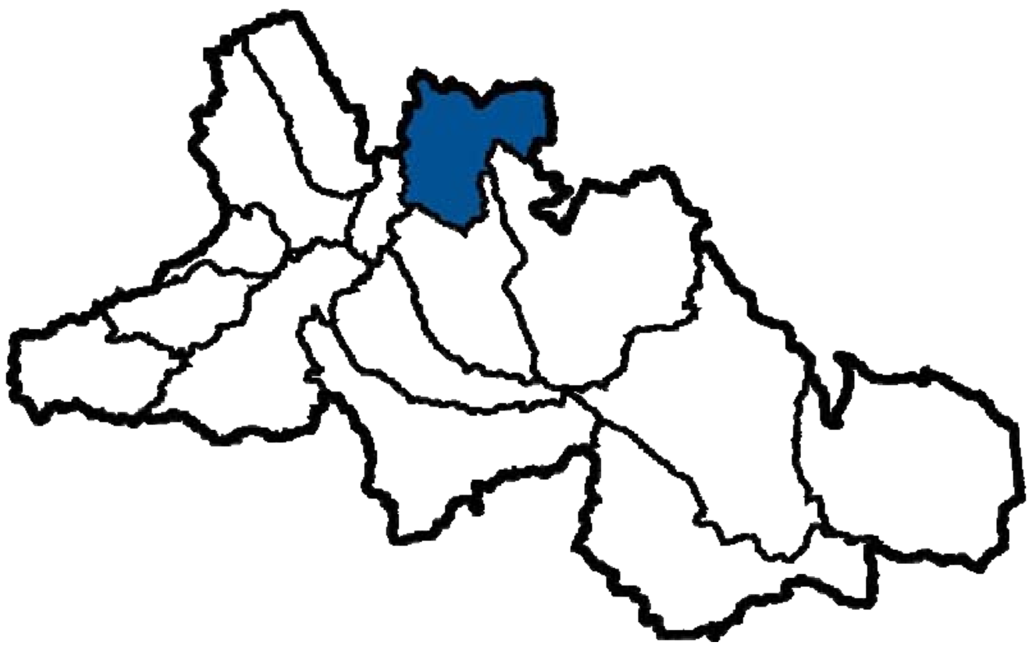
Buffalo Subwatershed



Red Deer River Watershed Alliance

State of the Watershed

4.8 Buffalo Subwatershed

4.8.1 Watershed Characteristics

The Buffalo subwatershed encompasses about 256,311 ha and is located in the counties of Camrose, Lacombe, Ponoka, Red Deer and Stettler No. 6 (Figure 215).

The Buffalo subwatershed is located in the northern region of the Red Deer River watershed. The subwatershed lies entirely in the Central Parkland Subregion (Figure 216) and is dominated by grassland with groves of aspen (*Populus* spp.). The grassland vegetation is dominated by rough fescue (*F. campestris*) (Heritage Community Foundation, 2008).

The geology of the subwatershed is dominated by the Paskapoo and Scollard Formations, which formed in the Paleocene epoch (56-65 million years ago) and the Upper Cretaceous period (65-100 million years ago). The Scollard Formation (Paleocene and Upper Cretaceous) consists of sandstone, mudstone and thick coal deposits, while the Paskapoo Formation (Paleocene) consists of diverse sandstones, siltstones/mudstones and shales (Alberta Geological Survey, 2006).

The climate of the Buffalo subwatershed is continental, with a mean annual temperature of 2 °C and a May-September average of 13 °C. The frost-free period averages 95 days. The mean annual precipitation is about 350-450 mm, with the May-September precipitation averaging 300 mm (Environment Canada, 2006).

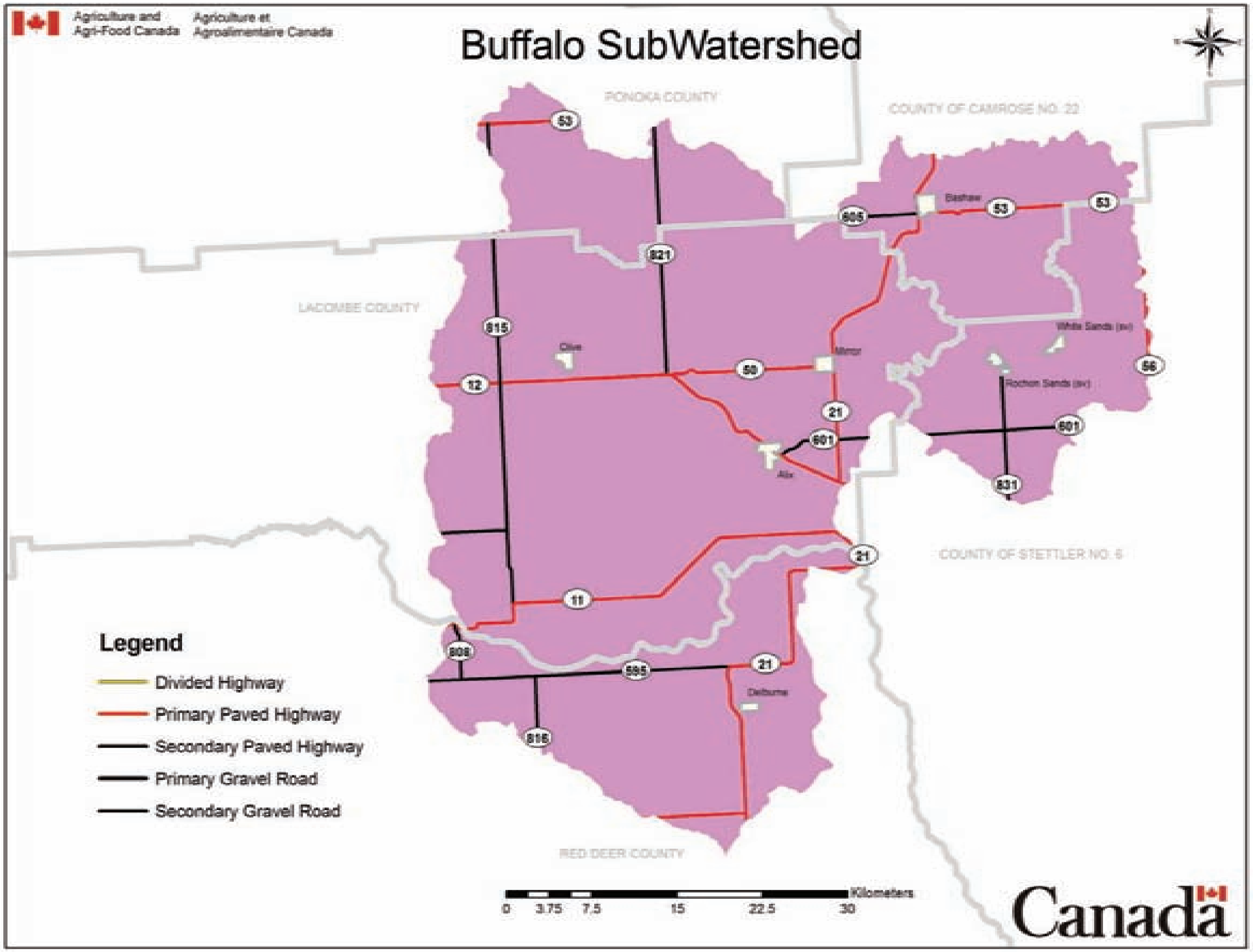


Figure 215. Location of the Buffalo subwatershed (AAFC-PFRA, 2008).

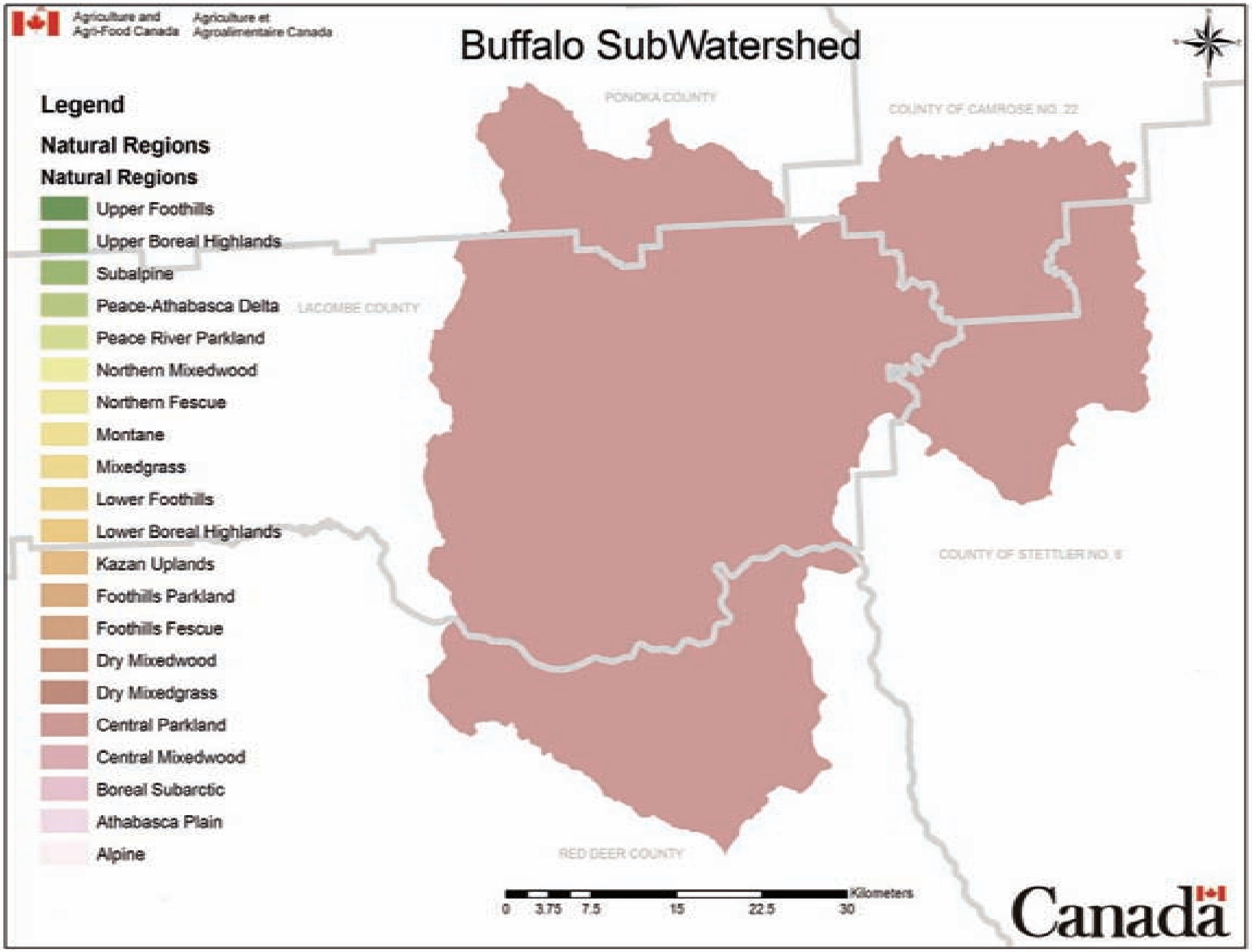


Figure 216. Natural Subregions of the Buffalo subwatershed (AAFC-PFRA, 2008).

4.8.2 Land Use Indicators

Changes in land use patterns reflect major development trends, such as forested lands converted to agriculture and agricultural lands developed and lost to urban sprawl. Land use changes and the subsequent changes in management practices impact both the quantity and quality of water within the Red Deer River watershed. Six metrics were used to indicate changes in land use and land use practices in the Red Deer River watershed and its 15 subwatersheds:

- Wetland Loss – Condition Indicator
- Riparian Health – Condition Indicator
- Livestock Manure Production – Risk Indicator
- Urban, Rural and Recreational Developments – Risk Indicator
- Linear Developments – Condition Indicator
- Oil and Gas Activities – Risk Indicator

These six land use change indicators also reflect socioeconomic growth in a region. Hence, while human activities in a region can have negative environmental impacts, it is important to strive for a balance between socioeconomic growth and the sustainable management of natural ecosystems to ensure their long-term health and enjoyment by future generations.

4.8.2.1 Wetland Loss

Wetlands serve many functions in the natural landscape including water storage, flood attenuation, wildlife habitat, groundwater recharge and general water quality improvements (e.g., nutrient uptake, degradation of pesticides, sediment retention). Additionally, wetlands provide a cost effective and sustainable alternative to engineered treatment options. The loss of wetlands to development and/or agriculture can be deleterious to surface and groundwater quantity and quality.

Land cover data indicate the presence of 6,120 ha of wetlands (2.39% of the total subwatershed area) in the Buffalo subwatershed (AAFC-PFRA, 2008). Only one sedge-dominated fen has been reported near Alix (Twp. 39/40, Rge. 22/23, W 4) (Sweetgrass Consultants Ltd., 1988). Vitt et al. (1996) recognized the need for the protection of this peatland due to the rarity of peatlands in the region. There are no data on any other classes, forms and types of wetlands (*sensu* National Wetlands Working Group, 1997) within the subwatershed; however, given the presence of lentic (lakes) and lotic (streams and rivers) systems, marshes and shallow open water wetlands are likely also present in the subwatershed. In addition, ephemeral, temporary, seasonal and semi-permanent wetlands (*sensu* Stewart and Kantrud, 1971) are likely present in the subwatershed as well.

The Buffalo landscape has been classified by Ducks Unlimited Canada (DUC) as a critical landscape and in need of immediate action to conserve, restore and enhance its highly productive waterfowl habitat. The objectives for this landscape will include the conservation and restoration of over 1,500 wetland basins and about 3,845 ha of upland habitat. Where possible, wetland basins will be restored to their original state and protected alongside those wetlands that are still intact using landowner agreements and conservation easements. Uplands will also be restored or converted by encouraging landowners to adopt wildlife-friendly agricultural practices and by planting high yield fall-seeded crops, such as winter wheat, that do not disturb spring waterfowl nesting (DUC, 2008).

The Prairie Habitat Joint Venture program (a partnership between federal and provincial governments, organizations and conservation groups in Manitoba, Saskatchewan and Alberta) has assessed the loss of wetlands in the Parkland Natural Region (in the Central Parkland Subregion) from 1985-2001 (Watmough and Schmoll, 2007). In Alberta, this Natural Region has lost 7% of its total wetland area and 8% of its total number of wetlands due to anthropogenic disturbances in that 16-year period. There appears to be no change in the rate of wetland loss in the Prairie Parkland Region over the past 50-70 years. Caution must be taken when extrapolating these data to the Buffalo subwatershed, since the Prairie Habitat Joint Venture program has assessed wetland losses along only one transect in this subwatershed (Watmough and Schmoll, 2007).

4.8.2.2 Riparian Health

Riparian areas are an important transition zone between uplands and water. They act as buffer zones, protecting water quality and attenuating floods. Contaminants are adsorbed onto sediments, assimilated by vegetation and transformed by soil microbes into less harmful forms. They have long been proven effective in reducing nutrients, sediments and other anthropogenic pollutants that enter surface waters via overland and subsurface flow.

Riparian health has not been assessed in the Buffalo subwatershed.

4.8.2.3 Livestock Manure Production

Areas of higher livestock density within a subwatershed, and their associated higher manure production, are expected to have greater impacts on downstream water quality. Streams that drain land with high intensity livestock operations have higher nutrient concentrations, dissolved nutrients, mass loads, fecal bacteria and exports of total dissolved phosphorus than streams with medium or low intensity livestock operations and manure production.

There are more than 30 feedlots/intensive livestock operations in the Buffalo subwatershed. The highest density occurs in the north and north-western areas of the subwatershed (Figure 217) (AAFC-PFRA, 2008). Most of the feedlots finish cattle/cows, swine and poultry, with a smaller number of beef and swine feeding operations.

Cattle density varies across the subwatershed, with the lowest intensity in the northeastern area of the subwatershed and along the Red Deer River (0.21-0.40 cattle/ha) and an increasing intensities towards the central and western areas of the subwatershed (0.41-0.60 cattle/ha) (Figure 218) (AAFC-PFRA, 2008). Manure production ranges from 2.6-5.0 tonnes manure/ha throughout the majority of the subwatershed; however, manure production increases to 5.1-7.5 tonnes manure/ha in the Mirror-Alix-Ponoka-Lacombe area and peaks at 7.6-10.0 tonnes manure/ha east of Ponoka (Figure 219) (AAFC-PFRA, 2008). The manure production quantity in the Buffalo subwatershed is considered low relative to the remainder of the Red Deer River watershed.

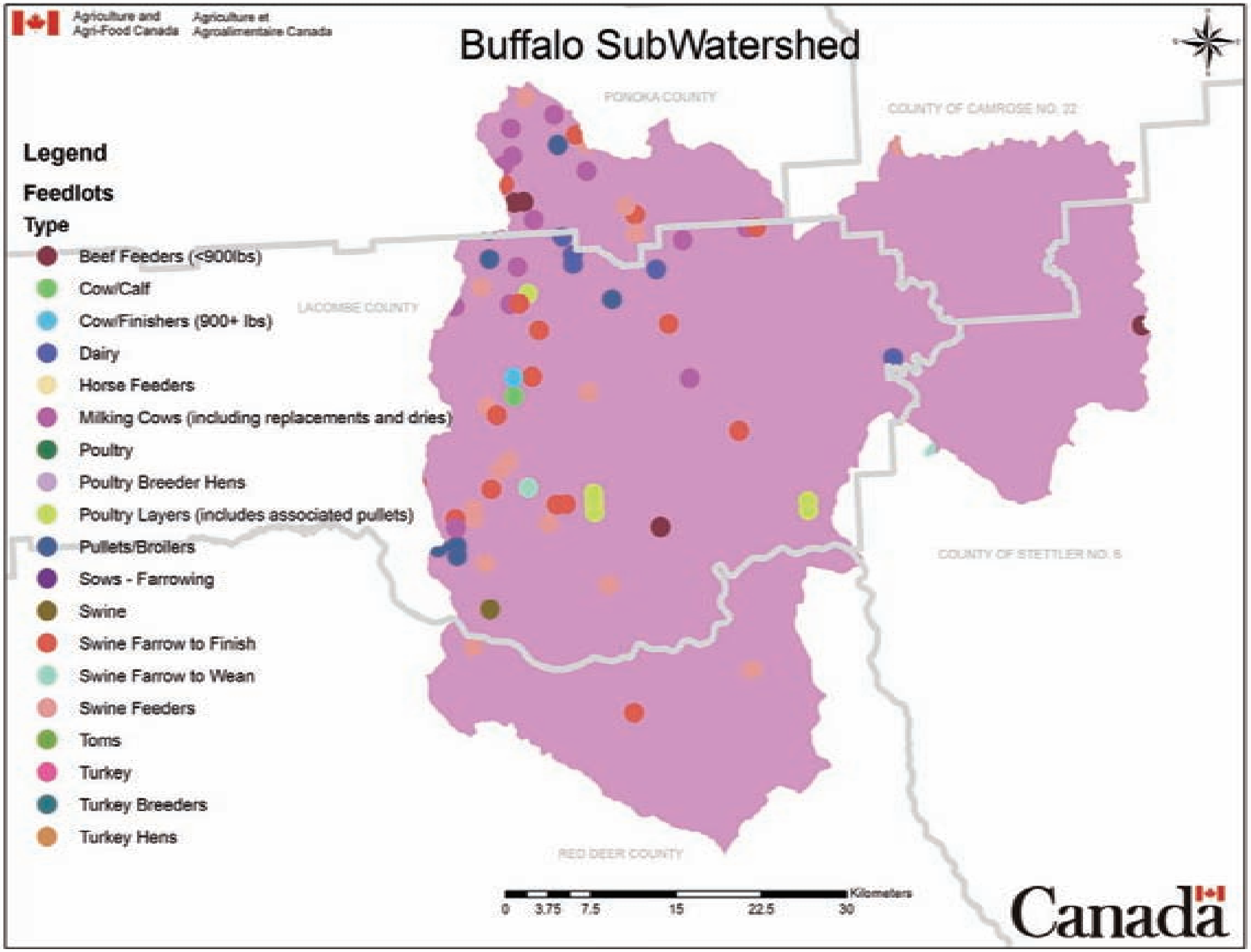


Figure 217. Feedlots and intensive livestock operations in the Buffalo subwatershed (AAFC-PFRA, 2008).

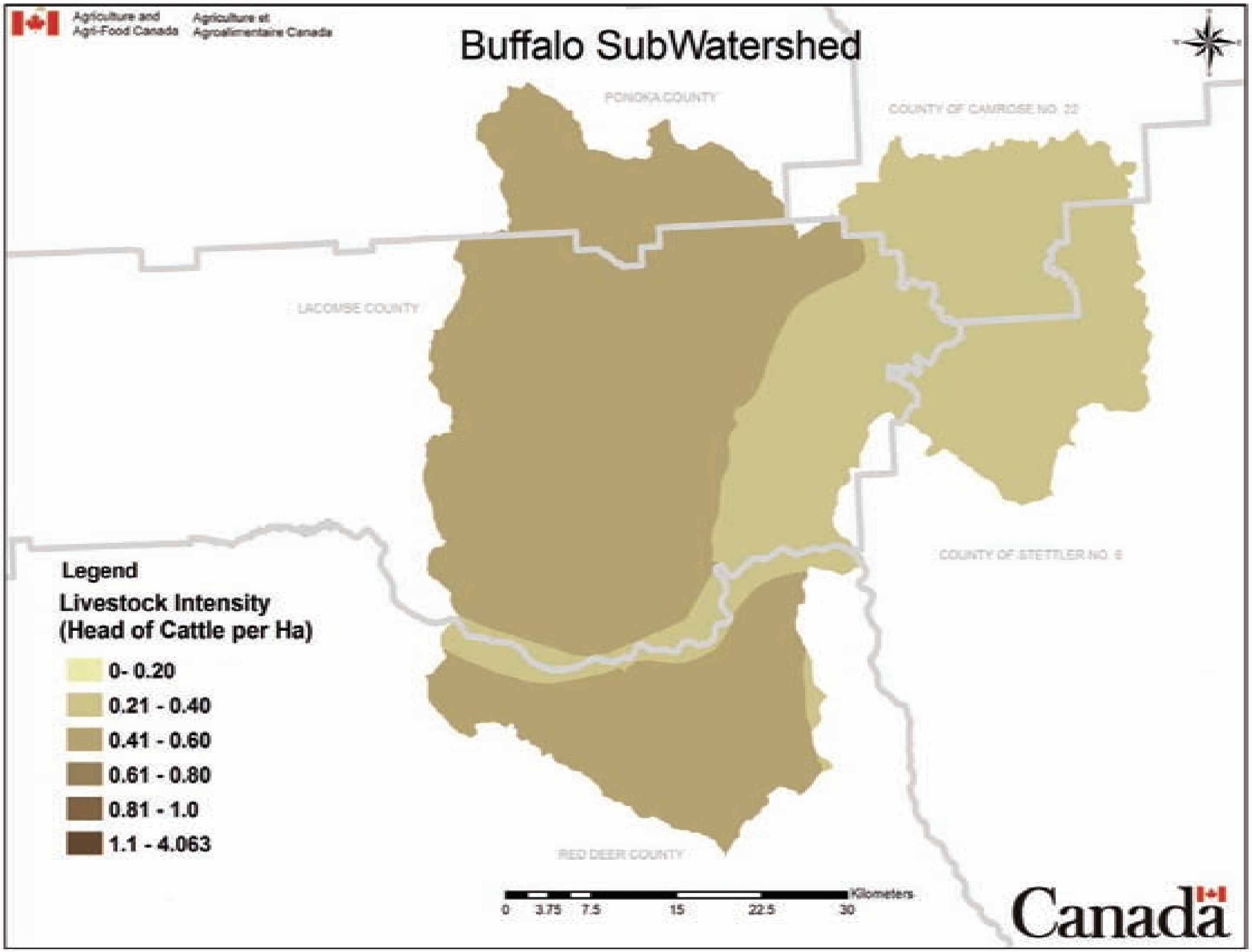


Figure 218. Cattle density (cattle/ha) in the Buffalo subwatershed (AAFC-PFRA, 2008).

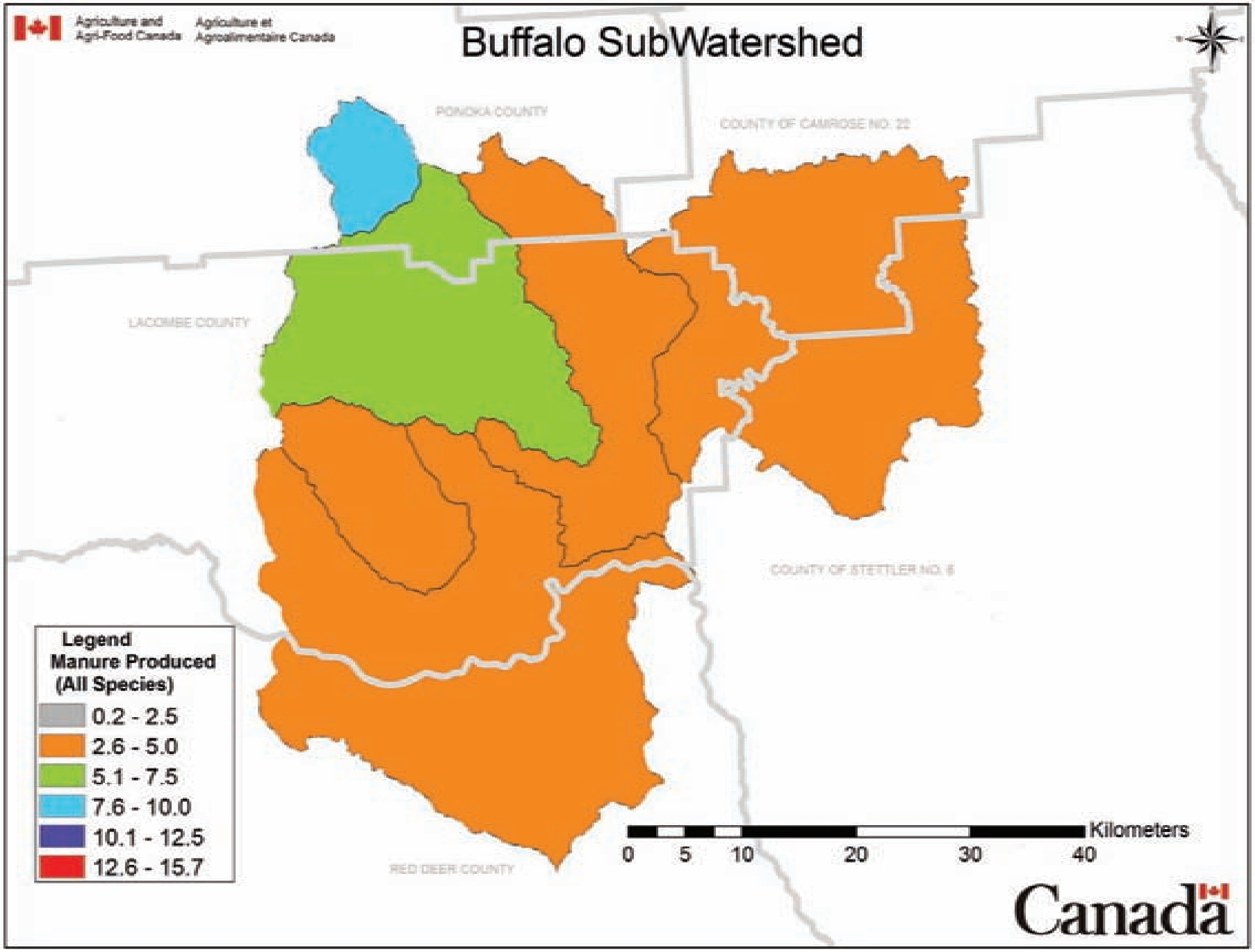


Figure 219. Manure production (tonnes/ha) in the Buffalo subwatershed (AAFC-PFRA, 2008).

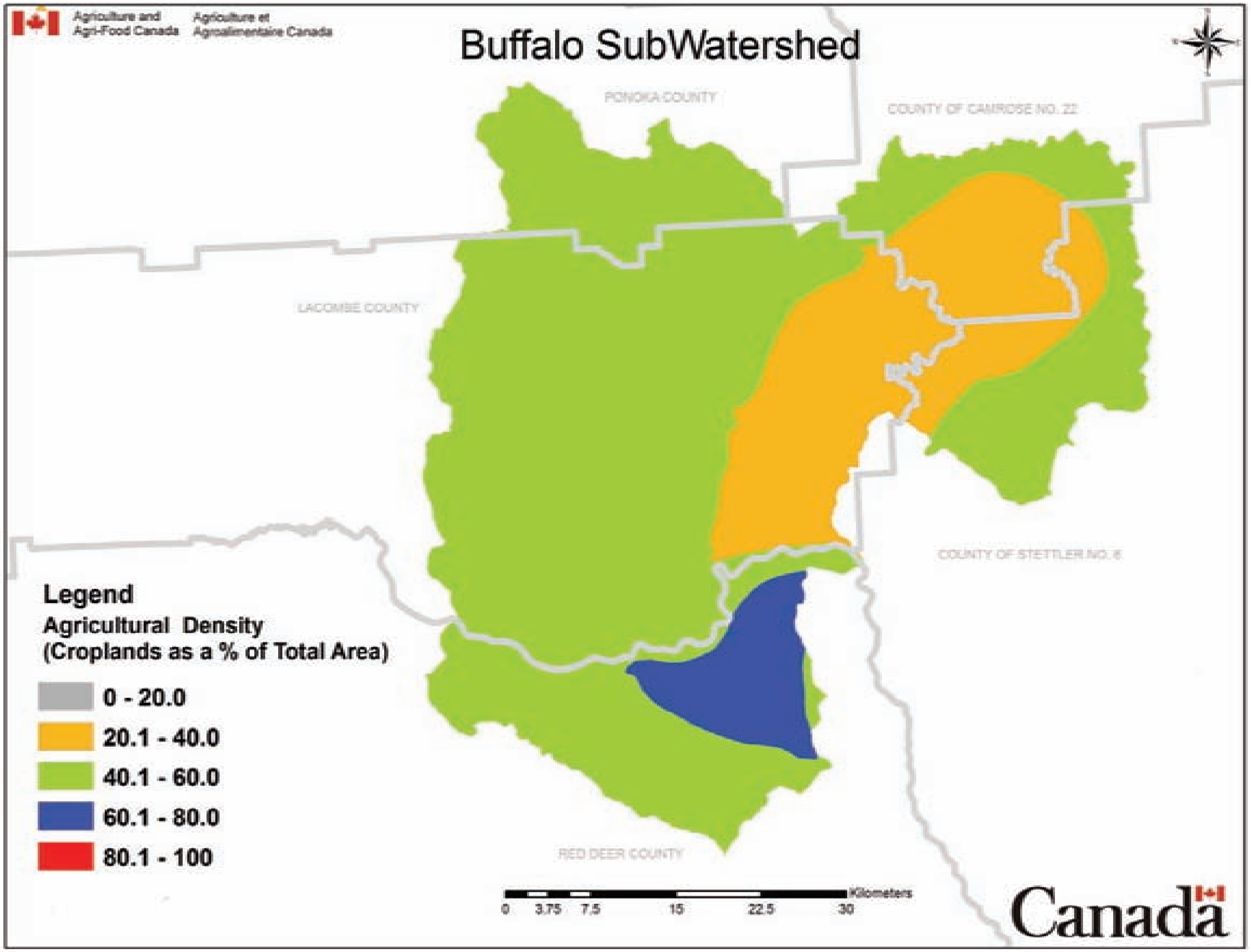


Figure 220. Agricultural intensity (% cropland) in the Buffalo subwatershed (AAFC-PFRA, 2008).

Agricultural intensity, expressed as the percent land cover used as croplands, ranges from 20-40% in the east-central and north-eastern areas to primarily 40-60% throughout the remainder of the subwatershed. Agricultural intensity is highest, 60-80% in the south-western area of the subwatershed (Figure 220) (AAFC-PFRA, 2008).

4.8.2.4 Urban, Rural, Agricultural and Recreational Developments

Urban sprawl, rural and recreational development is the expansion of urban areas, rural subdivisions and recreational areas into surrounding landscape. This expansion can have many negative effects on the environment, including the loss of wetlands, riparian areas, intermittent streams and wildlife habitat, as well as increased surface runoff into neighboring creeks, rivers and lakes.

Communities in the Buffalo subwatershed include the Town of Bashaw, the Villages of Alix, Clive and Mirror, the Summer Villages of Rochon Sands and White Sands and numerous hamlets, including Alix South Junction, Ardley, Chigwell, Coghill, Haynes, Heatburg, Hillsdown, Joffre, Lamerton, Nevis, Prentiss and Tees (Government of Canada, 2006). There are three recreational facilities in the subwatershed, two Provincial Recreation Areas (PRA) and one Provincial Park (PP) (Table 92) (Alberta Tourism, Parks and Recreation, 2008b).

Table 92. Recreational facilities in the Buffalo subwatershed (Alberta Tourism, Parks and Recreation, 2008b).

Facility	Characteristics
Buffalo Lake PRA	• 2.38 ha on Buffalo Lake • 30 unit campgrounds • “Watchable Wildlife” sites
Rochon Sands PP	• 119.49 ha on Buffalo Lake • 69 unit campgrounds, 20-unit group campgrounds, day use areas • “Watchable Wildlife” site
The Narrows PRA	• 24.04 ha on Buffalo Lake • 61 unit campgrounds • “Watchable Wildlife” site

Note: PP = provincial park, PRA = provincial recreation area.

Visitation statistics for three recreation facilities in the subwatershed indicate that the number of visitors to these recreation facilities varies considerably on an annual basis (Figure 221). For those years with available data, the average number of visitors per year was 4,231, 9,369 and 4,031 in Buffalo Lake PRA, Rochon Sands PP and the Narrows PRA, respectively. An average 17,631 visitors have used these three recreation facilities annually from 1994-2003; however, there are some years with incomplete visitation data (lack of group camping data), and the number of visitors to these facilities is likely substantially higher (Alberta Tourism, Parks and Recreation, 2008b).

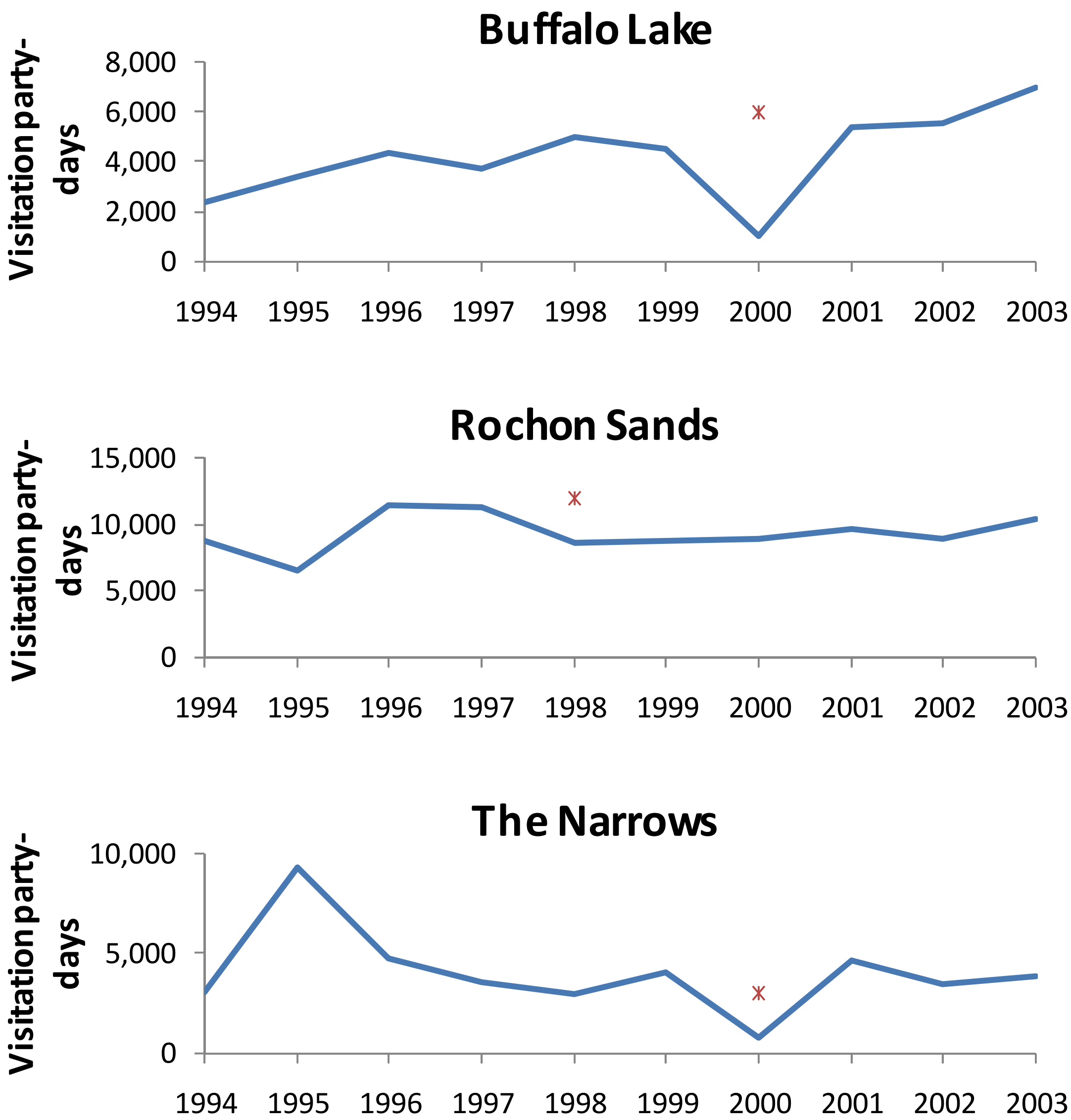


Figure 221. Visitation statistics for two recreation facilities in the Buffalo subwatershed (Alberta Tourism, Parks and Recreation, 2008b). Asterisks indicate years for which group camp data were not available.

4.8.2.5 Linear Developments

Linear developments include seismic lines, pipelines, roads, railways and utility right of ways. Quantifying linear development will help us understand potential changes in water quality and fish and wildlife populations, e.g., wildlife corridors can be interrupted by roads, and watersheds can have their drainage patterns permanently altered by increases in impervious or compacted surfaces.

The most prominent linear developments in the Buffalo subwatershed are urban and rural roads, which have a total length of 3,000 km and cover 48.0 km^2 of the subwatershed's landbase. Other major linear developments include cutlines/trails and pipelines (Table 93). In total, all linear developments cover an area of 72.7 km^2, or 2.8% of the total area of the subwatershed (Figure 222) (AAFC-PFRA, 2008).

Table 93. Linear developments in the Buffalo subwatershed (AAFC-PFRA, 2008). The dominant linear development is highlighted.

Linear Development	Length (km)	Width (m)	Area (km^2)	Proportion of total linear disturbances (%)
All roads	3,000	16	48.00	66.0
Cutlines/trails	1,760	6	10.56	14.5
Pipelines	460	15	6.90	9.5
Powerlines	160	30	4.80	6.6
Railways	162	15	2.43	3.3
Total	**5,542**		**72.69**	

In addition to linear developments, the Buffalo subwatershed has 191 bridges that cross waterbodies, mostly streams and creeks, or culverts that connect waterbodies (Figure 223) (AAFC-PFRA, 2008). The majority of pipeline crossings in the Buffalo subwatershed are located in the west-central and northern areas of the subwatershed near the City of Red Deer and in the Chain Lakes-McLeans Lake-Gadsby Lake area, respectively. The headwaters of Gaetz Creek also have a higher concentration of pipeline crossings (Figure 224) (AAFC-PFRA, 2008).

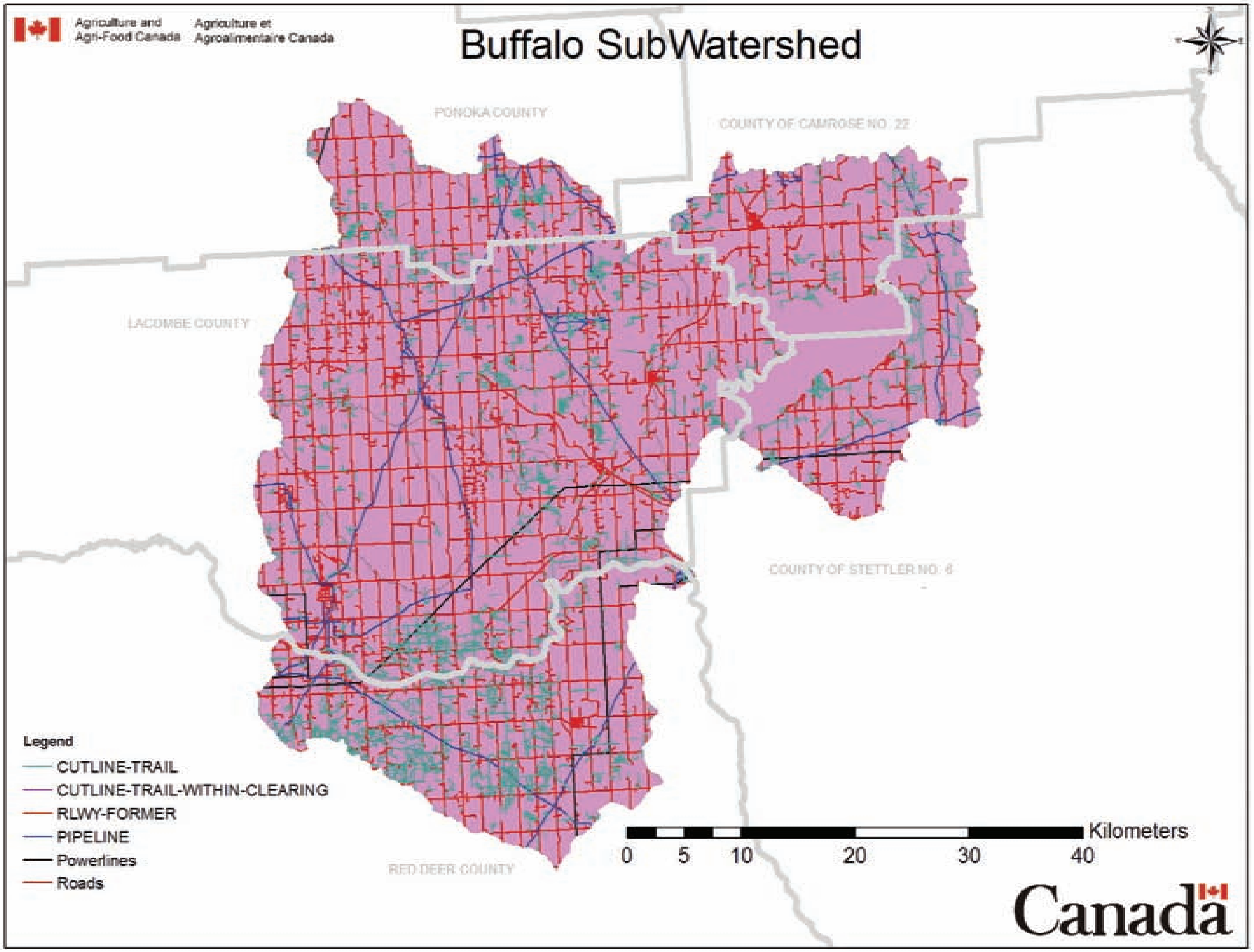


Figure 222. Linear developments in the Buffalo subwatershed (AAFC-PFRA, 2008).

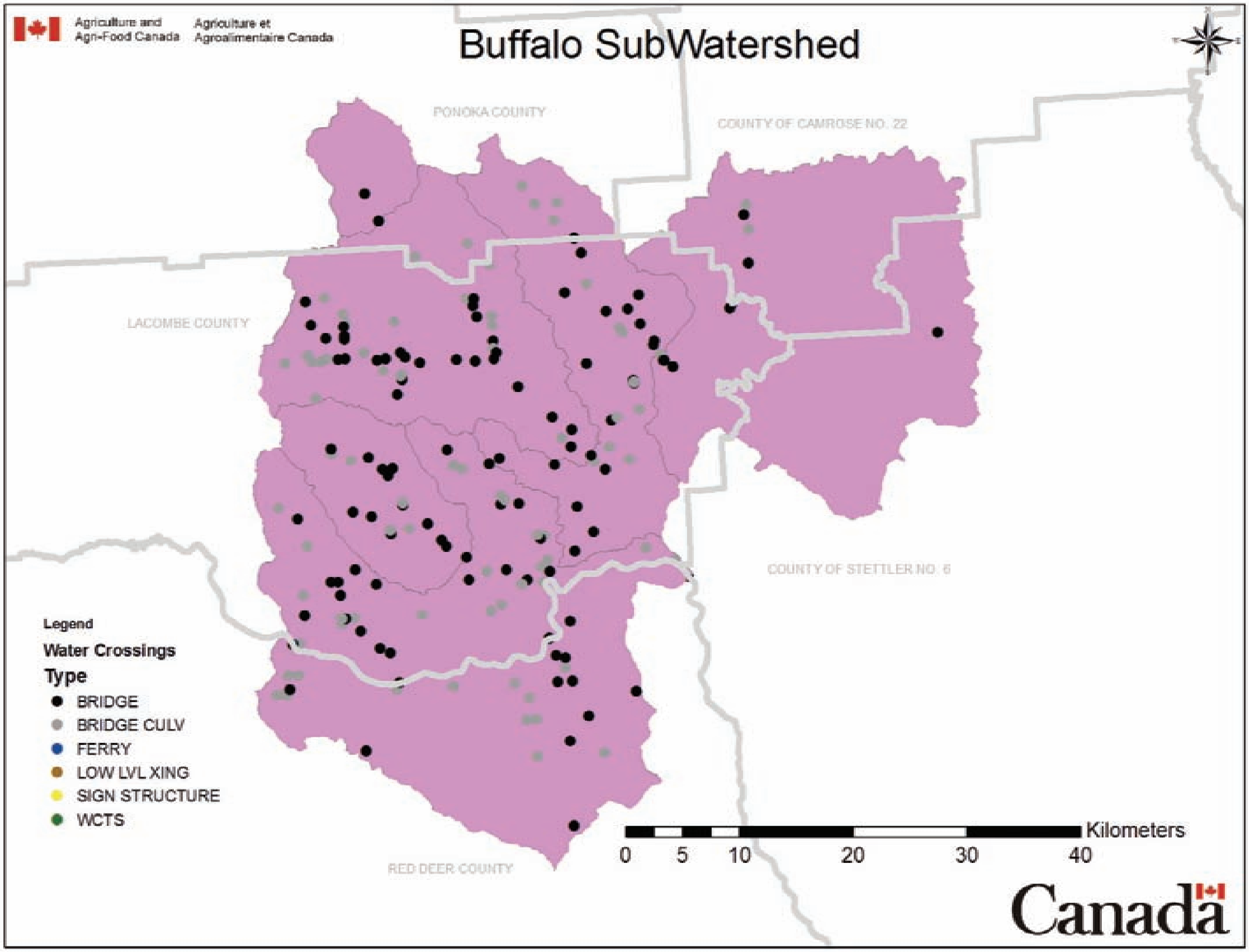


Figure 223. Waterbody crossings in the Buffalo subwatershed (AAFC-PFRA, 2008).

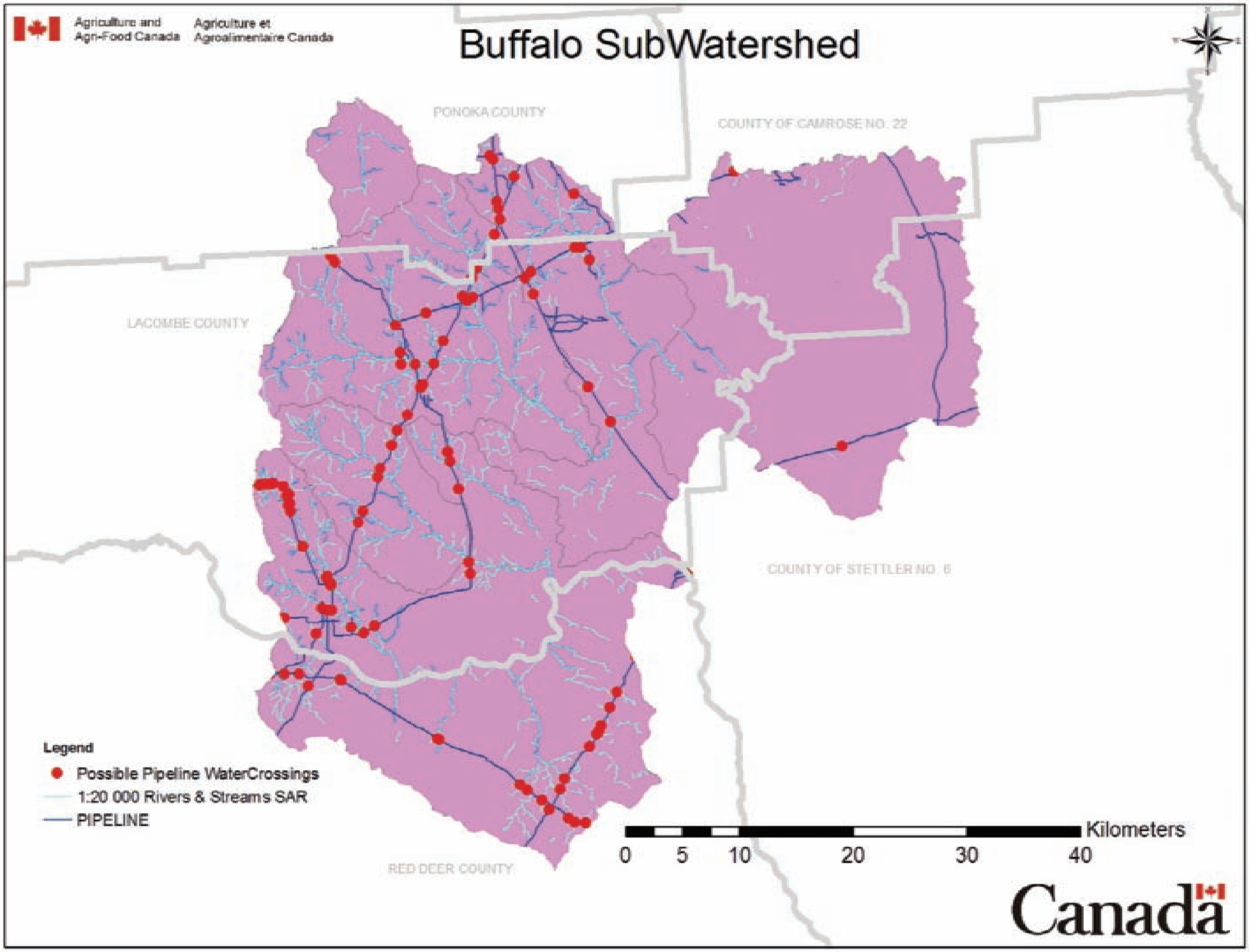


Figure 224. Pipeline crossings over waterbodies in the Buffalo subwatershed (AAFC-PFRA, 2008).

4.8.2.6 Oil and Gas Activities

Oil and gas activity is very common throughout the province of Alberta. With oil and gas development there can be a number of associated impacts, including loss of wetlands, habitat fragmentation, increased water use and surface water and groundwater contamination (Alberta Centre for Boreal Studies, 2001).

The Buffalo subwatershed has an average well density of 2.76 wells/km^2. Wells are distributed throughout the entire subwatershed; however, well density increases up to 10 wells/km^2 in the Joffre-Haynes corridor, on the north-shore of the Red Deer River, north and south of Clive and in the Mirror-Lamerton area near Gadsby Lake in the central region of the subwatershed. Near Clive, the oil/gas well density is greatest, reaching up to 40 wells/km^2 (Figure 225). About 65% of all wells are active, with the majority being unspecified wells, followed by gas and oil wells (Table 94) (AAFC-PFRA, 2008).

Table 94. Number of known active and abandoned oil, gas, water and other wells in the Buffalo subwatershed (AAFC-PFRA, 2008).

Well type	Quantity
Wells – active *	2,505
Wells – abandoned *	1,564
Total	**4,069**
Gas wells – active	1,500
Gas wells – abandoned	289
Total	**1,789**
Oil wells – active	534
Oil wells – abandoned	557
Total	**1,091**
Water wells – active	54
Water wells – abandoned	59
Total	**113**
Total active wells in subwatershed	**4,593**
Total abandoned wells in subwatershed	**2,469**
Total wells in subwatershed	**7,062**

* The purpose of these wells is undefined and may include standing, newly licensed, flowing coalbed methane, testing coalbed methane, carbon dioxide injector or general exploration wells.

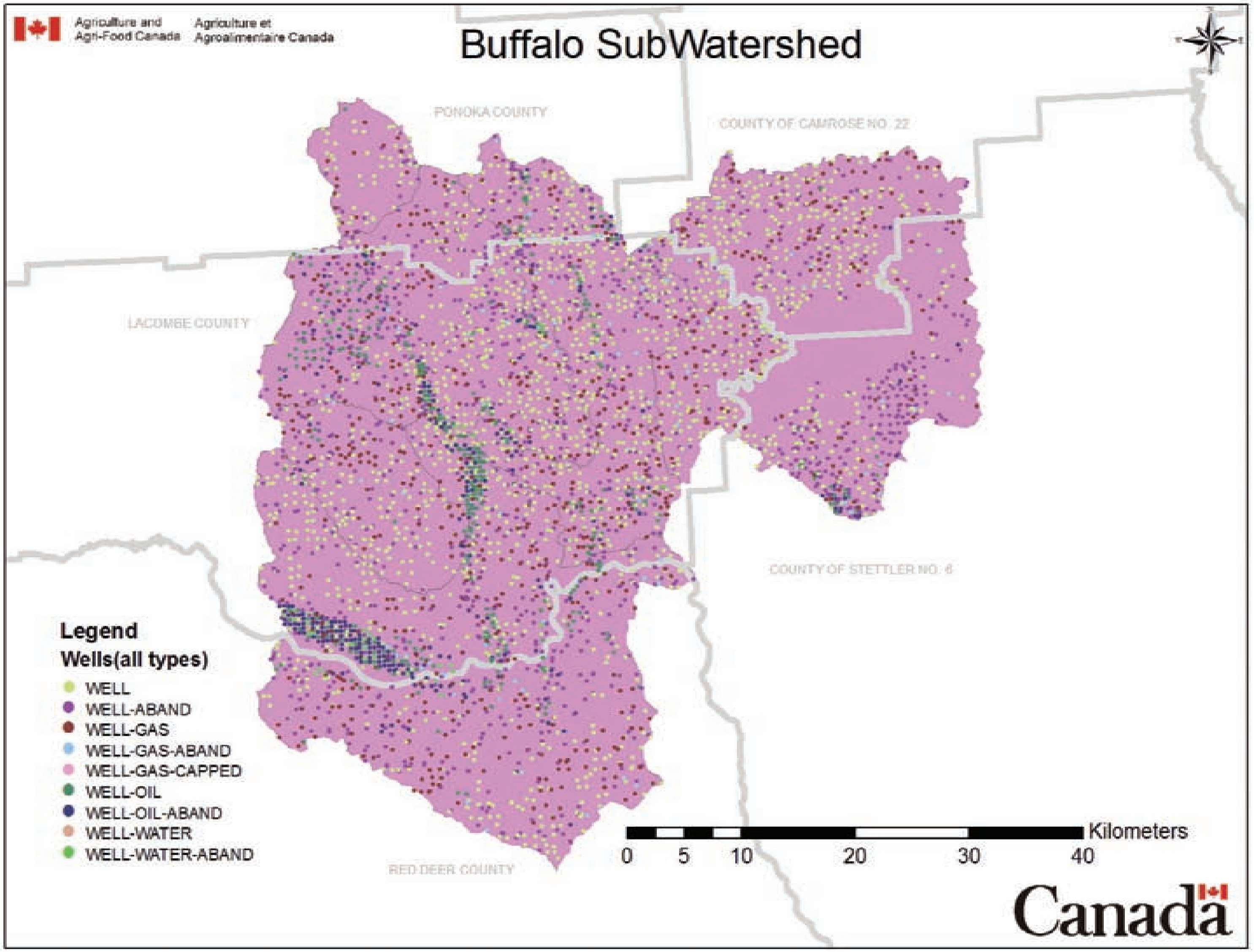


Figure 225. Known active and abandoned oil, gas, water and other wells in the Buffalo subwatershed (AAFC-PFRA, 2008).

Coal bed methane (CBM) is natural gas that is found within coal formations. It has received attention recently as an additional source of energy; however, it brings with it potential environmental impacts, some of which are similar to conventional oil and gas exploration and production endeavors. Conversely, some potential impacts it brings with it are new, including an increased intensity in wells, compressors, pipeline infrastructure and completion and production of natural gas from formations above the base of groundwater protection. Some CBM wells are estimated to produce over 65,000 L of waste water per day (Lennon, 2008). In addition, common to oil, gas and unconventional gas (CBM and Shale gas) production is the risk of groundwater contamination through fracturing. Fracturing results from pumping fluids or gases into bedrock formations at high rates and pressures to 'fracture' the bedrock and increase gas or oil production. Fracturing fluids may contain toxic or carcinogenic compounds, which may leach into groundwater sources and pose a threat to human health through contaminated drinking water (Natural Resources Defense Council, 2002).

4.8.3 Water Quality Indicators

Changes in water quality indicate either a deterioration or improvement in the condition of the watershed and demonstrate specific areas that require further attention or protection. Changes in water quality result from changes in land use or land management practices, landscape disturbance and natural events. The major anthropogenic impacts on water quality result from natural resource extraction and processing, wetland drainage, dredging, dam construction, agricultural runoff, industrial wastes, municipal wastes, land erosion, road construction and land development. Five metrics were used to indicate changes in water quality in the Red Deer River watershed and its 15 subwatersheds:

- Nutrients – Condition Indicator
- Bacteria – Condition Indicator
- Parasites – Condition Indicator
- Pesticides – Condition Indicator
- Point Source Inputs

These five water quality indicators reflect socioeconomic growth in a region. Hence, while human activities in a region can have negative impacts on aquatic ecosystems, it is important to strive for a balance between socioeconomic growth and the sustainable management of these aquatic ecosystems to ensure their long-term health and enjoyment by future generations.

4.8.3.1 Nutrients

Nitrogen and phosphorus are essential nutrients for most aquatic plants, whereby excess nutrients can lead to eutrophication, i.e., an excessive amount of aquatic plant and phytoplankton growth. Concomitant with increased plant and phytoplankton growth, oxygen levels may significantly decrease in the water column, which may negatively impact aquatic organisms, including fish. In addition, excessive phytoplankton growth, particularly of cyanobacteria, can lead to the release of toxins into the water column, which may be harmful to aquatic organisms, waterfowl, livestock and humans.

Total phosphorus (TP) concentrations are fairly high in Buffalo Lake, both historically and at the last time for which data was available (Figure 226). Most samples taken over the period of measurement were above the ASWQG PAL level of 0.05 mg/L. There are also two major peaks in relatively recent times.

The first peak was in 1992-1994, with total phosphorus levels reaching over 10 times the ASWQG PAL limit. This peak corresponded to a period of water levels that were well below their historical levels (Alberta Environment, 2004) and was potentially a result of reduced lake volume concentrating nutrients in solution. The second peak occurred in 1996 and signals the onset of a water diversion program from the Red Deer River via Alix Lake and Parlby Creek into Buffalo Lake to maintain and increase lake water levels (Alberta Environment, 2004). The peak in phosphorus concentrations was most likely due to increased nutrient loading resulting from this diversion, especially following the initial flush of nutrients from nutrient-rich Alix Lake.

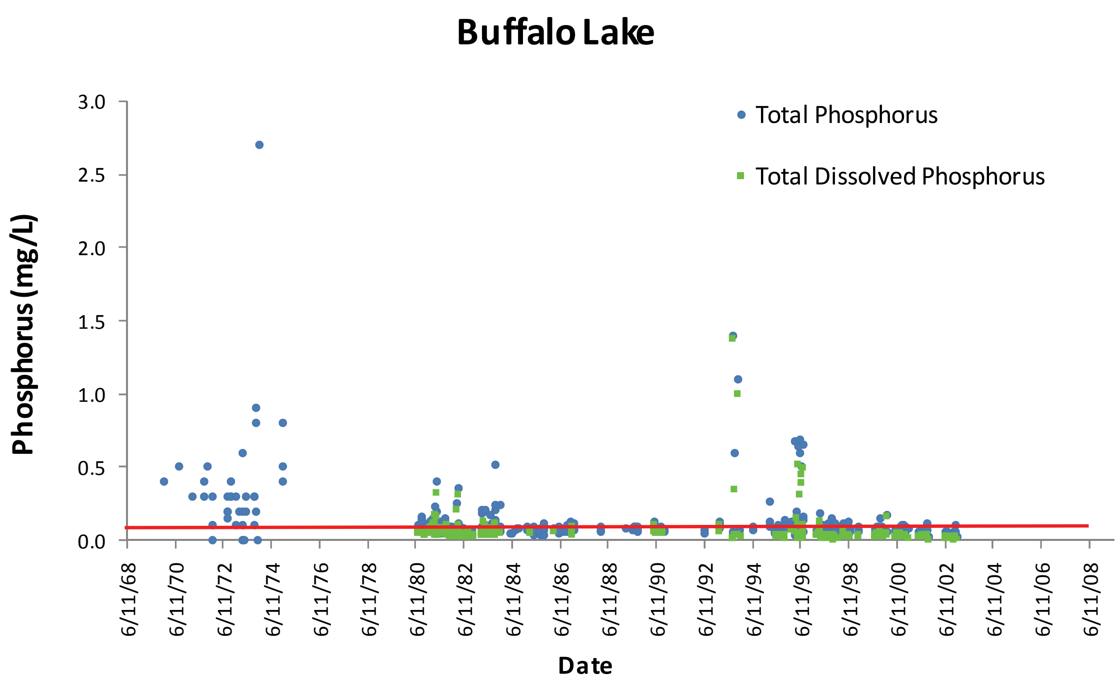


Figure 226. Total phosphorus (TP) and total dissolved phosphorus (TDP) concentrations in Buffalo Lake (data from Alberta Environment, 2008). The ASWQG PAL for TP (0.05 mg/L) is indicated by the red line.

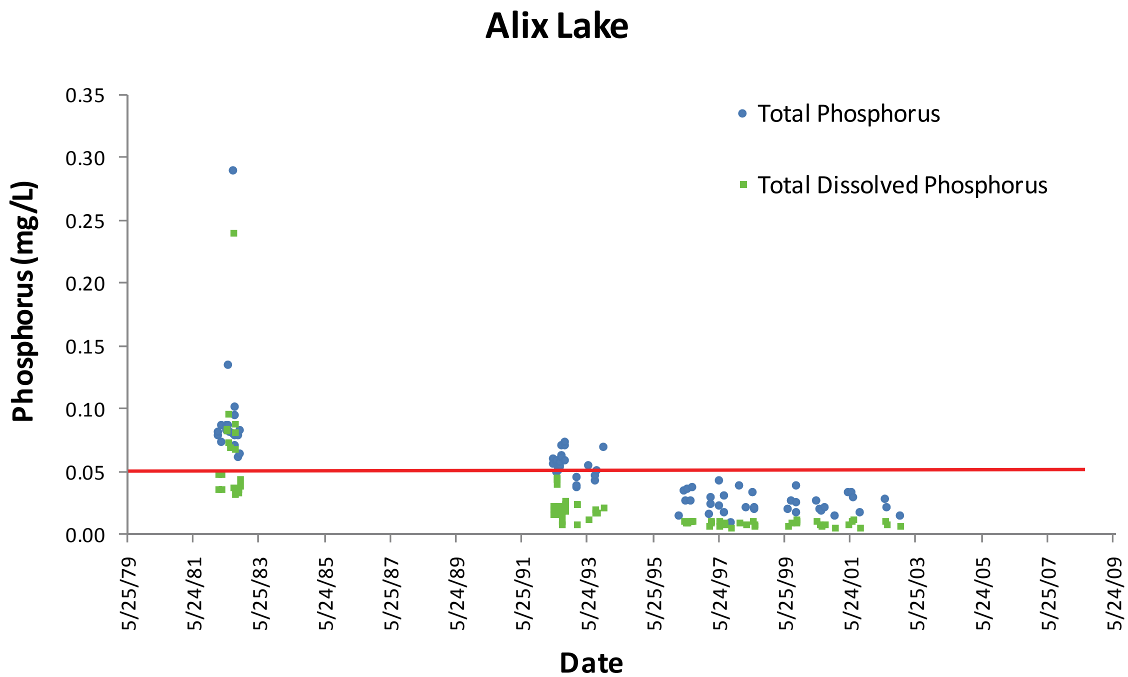


Figure 227. Total phosphorus (TP) and total dissolved phosphorus (TDP) concentrations in Alix Lake (data from Alberta Environment, 2008). The ASWQG PAL for TP (0.05 mg/L) is indicated by the red line.

TP and total dissolved phosphorus (TDP) concentrations have decreased in Alix Lake over the two decades for which data were available (1980s and 1990s) (Figure 227). Concentrations in the early 1980s were frequently above the ASWQG PAL limits for both water quality variables; however, no concentrations above this limit were reported for the last 7 years of data. The decreasing concentrations in TP and TDP are both statistically significant ($p < 0.01$ and $p<0.01$, respectively).

TN concentrations in Buffalo Lake are elevated, with concentrations generally above the ASWQG PAL of 1.0 mg/L (Figure 228). There are two major peaks in TN in the last decade for which data was available, from 1992-1994 and in 1996, corresponding to years of low water levels and the onset of diversion from the Red Deer River, respectively. The cause of the earlier peak during years with low water levels may have been the result of an algal bloom, a suggestion that appears to be supported by several periods of low oxygen concentrations in the water column during those years. The peak in 1996 may have been caused by an influx of suspended organic matter resulting from the initiation of a water diversion project and the subsequent flushing of Alix Lake. The peak in TN concentrations in 1980-1981 was accompanied by peaks in TP, NH_3, and NO_2^--NO_3^-, which suggests a large input of organic matter into Buffalo Lake or an algal bloom; however, the ultimate cause of this peak remains unknown.

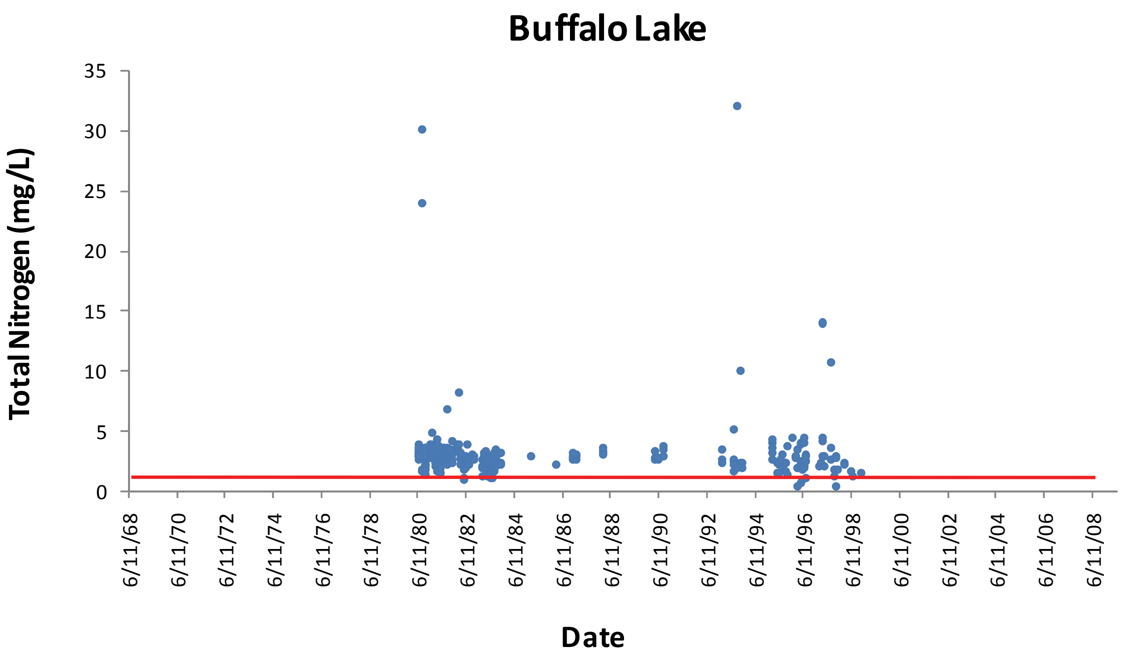


Figure 228. Total nitrogen (TN) concentration in Buffalo Lake (data from Alberta Environment, 2008). The ASWQG PAL for TN (1.0 mg/L) is indicated by the red line.

Total nitrogen (TN) concentrations in Alix Lake have been historically elevated, with the majority of samples taken prior to the mid-1990s exceeding the ASWQG PAL limit of 1.0 mg/L (Figure 229). These elevated concentrations may be linked to the occurrence of algal blooms in Alix Lake at the time. More recent samples show a decline in TN concentrations; however, with no data available after 1998, it is impossible to tell whether this trend has continued. The majority of TN in Alix Lake is in organic form, with dissolved ammonia, nitrate and nitrite constituting a relatively small fraction of TN (Figures 231, 233). The reduced nitrogen levels seen from 1996 onwards are consistent with the flushing of the lake resulting from the diversion of water from the Red Deer River through Alix Lake into Buffalo Lake.

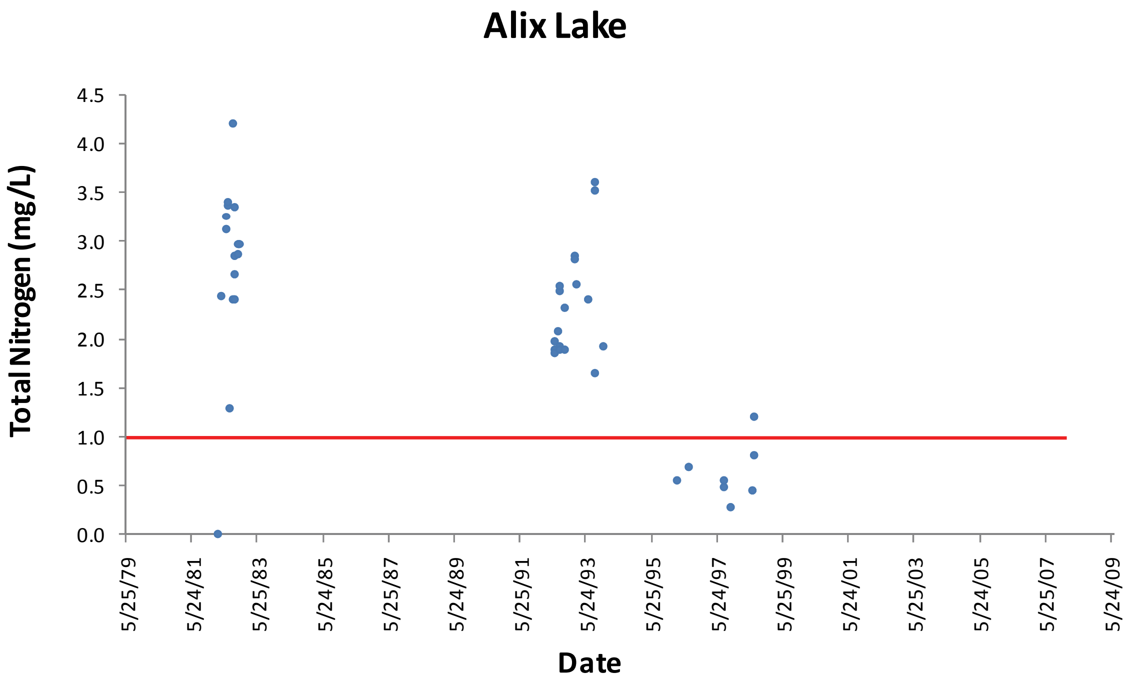


Figure 229. Total nitrogen (TN) concentrations in Alix Lake (data from Alberta Environment, 2008). The ASWQG PAL for TN (1.0 mg/L) is indicated by the red line.

NH_3 and NO_2^--NO_3^- concentrations in Buffalo Lake are relatively low compared to TN concentrations (Figures 230, 232), indicating that the majority of nitrogen is present in organic forms. The elevated values in late 1996 are indicative of the decay of organic matter under the ice. This surplus input of organic matter was likely brought into the system during the diversion of water from the Red Deer River and subsequent repeated flushing of Alix Lake into Buffalo Lake.

Ammonia (NH_3) concentrations in Alix Lake are generally low, with many samples taken since the mid-1990s below detection limits; however, there is a peak in NH_3 concentrations from 1992-1994 that coincides with high TN concentrations and low dissolved oxygen concentrations (Figures 231, 233). This peak in NH_3 concentrations is consistent with algal blooms and the by-products of decomposition released into the water quality following algal death.

NO_2^--NO_3^- concentrations in Alix Lake are generally low, with most of the nitrogen being likely in organic matter suspended in the water column. There has been a significant decline ($p = 0.0017$) in nitrate-nitrite concentrations in Alix Lake from 1992-1998. The reduced nitrate-nitrite concentrations since 1996 are consistent with the flushing of the lake resulting from the diversion of water from the Red Deer River through Alix Lake and into Buffalo Lake.

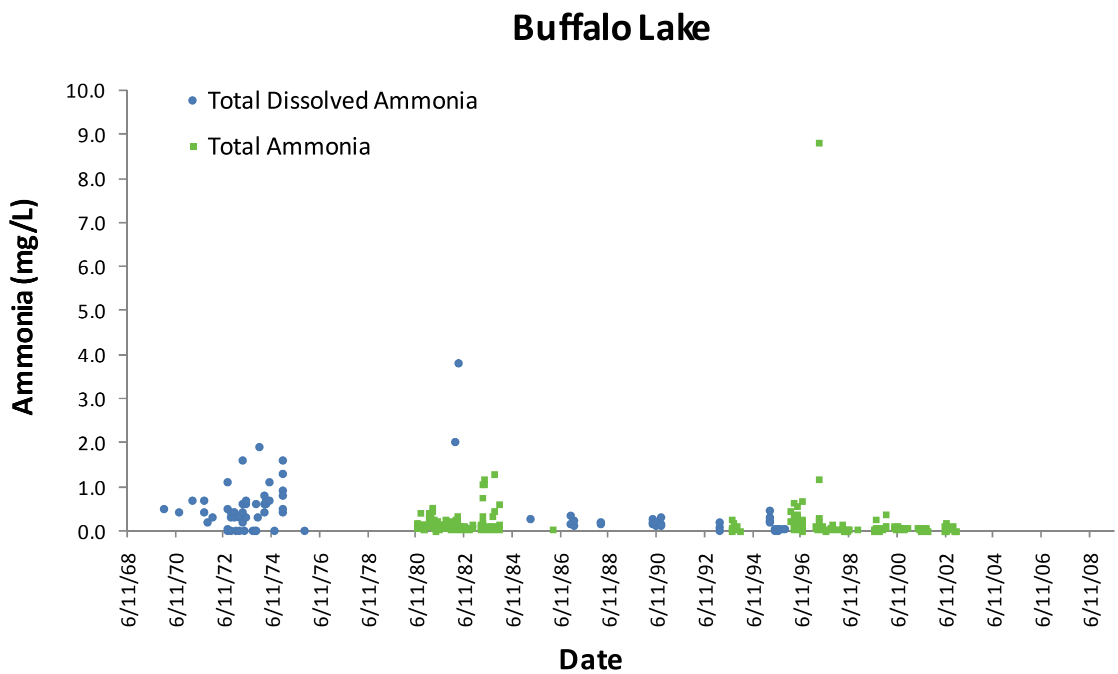


Figure 230. Total ammonia and total dissolved ammonia concentrations in Buffalo Lake (data from Alberta Environment, 2008).

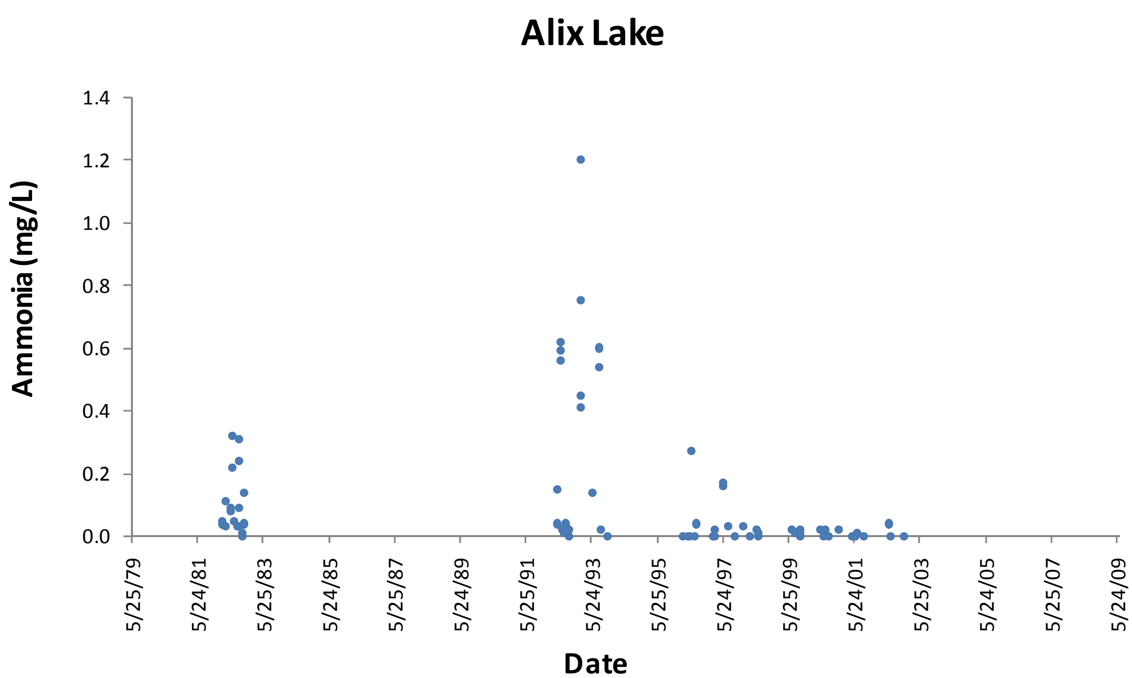


Figure 231. Total ammonia concentrations in Alix Lake (data from Alberta Environment, 2008).

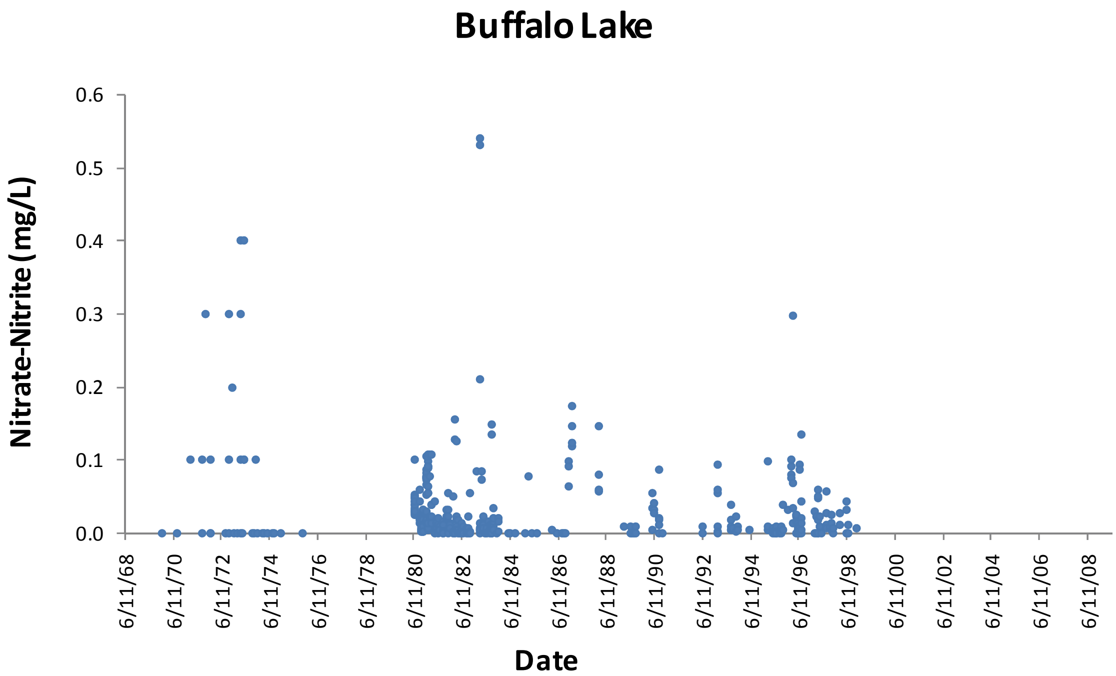


Figure 232. Nitrate-nitrite concentrations in Buffalo Lake (data from Alberta Environment, 2008).

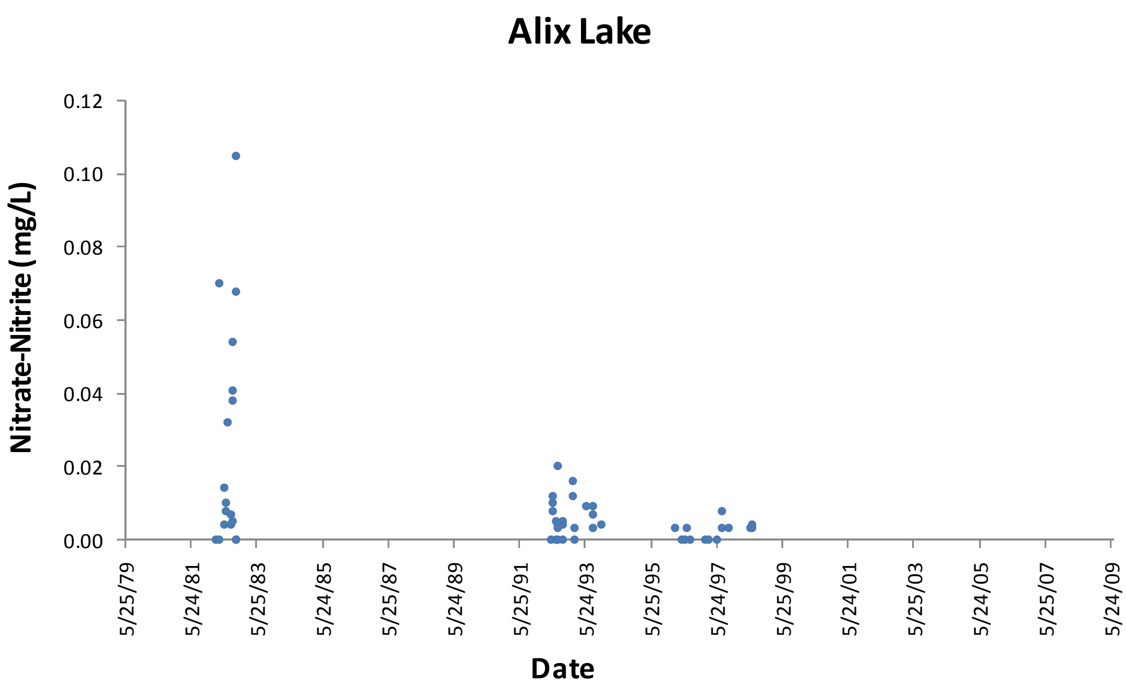


Figure 233. Nitrate-nitrite concentrations in Alix Lake (data from Alberta Environment, 2008).

Summertime dissolved oxygen (DO) concentrations in Buffalo Lake are generally higher than ASWQG limits; however, there have been numerous sampling events, predominantly during the winter months under ice cover, at which hypoxic or anoxic conditions prevailed (Figure 234). This suggests a fairly high risk of winterkill in this lake. There have also been repeated sharp declines in DO concentration that corresponded to peaks in phosphorus and nitrogen concentrations in the lake. The reduced DO concentrations in autumn and winter 1993 were consistent with an algal bloom. The reduced levels in 1996 occurred sporadically throughout the year, consistent with an influx of nutrients and organic matter from the flushing of Alix Lake. Following the onset of the Red Deer River water diversions into Buffalo Lake, there appear to have been fewer incidents of hypoxic conditions. This may be the result of increased lake water volume or the dilution of nutrients by the diverted river water resulting in generally reduced algal growth over the summer.

Since 1995, water samples collected in Alix lake show elevated concentrations of DO throughout the water column, while DO concentrations were below the ASWQG PAL minimum concentration of 5 mg/L prior to 1995 (Figure 235), indicating hypoxic to anoxic conditions. The associated high concentrations of TN (Figure 229) suggest algal blooms occurring at this time. The decomposition of the dead algae following the bloom consumes oxygen, thereby reducing oxygen availability for other aquatic organisms. Consequently, there was the potential for both winterkill and summerkill in Alix Lake, since anoxic or severely hypoxic conditions were recorded both in the summer and under the ice during winter.

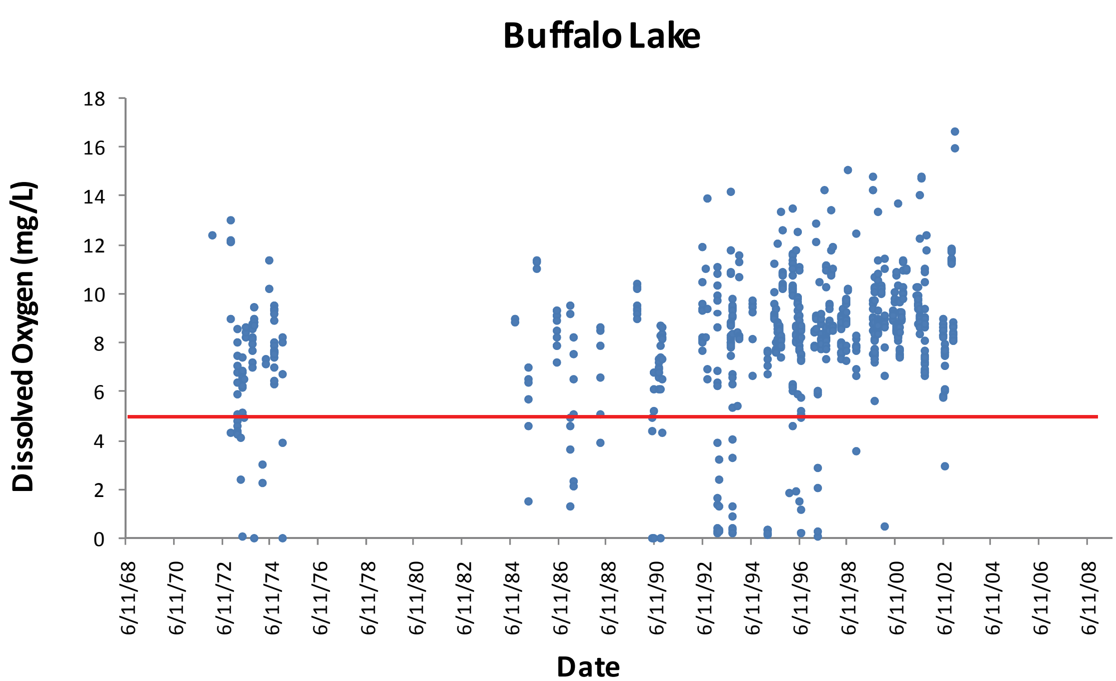


Figure 234. Dissolved oxygen (DO) concentrations in Buffalo Lake (data from Alberta Environment, 2008). The ASWQG PAL lower limit for DO (5.0 mg/L) is indicated by the red line.

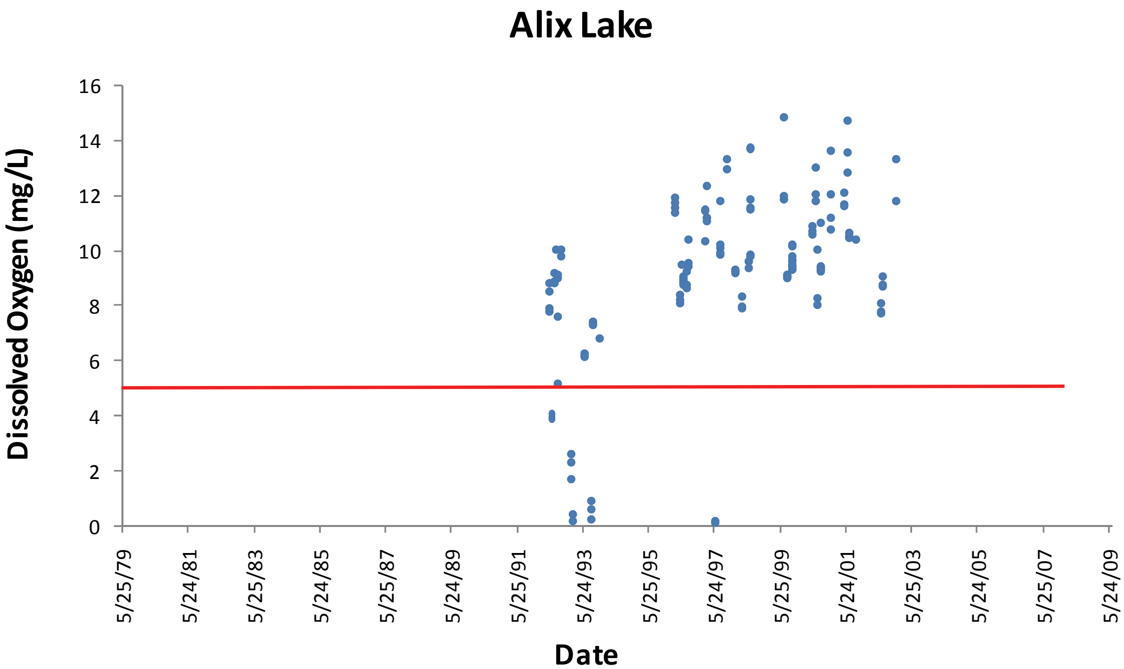


Figure 235. Dissolved oxygen (DO) concentrations in Alix Lake (data from Alberta Environment, 2008). The ASWQG PAL lower limit for DO (5.0 mg/L) is indicated by the red line.

Table 95. Water quality in Little Buffalo Creek. Data are average values of samples collected January-October 1997 (data from Alberta Environment, 2008). n = sample size. All concentrations in mg/L unless otherwise noted. Highlighted values exceed guidelines *.

Parameter	Mean	n
TP	0.833	12
TDP	0.464	12
TN	3.266	12
NO_3^--NO_2^-	0.799	12
NH_3	0.725	12
DO	---	---
Chl. *a* (µg/L)	---	---
pH	7.97	12
Specific Conductivity (µS/cm)	---	---
TDS	---	---
Total coliforms (CFU/100 mL)	---	---
Fecal coliforms (CFU/100 mL)	70	12

* TN from ASWQG PAL chronic exposure guideline; fecal and total coliforms from CCME-Agriculture/Irrigation guideline; all others from CCME PAL. Variable abbreviations as in Table 10.

Both TP and TN concentrations in Little Buffalo Creek and in Haynes Creek exceeded CCME PAL guidelines for TP and TN (0.05 mg/L and 1.0 mg/L, respectively) (Tables 95, 96). Sources of nitrogen and phosphorus may include surface application of manure and/or fertilizer by agricultural producers (Carpenter et al., 1998; Chambers et al., 2001), municipal wastewater effluents (Servos et al., 2001) and urban run-off (Marsalek et al., 2001), all of which have been demonstrated to be a source of excess nutrients to surface waterbodies. Both agricultural and livestock operations occur throughout the Buffalo subwatershed, and particularly manure production is high relative to the remainder of the province.

Table 96. Water quality in Haynes Creek. Data are average values of samples collected from March 1995-August 1996 (data from CAESAA). n = sample size. All concentrations in mg/L unless otherwise noted. Highlighted values exceed guidelines*.

Parameter	Mean	n
TP	0.839	55
TDP	0.769	49
TN	3.966	49
$NO_3^- + NO_2^-$	0.308	49
NH_3	0.468	49
DO	---	---
Chl. *a* (µg/L)	---	---
pH	7.74	53
Specific Conductivity (µS/cm)	---	---
TDS	---	---
Total coliforms (CFU/100 mL)	---	---
Fecal coliforms (CFU/100 mL)	188	17

* TN from ASWQG PAL chronic exposure guideline; fecal and total coliforms from CCME-Agriculture/Irrigation guideline; all others from CCME PAL. Variable abbreviations as in Table 10.

4.8.3.2 Bacteria

Coliforms are a broad class of bacteria found in human and animal wastes. Total coliforms include *Escherichia coli*, fecal bacteria and other coliforms that occur naturally in warm blooded animals. *E. coli* is one of three bacteria commonly used to measure the direct contamination of water by human or other mammal wastes. Ingestion of or exposure to fecal bacteria can have negative health impacts. Sources of this type of bacteria include agricultural and municipal runoff, wildlife, faulty septic systems and septic fields.

Coliform concentrations in Buffalo Lake are fairly low (Figure 236), with the majority of samples below the CCME Agriculture/Irrigation guidelines for both fecal and total coliforms. In the last decade for which data were available, only a single sample exceeded the CCME limit for fecal coliforms. This sample corresponded to the onset of the Red Deer River water diversion project, when water from Alix Lake and Parlby Creek were completely flushed into Buffalo Lake to stabilize its water levels, bringing with it elevated nutrients and sediments and likely causing a proliferation of bacteria in the water column.

Although infrequently sampled, both fecal and total coliform concentrations in Alix Lake appear to be fairly low (Figure 237). Concentrations have exceeded neither the CCME PAL guidelines nor the Health Canada Guidelines for Contact Recreation (200 CFU/100 mL; not shown on figure) in any of the available data; however, the lack of data over the past 15 years makes it impossible to make any statements about the current state of the lake with respect to current coliform concentrations.

Similar to concentrations in lakes, bacterial concentrations are also low in Little Buffalo Creek, although only concentrations of fecal coliform bacteria have been assessed to date. There are no data for total coliform bacterial concentrations (Table 95). Conversely, fecal coliform concentrations exceeded the CCME-Agriculture/Irrigation guideline in Haynes Creek (188 CFU/100 mL vs. 100 CFU/100 mL) (Table 96). There are a substantially higher number of feedlots near Haynes Creek than Little Buffalo Creek. Runoff from these operations into nearby waterbodies has been shown to increase fecal coliform bacterial concentrations.

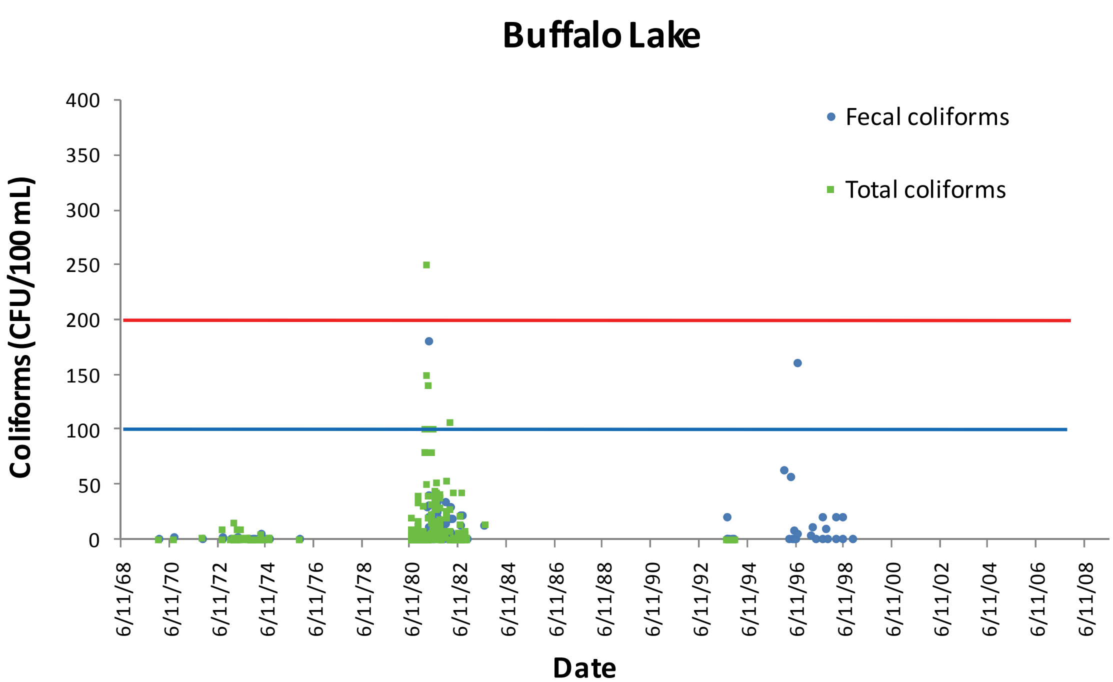


Figure 236. Total coliform and fecal coliform concentrations in Buffalo Lake (data from Alberta Environment, 2008). The CCME Agriculture/Irrigation guideline for fecal coliforms (100 CFU/100mL) is indicated by the blue line, and the CCME Agriculture/Irrigation guideline for total coliforms is indicated by the red line.

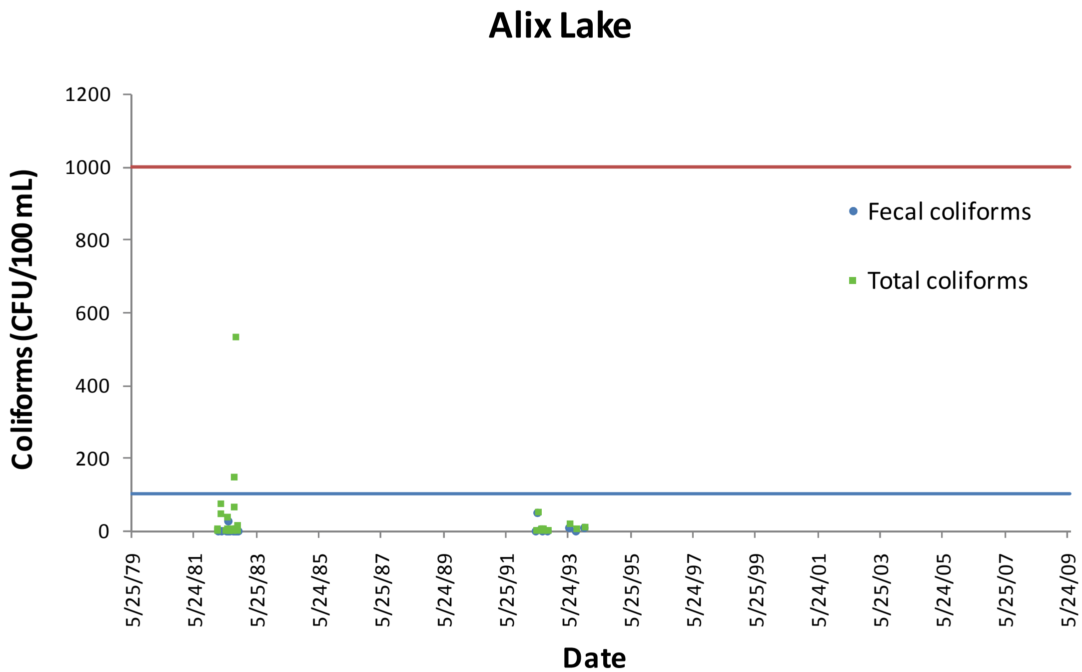


Figure 237. Total coliform and fecal coliform concentrations in Alix Lake (data from Alberta Environment, 2008). The CCME Agriculture/Irrigation guideline for fecal coliforms (100 CFU/100 mL) is indicated by the blue line, and the CCME Agriculture/Irrigation guideline for total coliforms (1,000 CFU/100 mL) is indicated by the red line.

4.8.3.3 Parasites

Waters that are polluted may contain several different disease-causing organisms, commonly called parasites. Enteric parasites, those that live in the intestine of warm blooded animals, can carry or cause a number of infectious diseases. *Cryptosporidium* and *Giardia* spp. are two such parasites. Both occur in almost all environments, including lakes, rivers, reservoirs and groundwater. They come from the feces of rodents, birds, cows, pigs and humans, and the ingestion of these parasites causes gastrointestinal conditions known as cryptosporidiosis and giardiasis.

Parasite data were not located for any waterbody in the Buffalo subwatershed.

4.8.3.4 Pesticides

Pesticides are a group of chemicals, including herbicides, insecticides, rodenticides and fungicides, used for many purposes, including pest control and aesthetics in urban areas, golf courses and in forestry and agricultural production. Pesticides are a common contaminant of streams and dugouts in the high intensity agricultural areas of Alberta.

Pesticide concentrations have been assessed in three waterbodies in the Buffalo subwatershed, with six different pesticides having been detected. The most commonly detected pesticides were 2,4-D, MCPA and Triallate, all of which are used to control broadleaf weeds. None of the pesticides had concentrations exceeding CCMA PAL guidelines in any of the waterbodies (Table 97).

Table 97. Pesticide concentrations in waterbodies in the Buffalo subwatershed. n = sample size. All concentrations in µg/L. The most common pesticides are highlighted.

Waterbody	Pesticide	Mean range *	Maximum	CCME PAL	n
Haynes Creek	2,4-D	0.057-0.066	0.230	4.0	7
	Bromoxynil	0.069-0.083	0.360	5.0	7
	Imazamethabenz-methyl	0.163-0.177	0.730	---	7
	MCPA	0.032-0.047	0.160	2.6	7
	Triallate	0.008-0.020	0.021	0.24	7
	Trifluralin	0.013-0.028	0.047	---	7
Windsor Lake	Triallate	0.008-0.022	0.031	0.24	4
Gadsby Lake	2,4-D	0.024-0.034	0.075	4.0	4
	MCPA	0.008-0.023	0.032	2.6	4

* A precise mean could not be determined because the analytical methods used do not distinguish between values of zero and values that are below the detection limit (BDL). The range of the mean was calculated by first assuming that all BDL samples were equal to zero (providing the lower end of the range), and then by assuming that all BDL samples were equal to the detection limit (providing the upper end of the range). Where no values below the detection limit were present, a single average value was calculated. In Haynes Creek, samples were collected April 1995-August 1996, in Windsor Lake, samples were collected from July 1995-September 1996; in Gadsby Lake, samples were collected from August 1995-September 1996 (data from CAESAA).

4.8.3.5 Point Source Inputs

Point source inputs include effluents from waste water treatment plants (WWTP), stormwater outfalls and industry. Effluent from WWTP's, although regulated, generally has higher concentrations of certain compounds (e.g., nutrients, solids, pharmaceuticals, metals, etc.) than the receiving environment. Similarly, stormwater outfalls contain elevated levels of nutrients, salts and solids compared to the receiving environment, and industrial effluents can contribute elevated levels of a suite of different contaminants, such as metals, solids, hydrocarbons and/or salts, as well as other chemicals used in processing or manufacturing, to aquatic ecosystems.

At least 32 upstream oil/gas facilities, one oil/gas refining/storage facility, one oil sands/heavy oil processing facility, three chemical manufacturing facilities and one power generating facility have released pollutants continuously or sporadically into the air in the Buffalo subwatershed since 1994. Pollutants from the upstream oil/gas facilities include carbon monoxide (CO), nitrous oxide (N_2O) and particulate matter < 2.5 µm in size, while those from the oil/gas refining/storage facility include only particulate matter < 10 µm in size. The oil sands/heavy oil processing facility has released CO and N_2O, and the power generating facility has released CO, N_2O, volatile organic compounds (VOCs), phosphorus, hydrocarbons and particulate matter < 10 µm in size into the environment. The pollutants from the chemical manufacturing facilities have been released the longest (since 1994) and are highly variable, including ethylene glycol, ammonia (NH_3), N_2O, CO, sulphuric acid (H_2SO_4), alcohols, particulate matter < 10 µm in size, hydrocarbons (e.g., toluene, xylene), metals (e.g., Cr, Ni, Zn and their compounds) and solvents. Most of these have been released into the air; however, particularly the metals and their compounds and phosphorus have been released into aquatic ecosystems. Other forms of disposal included incineration or injection into the ground (NPRI, 2008).

4.8.4 Water Quantity Indicators

Water quantity is important for the maintenance of aquatic habitat, it has functions related to water quality and it is essential for the treatment and production of sufficient volumes of drinking water to meet current demands. Irrigation, industry and livestock production are highly dependent on a minimum amount of water. Sufficient water quantity is necessary for many recreational activities, and in recent years many cottagers and recreational lake users across Alberta have voiced concerns about the decreasing volumes of water seen across the province. Five metrics were used as water quantity indicators in the Red Deer River watershed and its 15 subwatersheds:

- Volume
- Minimum Flows to Maintain Ecological Integrity – Condition Indicator
- Contributing Areas to the Watershed
- Allocations
- Groundwater Recharge/Discharge

Water discharge rates, allocations and minimum flow rates to maintain ecological integrity can reflect socioeconomic growth in a region. Human activities in a region frequently reduce available water quantities required to maintain healthy aquatic ecosystems. It is important to balance socioeconomic growth and the sustainable management of these aquatic ecosystems to ensure their long-term health and enjoyment by future generations.

4.8.4.1 Volume

Water volume is the amount of water flowing past one point over a given time, or in the case of lakes or other standing waterbodies, the total amount of water present in the waterbody at a given time. This amount varies seasonally and annually with shifts in weather patterns. Water withdrawals for consumptive uses have increased dramatically in recent years and have resulted in some watersheds within the province being closed to new water licenses.

The total length of all water courses in the Buffalo subwatershed is about 650 km (Figure 238) (AAFC-PFRA, 2008). The major creeks in the subwatershed include Gaetz Creek, Haynes creek, Jones Creek, Parlby Creek, Spotted Creek and Stone Creek. The largest lakes include Alix Lake, Buffalo Lake, Delburne Lakes, Gadsby Lake, Haunted Lakes, Lynn Lake, Magee Lake, Mazy Lake, McLean's Lake, Nelson Lake, Sittingstone Lake, Spotted Lake, Tait Lake, Tanglefoot Lake and Valley Lake (Government of Canada, 2006).

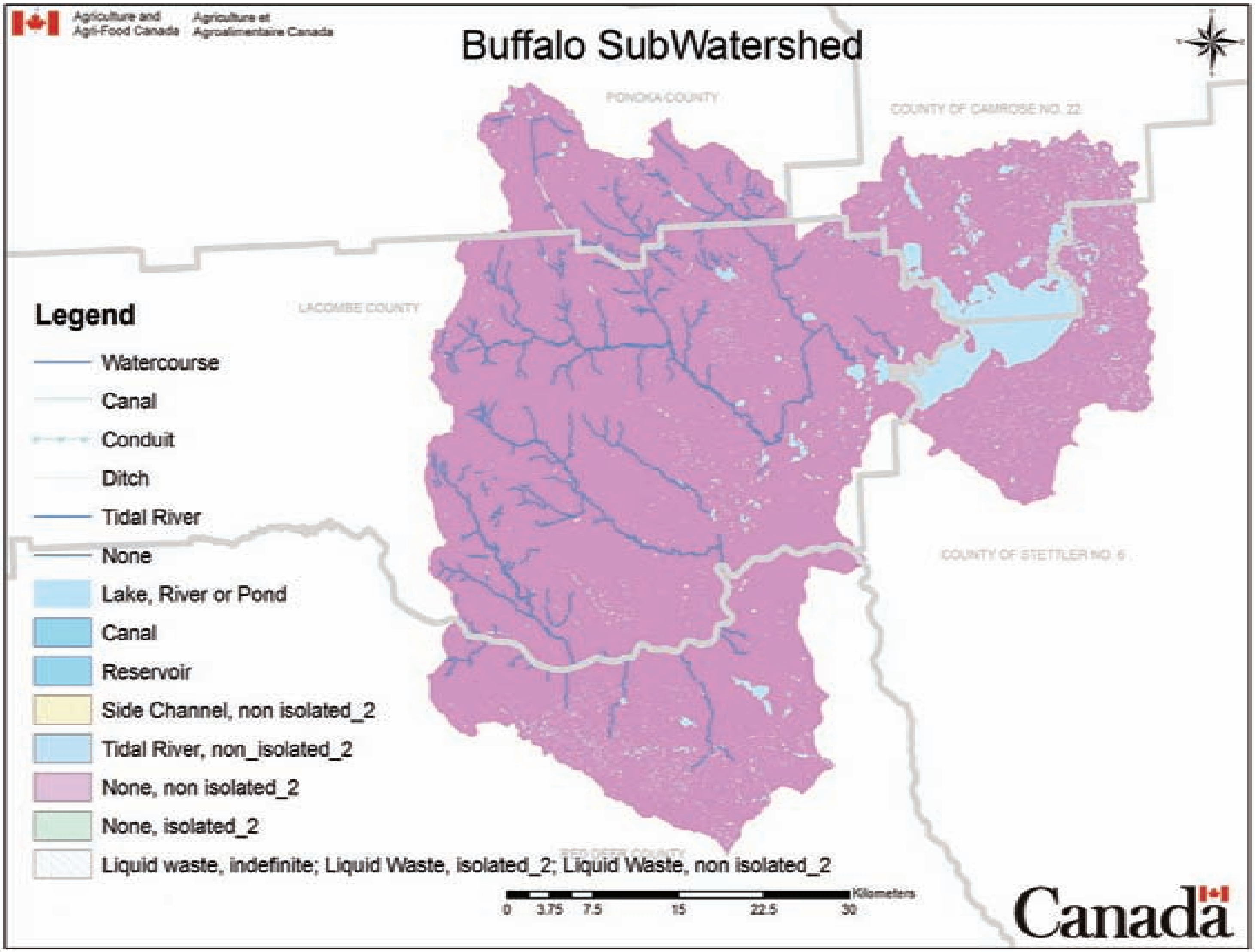


Figure 238. Waterbodies in the Buffalo subwatershed (AAFC-PFRA, 2008).

Alberta Environment has been monitoring water discharge rates at nine locations in the Buffalo subwatershed: Parlby Creek near Mirror (real-time active, 05CD902), Mirror backflood near Spotted Lake (active, 05CD905), Parlby Creek at Alix (real-time active, 05CD007), Haynes Creek near Joffre (active, 05CD913), Haynes Creek near Haynes (real-time active, 05CD006), Spotted lake near Mirror (discontinued, 05CD903), Buffalo Lake (active, 05CD005), Chain Lakes near Ponoka (discontinued, 05CD003) and at the upper Chain Lakes outlet near Ponoka (discontinued, 05CD001) (Government of Alberta, 2008c).

In Parlby Creek, water discharge rates are generally between 0.1-1.0 m^3/sec from April-August before decreasing to about 0.06-0.1 m^3/sec for the remainder of the year. Discharge rates have reached up to 4 m^3/sec in the spring and minima of less than 0.01 m^3/sec in the fall (Figure 239). Further downstream near Alix, water discharge rates are briefly < 1 m^3/sec in the spring before continually decreasing to < 0.1 m^3/sec by August. Water discharge ceases periodically in late summer and fall (Figure 240). In Haynes Creek near Haynes, water discharge rates fluctuate considerably throughout the spring and summer months before ceasing in late summer and fall. Discharge rates are low at generally < 1 m^3/sec (Figure 241) (Government of Alberta, 2008c).

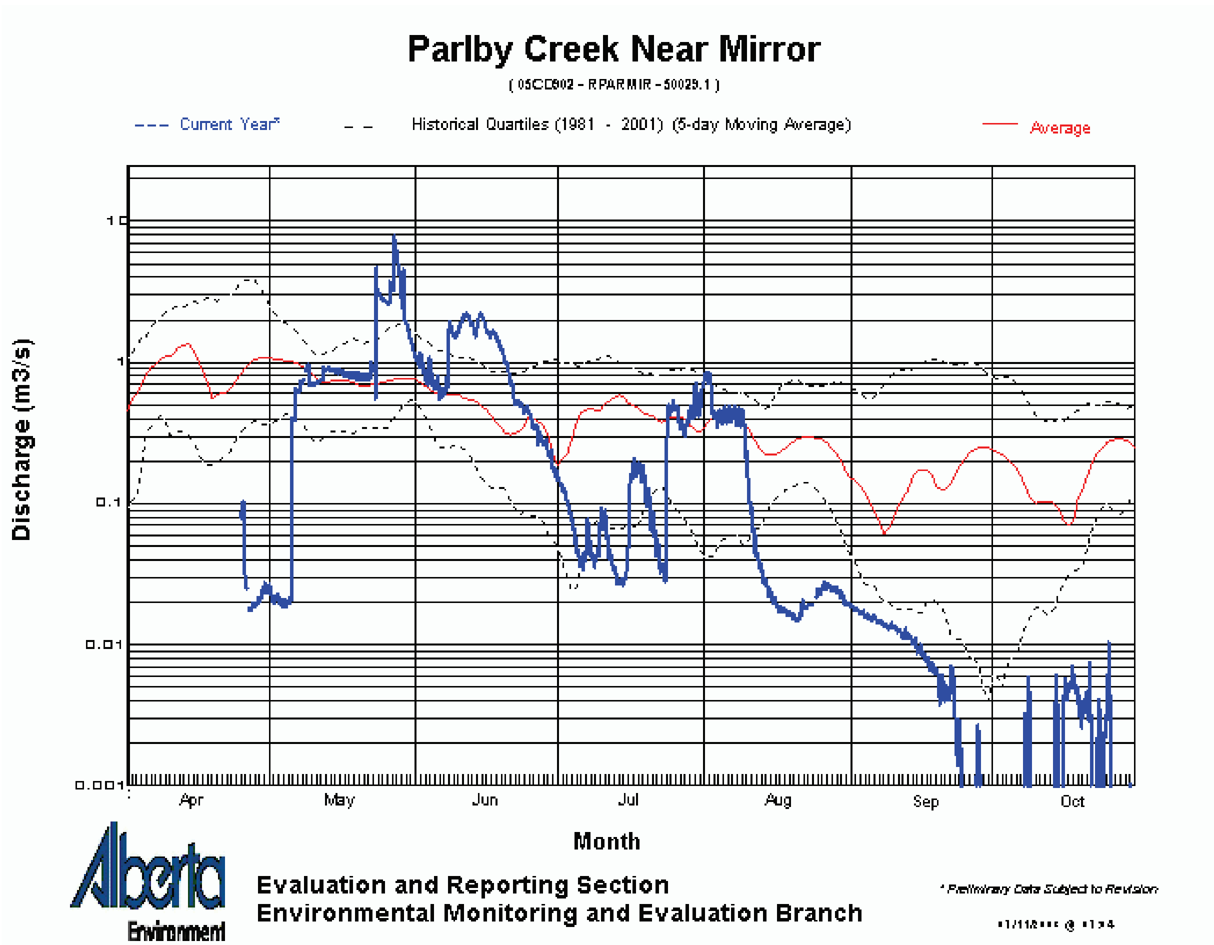


Figure 239. Discharge rates in Parlby Creek near Mirror (Government of Alberta, 2008c). "Current year" indicates water discharge rates in 2008.

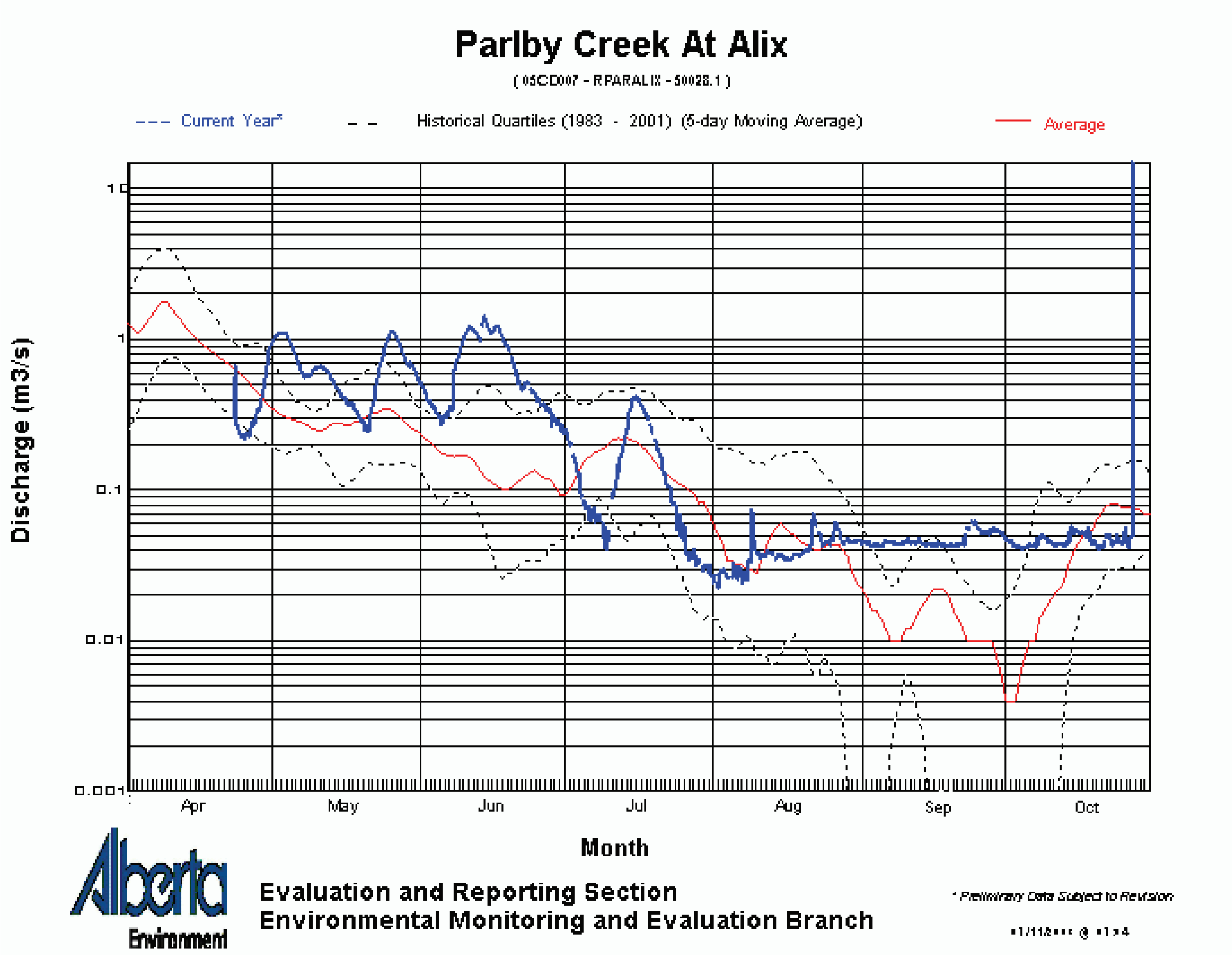


Figure 240. Discharge rates in Parlby Creek at Alix (Government of Alberta, 2008c). "Current year" indicates water discharge rates in 2008.

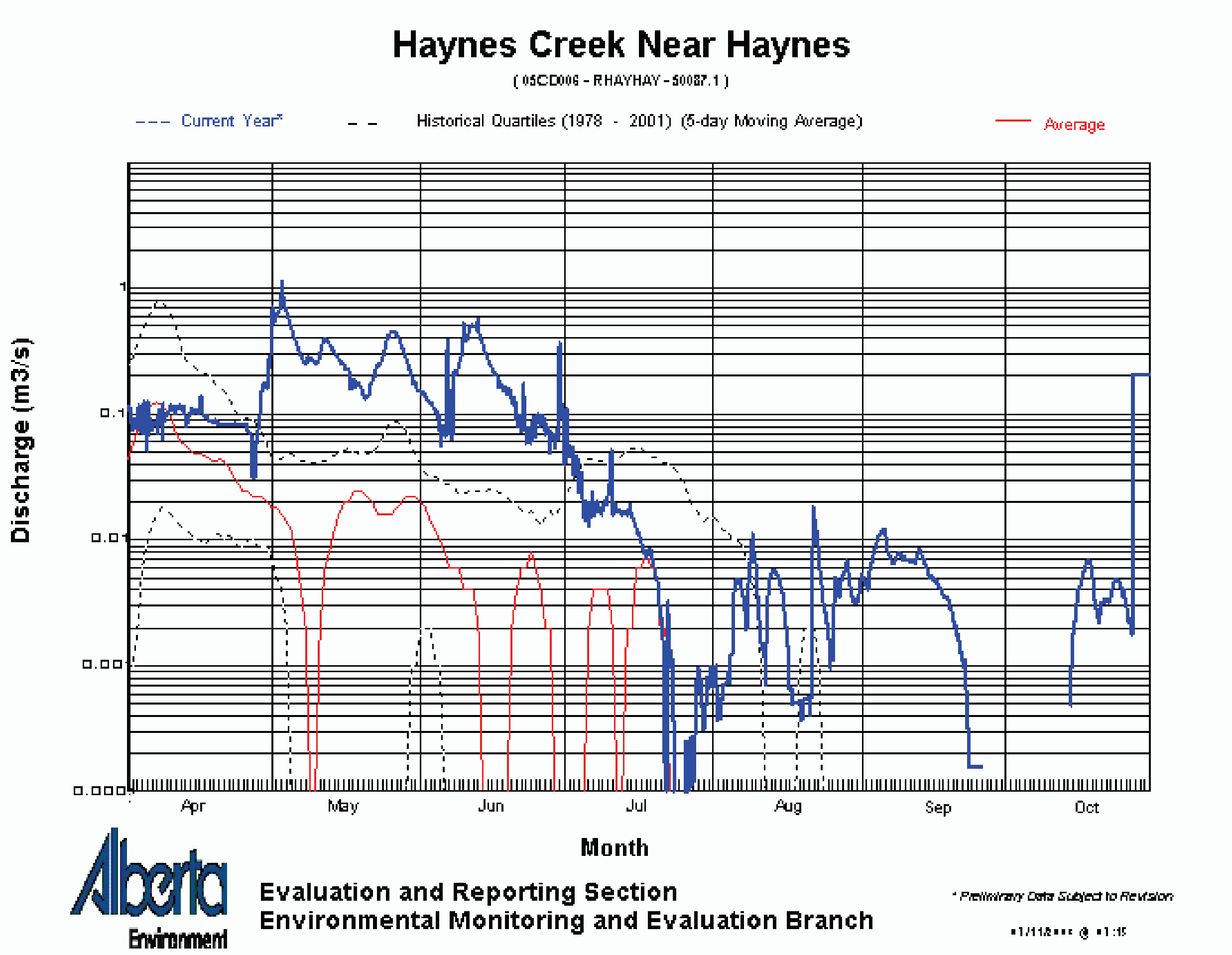


Figure 241. Discharge rates in Haynes Creek near Haynes (Government of Alberta, 2008c). "Current year" indicates water discharge rates in 2008.

Water discharge rates were above average levels at all three monitoring stations in the spring and early summer 2008. They exceeded 7 m^3/sec in Parlby Creek near Mirror and 1 m^3/sec near Alix. In Haynes Creek, they approached 1 m^3/sec on several occasions and remained well above average levels for the remainder of the year (Figures 239, 240, 241) (Government of Alberta, 2008c).

There are no major dams located in the Buffalo subwatershed, although there is a series of culverts and manholes located west of Buffalo Lake near Spotted Lake, Mirror and Alix that constitute part of the Parlby Creek-Buffalo Lake Water Management Project. This project was designed to provide agricultural flood control, fish and wildlife habitat enhancement, municipal water supplies and the stabilization of water levels in Buffalo Lake (Buffalo Lake Water Management Project, 2008). In addition, there are numerous smaller water infrastructures in the subwatershed, e.g., small dams, sluices, weirs and dykes, which control water flow.

4.8.4.2 Minimum Flows to Maintain Ecological Integrity

Minimum flows to maintain ecological integrity are the lowest flows or volumes (lakes) required to sustain native aquatic species and natural ecosystem functions. Minimum flows must be determined before allocation of water can safely take place to preserve the ecological functionality of aquatic ecosystems.

Minimum flow requirements for the maintenance of ecological integrity have not been determined in the Buffalo subwatershed.

4.8.4.3 Contributing Areas to the Watershed

Contributing areas to the watershed are areas from which runoff flows into the lakes, creeks and rivers of the watershed. These data are used to determine an estimated volume of water contributed to the river on an annual basis.

In the Buffalo subwatershed, 120,458 ha (or 46.9% of the total area of the subwatershed) of land do not contribute to the drainage of the subwatershed (Figure 242). These areas are located primarily in the southern and eastern areas of the subwatershed, e.g., south of Red Deer River and areas between tributaries of Buffalo Lake or the Red Deer River. In these areas, the topography is highly undulating and precipitation does not run off into nearby waterbodies (Figure 243) (AAFC-PFRA, 2008).

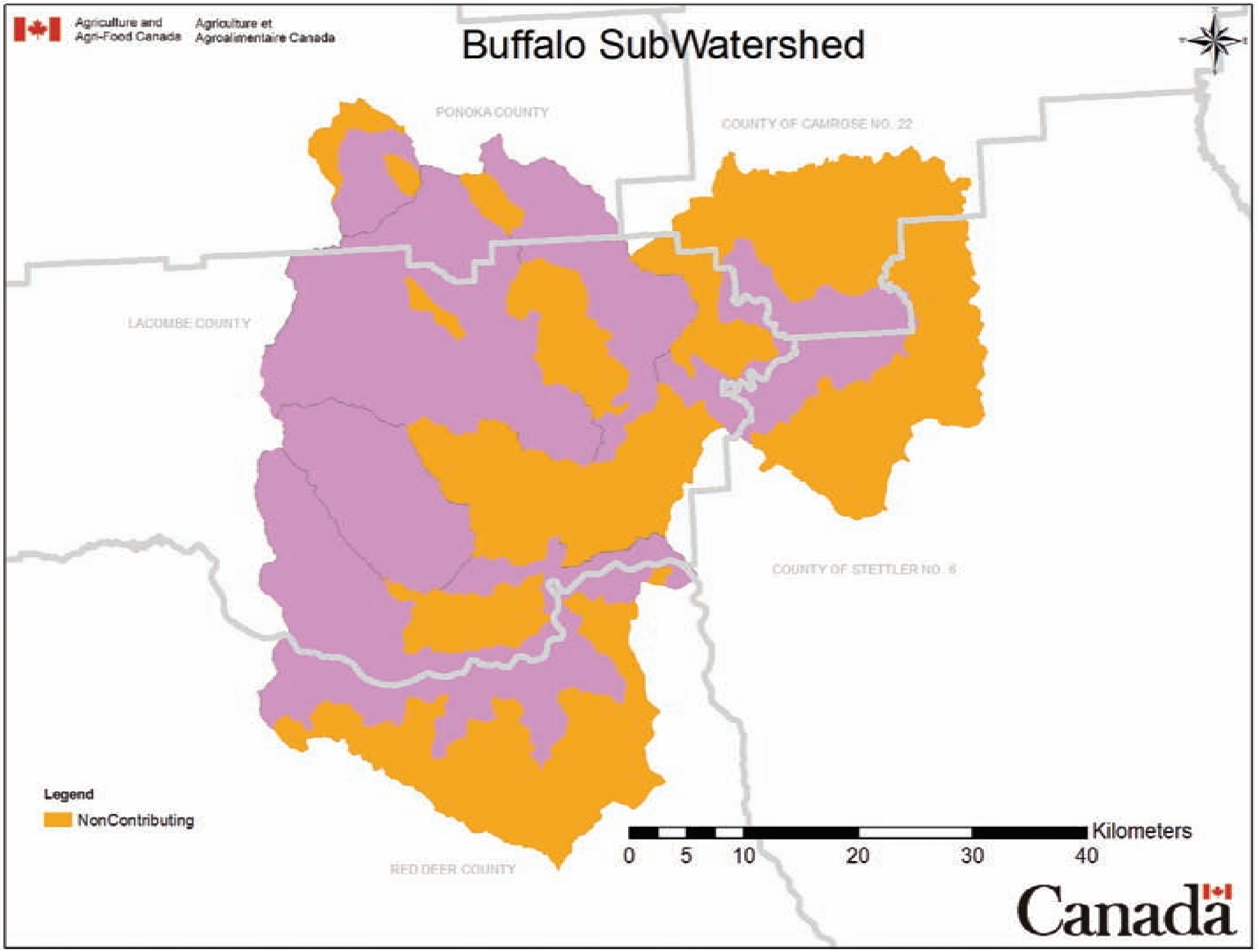


Figure 242. Non-contributing drainage area in the Buffalo subwatershed (AAFC-PFRA, 2008).

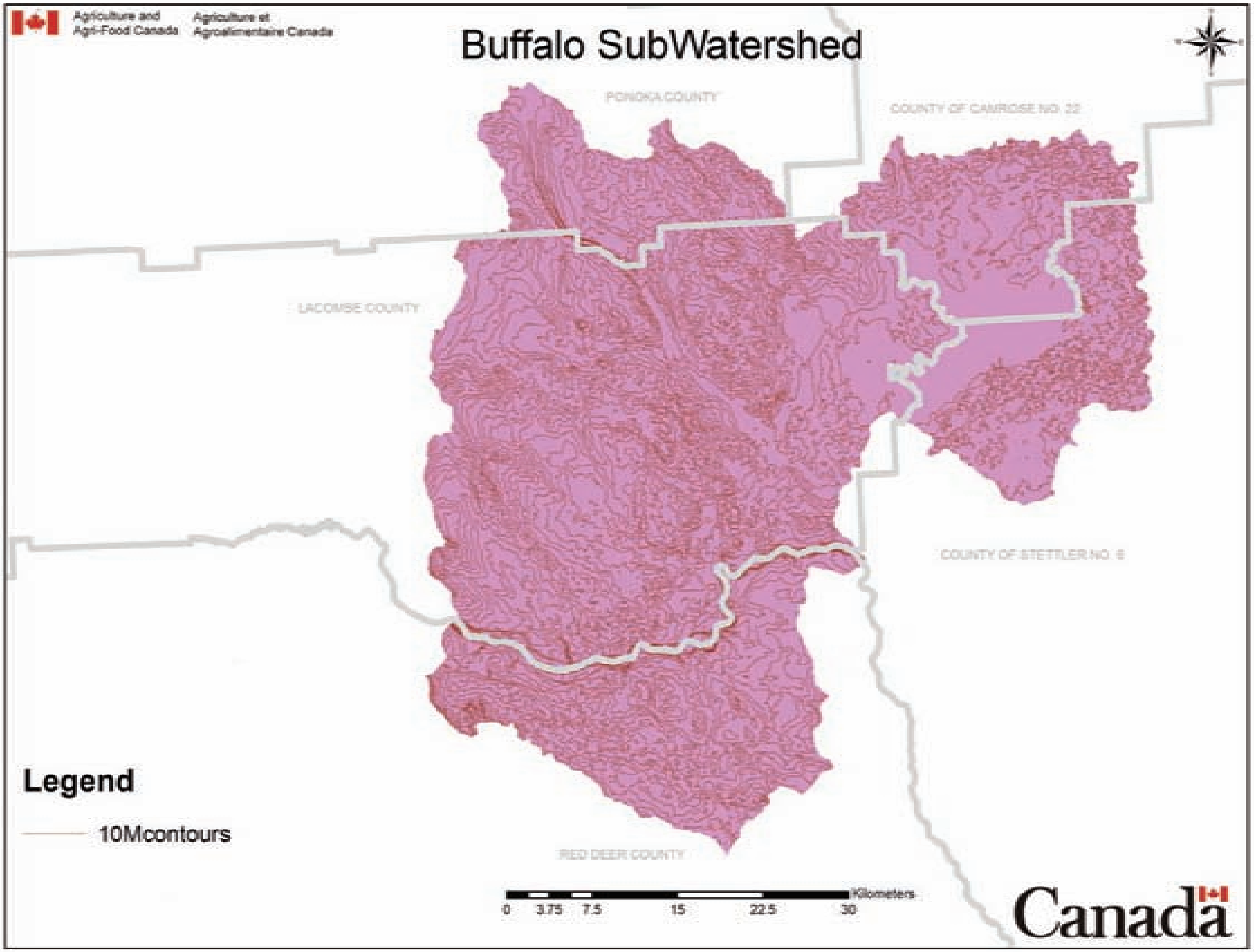


Figure 243. Topography (10-m contour intervals) of the Buffalo subwatershed (AAFC-PFRA, 2008).

4.8.4.4 Allocations

Surface and groundwater water withdrawal permits for the watershed are quantified by user sector along with information on licenses, consumption and return flows. This information will be used along with water flow data to identify areas of potential future constraints on surface water availability, which may have implications for future development.

In the Buffalo subwatershed, 2,342 surface water licenses and 1,306 groundwater licenses have been issued for water diversion projects (Figures 244, 245, respectively) (AAFC-PFRA, 2008). They are distributed throughout the entire subwatershed.

About 9.91 million m^3 of surface and groundwater are diverted annually in the Buffalo subwatershed (Government of Alberta, 2008d). The most prominent use of surface water are dewatering (63% of total surface water diversions) and industrial operations (16% of total surface water diversions), while the most prominent users of groundwater are agricultural (46% of total groundwater diversions) and commercial operations (37% of total groundwater diversions) (Table 98). The majority of water diverted in the entire subwatershed comes from surface water sources, e.g., lakes, streams and rivers (69%) (Government of Alberta, 2008d). Additional groundwater diversion information is provided in HCL (1998, 2001a, 2003a, 2005).

Table 98. Surface and groundwater diversions in the Buffalo subwatershed (Government of Alberta, 2008d). The highest uses for water have been highlighted. Data reported exclude any water diverted from the Red Deer River mainstem.

Purpose	Surface water (m^3/yr)	Groundwater (m^3/yr)
Agriculture	404,705	1,396,788
Commercial	99,432	1,104,446
Dewatering	4,341,850	---
Habitat enhancement	133,830	---
Industrial	1,110,000	480
Irrigation	418,760	---
Management of fish	17,270	53,817
Municipal	107,310	460,139
Other purposes specified by the Director	---	865
Recreation	253,090	6,655
Total	**6,886,247**	**3,023,190**
Grand total		**9,909,437**

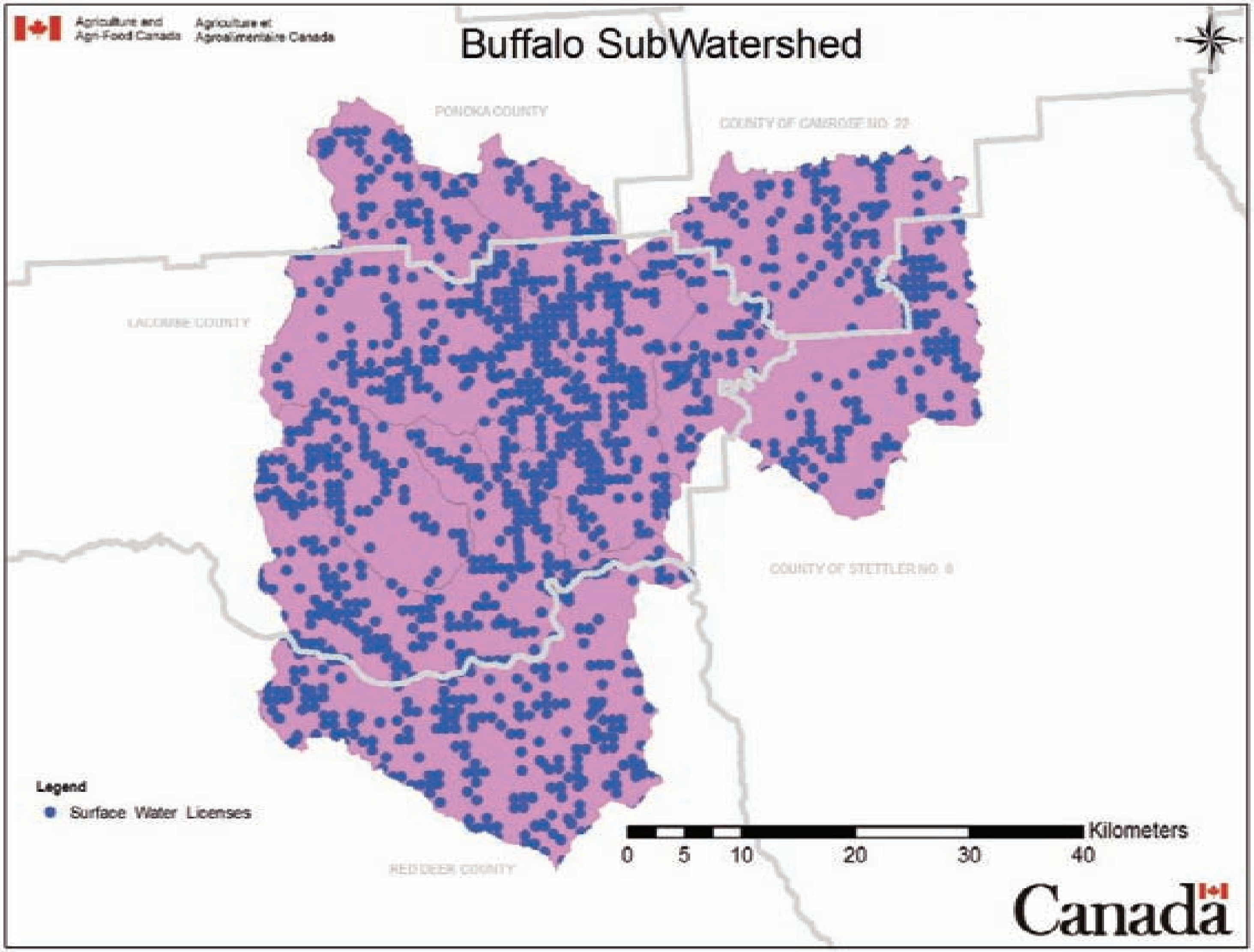


Figure 244. Surface water licenses in the Buffalo subwatershed (AAFC-PFRA, 2008).

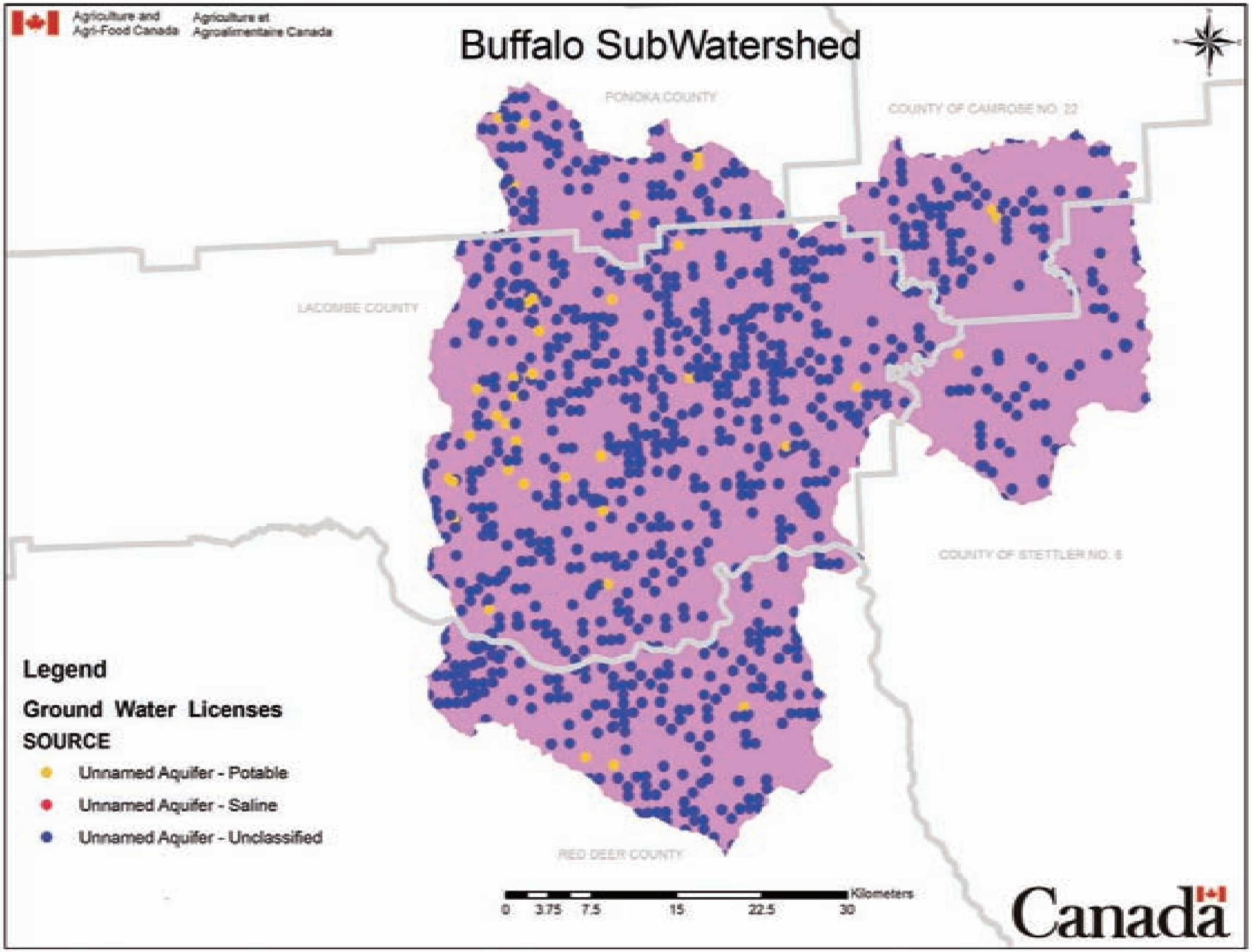


Figure 245. Groundwater licenses in the Buffalo subwatershed (AAFC-PFRA, 2008).

4.8.4.5 Groundwater Recharge/Discharge

Areas where groundwater gets recharged or discharges to the surface indicate areas where the groundwater table is close to the surface and the soils are generally more permeable. These areas are at greater risk of becoming negatively impacted from development or agricultural and/or industrial activities. Knowing where groundwater recharges and discharges occur will help to identify areas requiring special protection and limitations to land use.

Freshwater springs are points in the landscape where the aquifer surface meets the ground surface, i.e., freshwater springs are areas of groundwater discharge. The Buffalo subwatershed has about 25 freshwater springs, of which most are located in the northwestern area of the subwatershed near Clive, Chigwell and Morningside.

The Buffalo subwatershed lies in Camrose, Lacombe, Ponoka, Red Deer and Stettler No. 6 Counties. Groundwater assessments have been conducted for most counties, expect Camrose, by HCL (1998, 2001a, 2003a, 2005). The assessments indicated that most of the subwatershed is a groundwater recharge area (i.e., water moves from the surface into groundwater reservoirs), with only isolated pockets of groundwater discharge areas (i.e., water moves from groundwater reservoirs to the surface), particularly in the subwatershed areas that lie within Red Deer and Ponoka Counties. Specific areas of groundwater recharge include small depressions in the landscape and temporary and ephemeral wetlands, which collect rainwater and snow melt and release a proportion of this accumulated water into shallow groundwater and regional aquifers (van der Kamp and Hayashi, 1998; Hayashi et al., 2003). Additional information on aquifers, water quantity and quality of the groundwater associated with each aquifer, hydraulic relationship among aquifers and possible groundwater depletion areas associated with each upper bedrock aquifer is provided in HCL (1998, 2001a, 2003a, 2005).

4.8.5 Biological Indicators

Bioindicators are biological (plant and animal) data from which various aspects of ecosystem health can be determined or inferred. The presence, absence and abundance of such data can be linked to water quality, quantity and ultimately to overall watershed health. Four metrics were used as biological indicators in the Red Deer River watershed and its 15 subwatersheds:

- Wildlife Biodiversity
- Fish
- Land Cover – Condition Indicator
- Species at Risk

Changes in biological populations often reflect socioeconomic growth in a region. Human settlement and the subsequent exploration and extraction of natural resources alters the landscape and with it the habitat of the indigenous flora and fauna. It is important to balance socioeconomic growth with the preservation of natural habitat integrity to ensure the long-term health of natural biological populations.

4.8.5.1 Wildlife Biodiversity

Wildlife inventories to determine the biodiversity within the watershed will indicate changes in environmental conditions (e.g., habitat fragmentation, loss of nesting and breeding sites, nutrient enrichment, etc.). A loss of biodiversity can cause an ecosystem to become less stable and more vulnerable to environmental change. A change in diversity may also affect nutrient cycling and/or energy flow through the ecosystem.

Wildlife biodiversity assessment data have not been located for the Buffalo subwatershed.

4.8.5.2 Fish

Inventories of selected fish populations may show increases or declines through introductions or changes in environmental conditions. Indicator species sensitive to environmental pollution may show areas of concern through their absence, while others may show similar with their presence. Invasive species, if present, will indicate areas of concern requiring future monitoring.

Buffalo Lake fish records show the presence of only one species, which is northern pike (Figure 246). There were no significant changes in the pike populations during this time period ($p > 0.9$). Pike are found in sluggish streams and shallow, weedy places in lakes, as well as in cold, clear, rocky waters. Pike are typical ambush predators, feeding mainly on fish, but on occasion also feed on frogs, insect, leeches, water voles and ducklings (Nelson and Paetz, 1992; Scott and Crossman, 1998).

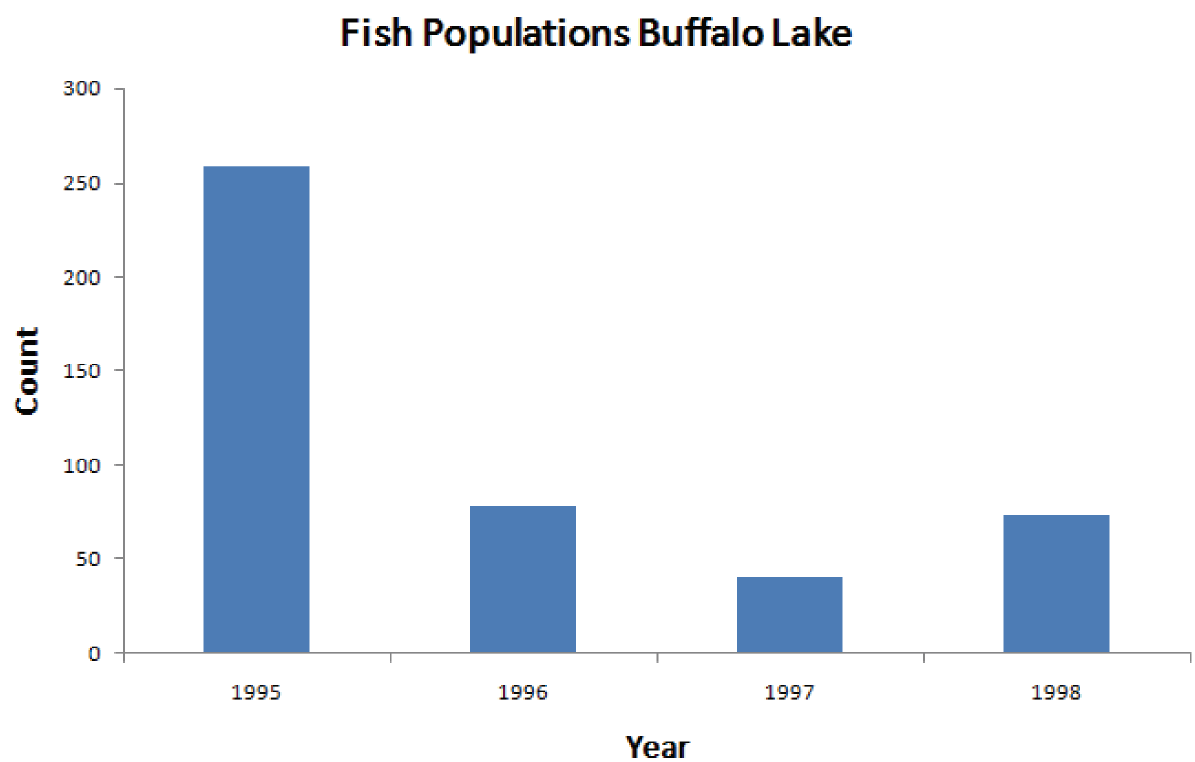


Figure 246. Northern pike populations in Buffalo Lake from 1995-1998 (data from Alberta Sustainable Resource Development, 2008).

4.8.5.3 Land Cover

Land cover is the type of vegetation, or lack thereof, covering the landscape. Inventory of vegetation populations may show increases or declines through introductions or changes in environmental conditions. Indicator species that are sensitive to environmental pollution may show areas of concern with their absence, while others may show areas of concern with their presence. Changes in land cover can indicate a change in land use and identify areas that need restoration, are at risk of erosion and/or areas with rare plant species that need protection. Land cover is a separate measurement from land use even though these two terms are sometimes used interchangeably.

The majority of the land base of the Buffalo subwatershed is covered by annual and perennial croplands/pastures (37% and 39%, respectively). The remaining land cover types cover < 7% individually (Figure 247, Table 99) (AAFC-PFRA, 2008).

Table 99. Land cover in the Buffalo subwatershed (AAFC-PFRA, 2008). The most prominent land cover types are highlighted.

Land cover type	**Area (ha)**	**Proportion of subwatershed area (%)**
Waterbodies	15,615	6.09
Exposed land	262	0.10
Developed land	2,486	0.97
Shrubland	12,659	4.94
Wetland	6,120	2.39
Grassland	5,622	2.19
Annual cropland	93,806	36.60
Perennial cropland/pastures	98,827	38.56
Coniferous forests	3,792	1.48
Deciduous forests	15,222	5.94
Mixed forest	1,899	0.74
Total	**256,311**	

There are four designated Ecologically Significant Areas in the Buffalo subwatershed: Buffalo Lake, Delburne wetlands, Peter's Pond and Wood Lake (Table 100). There are no nationally designated Ecologically Significant Areas in the subwatershed (Alberta Environmental Protection, 1997).

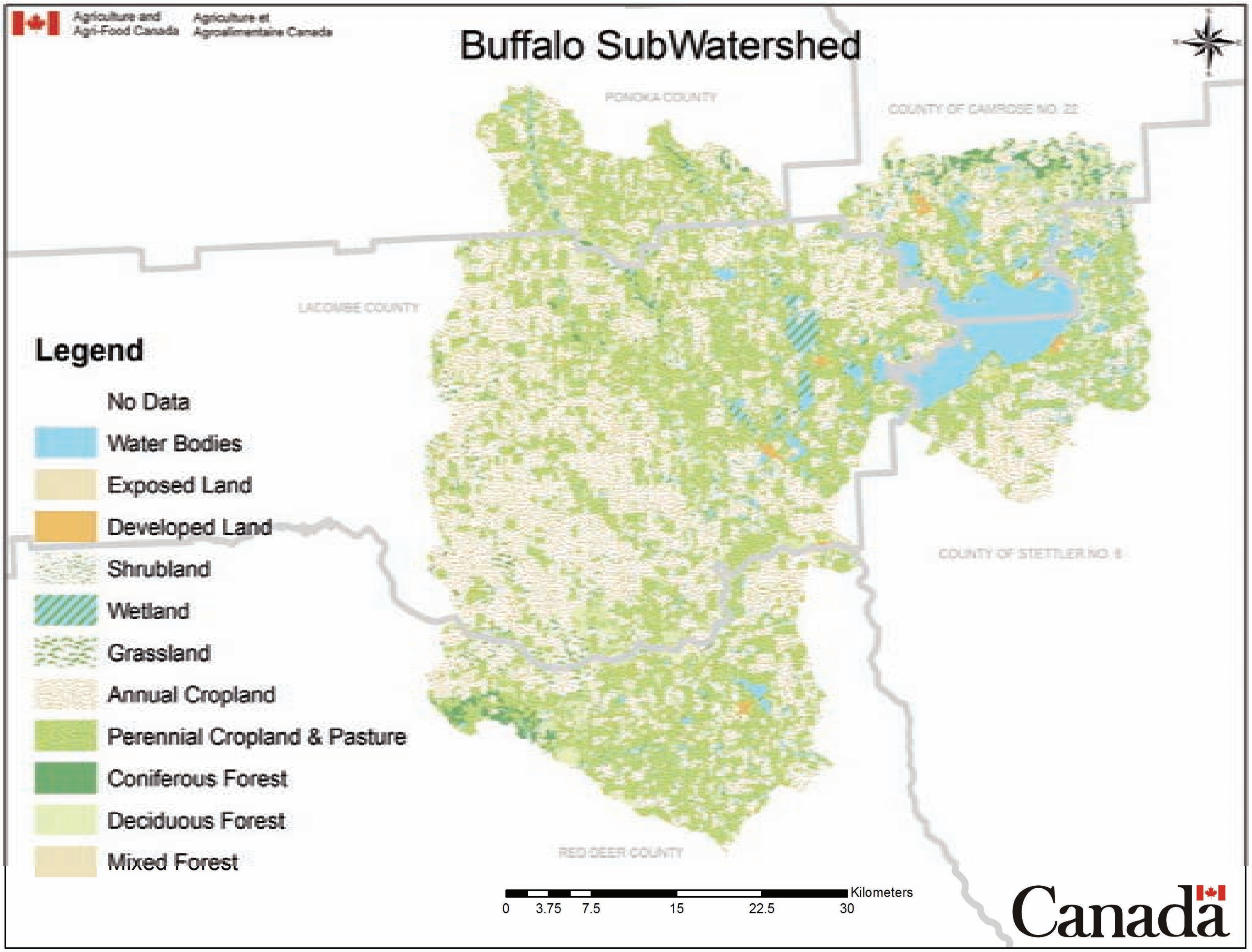


Figure 247. Land cover of the Buffalo subwatershed (AAFC-PFRA, 2008).

Table 100. Ecologically Significant Areas in the Buffalo subwatershed (Alberta Environmental Protection, 1997).

Ecologically Significant Area	Location	Area (ha)	Significance	Description
Buffalo Lake and some adjacent wetlands and uplands	Twp. 39-41, Rge. 20-22, W 4, Counties of Stettler, Lacombe and Camrose	17,440	Internationally	Large lake with islands and extensive marshes; significant piping plover (a COSEWIC endangered species in Canada and red-listed species in Alberta) nesting habitat (Rockland Bay); nationally significant production, staging and moulting lake for waterfowl and shorebirds; great blue heron colony observed on lake; significant mule deer and white-tailed deer habitat in immediate upland; important fishery (rearing, spawning and overwintering lake for northern pike, burbot and sauger); provincially significant ring-billed gull breeding habitat; local and uncommon Alberta birds, including Forster's tern, Virginia rail and yellow rail; low milkweed, a provincially uncommon plant, at Rochon Sands
Delburne wetlands	Twp. 37, Rge. 22-24, W 4, County of Red Deer	922	Provincially	Alkali lakes and ponds with some cattail marsh; some aspen and extensive willow in backshore vegetation, productive for a variety of waterfowl, including diving ducks and Canada geese; also used by migrating shorebirds
Peter's Pond and adjacent aspen parkland southwest of Delburne	Twp. 36-37, Rge. 22, W 4, County of Red Deer	341	Provincially	Extensive sedge, cattail and bulrush marsh; provincially significant duck and other marsh bird and waterfowl breeding habitat; key white-tailed deer habitat
Wood Lake and adjacent parkland east of Delburne	Twp. 37, Rge. 22, W 4, County of Red Deer	280	Provincially	Shallow lake and remnant aspen parkland, some areas of fescue grassland; provincially significant eared grebe and duck breeding habitat; key white-tailed deer habitat; some waterfowl production

4.8.5.4 Species at Risk

Identifying species at risk and their habitats will help to determine sensitive areas and level of protection required. The *Species at Risk Act* (*SARA*) was introduced in June 2003 to provide legal protection of wildlife species and conservation of biological diversity. The Act aims to prevent Canadian indigenous species, subspecies and distinct populations from becoming extirpated or extinct, to provide for the recovery of endangered or threatened species and encourage the management of other species to prevent them from becoming at risk. Currently, there are 363 species listed as either endangered (169 species), threatened (110 species) or of special concern (84 species) (Species at Risk, 2008).

"Endangered species" are those species that face imminent extirpation or extinction, while "threatened species" are those that are likely to become an endangered species if nothing is done to reverse the factors leading to its extirpation or extinction. "Species of special concern" are those species that warrant special attention to ensure their conservation.

The Buffalo subwatershed is home to one endangered species (piping plover, *C. melodus circumcinctus*), three threatened species (loggerhead shrike, *L. ludovicianus excubitorides*; peregrine falcon, *F. peregrinus anatum*; Sprague's pipit, *A. spragueii*) and two species of special concern (monarch butterfly, *D. plexippus*; yellow rail, *C. noveboracensis*). Detailed treaties of these species can be found in section 3.1.3.7.

4.8.6 Subwatershed Assessment

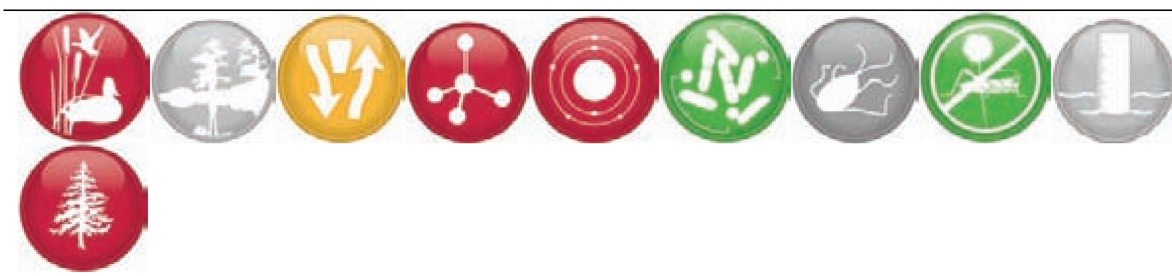
The Buffalo subwatershed lies entirely in the Central Parkland Subregion and is characterized by a low livestock and medium agricultural intensity relative to the Alberta average. There are more than 30 feedlots in the subwatershed, located primarily in the vicinity of urban centres, including the town of Bashaw, several villages, summer villages and hamlets. Resource exploration and extraction activities have contributed to a complex network of linear developments (mostly roads) and the establishment of 4,593 active wells (mostly for unspecified purposes) throughout the subwatershed. These land use practices have contributed to deteriorating water quality, particularly in Buffalo Lake, the dominant waterbody in the subwatershed, and several streams and creeks that feed into Buffalo Lake or the Red Deer River. Most frequently, TP and TN exceed CCME PAL water quality guidelines. In addition, fecal coliform bacterial concentrations have exceeded CCME Agriculture/Irrigation guidelines on occasion. No parasite data and limited pesticide data were located for waterbodies in the Buffalo subwatershed. Six different pesticides have been detected; however, none exceeded water quality guidelines. Water discharge rates of streams and creeks in the subwatershed range from 1-10 m^3/sec following the spring freshet or heavy precipitation events. Water resources are used primarily for dewatering and agricultural purposes. In total, 3,648 water licenses have been issued, which permit the diversion of 9.91 million m^3 of water annually. No biodiversity assessment data were located for the subwatershed. The dominant fish species in Buffalo Lake is northern pike, which centres on a vibrant sport fishery. The annual and perennial cropland and pasture-dominated subwatershed is home to one endangered species, three threatened species and two species of special concern.

An Indicator Workshop held in March 2008 identified a total of 20 indicators to be used to assess the overall health of the Red Deer River watershed and its 15 subwatersheds. These indicators included land use, water quality, water quantity and biological indicators. In November 2008, a subset of these indicators was selected to indicate the overall condition of, or risk to, the individual subwatersheds. There were nine “condition indicators” and three “risk indicators”. The condition indicators were ranked “good”, “fair” or “poor” based on existing guidelines, while risk indicators were ranked “low”, “medium” or “high” relative to the other subwatersheds. The overall subwatershed ranking is based on an “A”-“B”-“C” ranking system with “+” and “-” subrankings. The overall ranking system is based on a subjective evaluation of the combined rankings of the condition and risk indicators.

Based on the available data, the Buffalo subwatershed receives a rating of “poor” for the condition indicators and a rating of “medium” for the risk indicators (Tables 101, 102). Overall, this subwatershed receives a ranking of “C+”. There are substantial data gaps, and several of the condition rankings are based on limited data. Consequently, it is recommended to implement a detailed water quality sampling program, conduct a wetland inventory and regularly monitor riparian health conditions along the major waterbodies in the subwatershed. Of particular concern are (1) elevated nutrient concentrations that occasionally exceed water quality guidelines, likely due to widespread impaired riparian area health conditions and excessive agricultural runoff, municipal effluent and urban runoff that reach waterbodies throughout the subwatershed, (2) the loss of wetlands, which likely occurred as a result of agricultural land conversions, drainage, infilling and the disruption of their hydrology following linear developments, (3) conversion of the landbase from its natural state into annual and perennial croplands and pastures and (4) the high oil/gas well density, which represents a substantial risk to aquatic resources and habitats.

Table 101. Condition and risk indicator summary for the Buffalo subwatershed. Gray logos indicate data gaps.

Condition Indicators



Risk Indicators

Table 102. Condition and risk assessments of the Buffalo subwatershed. Indicators with a "poor" or "high" ranking are highlighted.

Indicators		Rating
Condition	Wetland loss	Poor
	Riparian health	---
	Linear developments	FAIR
	Nutrients	
	Total phosphorus	POOR
	Total nitrogen	POOR
	Bacteria	GOOD
	Parasites	---
	Pesticides	GOOD
	Minimum flows to maintain ecological integrity	---
	Land cover	POOR
Overall		**POOR**
Risk	Livestock manure production	LOW
	Urban, rural, agricultural and recreational developments	MEDIUM
	Oil/gas wells	HIGH
Overall		**MEDIUM**

