DRAFT – FOR DISCUSSION

SURFACE WATER QUALITY OBJECTIVES FOR THE MILK RIVER– OPEN WATER SEASON (DIVERSION AND NATURAL FLOW PERIODS)

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ACKNOWLDEDGEMENTS

MRWCC IWMP Team

Milk River WQO Review Committee

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1.0 Background

The Milk River watershed is the smallest of Alberta's major basins and the only watershed to drain south into the Missouri River. The watershed is transboundary in its geographical extent, and is shared by the provinces of Alberta and Saskatchewan and the state of Montana. The basin is located within the semi-arid mixed-grass and dry mixedgrass Natural Regions of the province; drought is a common occurrence in the basin. The watershed is mainly rural, with agriculture (farming and ranching) being the predominant land use. A low human population density and limited industrial development further describe the watershed.

Water is an essential part of the Milk River watershed and quantity and quality are at the forefront of community concerns. Water has been managed closely in the basin since 1909 when the Boundary Water's Treaty that apportions the flow of the St. Mary and Milk rivers was signed. In 1917, the St. Mary River diversion was constructed that allows the United States to access their share of the St. Mary River water by diverting flow through the Canadian segment of the Milk River. The diversion substantially augments the natural flow in the Milk River from about March through September each year. During the diversion period, water quality concerns include increased turbidity, suspended sediment and total phosphorus above natural conditions. During periods of natural flow, conductivity (i.e., salinity), total dissolved solids, calcium, chloride, sulphate and total nitrogen tend to increase. In addition, fecal coliform bacteria can be problematic during periods of heavy rainfall and/or periods of high temperature and low flow. High fecal coliform counts have led to public health notices being posted at Writing-on-Stone Provincial Park. The Town of Milk River is the largest community in the watershed and holds a license to release treated effluent annually into the river. However, the Town has not needed to discharge treated effluent into the Milk River as the treated effluent which is contained in the holding ponds has typically evaporated.

Surface water quality objectives (WQOs) provide important measures to determine whether water quality is meeting the needs of the aquatic environment and requirements for human and livestock use. The following describes the approach being taken to establish WQOs for the Milk River mainstem (Alberta segment). Surface WQOs are provided for 16 water parameters as "normal range" targets, and as thresholds (limits) that cannot be exceeded. Recommendations for water and land management are then provided in order that WQOs may be achieved.

2.0 Environmental Outcomes

- Maintain, and where possible, improve water quality in all watershed reaches.
- Water and adjacent land uses (that influence water quality) are managed in a manner that benefits communities while meeting the needs of the ecosystem and aquatic and riparian environments.
- Unpolluted water is available for human use, communities, terrestrial and aquatic life, irrigation farming, and recreational and industrial users in the Milk River watershed.
- Baseline water quality information is available to the public.
- Water quality and quantity information is used by resource managers to promote sustainable land and water use and to integrate water management with other uses and human activities.

- Healthy, functioning riparian areas contribute to streambank stability, good water quality, wildlife habitat, forage, animal shelter and biodiversity in the Milk River watershed.

- Having a clear understanding of the source and nature of water contaminants in the basin will assist users and managers in addressing these water issues.

3.0 Geographical Area

Water quality objectives apply to the Alberta portion of the Milk River from the point of entry into Alberta at the Western Crossing to the point of exit at the Eastern Crossing. Water quality objectives were are defined for four reaches within the Milk River, Alberta. These are the North Fork Milk River (Reach 1), South Fork Milk River (Reach 2), the Gravel Bed Reach (Reach 3) and the Sand Bed Reach (Reach 4) (Figure 1). These reaches were previously identified in "The Biology and Status of Riparian Poplars in Alberta" (Bradley et al. 1991) and modified in the "Study of Sedimentation and Erosion on the Milk River" (AMEC 2008) to reflect changes in river gradient and bed material in addition to riparian and morphological changes (Figure 1).

Table 2 provides the geographical location of the upper and lower ends of the defined Milk River reaches. Water quality in the South Fork Milk River (Reach 2) is not affected by St. Mary River diversion flows.

Table 2. Summary of coordinates associated with the upstream and downstream boundaries of the Milk River Reaches. Coordinates are reported as UTM, Zone 12, NAD 83.

Site	Coordinates
Upstream North Fork (at the US border)	N 5429385 E 353856
Upstream Milk River Gravel	N 5443450 E398708
Upstream Milk River Sand	N 5436243 E452825
Downstream Milk River Sand (at the US border)	N 5427521 E 533128

Palliser Environmental Services Ltd. (2012) reported that water quality differences among the four Reaches are due to the following influences within each river Reach: the local bed material, channel morphology, tributaries, groundwater influences, as well as differences in surface runoff due to varying precipitation patterns across the watershed.

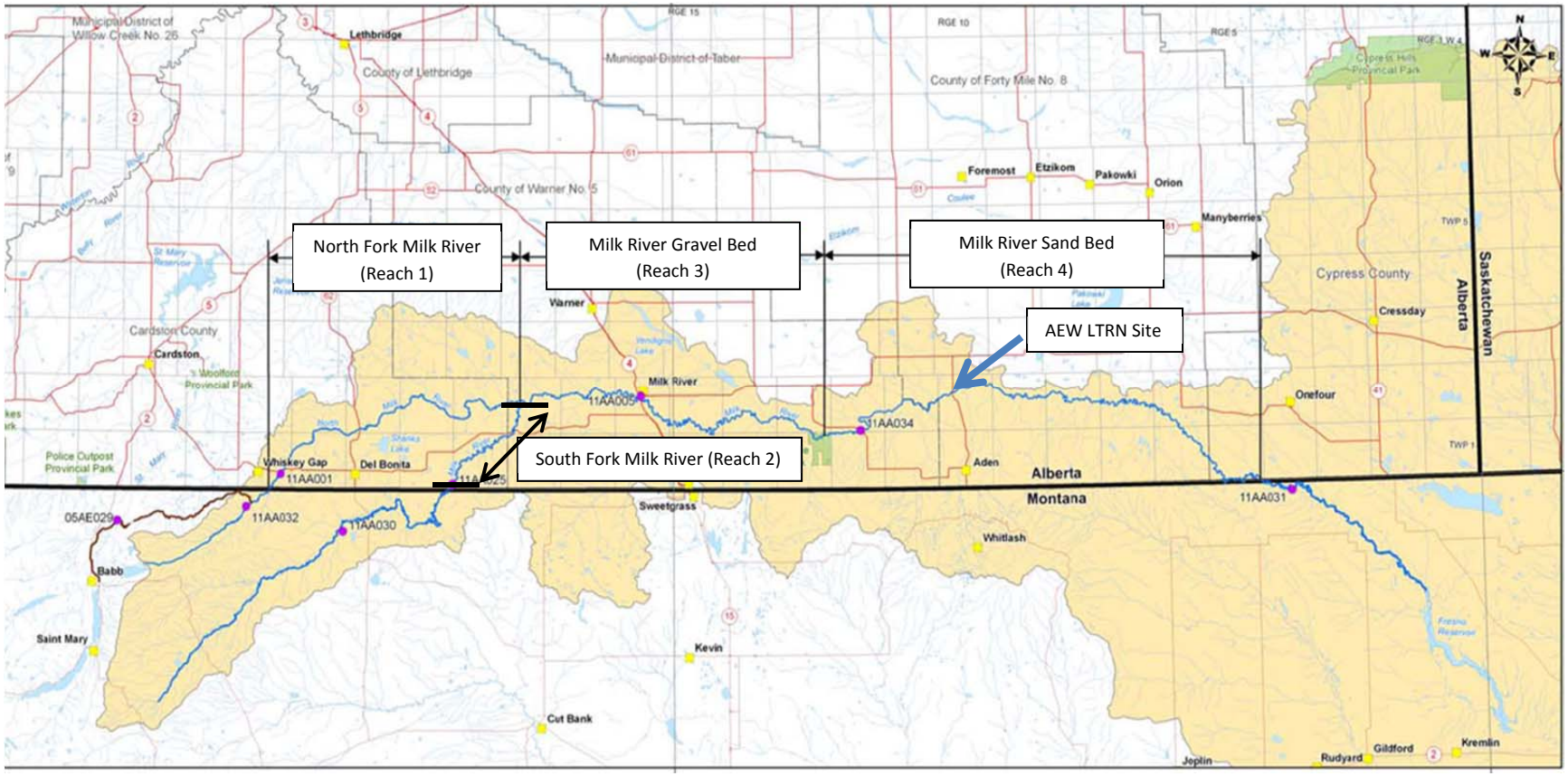


Figure 1. Map showing the four Milk River reaches applicable to the Water Quality Objectives (AMEC 2008).

4.0 Governing Jurisdictions

There are multiple agencies/organizations participating in the management of Milk River water resources, including water quality data collection and reporting. Table 1 summarizes the different jurisdictions involved in water monitoring.

Table 1. Applicable agencies/organizations involved in water monitoring and management and their role and activity in the Milk River watershed.

Agency	Role	Activity
Alberta Environment and Water	Undertakes surface water quality monitoring for the Province. The Transboundary Secretariat supports the development and implementation of Alberta's transboundary agreements for air, land, water, and biodiversity.	Monitors one Long-Term Network (LTRN) site at Hwy 880 Bridge monthly and undertakes under-ice dissolved oxygen monitoring at three sites. Completes the accounting for the allocation of flows from the St.Mary and Milk rivers.
Environment Canada	Member of the Prairie Provinces Water Board. Responsible for reporting on transboundary watersheds.	Measures water discharges at Battle Creek, Lodge Creek and Middle Creek. Monitors water quality at the Western Crossing and Eastern Crossing.
Milk River Watershed Council Canada	Non-profit society responsible for state of the watershed reporting and watershed management planning in the Milk River watershed, Alberta.	Monitors water quality at multiple sites on the mainstem of the Milk River and select tributaries.
Prairie Provinces Water Board (PPWB)	• Monitors the quality of the aquatic environment and makes comparisons with PPWB objectives; • Reviews the appropriateness of PPWB objectives; • Provides written reports on the quality of water in interprovincial river reaches and on water quality issues; • Promotes the establishment of compatible water quality objectives in the Prairie provinces; • Promotes a preventive and proactive ecosystem approach to interprovincial water quality management; and • Promotes the recognition of the interdependence of quality and quantity of water in the management of watercourses.	The PPWB has developed an active water quality program to assess whether PPWB objectives have been met. Monitors water discharge at Battle Creek, Lodge Creek and Middle Creek. No water quality data is collected by the PPWB at these sites.
Water Survey of Canada	The national authority responsible for the collection, interpretation and dissemination of standardized water resource data and information in Canada.	Measures water discharges at the Western and Eastern crossing of the Milk River.

5.0 Approach

Water quality objectives were established for the open water season, defined as the period April through October, for two distinct river flow periods: the diversion period and the natural flow period. The St. Mary River water diversion strongly influences water quality in the Milk River and, therefore, must be considered separately from the open-water natural flow period. The period of diversion which typically begins in March (sometimes during ice-cover conditions) and ends in September, is determined by State of Montana officials. The start and end dates vary depending on weather experienced in a particular year or if maintenance needs to be undertaken to maintain the diversion infrastructure (Table 2). The open-water period (April-October) applies to the South Fork Milk River (Reach 2) as it contains only natural flows during the open water season (i.e., diversion water from the St. Mary River only enters the North Fork of the Milk River).

Water quality objectives were not established for the ice-cover season (November through March as water quality data is either unavailable or insufficient for this season.

Table 2. St. Mary Diversion start-up and shut-down dates for the 2006 through 2011 period. (USBR 2012).

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

Water quality targets for the four reaches defined for the Milk River watershed were determined and are expressed as: 1) **triggers** based on the premise that maintaining or improving existing water quality is desirable; median concentrations for 16 water parameters are identified as desired targets, and 2) **thresholds** based on the premise that water quality can decline to a level that impairs aquatic biota or some other water use; thus, limits for each water parameter have been set which cannot be exceeded. This approach has been adopted in the Government of Alberta's anti-degradation and water protection philosophies (GOA 2010).

During 2009 - 2010, a draft surface water quality management framework (WQMF) was developed by Alberta Environment for the mainstem of the Bow, Milk, Oldman and South Saskatchewan rivers that defined water quality triggers and limits for a number of water quality parameters (GOA 2010). The WQMF outlines three environmental management conditions for water quality that trigger management actions to maintain water quality. These conditions can also be applied to the Milk River mainstem. A color code is used to describe general water quality conditions for the river; these are:

Green: the aquatic system is in a desired state. Green represents water quality values that are in a normal range.

Yellow: Water quality conditions are shifting away from desired conditions. Yellow represents water quality values that are rising into the cautionary range.

Red: Water quality conditions have exceeded set thresholds and have substantially deviated from historical baseline conditions. Water quality conditions may have deteriorated to the point where the most sensitive aquatic systems and human uses may no longer be protected from harm.

6.0 Water Quality Objectives

Water quality objectives (WQOs) were developed for the Milk River mainstem at the following 4 monitoring locations: North Milk River site (Reach 1), Milk River 501 site (Reach 2), the Upstream Milk River site (Reach 3) and the HWY 880 site (Long Term River Network – LTRN, station) (Reach 4) (see Figure 1). These WQOs, as presented in this first edition of the Milk River Basin Plan, are based on historic data collected in the basin and thus represent baseline conditions to which future monitoring results will be compared.

Water quality data from the Milk River Watershed Council Canada's Long-Term Water Monitoring Program (during the period 2006-2011) was used to determine WQOs (i.e., past water monitoring results (values) constitute the basis for establishing desired future water quality conditions). This approach is justified as the 2006 to 2011 monitoring period encompassed low precipitation years (i.e., 2006 – except for the month of June, and 2009), average precipitation years (i.e., 2007 and 2008) and high precipitation years (i.e., 2010 and 2011) and can therefore be considered representative of the Milk River system's range of natural variation (Figure 3). In 2011, the St. Mary Diversion did not start-up until the end of July thus water quality reflected "natural" conditions during the first half of the season. The historic monitoring data for 2006-2011 do not indicate that any unusual pollution events occurred which may have significantly impacted water quality and thus skewed the monitoring findings.

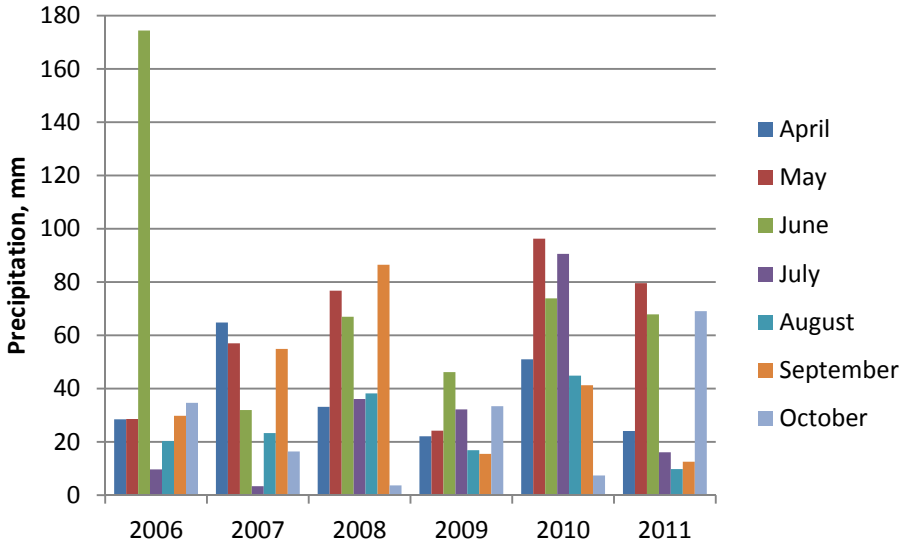


Figure 3. Precipitation at Masinasin (east of the Town of Milk River, Alberta) for the open-water period, 2006-2011 (AARD 2012).

To develop WQOs, the normal range for water quality was identified that included the lower limit (25th percentile), the upper limit (75th percentile) and the historical median target value (50th percentile) for a given water parameter. The normal range (coded green) signifies that the aquatic system is in a desired state.

A baseline threshold (90th percentile) for each parameter was also calculated. Values that lie between the upper limit of the "normal range" and the "threshold" (this range is coded yellow) signify that water quality conditions are shifting away from desired conditions and management actions may be required. A yellow condition is triggered whenever values that correspond with the "normal range" are exceeded.

Whenever **threshold** values, i.e., the 90th percentile, are exceeded (coded red), it signifies that water quality has substantially deviated away from ~~the~~ historical baseline conditions. It may also signify that water quality has deteriorated to the point that the most sensitive water dependant uses may no longer be protected (especially when WQO values are greater than established water quality guidelines). Once threshold limits are reached, environmental and human health risks are likely and potential impairments to natural systems are real.

For those parameters which are associated with human and livestock health (e.g., fecal coliform bacteria, specific conductivity) ~~and~~ should the Milk River historical baseline condition value become greater than established provincial, federal or state water quality guidelines (e.g., AENV (1999), PPWB (1991), CCME (1999), US EPA (1986, 2006) and Health Canada (2008)), the established guideline will take precedence over historical baseline conditions (i.e., the guideline will supersede any WQOs outlined in this plan). For parameters that do not pose a health risk, such as phosphorus and nitrogen, historical baseline WQOs presented in this basin plan take precedence over any established water quality guidelines. Figure 4 illustrates how the application of the water quality objectives might occur.

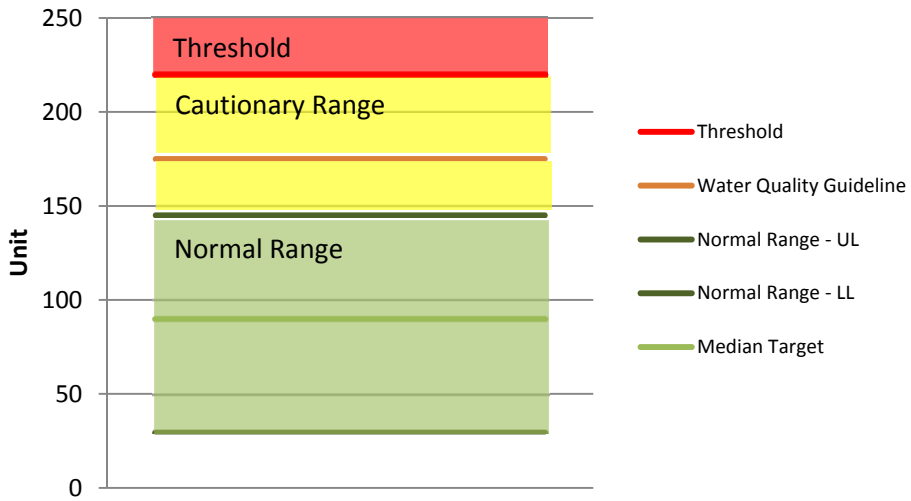


Figure 4. Graphic showing how the water quality objectives are applied. Note that the Water Quality Guideline takes precedence and is the threshold in this example. UL is upper limit and LL is lower limit.

Similar to the South Saskatchewan Water Quality Management Framework (GOA 2010), the parameters used to establish water quality objectives within the Milk River watershed are based on common water quality variables, for which an extensive database exists; these variables will continue to be monitored on a frequent basis in the future. They provide a reasonable description of water quality conditions based on pH, sediment (total suspended and total dissolved), nutrients (nitrate, nitrite, total nitrogen, total and dissolved phosphorus), major ions (chloride, calcium, sulphate), and indicators of waterborne pathogens (fecal coliform bacteria). Tables 3 through 6 provide the Water Quality Objectives for the Milk River mainstem sites (Reaches 1 through 4).

Table 3. Water quality objectives for Reach 1: N Milk River at 501.

Parameter	Flow Period	Sample Size[a]	Normal Range (25th to 75th Percentile)			Cautionary Range (75th to 90th Percentile)	Threshold (>90th Percentile)	Alberta Surface Water Quality Guidelines[b]
			Lower Limit	Median Target	Upper Limit			
Specific Conductivity (µS/cm)	Diversion	48	149	165	180	181 – 246	>246	≤1000 (Irrigation)
	Natural	19	418	445	485	486 – 512	>512	
pH (Value)	Diversion	46	8.09	8.12	8.19	<6.5 and >8.5	<6.5 and >8.5	>6.5 and <8.5
	Natural	11	8.38	8.39	8.40			
Total Dissolved Solids (mg/L)	Diversion	48	81	89	100	101 – 147	>147	≤500 and ≤3500 (Irrigation; Crop Type)
	Natural	19	236	257	273	274 – 294	>294	
Total Suspended Solids (mg/L)	Diversion	48	9	16	28	29 – 59	>59	No Guideline
	Natural	19	1	5	22	23 – 55	>55	
Total Phosphorus (mg/L)	Diversion	48	0.010	0.014	0.021	0.022 – 0.037	>0.037	≤0.05 (Aquatic Life)
	Natural	19	0.007	0.012	0.025	0.026 – 0.100	>0.100	
Total Dissolved Phosphorus (mg/L)	Diversion	48	0.002	0.003	0.005	0.006 – 0.007	>0.007	No Guideline
	Natural	19	0.002	0.005	0.009	0.010 – 0.066	>0.066	
Total Nitrogen (mg/L)	Diversion	47	0.170	0.240	0.365	0.366 – 0.468	>0.468	≤1.0 (Aquatic Life)
	Natural	19	0.725	0.900	1.263	1.264 – 1.578	>1.578	
Nitrate+Nitrite Nitrogen (mg/L)	Diversion	48	0.023	0.057	0.100	1.101 – 0.114	>0.114	No Guideline
	Natural	19	0.307	0.387	0.510	0.511 – 0.729	>0.728	
Nitrite-Nitrogen (mg/L)	Diversion	48	0.002	0.002	0.002	0.002	>0.002	≤0.06 (Aquatic Life)
	Natural	19	0.002	0.003	0.025	0.025	>0.025	
Nitrate-Nitrogen (mg/L)	Diversion	48	0.023	0.057	0.100	0.101 – 0.115	>0.114	≤2.93 (Aquatic Life)
	Natural	19	0.307	0.387	0.510	0.511 – 0.729	>0.728	
Total Ammonia (mg/L)	Diversion	38	0.025	0.025	0.048	0.049 – 0.081	>0.080	Based on pH & Temperature (Appendix A)
	Natural	9	0.025	0.025	0.130	0.131 – 0.165	>0.164	
Fecal Coliforms (cfu/100 mL)	Diversion	45	14	27	98	99 – 140	>140	≤100 (Irrigation)
	Natural	16	8	55	98	99 – 668	>668	
Turbidity (NTU)	Diversion	38	6.4	9.1	21.0	22.1 – 39.2	>39.2	No Guideline
	Natural	9	1.0	1.8	2.3	2.4 – 2.7	>2.7	
Calcium (mg/L)	Diversion	46	20.0	22.0	23.9	24.0 – 30.6	>30.5	≤1000 (Livestock)
	Natural	11	46.2	50.0	53.7	53.8 – 56.0	>56.0	
Chloride (mg/L)	Diversion	46	0.3	0.6	1.0	1.1 – 2.0	>2.0	≤100 (Irrigation)
	Natural	11	1.6	1.9	2.8	2.9 – 4.0	>4.0	
Sulphate (mg/L)	Diversion	46	4.2	5.8	7.0	7.1 – 9.6	>9.5	≤1000 (Livestock)
	Natural	11	6.4	7.4	8.7	8.8 – 9.0	>9.0	

[a] Sample size refers to the number of samples on which the WQO is based.

[b] Surface Water Quality Guidelines for Use in Alberta (AENV 1999).

Table 4. Reach 2: Sout Fork Milk River at 501. Note the flow period is from April-October since the South Fork Milk River is not subject to flow augmentation.

Parameter	Flow Period	Sample Size	Normal Range (25th to 75th Pecentile)			Cautionary Range (75th to 90th Percentile)	Threshold (>90th Percentile)	Alberta Surface Water Quality Guidelines
			Lower Limit	Median Target	Upper Limit			
Specific Conductivity (µS/cm)	Apr-Oct	59	441	510	716	717 - 882	>882	≤1000 (Irrigation)
pH (Value)	Apr-Oct	49	8.32	8.44	8.50	<6.5 and >8.5	<6.5 and >8.5	>6.5 and <8.5
Total Dissolved Solids (mg/L)	Apr-Oct	59	260	304	430	431 - 546	>546	≤500 and ≤3500 (Irrigation; Crop Type)
Total Suspended Solids (mg/L)	Apr-Oct	59	6	14	61	62 - 247	>247	No Guideline
Total Phosphorus (mg/L)	Apr-Oct	59	0.012	0.019	0.049	0.050 - 0.186	>0.186	≤0.05 (Aquatic Life)
Total Dissolved Phosphorus (mg/L)	Apr-Oct	59	0.004	0.006	0.008	0.009 - 0.015	>0.015	No Guideline
Total Nitrogen (mg/L)	Apr-Oct	58	0.363	0.600	0.835	0.836 - 1.360	>1.360	≤1.0 (Aquatic Life)
Nitrate+Nitrite Nitrogen (mg/L)	Apr-Oct	59	0.002	0.025	0.120	0.121 - 0.383	>0.383	No Guideline
Nitrite-Nitrogen (mg/L)	Apr-Oct	59	0.002	0.002	0.005	0.006 - 0.025	>0.025	≤0.06 (Aquatic Life)
Nitrate-Nitrogen (mg/L)	Apr-Oct	59	0.002	0.025	0.130	0.131 - 0.440	>0.440	≤2.93 (Aquatic Life)
Total Ammonia (mg/L)	Apr-Oct	39	0.025	0.030	0.070	0.071 - 0.092	>0.092	Based on pH & Temperature (Appendix A)
Fecal Coliforms (cfu/100 mLs)	Apr-Oct	54	15	77	223	224 - 619	>619	≤100 (Irrigation)
Turbidity	Apr-Oct	39	6.8	12.0	23.5	23.6 - 74.0	>74.0	No Guideline
Calcium (mg/L)	Apr-Oct	49.0	29.0	43.0	50.0	50.1 - 53.6	>53.6	≤1000 (Livestock)
Chloride (mg/L)	Apr-Oct	49.0	2.4	4.0	7.0	7.1 - 11.8	>11.8	≤100 (Irrigation)
Sulphate (mg/L)	Apr-Oct	49.0	42.0	76.0	166.0	166.1 - 270.8	>270.8	≤1000 (Livestock)

[a]Sample size refers to the number of samples on which the WQO is based.

[b]Surface Water Quality Guidelines for Use in Alberta (AENV 1999).

Table 5. Reach 3: Upstream of the Town of Milk River.

Parameter	Flow Period	Sample Size[a]	Normal Range (25th to 75th Pecentile)			Cautionary Range (75th to 90th Percentile)	Threshold (>90th Percentile)	Alberta Surface Water Quality Guidelines[b]
			Lower Limit	Median Target	Upper Limit			
Specific Conductivity (µS/cm)	Diversion	49	169	210	250	251 – 398	>398	≤1000 (Irrigation)
	Natural	20	477	570	652	653 – 674	>674	
pH (Value)	Diversion	47	8.14	8.20	8.30	<6.5 and >8.5	<6.5 and >8.5	>6.5 and <8.5
	Natural	12	8.39	8.41	8.44			
Total Dissolved Solids (mg/L)	Diversion	49	92	112	150	151 – 240	>240	≤500 and ≤3500 (Irrigation; Crop Type)
	Natural	20	276	342	391	392 – 418	>418	
Total Suspended Solids (mg/L)	Diversion	49	31	56	150	151 – 282	>282	No Guideline
	Natural	20	4	7	117	118 – 267	>267	
Total Phosphorus (mg/L)	Diversion	49	0.028	0.044	0.090	0.091 – 0.148	>0.148	≤0.05 (Aquatic Life)
	Natural	20	0.008	0.013	0.076	0.077 – 0.504	>0.504	
Total Dissolved Phosphorus (mg/L)	Diversion	49	0.002	0.003	0.006	0.007 – 0.010	>0.010	No Guideline
	Natural	20	0.003	0.005	0.015	0.016 – 0.173	>0.173	
Total Nitrogen (mg/L)	Diversion	48	0.220	0.325	0.453	0.453 – 0.667	>0.667	≤1.0 (Aquatic Life)
	Natural	20	0.313	0.680	1.134	1.135 – 1.637	>1.637	
Nitrate+Nitrite Nitrogen (mg/L)	Diversion	49	0.020	0.043	0.086	0.087 – 0.141	>0.141	No Guideline
	Natural	20	0.036	0.096	0.324	0.325 – 0.479	>0.479	
Nitrite-Nitrogen (mg/L)	Diversion	49	0.002	0.002	0.002	0.003 – 0.004	>0.004	≤0.06 (Aquatic Life)
	Natural	20	0.002	0.025	0.025	0.026 – 0.004	>0.004	
Nitrate-Nitrogen (mg/L)	Diversion	49	0.020	0.043	0.086	0.087 – 0.133	>0.133	≤2.93 (Aquatic Life)
	Natural	20	0.025	0.096	0.324	0.324 – 0.478	>0.478	
Total Ammonia (mg/L)	Diversion	39	0.025	0.025	0.030	0.031 – 0.084	>0.084	Based on pH & Temperature (Appendix A)
	Natural	10	0.025	0.025	0.059	0.060 – 0.094	>0.094	
Fecal Coliforms (cfu/100 mLs)	Diversion	47	31	68	133	134 – 272	>272	≤100 (Irrigation)
	Natural	20	10	49	207	208 – 522	>522	
Turbidity (NTU)	Diversion	39	20.0	33.0	53.0	53.1 – 148.0	>148.0	No Guideline
	Natural	10	2.3	2.7	4.3	4.4 – 6.2	>6.2	
Calcium (mg/L)	Diversion	47	21.3	24.9	31.5	31.6 – 35.4	>35.4	≤1000 (Livestock)
	Natural	12	37.0	40.5	45.5	45.6 – 47.0	>47.0	
Chloride (mg/L)	Diversion	47	0.7	1.0	1.8	1.9 – 3.1	>3.1	≤100 (Irrigation)
	Natural	12	2.9	4.3	5.2	5.3 – 6.0	>6.0	
Sulphate (mg/L)	Diversion	47	6.9	11.6	18.5	18.6 – 56.0	>56.0	≤1000 (Livestock)
	Natural	12	47.8	62.9	90.9	91.0 – 108.2	>108.2	

[a]Sample size refers to the number of samples on which the WQO is based.

[b]Surface Water Quality Guidelines for Use in Alberta (AENV 1999).

Table 6. Reach 4: Hwy 880.

Parameter	Flow Period	Sample Size[a]	Normal Range (25th to 75th Pecentile)			Cautionary Range (75th to 90th Percentile)	Threshold (>90th Percentile)	Alberta Surface Water Quality Guidelines[b]
			Lower Limit	Median Target	Upper Limit			
Specific Conductivity (µS/cm)	Diversion	51	200	250	305	306 – 540	>540	≤1000 (Irrigation)
	Natural	17	684	727	770	771 – 936	>936	
pH (Value)	Diversion	51	8.20	8.24	8.30	<6.5 and >8.5	<6.5 and >8.5	>6.5 and <8.5
	Natural	17	8.41	8.46	8.50			
Total Dissolved Solids (mg/L)	Diversion	51	110	140	178	179 – 330	>330	≤500 and ≤3500 (Irrigation; Crop Type)
	Natural	17	415	450	490	491 – 593	>593	
Total Suspended Solids (mg/L)	Diversion	49	64	131	234	235 – 384	>384	No Guideline
	Natural	17	4	13	75	76 – 228	>228	
Total Phosphorus (mg/L)	Diversion	51	0.059	0.088	0.135	0.136 – 0.220	>0.220	≤0.05 (Aquatic Life)
	Natural	17	0.008	0.013	0.030	0.031 – 0.086	>0.086	
Total Dissolved Phosphorus (mg/L)	Diversion	51	0.003	0.004	0.005	0.006 – 0.011	>0.011	No Guideline
	Natural	17	0.002	0.004	0.008	0.009 – 0.021	>0.021	
Total Nitrogen (mg/L)	Diversion	50	0.270	0.365	0.460	0.461 – 0.668	>0.668	≤1.0 (Aquatic Life)
	Natural	17	0.250	0.320	1.170	1.171 – 1.400	>1.400	
Nitrate+Nitrite Nitrogen (mg/L)	Diversion	51	0.014	0.030	0.080	0.081 – 0.120	>0.120	No Guideline
	Natural	17	0.014	0.036	0.140	0.141 – 0.538	>0.538	
Nitrite-Nitrogen (mg/L)	Diversion	51	0.002	0.002	0.002	0.002	>0.002	≤0.06 (Aquatic Life)
	Natural	17	0.002	0.002	0.002	0.002 – 0.003	>0.003	
Nitrate-Nitrogen (mg/L)	Diversion	51	0.014	0.030	0.079	0.080 – 0.120	>0.120	≤2.93 (Aquatic Life)
	Natural	17	0.014	0.036	0.140	0.141 – 0.532	>0.532	
Total Ammonia (mg/L)	Diversion	43	0.025	0.025	0.045	0.046 – 0.068	>0.068	Based on pH & Temperature (Appendix A)
	Natural	15	0.025	0.025	0.045	0.046 – 0.066	>0.066	
Fecal Coliforms (cfu/100 mLs)	Diversion	49	44	78	160	161 – 280	>280	≤100 (Irrigation)
	Natural	16	18	29	50	51 – 163	>163	
Turbidity (NTU)	Diversion	43	39	58	104	105 – 158	>158	No Guideline
	Natural	15	4	12	76	77 – 178	>178	
Calcium (mg/L)	Diversion	51	23.0	27.0	31.0	32.0 – 41.0	>41.0	≤1000 (Livestock)
	Natural	17	44.0	47.4	52.0	53.0 – 55.0	>55.0	
Chloride (mg/L)	Diversion	51	0.8	1.4	2.0	2.1 – 3.0	>3.0	≤100 (Irrigation)
	Natural	17	5.7	6.0	8.6	8.7 – 10.8	>10.8	
Sulphate (mg/L)	Diversion	51	13.6	21.8	30.5	30.6 – 83.0	>83.0	≤1000 (Livestock)
	Natural	17	130.0	146.0	170.0	171.0 – 229.0	>229.0	

[a]Sample size refers to the number of samples on which the WQO is based.

[b]Surface Water Quality Guidelines for Use in Alberta (AENV 1999).

7.0 Application of Water Quality Objectives

Future median values for water quality data (that are collected during the plan implementation stage) for the diversion period and the natural flow period will be compared to established WQOs (in Tables 3 to 6) to determine if newly acquired monitoring data / results fall within the "normal" range of water quality within each river Reach.

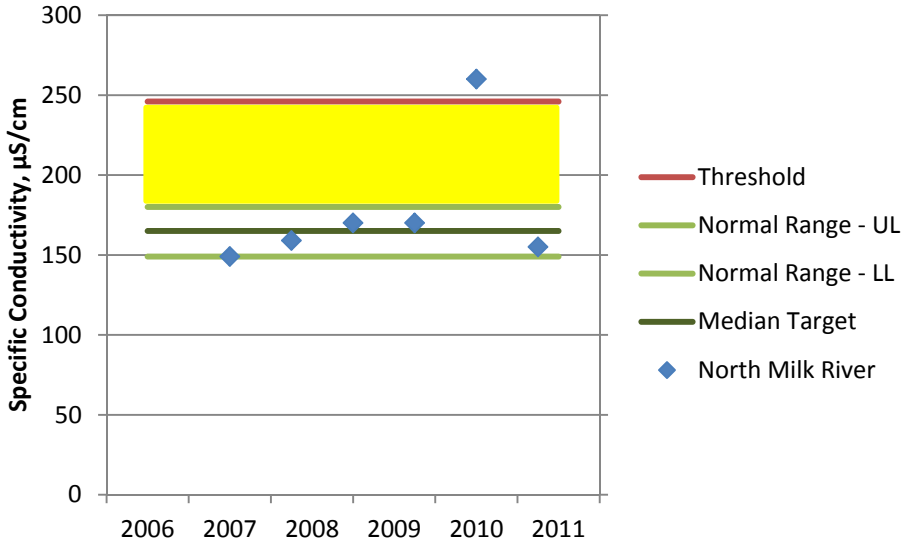
Individual samples will be compared to WQOs to determine if they meet the stated threshold values and existing water quality guidelines. At least 90 percent of all samples that are collected from a given river Reach throughout the calendar year should fall within the "normal range" or "cautionary range" of WQOs identified in this plan.

If a given WQO is not being met on two consecutive monitoring occasions, a Water Quality Review Committee will be struck to determine the cause and to ascertain the risk potential to water uses based on the degree and the frequency of known exceedences. The Water Quality Review Committee will determine if the exceedence constitutes a significant water quality issue and will recommend actions to remedy the concern to the MRWCC Board of Directors, appropriate government agency, or other relevant governing body.

Long-term water monitoring data will be analyzed against the WQOs to detect changes or trends in water sample results that may be indicative of a decline in water quality.

Where water quality is found to be better than what is required through the established WQOs, water managers, land owners and basin users should strive to maintain the existing superior water quality condition. However, should existing water quality fall below the established WQOs because of human activities, reasonable and practical measures should be taken to improve the instream water quality to meet the objective.

Example: The following example illustrates how the water quality objectives would be applied. Note that the Alberta Surface Water Quality Guideline (AENV 1999) does not show on this graph as values did not approach 1000 µS/cm. (LL=Lower Limit; UL=Upper Limit).



8.0 Recommendations

a) Continue with the Milk River Long-Term Water Monitoring Program at select locations to determine conformity (correspondence) with water quality objectives in this plan.

b) Continue and expand tributary monitoring in order to establish WQOs for tributaries.

c) Dissolved oxygen should be added to the list of water sampling parameters in the Milk River Long-Term Water Monitoring Program.

d) A fecal coliform source-tracking project should be completed to determine sources of bacteria on the Milk River.

e) Appropriate river flows should be identified to maintain water quality within the normal range for those parameters influenced by flow augmentation.[1]

f) Streambank stabilization measures should be applied, where feasible, to reduce erosion and subsequent sediment transport.

g) Riparian condition should be improved, where needed, to improve water quality functions.

h) Implementation of industry Best Management Practices (agricultural cropping, livestock management, oil and gas activity, sand and gravel operations, subdivision design, etc.) should be promoted to protect water quality: (to be expanded)

For Municipalities:

- Stormwater should be captured and treated prior to release into the Milk River.
- Stormwater should be released at an appropriate rate and volume (e.g., predevelopment rates and volumes) to reduce occurrence of erosion.
- Appropriate water body and riparian setbacks should be implemented for developments located adjacent to the Milk River and its tributaries.

For Agriculture:

- Creation of riparian pastures within a rotational grazing system.
- Implementation of offstream watering systems.
- Proper siting for livestock wintering areas to control runoff.
- Minimizing surface runoff of fertilizers and pesticides from cropped fields

[1] Through this recommendation the MRWCC and AB GoA officials are being encouraged to explore with their Montana counterparts how water flows might be managed, under existing treaty requirements and agreements, to achieve environmental and water quality objectives in Canada.

For Other Industry:

- To follow best management practices outlined in the *Code of Practice for Watercourse Crossings*.
- water body and riparian setbacks should be observed.

i) Establish a Milk River Water Quality Review Committee to address water quality issues that may arise based on water monitoring findings.

9.0 Literature Cited

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10.0 List of Acronyms and Glossary of Terms

AARD — Alberta Agriculture and Rural Development

AEW — Alberta Environment and Water

BMPs — Best Management Practices

Indicator — A *"parameter* [variable] *that, when tracked over time, provides information on trends in the condition of a* [social or environmental] *phenomenon"* (OECD 1994). Indicators are used to measure the state or condition of an ecosystem (or ecosystem component), social value, or human activity.

Percentile — The value of a variable below which a certain percent of observations fall. For example, if the 50^{th} percentile value is 337, 50% of values within the data set are equal to or less than 337. If the 90^{th} percentile is 423, 90% of values in the data set are equal to or less than 423.

PPWB — Prairie Provinces Water Board

Riparian Area — 1) Of, pertaining to, situated or dwelling on the margin of a river or other water body. 2) Also applies to banks on water bodies where sufficient soil moisture supports the growth of mesic vegetation that requires a moderate amount of moisture. Also referred to as riparian zone or riparian habitat (Armantrout 1998).

Sample Size — The number (value) of observations in a data set.

MRWCC — Milk River Watershed Council Canada

Target — Either numerical or written statements that provide a measurable indication of success in achieving objectives. A target identifies a clearly defined outcome (what is wanted or needed), expressed in concrete quantitative or qualitative terms.

Threshold — The point at which a relatively small change in external conditions causes a rapid change in an ecosystem. When an ecological threshold has been passed, the ecosystem may no longer be able to return to its natural state. The trespassing of an ecological threshold often leads to a rapid undesirable decline in ecosystem health.

A threshold *"is a technically or socially-based standard that identifies the point* [limit] *at which an indicator changes to an unacceptable condition"* (Salmo Consulting Inc. 2006). Thresholds (usually established as a fixed point) can be expressed from an ecological (scientific) or social (public value) perspective. To select thresholds, stakeholders and planners must first identify the conditions and components of the landscape that are a high priority and translate these into indicators. Generally thresholds are viewed in the following way: below a given threshold we are thought to be "safe", and above it we are "not safe". True

thresholds either do not exist or often are unknown – we surmise what appropriate thresholds might be based on inconclusive evidence or insufficient information. Thresholds can take on a negative connotation when they are thought to act as a barrier to economic development.

Thresholds and targets are linked to and correspond with selected indicators. While a **threshold** identifies a limit (for a human activity or disturbance) that should not be exceeded, a **target** is generally used to identify the level/amount/state of an environmental condition or human activity that is desirable or being sought.

WQOs Water Quality Objectives

Appendix A. Total Ammonia Nitrogen Objectives

Total Ammonia Nitrogen (mg/L)** based on Temperature and pH

The toxicity of ammonia relates primarily to the un-ionized form (NH_3). The concentration of un-ionized ammonia present in water increases with pH and temperature. The values below represent total ammonia-nitrogen concentrations (at various temperatures and pH levels) above which accompanying NH_3 concentrations may be harmful to aquatic life.
Total Ammonia (NH_3 + NH_4+)

(Maximum levels expressed as N at various pH/temperature conditions)

Toxicity of Ammonia under varying Temperature and pH Conditions							
pH Units	**Water Temperature (°C)**						
	0°	**5°**	**10°**	**15°**	**20°**	**25°**	**30°**
6.50	2.06	1.97	1.81	1.81	1.22	0.85	0.60
6.75	2.06	1.97	1.81	1.81	1.22	0.85	0.61
7.00	2.06	1.97	1.81	1.81	1.22	0.85	0.61
7.25	2.06	1.97	1.81	1.81	1.23	0.86	0.61
7.50	2.06	1.97	1.81	1.81	1.23	0.87	0.62
7.75	1.89	1.81	1.73	1.64	1.15	0.81	0.58
8.00	1.26	1.18	1.13	1.09	0.76	0.54	0.39
8.25	0.72	0.67	0.64	0.62	0.44	0.32	0.23
8.50	0.40	0.39	0.37	0.37	0.26	0.19	0.15
8.75	0.23	0.22	0.21	0.22	0.16	0.12	0.09
9.00	0.13	0.13	0.13	0.13	0.11	0.08	0.06

** Excerpt from the "Surface Water Quality Objectives", Water Quality Branch Saskatchewan Environment and Public Safety, November, 1988 (WQ 110) as per the Prairie Provinces Water Board water quality objectives.e