1	0.006	-	-	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

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 (Yellow); 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, 2013 to 2016.

Site	Flow Period	WQO		2013				2014				2015				2016			
		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	9	0.003	**0.008**	0.003-0.010	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
	Natural	0.005	0.066	1	0.003	-	-	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
Milk R. at 501	Apr-Oct	0.006	0.015	10	0.003	0.009	0.003-0.010	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
U/S Milk River	Diversion	0.003	0.010	9	0.003	0.008	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
	Natural	0.005	0.173	1	0.003	-	-	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
HWY 880	Diversion	0.004	0.011	6	0.003	0.008	0.002-0.010	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
	Natural	0.004	0.021	1	0.013	-	-	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
Pinhorn	Diversion	0.004	0.011	9	0.003	0.009	0.003-0.010	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
	Natural	0.004	0.021	1	0.003	-	-	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

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 (Yellow); 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 0.134 mg/L at the North Fork at 501 site to 0.385 mg/L at the Pinhorn site (Table 12). During the natural flow period, total nitrogen ranged from 0.275 mg/L at the U/S Milk River site to 0.416 mg/L at the Pinhorn site. In 2016, total nitrogen ranged from 0.295 to 1.070 mg/L (median: 0.405 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. The WQO-90 objective for total nitrogen was met at all sites in 2016 during the diversion period (Table 12).

3.4.5 Total Suspended Solids

During the diversion period, median total suspended solids concentrations ranged from 12.0 mg/L at the North Fork at 501 site to 169 mg/L at the Pinhorn site (Table 13). During the natural flow period, median total suspended solids ranged from 1.5 mg/L at the U/S Milk River site to 13.7 mg/L at the Pinhorn site (Table 13). Total suspended solids concentration ranged from 7.0 to 84.0 mg/L (median: 11.0 mg/L) at the Milk River at 501 site in 2016 (April-October, natural flow only).

During the diversion period, total suspended solids 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, all sites met the WQO-50 objective. The WQO-90 objective was met at all sites in 2016 during the diversion period (Table 13).

3.4.6 Fecal Coliform Bacteria

Fecal coliform bacteria counts were generally high in 2016. During the diversion period, median fecal coliform bacteria counts ranged from 38 cfu/100 mL at the U/S Milk River site, to 85 cfu/100 mL at the Pinhorn site (Table 14). During the natural flow period, median fecal coliform bacteria counts ranged from 34 cfu/100 mL at the HWY 880 site, to 154 cfu/100 mL at the N. Milk River at 501 site. Fecal coliform bacteria counts ranged from 1 to 3400 cfu/100 mL (median: 122 cfu/100 mL) at the Milk River at 501 site in 2016 (April-October, natural flow only).

The median fecal coliform bacteria counts met the WQO-50 objective at all the sites during the diversion period except at the N. Milk River at 501 site (Table 14). During the natural flow period, the WQO-50 was met at the Upstream of Milk River and HWY 880 sites and was not met at the N. Milk River at 501 and Pinhorn sites (Table 14). The WQO-90 objective was only met at the Pinhorn site during the diversion period (Table 14). The WQO-50 and WQO-90 objectives were not met at the Milk River at 501 site in 2016.

Table 12 - Summary of total nitrogen concentrations (mg/L) at Milk River, 2013 to 2016.

Site	Flow Period	WQO		2013				2014				2015				2016			
		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	9	0.136	0.290	0.136-0.334	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
	Natural	0.900	1.578	1	0.488	-	-	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
Milk R. at 501	April-October	0.600	1.360	10	0.411	0.578	0.316-0.871	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
U/S Milk River	Diversion	0.325	0.667	9	0.296	0.434	0.136-0.506	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
	Natural	0.680	1.637	1	0.326	-	-	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
HWY 880	Diversion	0.365	0.668	6	0.330	0.435	0.160-0.470	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
	Natural	0.320	1.400	1	0.210	-	-	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
Pinhorn	Diversion	0.365	0.668	9	0.446	0.682	0.136-0.806	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
	Natural	0.320	1.400	1	0.136	-	-	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

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 (**Yellow**); 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, 2013 to 2016.

Site	Flow Period	WQO		2013				2014				2015				2016			
		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	9	9	39	2-45	4	15	30	7.9-34.6	4	11.4	21.0	1.5-22	8	12	45	2-99
	Natural	5	55	1	2	-	-	5	2	6.4	1.5-9.3	6	4.8	10.8	1.5-12	2	3.1	-	1.5-4.7
Milk R. at 501	April-October	14	247	10	10	-	2-39	10	14.7	98.6	1.5-112	8	6	6.9	1.5-7.3	7	11	47	7-84
U/S Milk River	Diversion	56	282	9	40	66	22-90	5	78	239	47.7-267	6	88.2	160.0	15.3-175	8	52	134	21-212
	Natural	7	267	1	2	-	-	5	17.6	88.0	1.5-132	4	4.1	21.6	1.5-28	2	1.5	-	1.5-1.5
HWY 880	Diversion	131	384	6	130	290	42-410	5	151	386.8	87.6-388	6	154	212	36.7-250	8	89	174	14-259
	Natural	13	228	1	2	-	-	4	20.8	226.2	1.5-306	4	10.8	39.1	1.5-47.3	2	4.7	-	3.3-6
Pinhorn	Diversion	131	384	9	163	298	30-463	5	213	488	137-540	6	185	292	113-293	8	169	193	23-202
	Natural	13	228	1	2	-	-	4	36.8	195.4	3.8-251	4	20.0	57.5	1.5-67	2	13.7	-	8.7-18.7

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 (**Yellow**); 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, 2013 to 2016.

Site	Flow Period	WQO		2013				2014				2015				2016			
		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	9	64	320	8-400	5	138	201.2	56-226	6	90	133	44-138	8	51	441	6-1100
	Natural	55	668	1	28	-	-	5	11	46	5-53	4	78	160	3-164	2	154	-	8-300
Milk R. at 501	April-October	77	619	10	53	410	1-500	10	104	2030	4-3200	8	**86**	462	4-900	7	122	2080	1-3400
U/S Milk River	Diversion	68	272	9	32	71	1-102	5	158	289	89-360	6	176	193	104-194	8	38	491	7-1300
	Natural	49	522	1	2	-	-	5	5	91.2	2-142	4	8	46	1-62	2	39	-	7-71
HWY 880	Diversion	78	280	6	40	1118	1-2100	5	142	206	70-210	6	156	741	84-1100	8	43	530	1-600
	Natural	29	163	1	18	-	-	4	5.5	42	1-57	4	20	57	1-65	2	34	-	5-62
Pinhorn	Diversion	78	280	9	48	206	17-300	5	128	189	48-229	6	157	277	115-366	8	85	216	18-318
	Natural	29	163	1	7	-	-	4	13	33	2-38	4	39	46	8-45	2	47	-	37-56

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 (**Yellow**); 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 2016 was similar across five weather stations, ranging from 304.0 to 323.1 (April to October). May was the wettest month in 2016 and August was the driest month. At the three Milk River sites augmented by the diversion, flow generally ranged from 15 to 18 m^3/s during normal diversion operation but was reduced to between 6 and 7 m^3/s from May 24 to June 6 to alleviate flooding concerns in Montana.

Red Creek

- Median dissolved oxygen concentrations were compliant with acute and chronic guidelines in 2016 at the Red Creek sites; however, some individual samples did not meet the acute or chronic guideline.
- All pH values met the aquatic life guidelines at the three Red Creek sites in 2016.
- No individual specific conductivity sample (range: 2290 to 3450 µS/cm) nor the median conductivity met irrigation guidelines at any of the three Red Creek sites in 2016.
- TSS concentrations (range: 2 to 13 mg/L) were generally low at Red Creek in 2016 and no TSS trends are apparent from 2013 to 2016.
- Median fecal coliform concentrations met the irrigation guideline at the two upstream sites at Red Creek but were exceeded at the downstream site in 2016. Median fecal coliform counts at the downstream site generally have not met irrigation guidelines from 2013 to 2016 and very high counts of individual samples have been recorded (maximum: 17,800 cfu/100 mL).

Eastern Tributaries

- Dissolved oxygen was compliant with acute and chronic guidelines in 2016 at Eastern tributaries.
- All pH values met the aquatic life guidelines at the Eastern tributaries in 2016.
- 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.
- TSS concentrations (range: 2 to 17 mg/L) were generally low at the Eastern tributaries in 2016 and no TSS trends are apparent from 2013 to 2016.
- Fecal coliform concentrations were generally low at the Eastern tributaries in 2016 and median fecal coliform concentrations have met the irrigation guideline from 2013 to 2016.

Milk River Mainstem

- Milk River Water Quality Objectives (WQOs) were used to determine water quality at sites in 2016 (i.e., WQO-50 [50^{th} percentile or median] and WQO-90 [90^{th} percentile]).
- pH and dissolved oxygen met aquatic life guidelines at all Milk River sites.
- Conductivity (salts) met the median WQO-50 and WQO-90 at all sites except the WQO-90 at 'Milk River at 501'. The median conductivity met the guideline for irrigation of sensitive crops at all Milk River sites.
- Total phosphorus exceeded the median WQO-50 at the 'Pinhorn' site during the natural and diversion flow period, and at the 'Milk River at 501' site. All sites met the WQO-90 for both flow periods.
- 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 natural flow period.
- Total suspended solids 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 flow period.

- Fecal coliform bacteria exceeded the WQO-50 during the diversion flow period at 'N. Fork at 501'; fecal coliform bacteria also exceeded the WQO-50 during the natural flow period at 'N. Fork at 501', 'Milk River at 501', 'HWY 880' and 'Pinhorn' sites. The WQO-90 objective was exceeded at 'N. Fork at 501', 'U/S Milk River' and 'HWY 880' during the diversion flow period and at 'Milk River at 501' 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 Leopard Frogs, 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 fecal coliform source tracking to determine the source of 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, if desired.

Milk River

- Water quality sampling at the existing Milk River (mainstem) sites should continue.
- The site downstream of the Milk River 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.

6.0 LITERATURE CITED

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