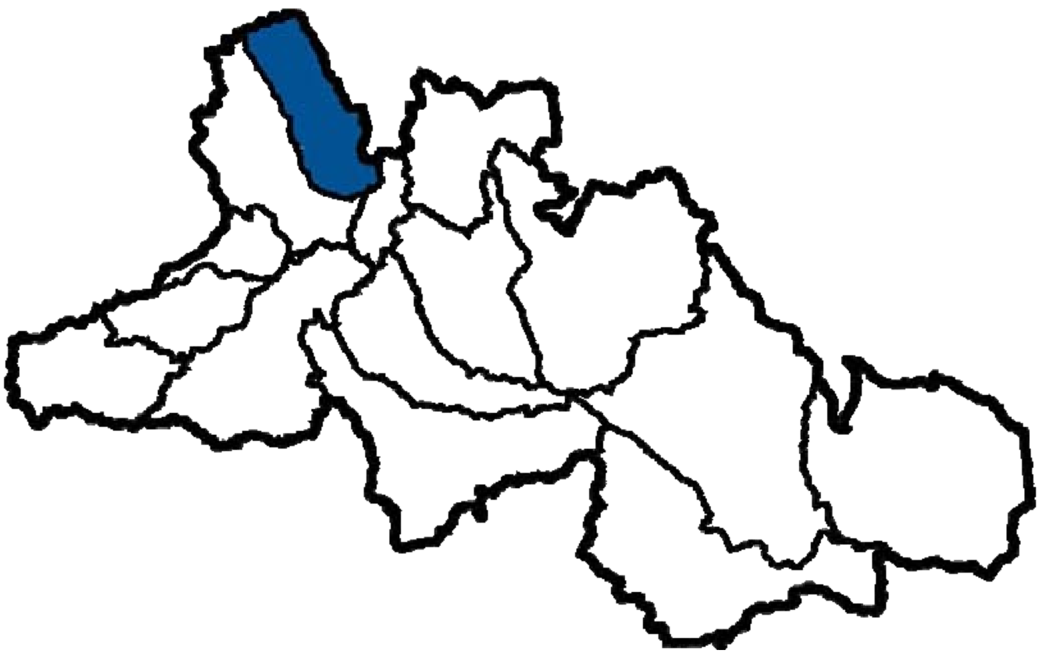
# Blindman Subwatershed



Red Deer River Watershed Alliance

State of the Watershed

## 4.6 Blindman River Subwatershed

### *4.6.1 Watershed Characteristics*

The Blindman River subwatershed encompasses about 229,837 ha and is located in the counties of Lacombe, Ponoka, Red Deer and Wetaskiwin No. 10 (Figure 160).

The Blindman River subwatershed is located in the northwest of the Red Deer River watershed. The subwatershed lies in the Lower Foothills, Central Mixedwood, Dry Mixedwood and Central Parkland Subregions (Figure 161). The Lower Foothills Subregion lies at an elevations of about 1,250-1,450 m and is dominated by mixed forests of white spruce (*P. glauca*), black spruce (*P. mariana*), lodgepole pine (*P. contorta*), balsam fir (*A. balsamea*), aspen (*Populus* spp.), balsam poplar (*P. balsamifera*) and paper birch (*B. papyrifera*). The vegetation of the Central Mixedwood Subregion is similar to that of the Dry Mixedwood Subregion. The differences are largely in the proportion of various vegetation types and other landscape features. Aspen (*Populus* spp.) is the characteristic forest species occurring in both pure and mixed stands, while balsam poplar (*P. balsamifera*) frequently occurs with aspen, especially on moister sites in depressions and along streams. Jack pine (*P. banksiana*) forests with a prominent ground cover of lichens typically occupy dry, sandy upland sites. Peatlands are a common feature in this Subregion. Forests in the Dry Mixedwood Subregion are dominated by aspen (*Populus* spp.), balsam poplar (*P. balsamifera*), white spruce (*P. glauca*) and, in some areas, balsam fir (*A. balsamea*). Pure deciduous stands are common in the southern part of the Subregion, and dry, sandy sites are usually occupied by jack pine (*P. banksiana*). Peatlands are common and may be extensive. The Central Parkland Subregion is dominated by grassland with groves of aspen (*Populus* spp.), with the grassland vegetation being dominated by rough fescue (*F. campestris*) (Heritage Community Foundation, 2008).

The geology of the Blindman River subwatershed is dominated by the Paskapoo Formation in addition to less prominent geologic features of the Scollard and Horseshoe Canyon Formations in the eastern regions of the subwatershed. These formations formed in the Paleocene epoch (56-65 million years ago) and in the Upper Cretaceous period (65-100 million years ago). The youngest of the formations from the Paleocene, Paskapoo, consists of diverse sandstones and siltstones/mudstones and minor shale deposits. The Scollard Formation (Paleocene and Upper Cretaceous) consists of sandstone, mudstone and thick coal deposits. The Horseshoe Canyon Formation (Upper Cretaceous) consists of sandstones, mudstones, shales, ironstone, bentonite and minor limestone deposits (Alberta Geological Survey, 2006).

The climate of the Blindman River subwatershed is subhumid and continental. Mean May-September temperatures range from 11-13 °C, and the total annual precipitation ranges from 350-465 mm. Upwards of 2/3 of the total annual precipitation falls between May and September, with June and July being the wettest months (Environment Canada, 2006).

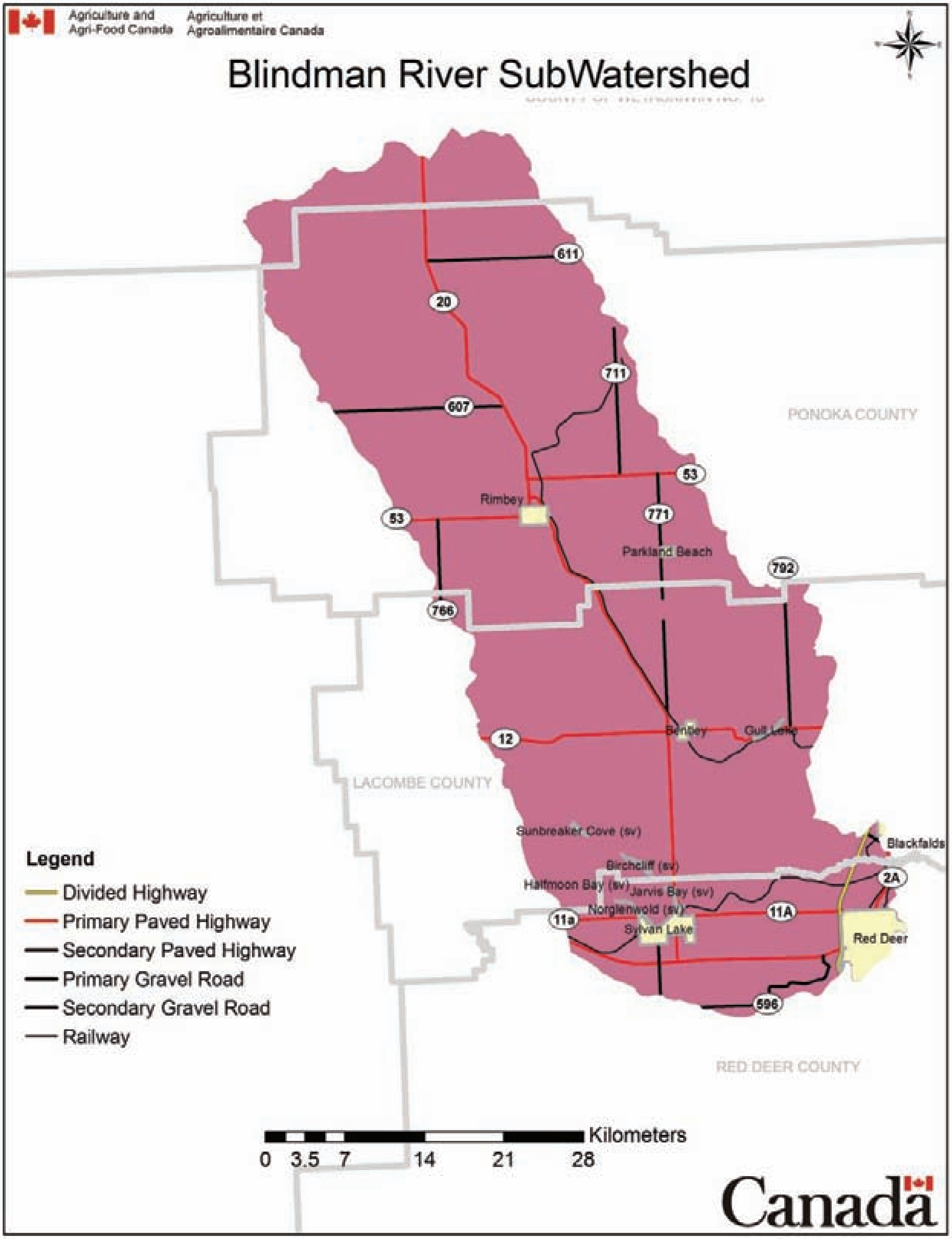



**Figure 160.** Location of the Blindman River subwatershed (AAFC-PFRA, 2008).

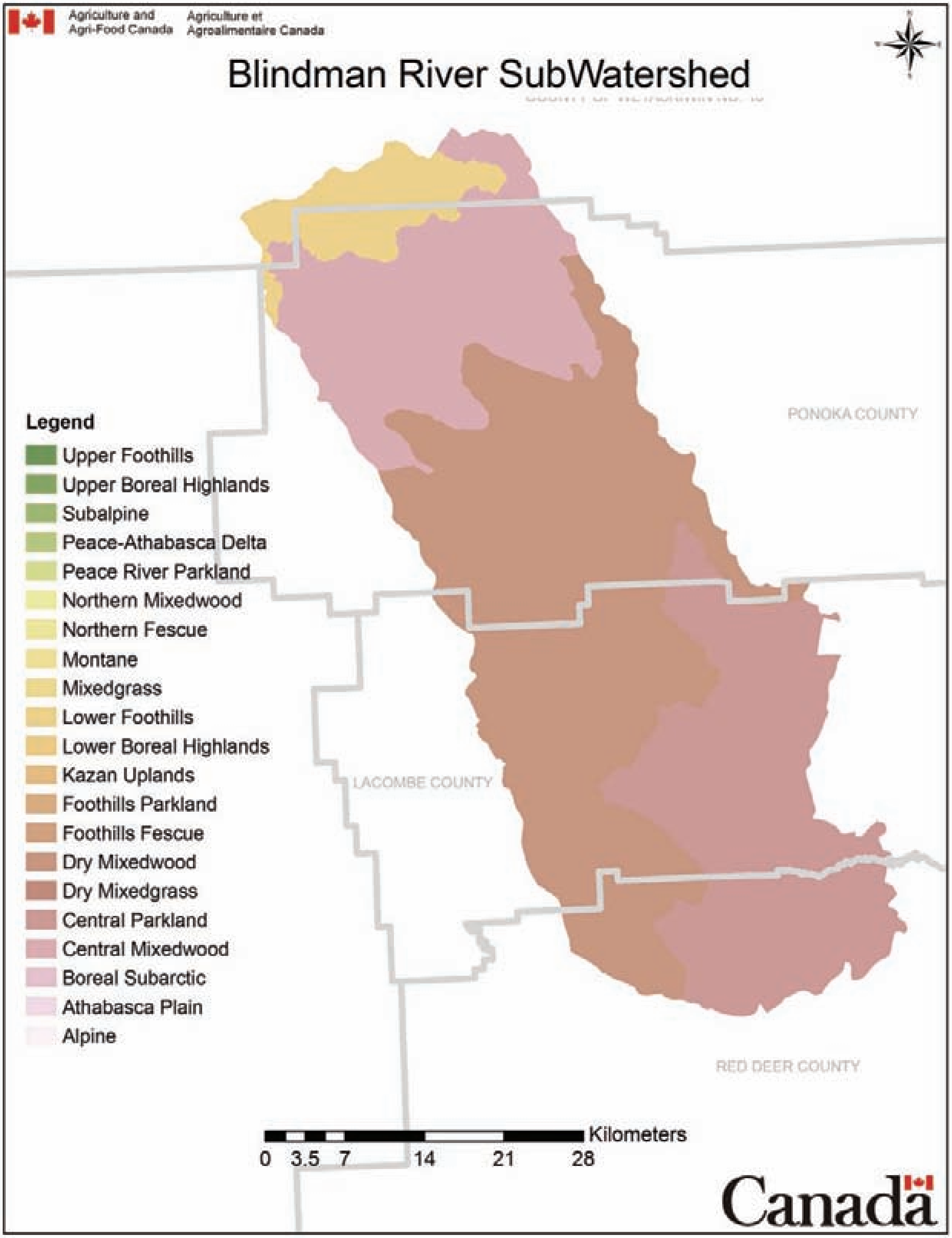



**Figure 161.** Natural subregions of the Blindman River subwatershed (AAFC-PFRA, 2008).

### *4.6.2 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.

#### 4.6.2.1 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 5,744 ha of wetlands (2.50% of the total subwatershed area) in the Blindman River subwatershed (AAFC-PFRA, 2008); however, there are no data on the classes, forms and types of wetlands (*sensu* National Wetlands Working Group, 1997) within the subwatershed. Given the presence of lentic (lakes) and lotic (streams and rivers) systems in the subwatershed, marshes and shallow open water wetlands are likely present. Peatlands (bogs and fens) may be present (Heritage Community Foundation, 2008). In addition, ephemeral, temporary, seasonal and semi-permanent wetlands (*sensu* Stewart and Kantrud, 1971) are likely present in the subwatershed as well.

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 and Boreal Natural Regions (in the Central Parkland and Dry Mixedwood Subregions, respectively) from 1985-2001 (Watmough and Schmoll, 2007). These two Natural Regions predominate in the Blindman River subwatershed. In Alberta, the Central Parkland Subregion 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. Comparatively, there have been losses of 3% in total wetland area and 1% in total number of wetlands in the Dry Mixedwood Subregions. 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 entire subwatershed, since the Prairie Habitat Joint Venture program did not assess wetland losses along any transects in this subwatershed (Watmough and Schmoll, 2007).

#### 4.6.2.2 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.

Videography riparian assessments have been conducted for Sylvan Lake and Gull Lake by Alberta Sustainable Resource Development in August 2007 (Alberta Sustainable Resource Development, 2008c, d). For Sylvan Lake, the assessment showed that 51% of the riparian areas were healthy, while 7% were moderately impaired and 42% were highly impaired. The most common causes of impairment were encroachments by residential developments, including vegetation removal and the establishment of private beaches, boat lifts and marinas, as well as ATV trails and livestock grazing. The southern shoreline near the Town of Sylvan Lake and the shorelines near the Summer Villages of Birchcliff, Half Moon Bay, Jarvis Bay and Sunbreaker Cove were highly impaired in particular. The majority of the remainder of the riparian areas of Sylvan Lake was generally in healthy condition and characterized by dense stands of emergent vegetation (primarily *Carex* spp., *Scirpus* spp., *Typha latifolia* and grasses) and shrubs and trees along the shoreline (Alberta Sustainable Resource Development, 2008c).

The riparian areas of Gull Lake were in poorer condition than those of Sylvan Lake. For Gull Lake, 36% of the riparian zones were considered healthy, while 35% were moderately impaired and 29% were highly impaired. Similar to Sylvan Lake, the most common causes of impairment were encroachments by residential developments, ATV trails and livestock grazing. Of particular concern were the shorelines near the Summer Villages of Gull Lake and Parkland Beach as well as isolated stretches along the eastern shoreline. In contrast, healthy riparian zones were characterized by stands of emergent vegetation (primarily *Typha latifolia* L., *Scirpus* spp. and grasses) and undeveloped and undisturbed rocky or densely treed shorelines (Alberta Sustainable Resource Development, 2008d).

#### 4.6.2.3 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 40 feedlots/intensive livestock operations in the Blindman River subwatershed. Most of them are located east and south of Gull Lake and in the west-central area of the subwatershed. These feedlots predominantly finish cattle/cows, swine and chickens (Figure 162) (AAFC-PFRA, 2008).

Cattle density ranges from 0-0.20 cattle/ha in the northwestern area of the subwatershed to 0.61-0.80 cattle/ha throughout most of the remainder of the subwatershed. Cattle density is intermediate along the north-eastern and eastern areas of the subwatershed (Figure 163) (AAFC-PFRA, 2008). Generally, cattle and all other livestock operations produce 2.6-5.0 tonnes manure/ha in the northwestern area of the subwatershed and north of the Blindman River and 5.1-7.5 tonnes manure/ha south of the Blindman River and towards the City of Red Deer (Figure 164) (AAFC-PFRA, 2008). These manure production quantities are considered medium relative to the remainder of the Red Deer River watershed.

Agricultural intensity, expressed as the percent land cover used as croplands, ranges from 0-40% in the northern and northeastern areas of the Blindman River subwatershed and increases to 40-60% throughout most of the remainder of the subwatershed. Agricultural intensity is greatest near the City of Red Deer (60-80%) (Figure 165) (AAFC-PFRA, 2008).

The Medicine Lake Provincial Grazing Reserve is located about 12 km southwest of Winfield. It covers an area of 6,775 ha and can accommodate about 2,500 head of mature livestock. It has been in operation since 1967 and is open for livestock grazing from May-November. The reserve is a preferred area to hunt white-tailed and mule deer, elk and upland game birds, such as sharptail and ruffed grouse. Trail riding, snowmobile rallies and cross-country skiing are also popular activities. The reserve has an active oil field with numerous existing wells sites located on the west and east sides of the reserve (Alberta Sustainable Resource Development, 2008b).

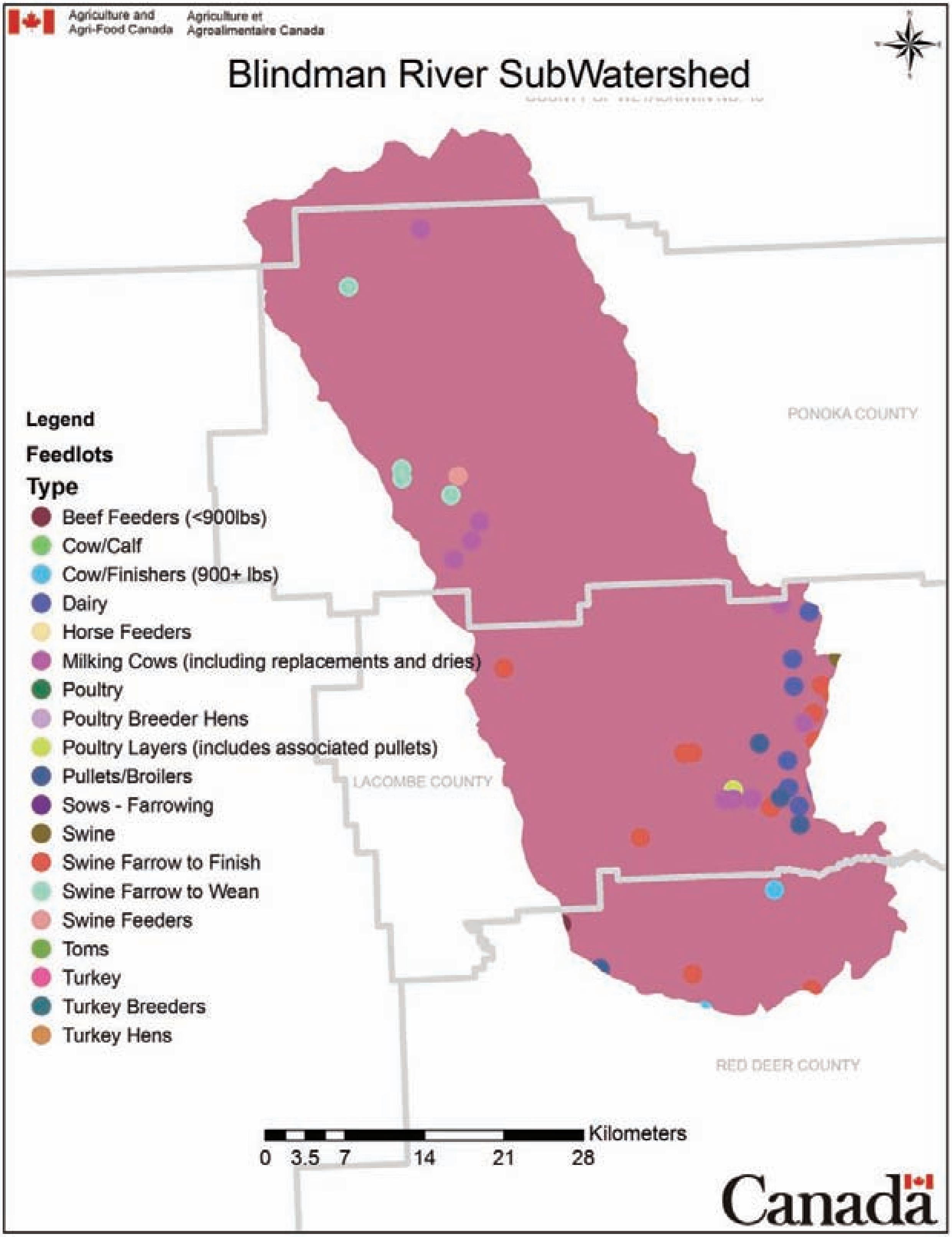



**Figure 162.** Feedlots and intensive livestock operations in the Blindman River subwatershed (AAFC-PFRA, 2008).

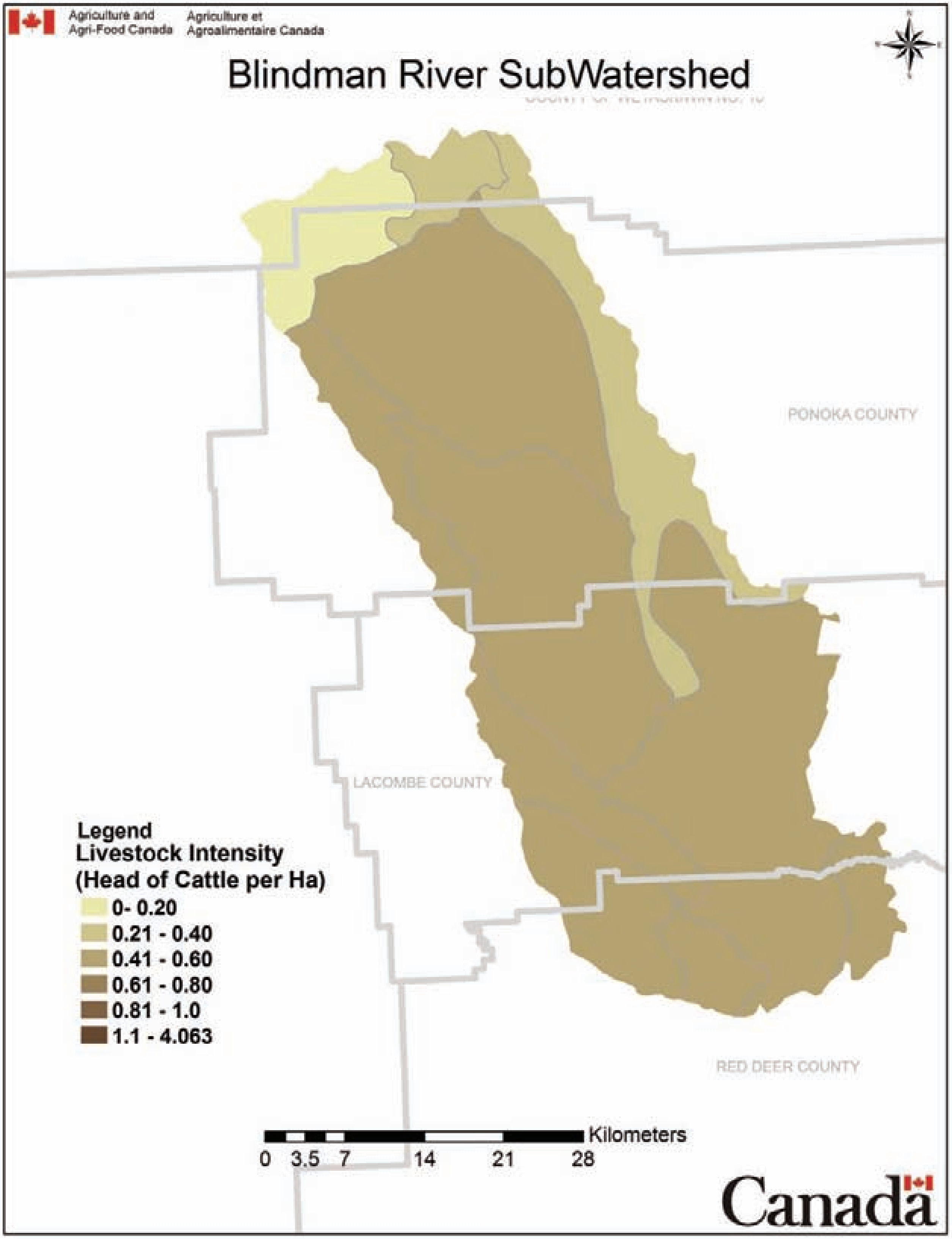



**Figure 163.** Cattle density (cattle/ha) in the Blindman River subwatershed (AAFC-PFRA, 2008).

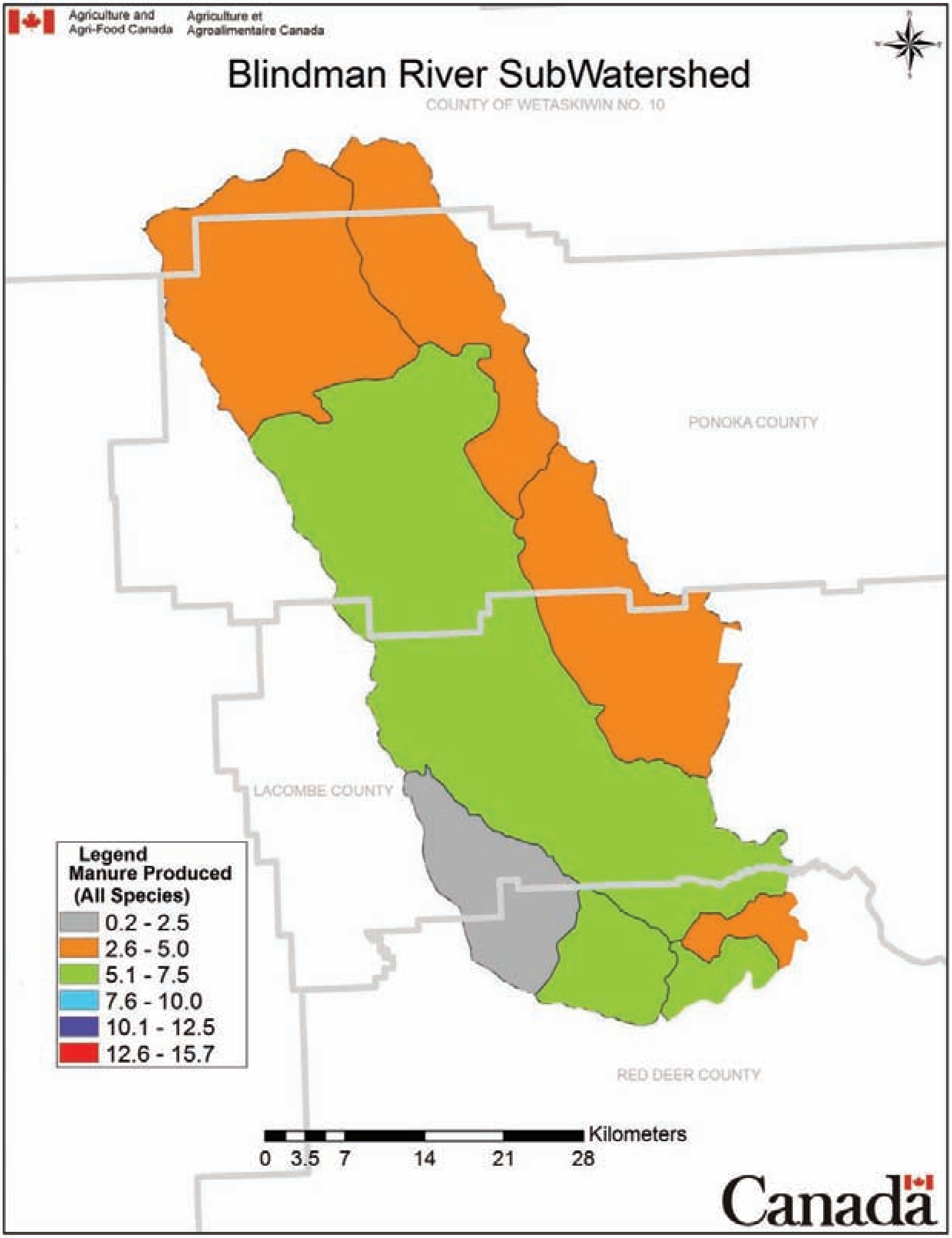



**Figure 164.** Manure production (tonnes/ha) in the Blindman River subwatershed (AAFC-PFRA, 2008).

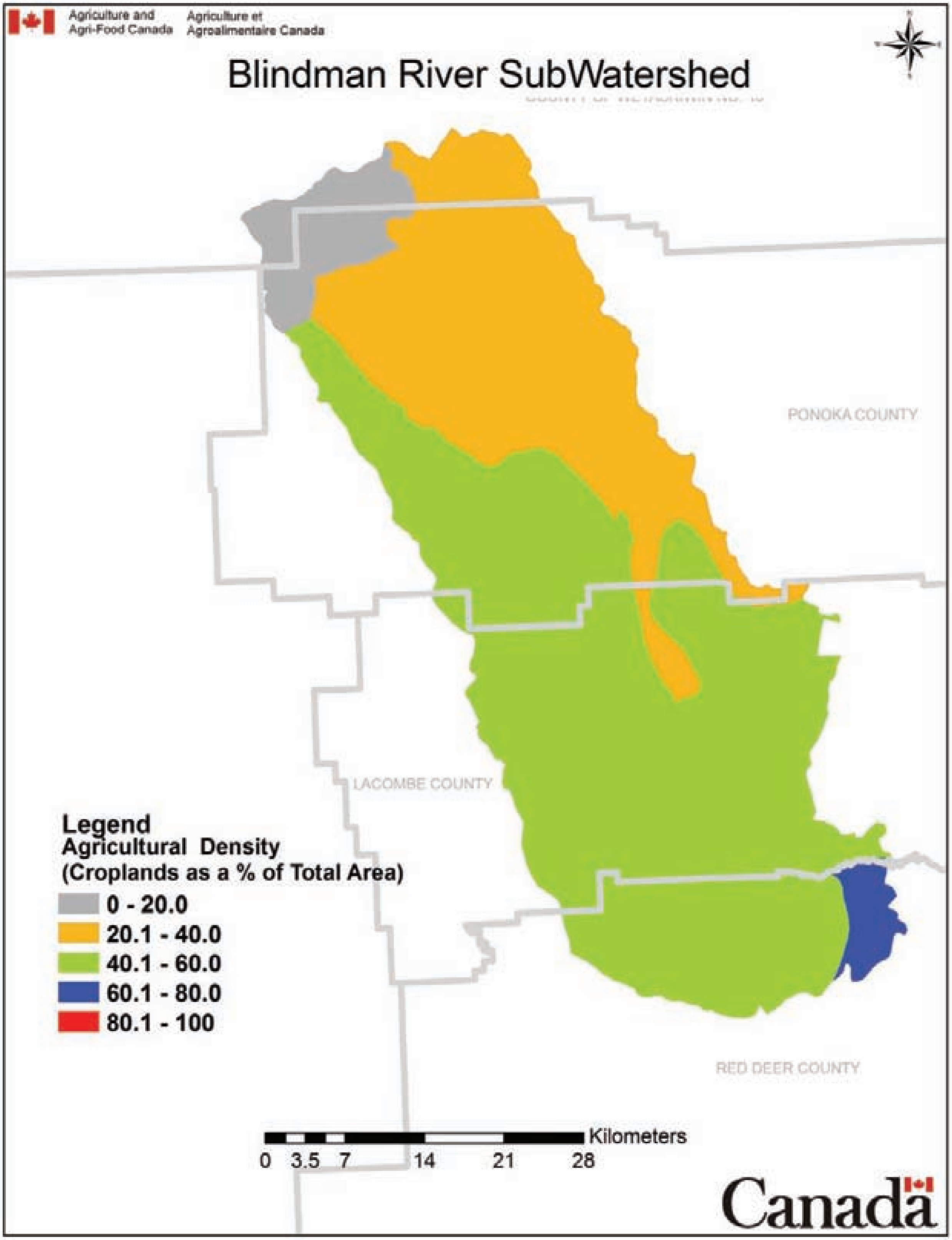



**Figure 165.** Agricultural intensity (% cropland) in the Blindman River subwatershed (AAFC-PFRA, 2008).

#### 4.6.2.4 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 Blindman River subwatershed include the City of Red Deer, the Towns of Bentley, Blackfalds, Rimbey, Sylvan Lake, the Summer Villages of Birchcliff, Gull Lake, Half Moon Bay, Jarvis Bay, Norglenwold, Parkland Beach and Sunbreaker Cove as well as several hamlets, including Bluffton, Briggs, Cygnet, Forshee, Hoadley, Labuma, Lavesta and Lockhart (Government of Canada, 2006). Three Provincial Parks (PP) and one Provincial Natural Area (PNA) are located in the subwatershed (Table 77) (Alberta Tourism, Parks and Recreation, 2008b).

**Table 77.** Recreational facilities in the Blindman River subwatershed (Alberta Tourism, Parks and Recreation, 2008b).

| Facility | Characteristics |
|---|---|
| Aspen Beach PP | • 214.02 ha on Gull Lake<br>• 595 units in two campgrounds (70 with water, 152 with electrical hookups), 175 unit group campgrounds<br>• day use sites<br>• boat launches, access to lake for snowmobiles, fish cleaning station |
| Jarvis Bay PP | • 85.84 ha on Sylvan Lake<br>• 169 unit campgrounds (22 with electrical hookups), 40 group units in two group campgrounds |
| Sylvan Lake PNA | • 13.436 ha on Sylvan Lake |
| Sylvan Lake PP | • 85.29 ha on Sylvan Lake<br>• day use site<br>• boat launches |

Note: PNA = provincial natural area, PP = provincial park.

Visitation statistics for three recreation facilities in the subwatershed indicate that the number of visitors to these facilities s varies considerably on an annual basis (Figure 166). For those years with available data, the average number of visitors per year was 90,721, 13,256 and 62,316 in Aspen Beach, Jarvis Bay and Sylvan Lake PPs, respectively. An average 166,293 visitors have used these three recreation facilities annually from 1994-2003; however, there are several 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).

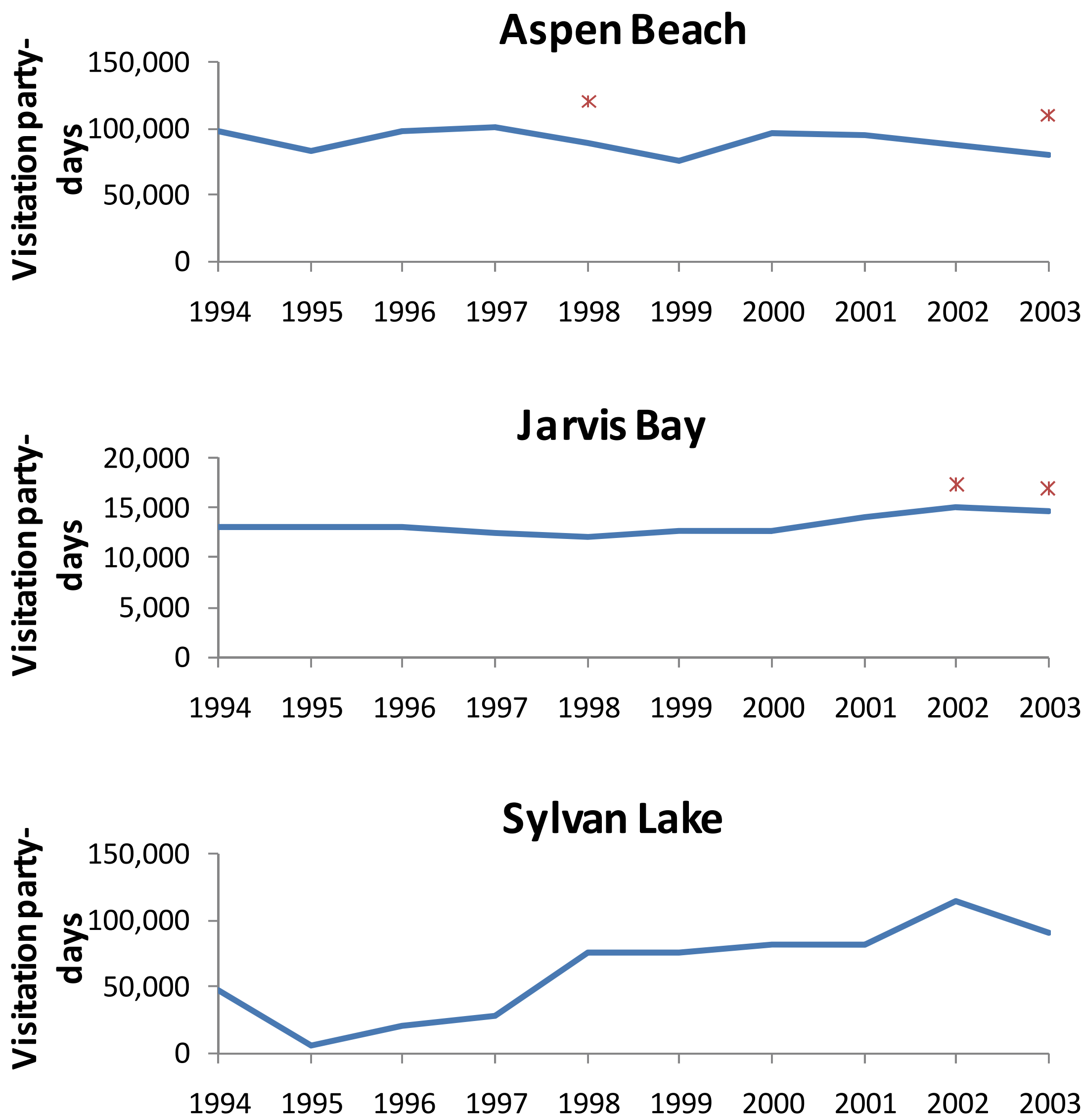



**Figure 166.** Visitation statistics for three recreation facilities in the Blindman River subwatershed (Alberta Tourism, Parks and Recreation, 2008b). Asterisks indicate years for which group camp data were not available.

4.6.2.5 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 Blindman River subwatershed are urban and rural roads, which have a total length of 2,700 km and cover 43.2 km$^2$ of the subwatershed's landbase. Other major linear developments include pipelines and cutlines/trails (Table 78). In total, all linear developments cover an area of 69.8 $km^2$, or 3.0% of the total area of the subwatershed (Figure 167) (AAFC-PFRA, 2008).

**Table 78.** Linear developments in the Blindman River 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 | 2,700 | 16 | 43.20 | 61.9 |
| Cutlines/trails | 1,600 | 6 | 9.60 | 13.8 |
| Pipelines | 680 | 15 | 10.20 | 14.6 |
| Powerlines | 140 | 30 | 4.20 | 6.0 |
| Railways | 173 | 15 | 2.59 | 3.7 |
| **Total** | **5,293** | | **69.79** | |

In addition to linear developments, the Blindman River subwatershed has 253 bridges that cross waterbodies, mostly streams and creeks, or culverts that connect waterbodies (Figure 168) (AAFC-PFRA, 2008). These are primarily associated with the Blindman River and Boyd and Lloyd Creeks. Pipeline crossings are distributed throughout the Blindman River subwatershed, although their density is higher between Sylvan and Gull Lakes near Bentley as well as in the northern area of the subwatershed near Bluffton and Hoadley and the headwaters of Boyd Creek (Figure 169) (AAFC-PFRA, 2008).

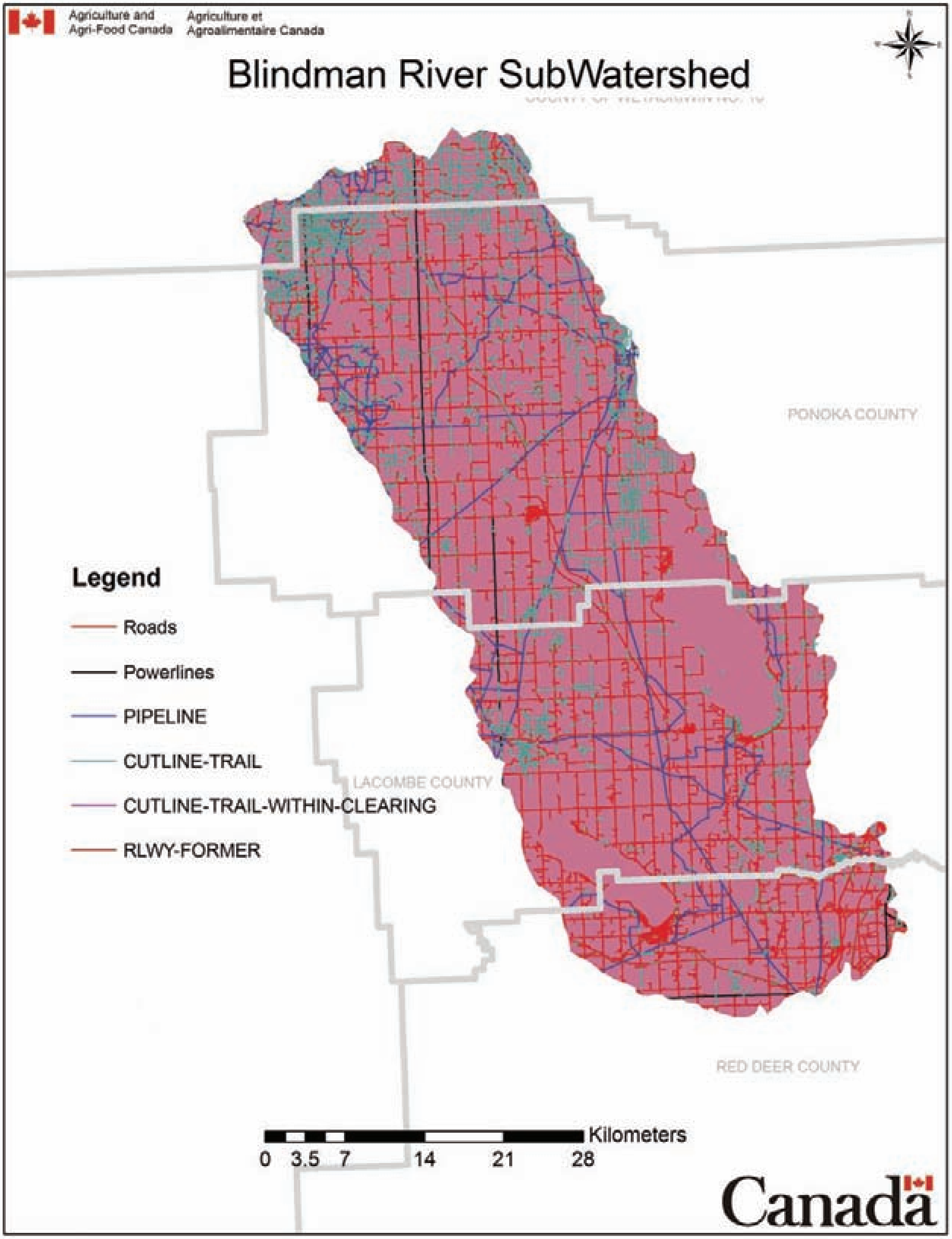



**Figure 167.** Linear developments in the Blindman River subwatershed (AAFC-PFRA, 2008).

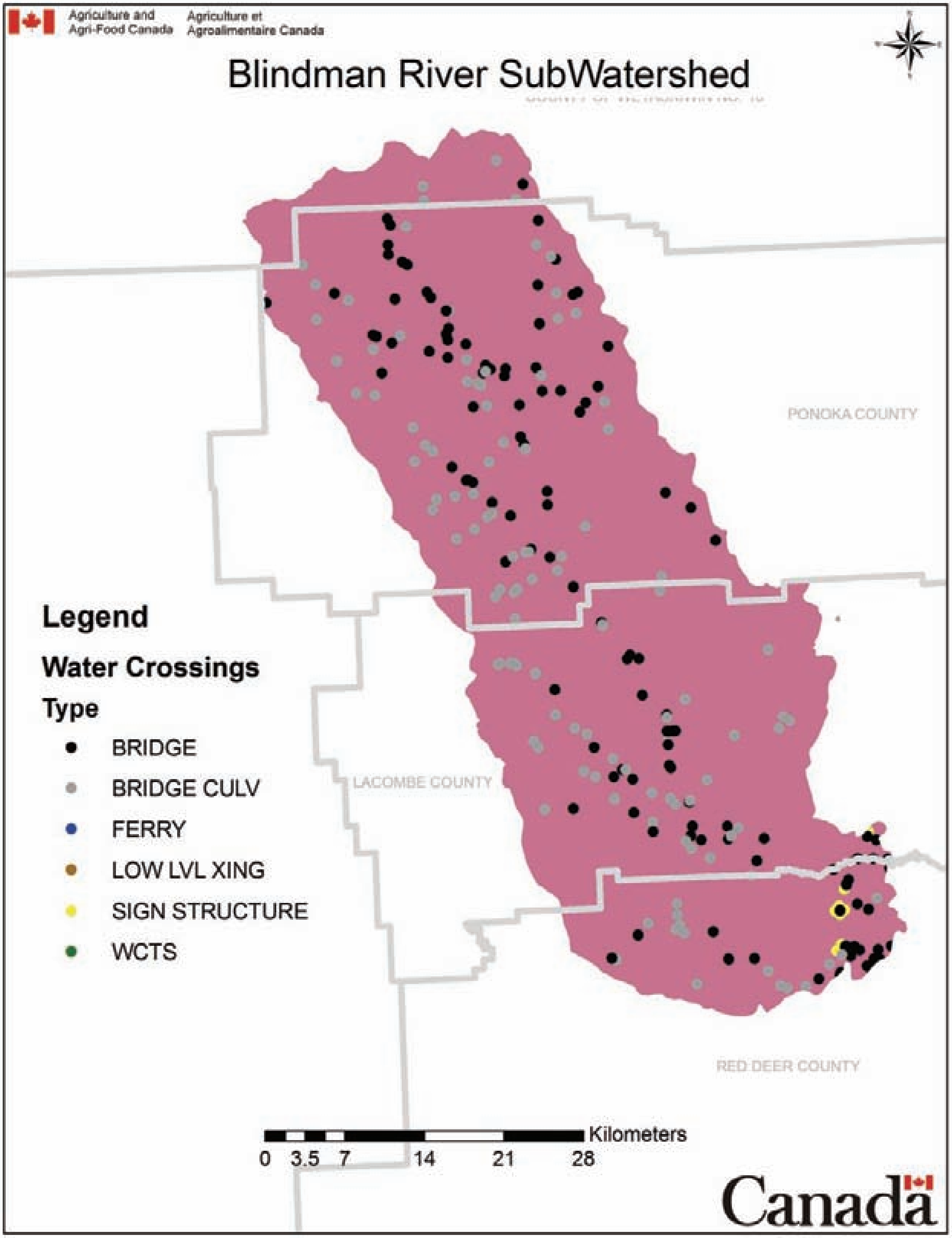



**Figure 168.** Waterbody crossings in the Blindman River subwatershed (AAFC-PFRA, 2008).

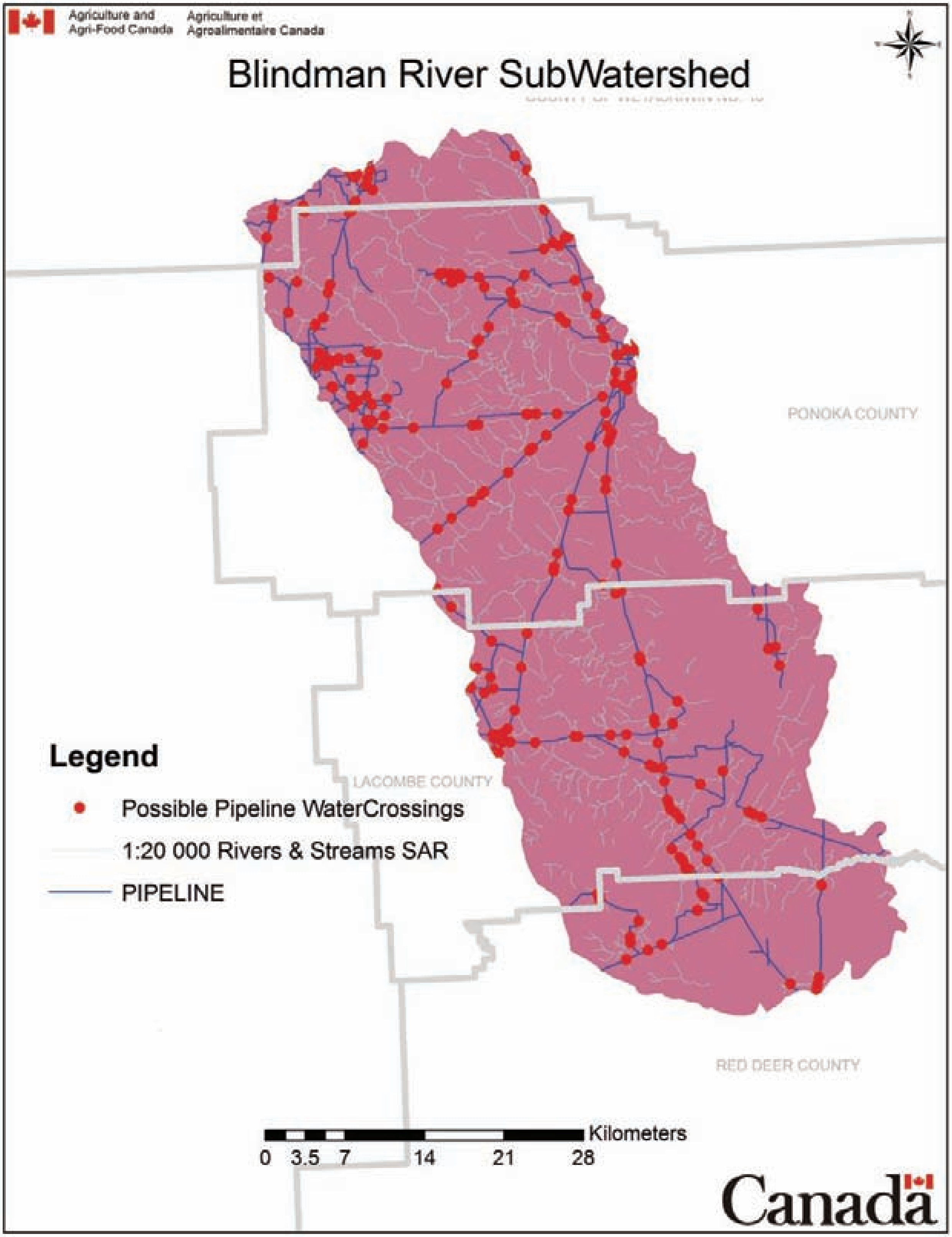



**Figure 169.** Pipeline crossings over waterbodies in the Blindman River subwatershed (AAFC-PFRA, 2008).

4.6.2.6 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 Blindman River subwatershed has an average well density of 1.92 wells/km$^2$. Wells are distributed throughout the entire subwatershed, although the well density increases up to 10 wells/km$^2$ south and south-west of Gull Lake near Bentley, near Crooked Lake north of Sylvan Lake and near Rimbey north-west of Gull Lake (Figure 170). About 61% of all wells are active, with the majority being gas wells, followed by unspecified and oil wells (Table 79) (AAFC-PFRA, 2008).

**Table 79.** Number of known active and abandoned oil, gas, water and other wells in the Blindman River subwatershed (AAFC-PFRA, 2008).

| **Well type** | **Quantity** |
|---|---|
| Wells – active * | 790 |
| Wells – abandoned * | 1,284 |
| **Total** | **2,074** |
| Gas wells – active | 1,588 |
| Gas wells – abandoned | 105 |
| **Total** | **1,693** |
| Oil wells – active | 257 |
| Oil wells – abandoned | 305 |
| **Total** | **562** |
| Water wells – active | 35 |
| Water wells – abandoned | 40 |
| **Total** | **75** |
| **Total active wells in subwatershed** | **2,670** |
| **Total abandoned wells in subwatershed** | **1,734** |
| **Total wells in subwatershed** | **4,404** |

* 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.

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).

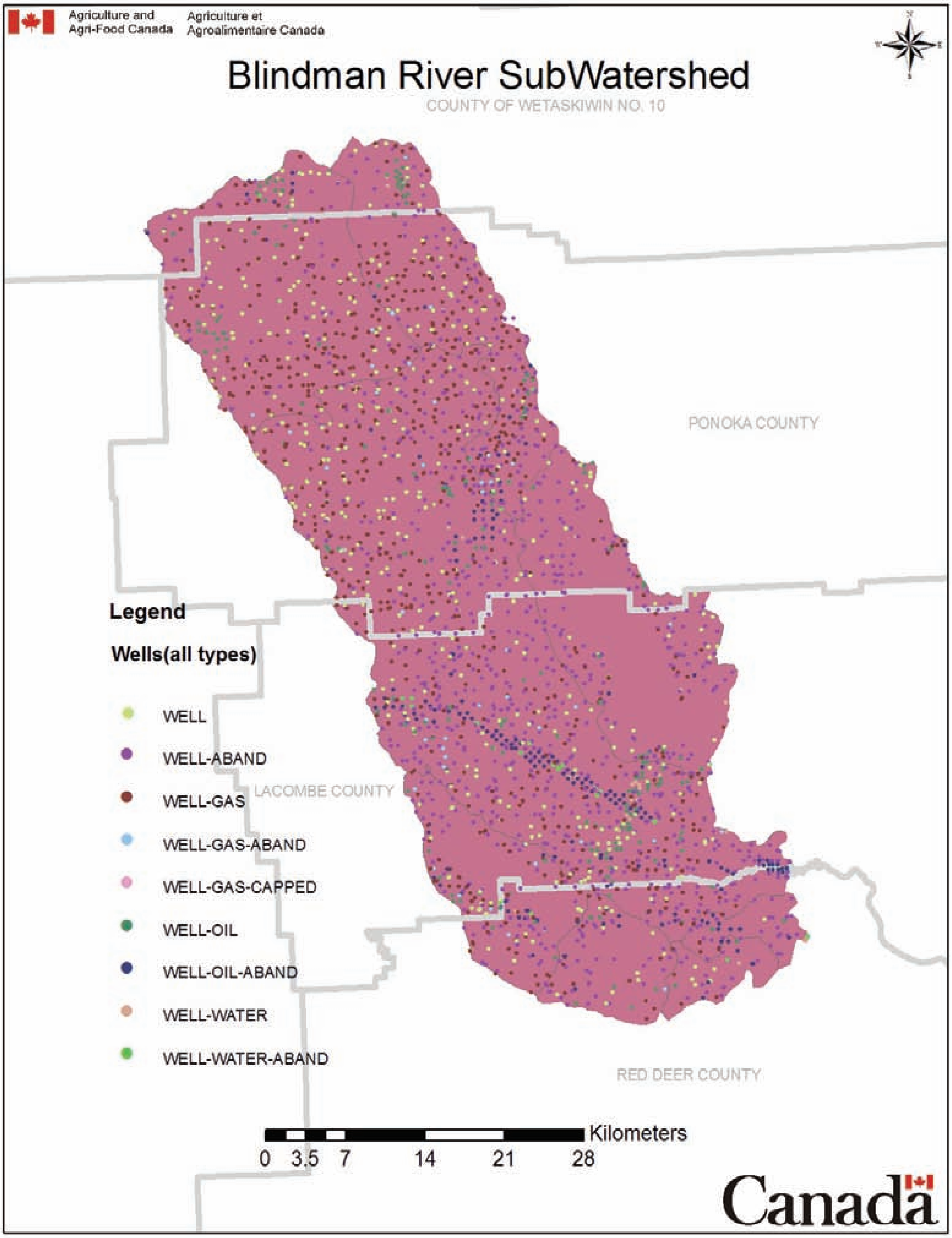



**Figure 170.** Known active and abandoned oil, gas, water and other wells in the Blindman River subwatershed (AAFC-PFRA, 2008).

### *4.6.3 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.

#### 4.6.3.1 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.

TP concentrations in Gull Lake and Sylvan Lake are moderate, with most values in the last two decades of sampling at or below the ASWQG PAL limit (Figures 171, 172, respectively). Levels prior to that time were substantially higher, with some values exceeding the ASWQG PAL 20-fold or more. A linear regression of TP concentrations over time using StatFi in Excel 2007 shows a significant negative trend ($p < 0.01$), i.e., TP concentrations in Gull Lake have significantly decreased over the past 40 years.

Seasonal trends in TP and TDP concentrations are difficult to discern from these data, because of the lack of regular sampling. Since the late 1990s, there have been no recorded instances of TP concentrations exceeding the ASWQG PAL limit of 0.05 mg/L in either lake. In the preceding decade, there were a number of sampling events in which TP concentrations exceeded this limit. This might indicate a decreasing trend in TP concentrations; however, samples have been collected less frequently in the past decade, so some spikes in phosphorus concentrations may have been missed. A simple linear regression indicated a significant decrease in TP concentrations since the early 1970s; however, this trend is primarily a result of high concentrations recorded in the late 1960s to mid-1970s. TP concentrations have been fairly consistent since then.

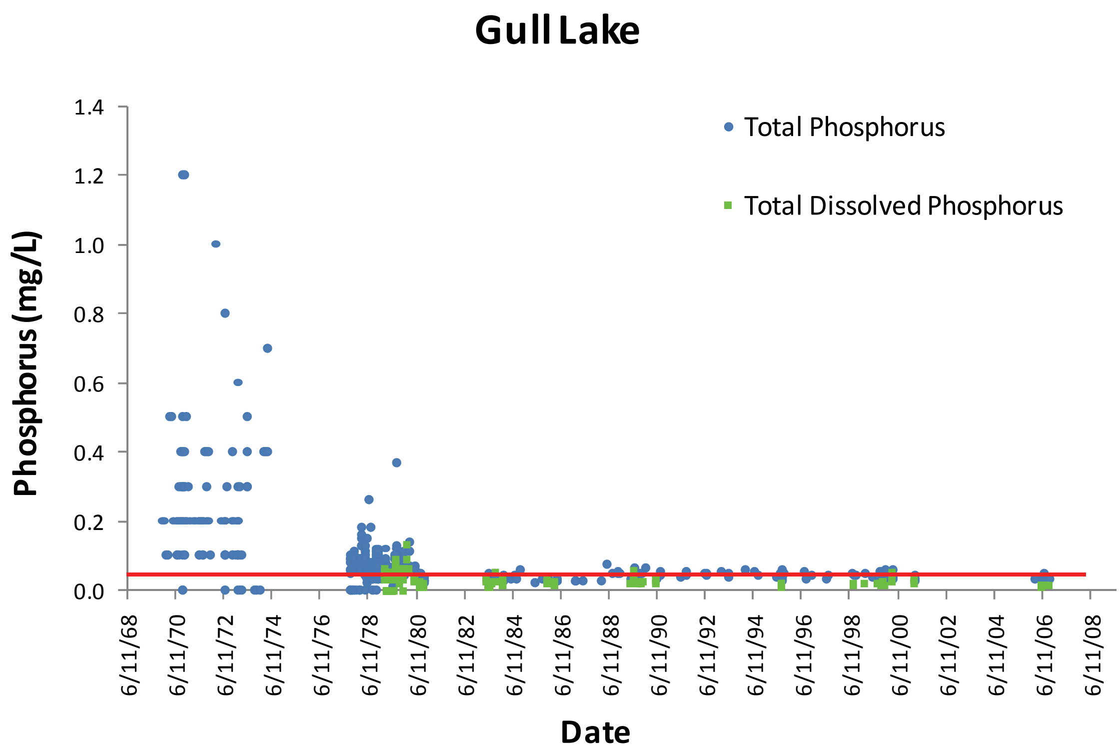



**Figure 171.** Total phosphorus (TP) and total dissolved phosphorus (TDP) concentrations in Gull Lake (data from Alberta Environment, 2008). The ASWQG PAL for TP (0.05 mg/L) is indicated by the red line.

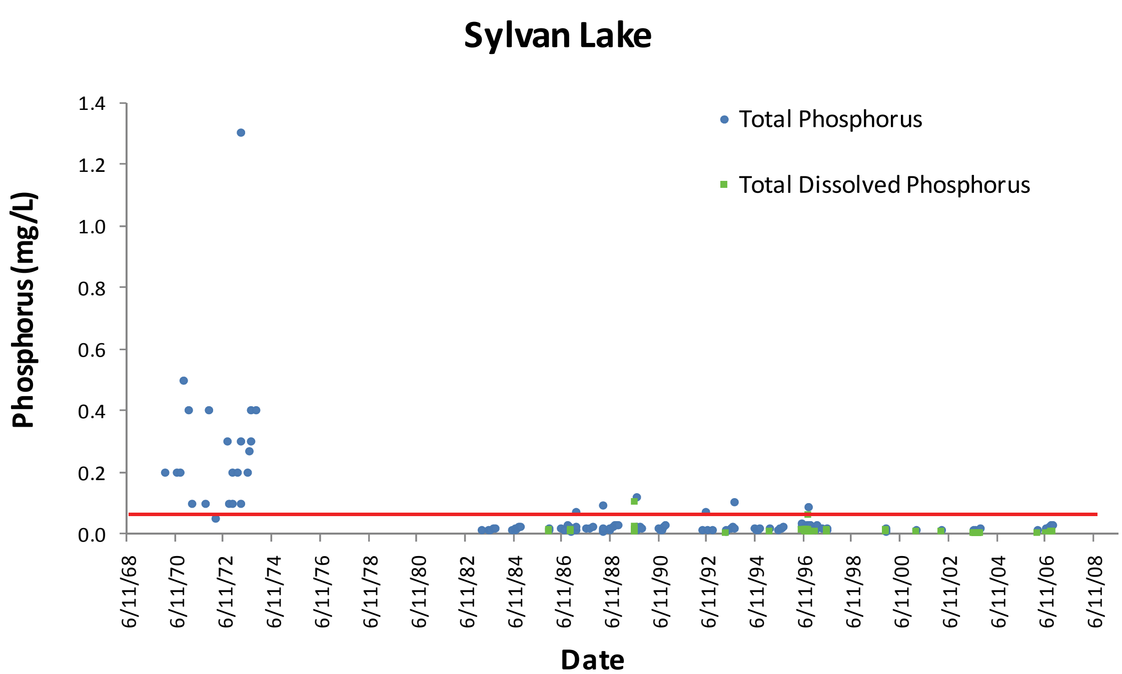



**Figure 172.** Total phosphorus (TP) and total dissolved phosphorus (TDP) concentrations in Sylvan Lake (data from Alberta Environment, 2008). The ASWQG PAL for total phosphorus (0.05 mg/L) is indicated by the red line.

TP and TDP concentrations in the Blindman River are consistently high; however, there is a negative trend in TP concentrations over time (Figure 173). A linear regression performed using StatFi in Excel 2007 showed that this negative trend is significant (p = 0.002), which may be driven primarily by a reduction in the frequency of exceedingly high concentrations, such as those occurring from the late 1960s to the mid-1970s.

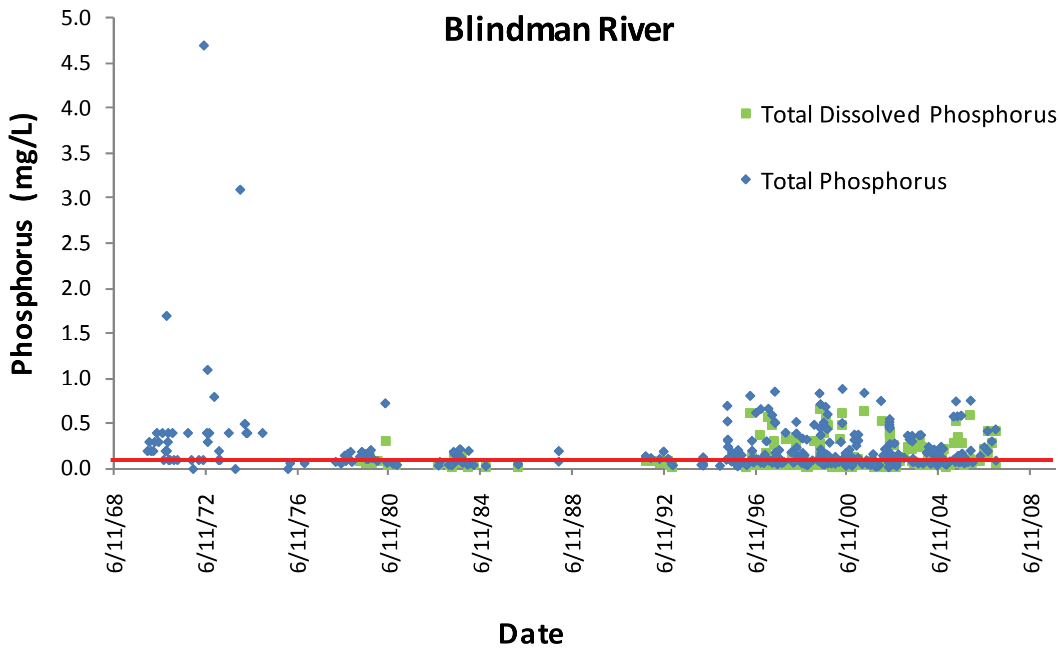



**Figure 173.** Total phosphorus (TP) and total dissolved phosphorus (TDP) concentrations in the Blindman River (data from Alberta Environment, 2008). The ASWQG PAL for TP (0.05 mg/L) is indicated by the red line.

TN concentrations in Gull Lake have consistently been above the ASWQG PAL limit of 1.0 mg/L (Figure 174); however, TN concentrations have decreased over the past 30 years. A linear regression of TN concentrations over time using StatFi in Excel 2007 shows that this decrease is significant ($p < 0.01$). TN concentrations have been relatively stable in recent years, ranging from 1.5-2.0 mg/L. In contrast to Gull Lake, TN concentrations in Sylvan Lake have been generally below the ASWQG PAL limit of 1.0 mg/L (Figure 175). Over the past two decades, TN concentrations have been relatively constant, ranging from 0.6-1.0 mg/L. TN concentrations in the Blindman River are consistently high (mean of 1.8 mg/L over the past 30 years), with values frequently exceeding the ASWQG PAL limit of 1.0 mg/L (Figure 176). In contrast to TP concentrations, there is a significant increase in TN concentrations over time (p = 0.005).

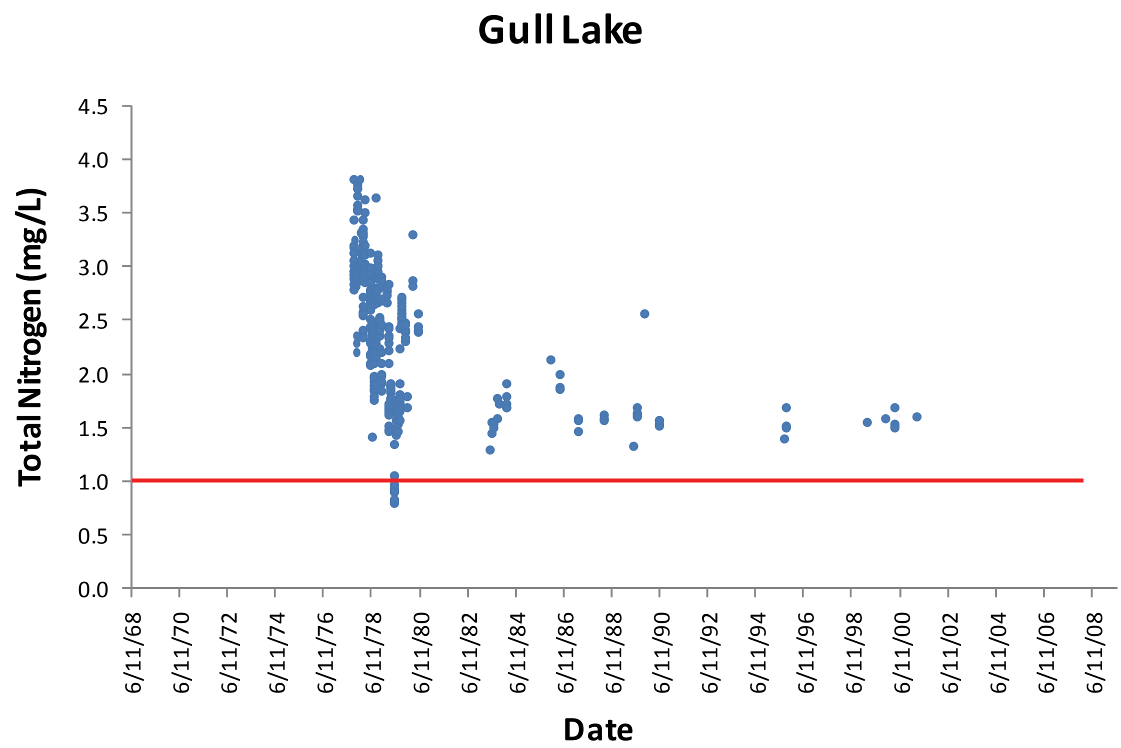



**Figure 174.** Total nitrogen (TN) concentration in Gull Lake (data from Alberta Environment, 2008). The ASWQG PAL for TN (1.0 mg/L) is indicated by the red line.

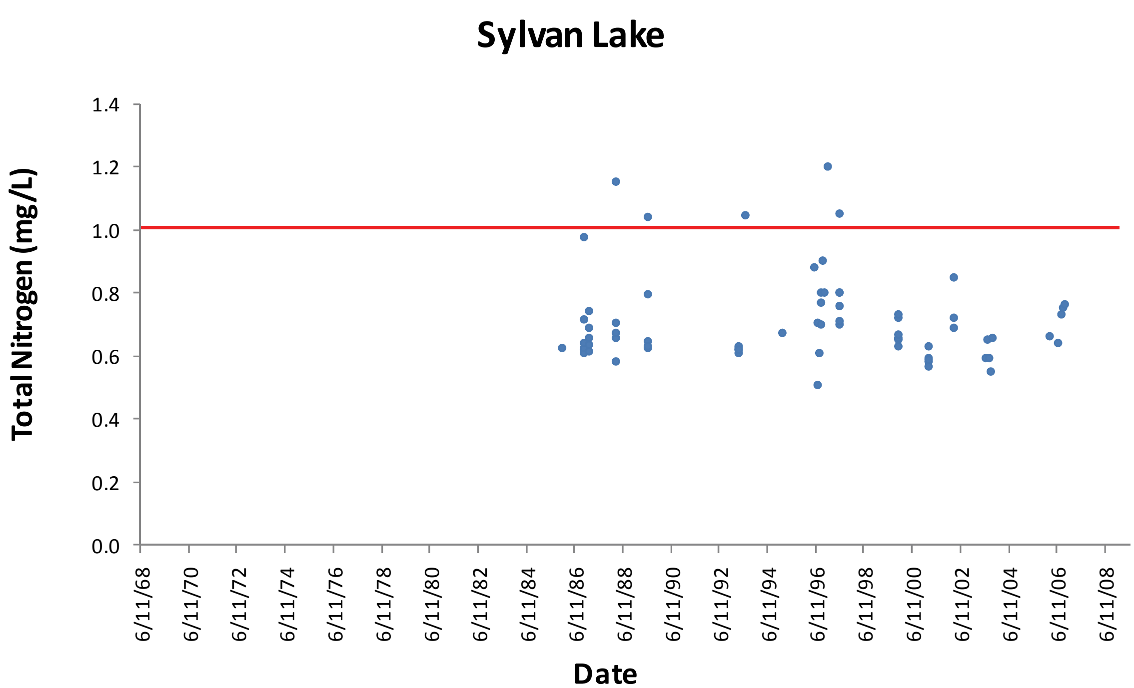



**Figure 175.** Total nitrogen (TN) concentration in Sylvan Lake (data from Alberta Environment, 2008). The ASWQG PAL for TN (1.0 mg/L) is indicated by the red line.

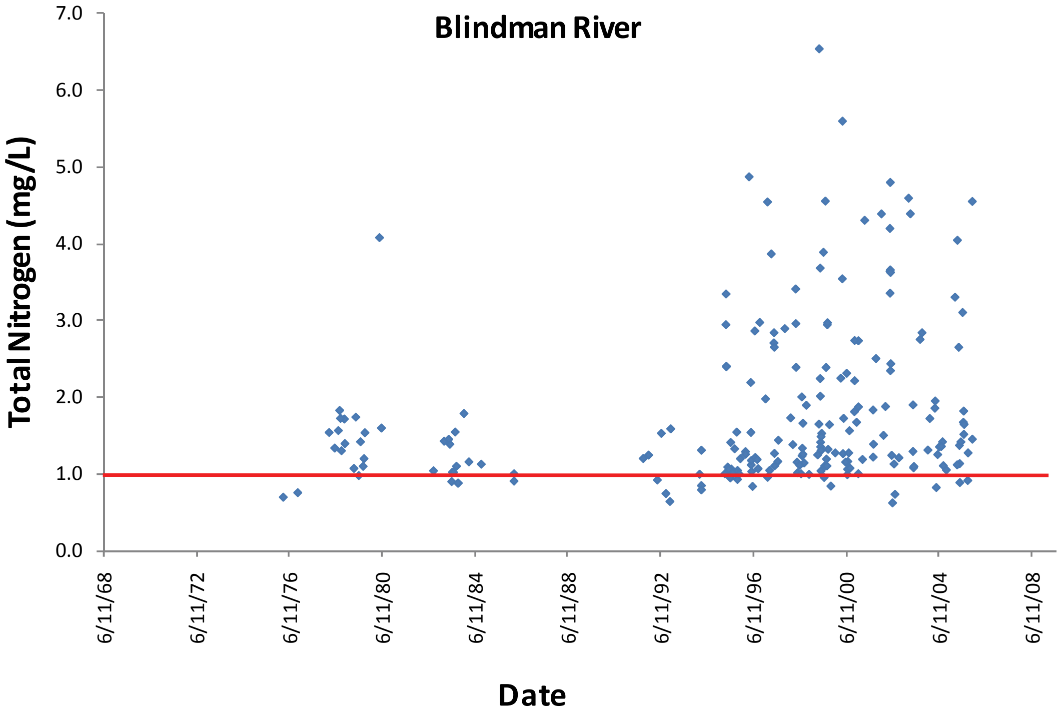



**Figure 176.** Total nitrogen (TN) concentrations in the Blindman River (data from Alberta Environment, 2008). The ASWQG PAL for TN (1.0 mg/L) is indicated by the red line.

$NH_3$ and $NO_3^-$-$NO_2^-$ concentrations in Gull Lake have been relatively stable over the past three decades (Figures 177, 179, respectively). Elevated levels during the early 1970s correspond to times of elevated TN concentrations, and during those times $NH_3$ appears to have made up a substantial fraction of the TN at that time. In more recent years, $NH_3$ constituted a substantially smaller portion of the TN, indicating that perhaps a greater proportion of the nitrogen in Gull Lake is bound in organic matter.

$NH_3$ concentrations in Sylvan Lake were highly variable in the 1970s and 1980s but have stabilized in the past decade (Figure 178), often being below detection limits. Over the past four decades, $NH_3$ concentrations have decreased; however, this decrease has not been significant ($p > 0.05$). $NO_3^-$-$NO_2^-$ concentrations in Sylvan Lake have generally been low (Figure 180), with most samples at or below detection limits. The high values for $NO_3^-$-$NO_2^-$ concentrations generally occur during the winter or early spring under ice cover and are consistent with the liberation of nutrients during the decay or organic matter.

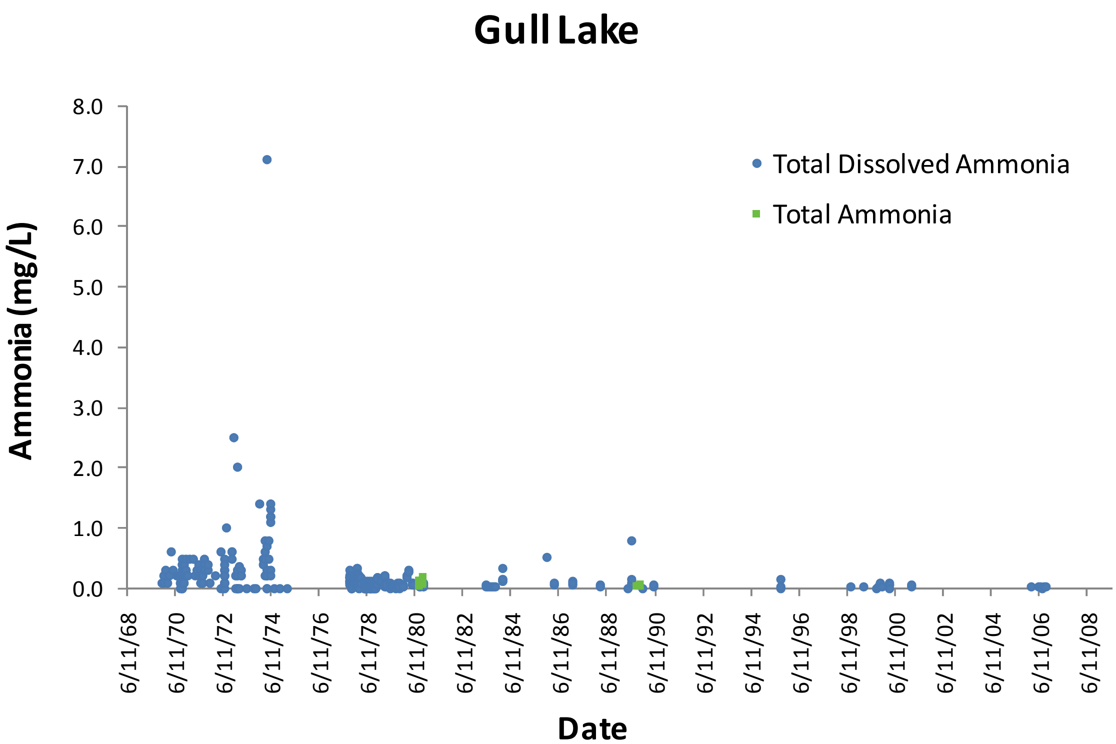



**Figure 177.** Total ammonia and total dissolved ammonia concentrations in Gull Lake (data from Alberta Environment, 2008).

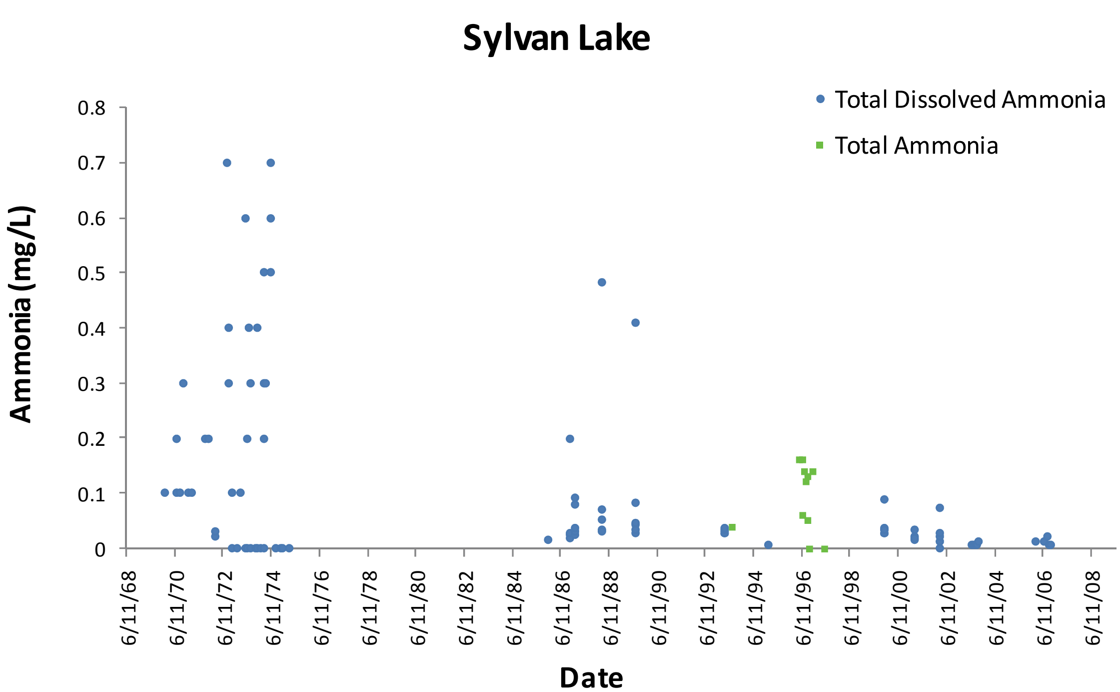



**Figure 178.** Total and total dissolved ammonia concentrations in Sylvan Lake (data from Alberta Environment, 2008).

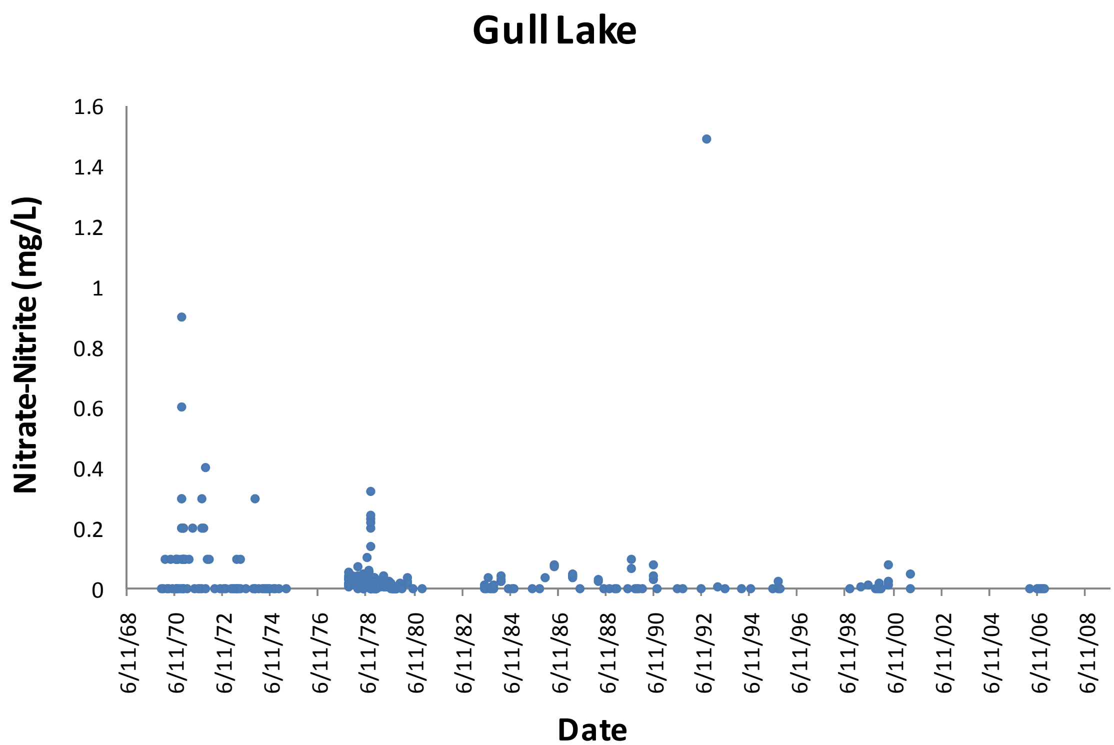



**Figure 179.** Nitrate-nitrite concentrations in Gull Lake (data from Alberta Environment, 2008).

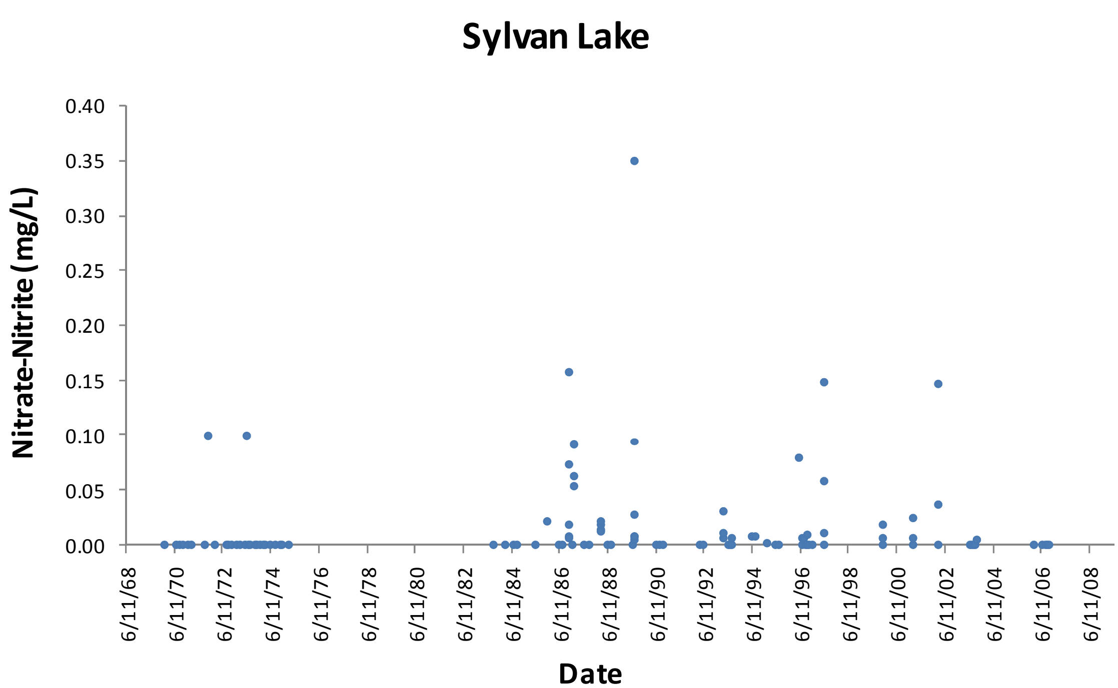



**Figure 180.** Nitrate-nitrite concentrations in Sylvan Lake (data from Alberta Environment, 2008).

Dissolved oxygen (DO) concentrations in Gull Lake have been relatively stable since the early 1970s (Figure 181). DO concentrations have dropped below the ASWQG PAL limit of 5.0 mg/L on occasion, more frequently in the 1970s and 1980s, particularly at greater depths and in winter months. The frequent occurrence of hypoxic conditions during winter suggests that there is a risk of winterkill in Gull Lake.

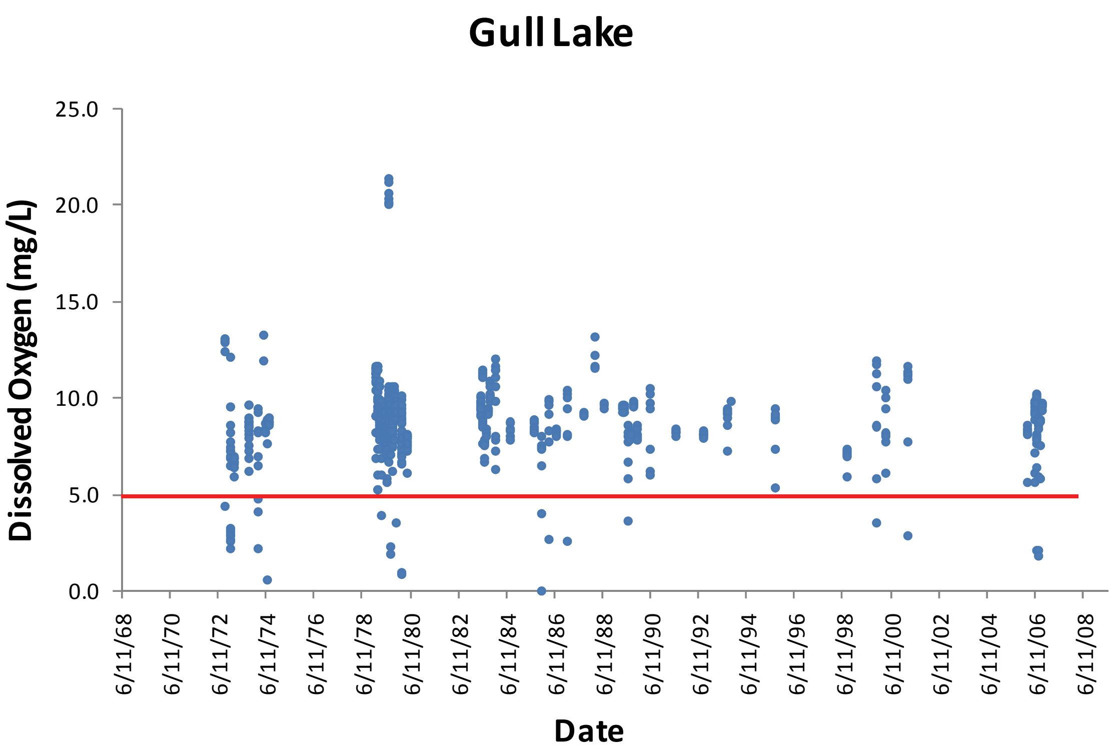



**Figure 181.** Dissolved oxygen (DO) concentrations in Gull Lake (data from Alberta Environment, 2008). The ASWQG PAL lower limit for DO (5.0 mg/L) is indicated by the red line.

Seasonal trends in DO concentrations in Sylvan lake are difficult to discern (Figure 182), because of the lack of regular sampling within a given year. Concentrations frequently fall below the ASWQG PAL limit of 5.0 mg/L; however, most of these low measurements occurred at depths greater than 13 m, i.e., towards the bottom of the water column, and rarely at depths less than that. Hence, there is a limit risk for winterkill in Sylvan Lake.

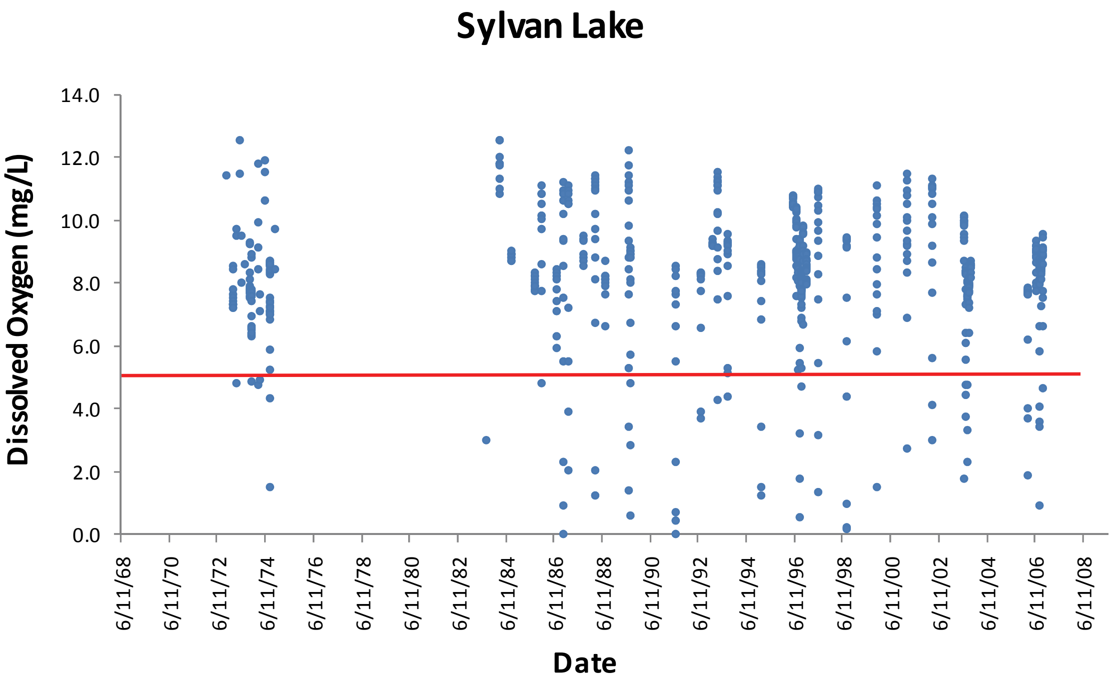



**Figure 182.** Dissolved oxygen (DO) concentrations in Sylvan Lake (data from Alberta Environment, 2008). The ASWQG PAL lower limit for DO (5.0 mg/L) is indicated by the red line.

A nutrient budget for Sylvan Lake showed that nutrient inputs are dominated by surface loading from the surrounding drainage basin (AXYS Environmental Consulting Ltd., 2005). Under worst-case scenario calculations, surface inflows (i.e., tributary streams) were estimated to contribute an annual average of about 74% and 55% of TP and TN loads to the lake, respectively. Atmospheric inputs are more significant for TN than for TP, constituting about 33% and 9% of total inputs, respectively. Groundwater and septic field effluent inflow collectively contribute an estimated 16% and 12% of annual loads of TP and TN, respectively. The relatively low annual average outflow and a high water residence time (> 100 years) result in high (> 95%) nutrient retention rates, indicating that the vast majority of nutrients entering the lake are deposited in sediments, which makes Sylvan Lake particularly vulnerable to both external and internal nutrient loading (AXYS Environmental Consulting Ltd., 2005).

Nearly every stream monitored for water quality has TP and TN concentrations above CCME PAL guidelines. For TP, the worst water quality was seen in Sunrise Creek, Sailing Club Creek and Birchcliff Creek (1.766 mg/L, 1.752 mg/L and 1.703 mg/L, respectively) (Table 80). These concentrations exceed CCME PAL guidelines (0.05 mg/L) over 34-fold. TN concentrations are similarly elevated, with the highest concentrations seen in Sailing Club Creek (8.717 mg/L), Birch Bay Creek (8.103 mg/L), Birchcliff Creek (7.354 mg/L) and Sunrise Creek (6.387 mg/L) (Table 80). These concentrations exceed CCME PAL guidelines for TN about 6-9-fold. 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.

**Table 80.** Water quality in creeks in the Blindman River subwatershed. n = sample size. All concentrations in mg/L unless otherwise noted. Concentrations exceeding water quality guidelines are highlighted *.

| Parameter | Beaver Creek | | Birch Bay Creek | | Birchcliff Creek | | Eastside Creek | | Golf Course Creek | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | n | Mean | n | Mean | n | Mean | n | Mean | n |
| TP | 1.012 | 9 | 1.020 | 4 | 1.703 | 3 | 0.876 | 7 | 0.305 | 11 |
| TDP | 0.871 | 9 | 0.63 | 4 | 1.493 | 3 | 0.710 | 7 | 0.262 | 9 |
| TN | 4.135 | 9 | 8.103 | 4 | 7.354 | 3 | 3.951 | 7 | 2.113 | 11 |
| $NO_3^-$-$NO_2^-$ | 0.757 | 9 | 4.483 | 4 | 1.777 | 3 | 1.933 | 7 | 0.384 | 11 |
| $NH_3$ | 0.672 | 9 | 0.288 | 4 | 0.091 | 3 | 0.436 | 7 | 0.185 | 11 |
| DO | 9.73 | 9 | 10.46 | 4 | 11.39 | 1 | 9.16 | 7 | 10.47 | 11 |
| Chl. *a* (µg/L) | --- | --- | --- | --- | --- | --- | --- | --- | --- | -- |
| pH | 7.79 | 9 | 7.45 | 4 | 7.21 | 1 | 7.53 | 7 | 7.84 | 11 |
| Specific Conductivity (µS/cm) | 235 | 9 | 749 | 4 | 91 | 1 | 377 | 7 | 410 | 11 |
| TDS | --- | --- | --- | --- | 56 | 1 | --- | --- | 210 | 8 |
| Total coliforms (CFU/100 mL) | --- | --- | --- | --- | --- | --- | --- | --- | 550 | 2 |
| Fecal coliforms (CFU/100 mL) | 249 | 9 | 156 | 4 | 347 | 3 | 147 | 6 | 365 | 11 |

* TN from ASWQG PAL chronic exposure guideline; fecal and total coliforms from CCME-Agriculture/Irrigation guideline; all others from CCME PAL. The Beaver Creek and Birch Bay Creek samples were collected April-December 1999; the Birchcliff Creek samples were collected March-November 2001, and October 2003; the Eastside Creek samples were collected March-December 1999; the Golf Course Creek samples were collected June-July 1993, March and July 2001, and April 2003-November 2004; the Gull Lake Diversion samples were collected February-December 1999, and April 2002-November 2003; the Honeymoon Creek samples were collected March-November 2001, and April 2003-May 2004; the Lambe Creek samples were collected in August 2001 and October 2003; the Lloyd Creek samples were collected March 1995-September 1997; the North Creek samples were collected April 1999-September 2000; the Northeast Creek samples were collected June 1993, July 1999-July 2001, and April 2003-November 2004; the Parkland Creek samples were collected April 1999-April 2000; the Sunrise Creek, Sucker Creek and Wilson Creek samples were collected April 1999-October 2000; the Sylvan Creek samples were collected June-July 1993; the Trout Farm Creek samples were collected March and July 1999; the Weise Street Creek samples were collected July 1999-August 2000; the Willow Street Creek samples were collected February-September 1999 (data from Alberta Environment). Variable abbreviations as in Table 10.

**Table 80** (cont.)

| Parameter | Gull Lake Diversion | | Honeymoon Creek | | Lambe Creek | | Lloyd Creek | | North Creek | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **n** | **Mean** | **n** | **Mean** | **n** | **Mean** | **n** | **Mean** | **n** |
| TP | 0.240 | 26 | 0.242 | 7 | 1.394 | 2 | 0.174 | 61 | 0.289 | 13 |
| TDP | 0.196 | 26 | 0.339 | 7 | 1.287 | 2 | 0.105 | 42 | 0.250 | 13 |
| TN | 2.040 | 26 | 2.646 | 7 | 4.798 | 2 | 1.338 | 60 | --- | --- |
| $NO_3^-$-$NO_2^-$ | 0.723 | 26 | 0.372 | 7 | 0.888 | 2 | 0.073 | 60 | 0.067 | 13 |
| $NH_3$ | 0.146 | 26 | 0.360 | 7 | 0.8425 | 2 | 0.115 | 60 | 0.167 | 13 |
| | | | | | | | | | | |
| DO | 9.60 | 21 | 5.88 | 5 | 12.06 | 1 | --- | --- | 6.66 | 13 |
| Chl. *a* (µg/L) | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pH | 7.80 | 26 | 7.28 | 7 | 7.30 | 1 | 7.87 | 48 | 7.21 | 13 |
| Specific Conductivity (µS/cm) | 399 | 26 | 403 | 7 | 131 | 1 | 442 | 5 | 342 | 13 |
| TDS | 202 | 6 | 164 | 3 | 78 | 1 | 243 | 5 | --- | --- |
| | | | | | | | | | | |
| Total coliforms (CFU/100 mL) | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Fecal coliforms (CFU/100 mL) | 622 | 25 | 40 | 7 | 365 | 2 | --- | --- | 232 | 15 |

**Table 80** (cont.)

| Parameter | Northeast Creek | | Parkland Creek | | Sailing Club Creek | | Sonrise Creek | | Sucker Creek | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **n** | **Mean** | **n** | **Mean** | **n** | **Mean** | **n** | **Mean** | **n** |
| TP | 0.713 | 17 | 0.480 | 5 | 1.752 | 19 | 1.766 | 15 | 0.382 | 10 |
| TDP | 0.653 | 16 | 0.392 | 5 | 1.673 | 19 | 1.655 | 15 | 0.329 | 10 |
| TN | 2.840 | 17 | 1.818 | 5 | 8.717 | 19 | 6.387 | 15 | 1.939 | 10 |
| $NO_3^-$-$NO_2^-$ | 0.472 | 17 | 0.186 | 5 | 4.577 | 19 | 0.673 | 15 | 0.293 | 10 |
| $NH_3$ | 0.379 | 17 | 0.241 | 5 | 0.629 | 19 | 2.011 | 15 | 0.085 | 10 |
| DO | 9.75 | 15 | 9.63 | 65 | 7.61 | 18 | 7.06 | 14 | 9.68 | 10 |
| Chl. *a* (µg/L) | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pH | 7.67 | 17 | 7.66 | 5 | 7.39 | 18 | 7.54 | 14 | 7.65 | 10 |
| Specific Conductivity (µS/cm) | 429 | 17 | 499 | 5 | 576 | 18 | 514 | 14 | 462 | 10 |
| TDS | 275 | 11 | --- | --- | --- | --- | --- | --- | --- | --- |
| Total coliforms (CFU/100 mL) | 17 | 1 | --- | --- | --- | --- | --- | --- | --- | --- |
| Fecal coliforms (CFU/100 mL) | 225 | 15 | 910 | 6 | 1,798 | 20 | 469 | 16 | 182 | 10 |

**Table 80** (cont.)

| Parameter | Sylvan Creek | | Trout Farm Creek | | Weise Street Creek | | Willow Street Creek | | Wilson Creek | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | n | Mean | n | Mean | n | Mean | n | Mean | n |
| TP | 0.076 | 8 | 1.078 | 2 | 1.180 | 3 | 0.977 | 4 | 0.940 | 19 |
| TDP | --- | --- | 0.897 | 2 | 1.124 | 10 | 0.844 | 4 | 0.851 | 18 |
| TN | 0.812 | 8 | 4.575 | 2 | 7.076 | 10 | 6.792 | 4 | 4.473 | 19 |
| $NO_3^-$-$NO_2^-$ | 0.005 | 8 | 1.750 | 0 | 2.425 | 10 | 2.505 | 4 | 1.343 | 19 |
| $NH_3$ | 0.026 | 8 | 0.685 | 2 | 0.529 | 10 | 0.351 | 4 | 0.610 | 19 |
| | | | | | | | | | | |
| DO | --- | --- | 8.51 | 2 | 7.11 | 9 | 8.84 | 4 | 9.39 | 18 |
| Chl. *a* (µg/L) | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pH | 8.60 | 8 | 7.31 | 2 | 7.41 | 9 | 7.20 | 4 | 7.73 | 18 |
| Specific Conductivity (µS/cm) | 594 | 8 | 745 | 2 | 513 | 9 | 469 | 4 | 342 | 18 |
| TDS | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | | | | | | | | |
| Total coliforms (CFU/100 mL) | 179 | 6 | --- | --- | --- | --- | --- | --- | --- | --- |
| Fecal coliforms (CFU/100 mL) | 142 | 8 | 400 | 1 | 287 | 13 | 34 | 3 | 1,170 | 20 |

4.6.3.2 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 Gull Lake have always been very low (Figure 183), never exceeding CCME Agriculture/Irrigation guidelines (100 CFU/100 mL) or the Health Canada Guidelines for Contact Recreation (200 CFU/100 mL); however, these types of bacterial data are very sparse and no definitive conclusions can be reached regarding coliform concentrations in Gull Lake.

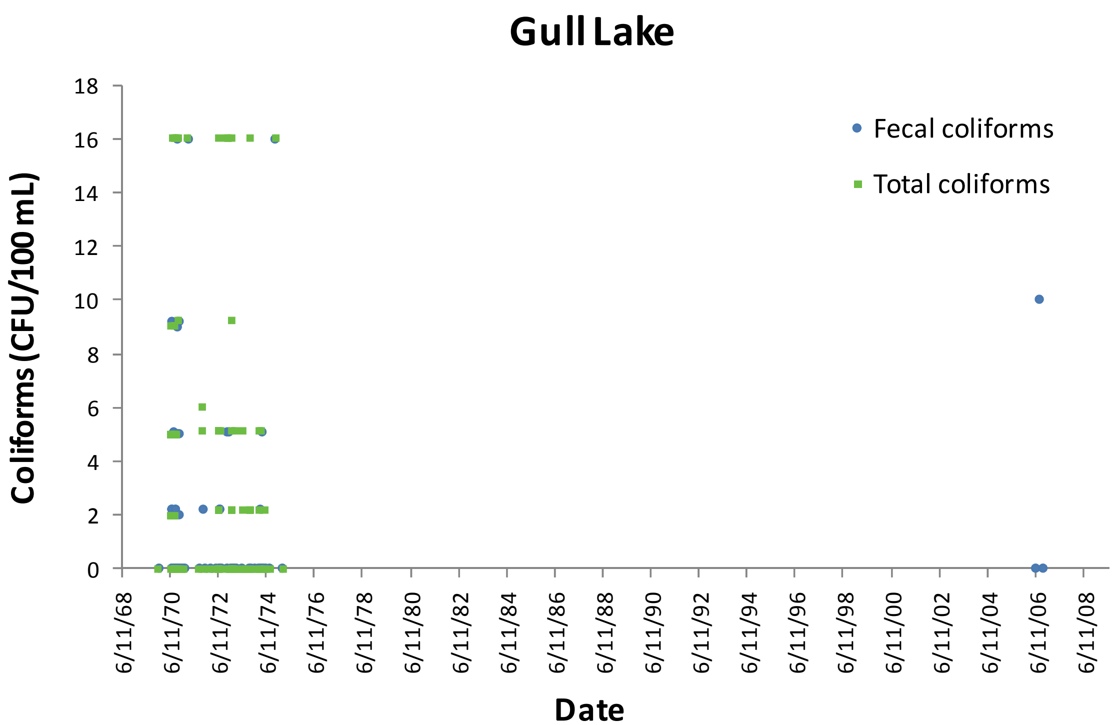



**Figure 183.** Total coliform and fecal coliform concentrations in Gull Lake (data from Alberta Environment, 2008).

Coliform concentrations, both fecal and total, have not been sampled frequently or recently enough to draw any conclusions as to the current state of Sylvan Lake. The last samples were collected in 1993, and the fecal coliform concentration greatly exceeded the CCME limits for Agriculture/Irrigation (100 CFU/100 mL) as well as the Health Canada Guidelines for Contact Recreation (200 CFU/100 mL) at that time (Figure 184); however, a water quality assessment performed in 2004 (AXYS Environmental Consulting, 2005) showed low levels of both fecal coliform bacteria and *E. coli*, although the exact levels were not specified in the report.

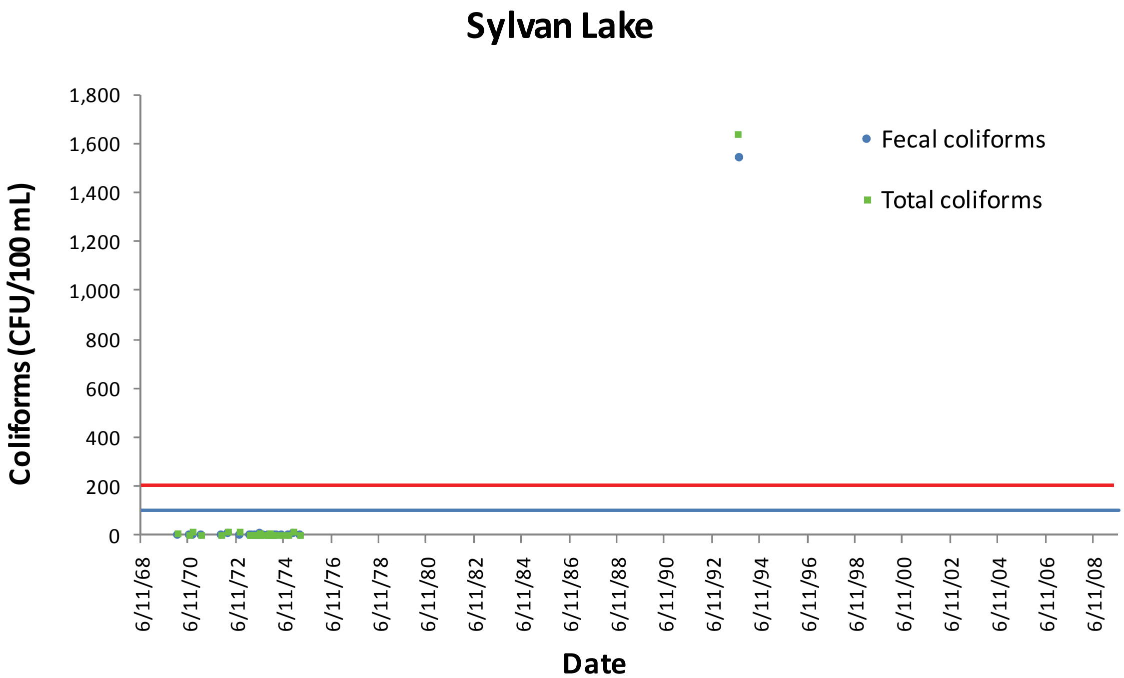



**Figure 184.** Total coliform and fecal coliform concentrations in Sylvan Lake (data from Alberta Environment, 2008). The CCME Agriculture/Irrigation guideline for fecal coliforms (100 CFU/100mL) is indicated by the blue line, and the CCME Agriculture/Irrigation guideline for total coliforms is indicated by the red line.

Nearly every stream in the Blindman River subwatershed has concentrations of fecal coliform bacteria that exceed CCME Agriculture/Irrigation guidelines (100 CFU/100 mL). Average concentrations are highest in Sailing Club Creek (1,798 CFU/100 mL), Wilson Creek (1,170 CFU/100 mL), Parkland Creek (910 CFU/100 mL) and the Gull Lake Diversion (922 CFU/100 mL) (Table 80).

The most detailed assessment of coliform bacterial concentrations in the entire subwatershed originates from the Blindman River, where data have been collected since 1970. Fecal coliform concentrations are extremely high and over the past ten years have exceeded CCME Agriculture/Irrigation and Health Canada Guideline for Recreational Water Quality (Figure 185). In contrast, total coliform concentrations in the Blindman River are generally moderate, with very few samples exceeding CCME Agriculture/Irrigation guidelines (Figure 186). Noteworthy is the decreasing emphasis on total coliform assessments since 1970, while assessments of fecal coliforms have increased over the same period.

Fecal coliform bacteria originate primarily from agricultural and municipal runoff, wildlife and faulty septic systems and septic fields. It is likely that the heavy concentration of feedlots, the medium-high density of agricultural operations, and high manure production rates throughout most of the subwatershed are responsible for the poor water quality in many of the subwatershed's streams.

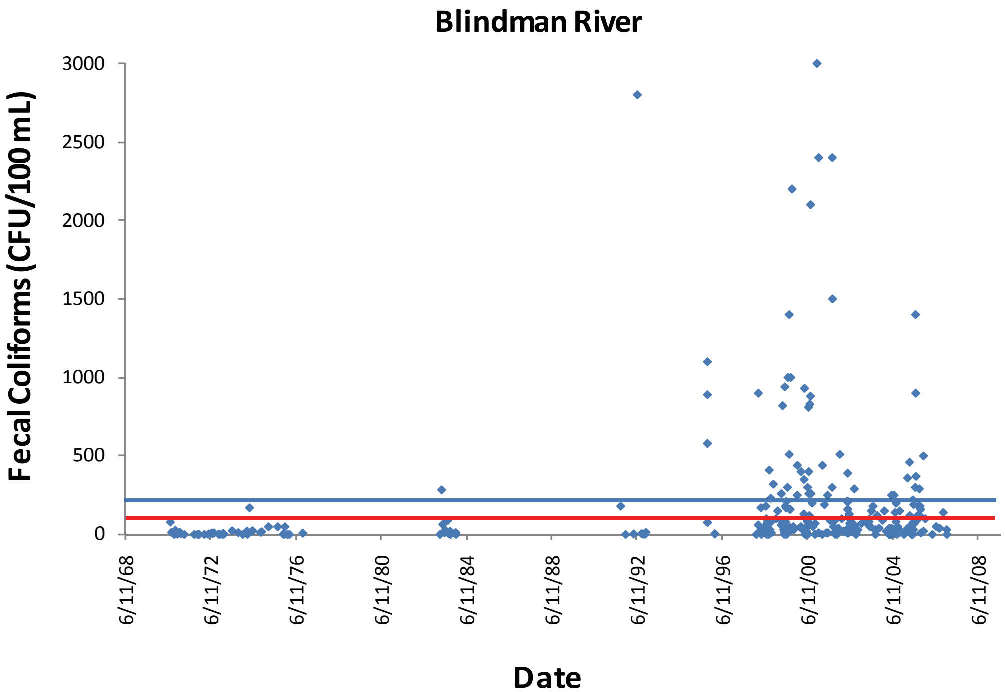



**Figure 185.** Fecal coliform concentrations in the Blindman River (data from Alberta Environment, 2008). The CCME Agriculture/Irrigation guideline for fecal coliforms (100 CFU/100 mL) is indicated by the red line and the Health Canada Guideline for Recreational Water Quality for fecal coliforms (200 CFU/100 mL) is indicated by the blue line.

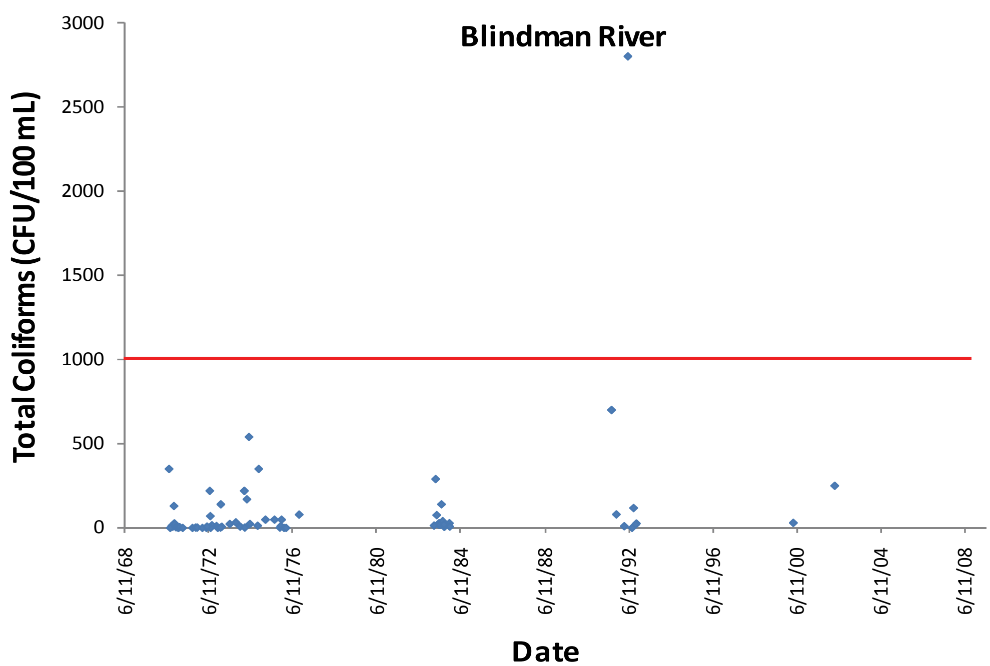



**Figure 186.** Total coliform concentrations in the Blindman River (data from Alberta Environment, 2008). The CCME Agriculture/Irrigation guideline for total coliforms (1,000 CFU/100 mL) is indicated by the red line.

4.6.3.3 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 Blindman River subwatershed.

4.6.3.4 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.

In the Blindman River subwatershed, 14 pesticides have been detected in 15 waterbodies (Table 81). None of them exceeded CCME PAL guidelines; however, there are no guidelines for six of the 14 pesticides. The most common pesticides were 2,4-D and MCPA, which occurred in 12 of the 14 waterbodies, Picloram, which occurred in 9 of the 14 waterbodies, and Clopyralid, which occurred in 8 of the 14 waterbodies. These pesticides control the growth of broadleaf herbaceous plants and woody shrubs.

4.6.3.5 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 60 upstream oil/gas facilities, nine oil/gas processing facilities, 10 commercial facilities, two municipal water and waste water facilities and one chemical manufacturing facility have released pollutants continuously or sporadically into the air in the subwatershed since 2002. Pollutants from the upstream oil/gas facilities include volatile organic compounds (VOCs), carbon monoxide (CO), nitrous oxide ($N_2O$) and particulate matter < 10 µm in size, while those from the oil/gas processing facilities include VOCs, $N_2O$, CO, some alcohols, hydrocarbons (e.g., xylene) and hydrochloric acid (HCl). The commercial facilities have released CO, $N_2O$, sulphur dioxide ($SO_2$), VOCs, a suite of hydrocarbons as well as Cu- and Cr-containing chemicals. The chemical plant has released a suite of alcohols and other hydrocarbons (e.g., xylene) into the air. Pollutants from the municipal water and waste water treatment facilities include ammonia ($NH_3$), phosphorus, nitrate ($NO_3^-$) and several heavy metals (e.g., Cd, Hg and Pb) and have been released primarily into the Red Deer River (NPRI, 2008).

**Table 81.** Pesticide concentrations in waterbodies in the Blindman River subwatershed. n = sample size. All concentrations in µg/L. The most common pesticides are highlighted.

| Waterbody | Pesticide | Mean range * | Maximum | CCME PAL | n |
|---|---|---|---|---|---|
| Birchcliff Creek | Clopyralid | 0.114-0.124 | 0.227 | --- | 2 |
| | Imazamethabenz-methyl | 1.389 | 2.686 | --- | 2 |
| | MCPA | 0.069-0.071 | 0.137 | 2.6 | 2 |
| Blindman River | 2,4-D | 0.006-0.010 | 0.105 | 4.0 | 137 |
| | Bis(2-ethylhexyl) phthalate | 4.571-5.285 | 29.0 | --- | 7 |
| | Bromoxynil | 0.0003-0.0056 | 0.008 | 5.0 | 137 |
| | Butylbenzyl phthalate | 10.00-10.71 | 50.0 | --- | 7 |
| | Clopyralid | 0.001-0.020 | 0.059 | --- | 132 |
| | Di-n-butyl phthalate | 0.714-1.285 | 3.00 | 19.0 | 7 |
| | Dicamba | 0.0002-0.011 | < 0.020 | 10.0 | 137 |
| | Hexadecanoic acid | 0.714-2.857 | 3.00 | 4.0 | 7 |
| | MCPA | 0.002-0.007 | 0.041 | 2.6 | 137 |
| | MCPP | 0.001-0.006 | 0.093 | --- | 132 |
| | Picloram | 0.010-0.015 | 0.193 | 29.0 | 137 |
| | Triclopyr | 0.017-0.023 | 0.195 | --- | 68 |
| Golf Course Creek | 2,4-D | 0.0463 | 0.061 | 4.0 | 3 |
| | Bromoxynil | 0.003-0.007 | 0.010 | 5.0 | 3 |
| | Clopyralid | 0.022-0.029 | 0.047 | --- | 3 |
| | Dicamba | 0.015-0.016 | 0.027 | 10.0 | 3 |
| | Imazamethabenz-methyl | 0.105-0.139 | 0.316 | --- | 3 |
| | MCPA | 0.049 | 0.104 | 2.6 | 3 |
| | MCPP | 0.064 | 0.087 | -- | 3 |
| | Picloram | 0.031-0.034 | 0.092 | 29.0 | 3 |
| Gull Lake Diversion | 2,4-D | 0.009-0.011 | 0.017 | 4.0 | 3 |
| | Dicamba | 0.005-0.008 | 0.014 | 10.0 | 3 |
| | MCPA | 0.006-0.008 | 0.012 | 2.6 | 3 |
| | Picloram | 0.021-0.024 | 0.063 | 29.0 | 3 |
| | Triclopyr | 0.022-0.029 | 0.067 | --- | 3 |
| Honeymoon Creek | 2,4-D | 0.003-0.006 | 0.006 | 4.0 | 2 |
| | Clopyralid | 0.015-0.030 | 0.030 | -- | 2 |
| | Dicamba | 0.009-0.012 | 0.018 | 10.0 | 2 |
| | Imazamethabenz-methyl | 0.131-0.157 | 0.263 | --- | 2 |
| | MCPA | 0.008-0.010 | 0.015 | 2.6 | 2 |
| | Triclopyr | 0.007-0.012 | 0.013 | --- | 2 |
| Lambe Creek | Triclopyr | 0.205 | 0.205 | --- | 1 |
| Lloyd Creek | Bromoxynil | 0.001-0.002 | 0.002 | 5.0 | 3 |
| | Dicamba | 0.004-0.017 | 0.011 | 10.0 | 3 |
| | MCPA | 0.002-0.006 | 0.007 | 2.6 | 3 |
| North Creek | 2,4-D | 0.008-0.011 | 0.016 | 4.0 | 2 |
| | Picloram | 0.046 | 0.058 | 29.0 | 2 |

| | | | | | |
|---|---|---|---|---|---|
| Northeast Creek | 2,4-D | 0.070 | 0.01 | 4.0 | 2 |
| | Picloram | 0.025-0.027 | 0.049 | 29.0 | 2 |
| | Triclopyr | 0.019-0.024 | 0.037 | --- | 2 |
| Parkland Creek | 2,4-D | 0.067-0.069 | 0.143 | 4.0 | 4 |
| | Bromoxynil | 0.002-0.005 | 0.006 | 5.0 | 4 |
| | MCPA | 0.002-0.006 | 0.008 | 2.6 | 4 |
| | MCPP | 0.038-0.041 | 0.094 | --- | 4 |
| | Picloram | 0.119-0.123 | 0.477 | 29.0 | 4 |
| Sailing Club Creek | 2,4-D | 0.109 | 0.194 | 4.0 | 3 |
| | Clopyralid | 0.307 | 0.433 | -- | 3 |
| | Dicamba | 0.006-0.019 | 0.018 | 10.0 | 3 |
| | Imazamethabenz-methyl | 1.107 | 2.689 | -- | 3 |
| | MCPA | 0.045 | 0.067 | 2.6 | 3 |
| | MCPP | 0.031-0.032 | 0.054 | --- | 3 |
| | Picloram | 0.302 | 0.446 | 29.0 | 3 |
| Sonrise Creek | 2,4-D | 0.003-0.006 | 0.009 | 4.0 | 3 |
| | Bromoxynil | 0.914-0.916 | 2.68 | 5.0 | 3 |
| | Clopyralid | 0.008-0.021 | 0.025 | --- | 3 |
| | Imazamethabenz-methyl | 0.110-0.143 | 0.33 | --- | 3 |
| | MCPA | 0.007-0.010 | 0.02 | 2.6 | 3 |
| | Trifluralin | 0.001-0.004 | < 0.005 | 0.2 | 3 |
| Sucker Creek | 2,4-D | 0.227 | 0.242 | 4.0 | 2 |
| | MCPA | 0.062 | 0.101 | 2.6 | 2 |
| | MCPP | 0.026-0.029 | 0.052 | --- | 2 |
| | Picloram | 0.812 | 1.360 | 29.0 | 2 |
| Weise Street Creek | 2,4-D | 0.088 | 0.136 | 4.0 | 2 |
| | Clopyralid | 0.018-0.028 | 0.035 | --- | 2 |
| | Imazamethabenz-methyl | 0.024-0.049 | < 0.05 | --- | 2 |
| | MCPA | 0.074 | 0.101 | 2.6 | 2 |
| | MCPP | 0.025-0.027 | < 0.05 | --- | 2 |
| | Picloram | 0.306 | 0.432 | 29.0 | 2 |
| Wilson Creek | 2,4-D | 0.348 | 0.948 | 4.0 | 3 |
| | Clopyralid | 0.124 | 0.219 | --- | 3 |
| | Dicamba | 0.002-0.015 | < 0.02 | 10.0 | 3 |
| | Imazamethabenz-methyl | 0.617 | 0.901 | --- | 3 |
| | MCPA | 0.147 | 0.215 | 2.6 | 3 |
| | MCPP | 0.004-0.007 | 0.011 | --- | 3 |

* 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 Birchcliff Creek, water samples were collected in November 2001 and October 2003; in Blindman River, water samples were collected from July 1970-December 2006 (data from Alberta Environment and CAESAA); in Golf Course Creek, water samples were collected on July 2001, October 2003, and May 2004; in the Gull Lake Diversion, water samples were collected in April 2002 and from September-November 2003; in Honeymoon Creek and Northeast Creek, water samples were collected in October 2003 and May 2004; in Lambe Creek, water samples were collected in October 2003; in Lloyd Creek, water samples were collected in April and June 1997; in North Creek, water samples were collected in March and September 2000; in Parkland Creek and Sucker Creek, water samples were collected in April and September 2000; in Sailing Club Creek, water samples were collected in March and from July-October 2000; in Sunrise Creek and Wilson Creek, water samples were collected from February-October 2000; in Weise Street Creek, water samples were collected in August and September 2000 (data from Alberta Environment).

#### *4.6.4 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.

##### 4.6.4.1 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 water courses in the Blindman River subwatershed is about 600 km (Figure 187) (AAFC-PFRA, 2008). The major streams in the subwatershed are Anderson Creek, Boyd Creek, Lloyd Creek, Potter Creek, Rainy Creek and Sylvan Creek. Crestomere Lake, Crooked Lake, Cygnet Lake, Grim Lake, Gull Lake and Sylvan Lake are the major lakes of the subwatershed. In addition, there are numerous small creeks and sloughs (Government of Canada, 2006).

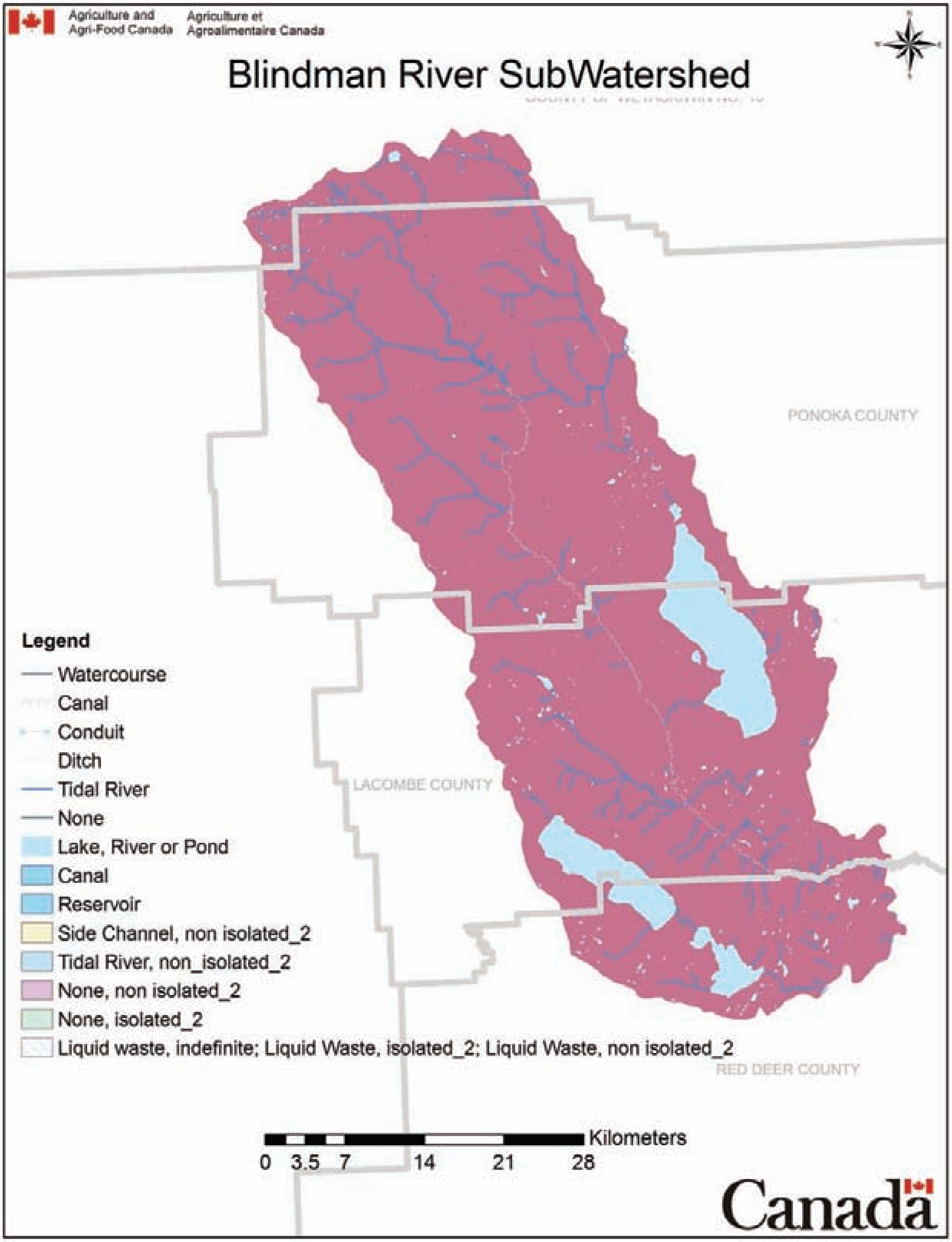



**Figure 187.** Waterbodies in the Blindman River subwatershed (AAFC-PFRA, 2008).

Alberta Environment has been monitoring water discharge rates at four locations in the Blindman River subwatershed: below the confluence of Anderson Creek and Blindman River near Bluffton (real-time active, 05CC008), in Lloyd Creek (active, 05CC009), in Blindman River near Blackfalds (real-time active, 05CC001) and in Sylvan Creek (discontinued, 05CC901) (Government of Alberta, 2008c).

Near Bluffton, discharge rates of the Blindman River are highest in spring, ranging from 1-2 $m^3$/sec (April-May) and then decline throughout the remainder of the year to about 0.1-0.2 $m^3$/sec (June-October). Historically, discharge rates show a similar trend, but have reached maxima as high as 6 $m^3$/sec and minima as low as 0.03 $m^3$/sec (Figure 188) (Government of Alberta, 2008c).

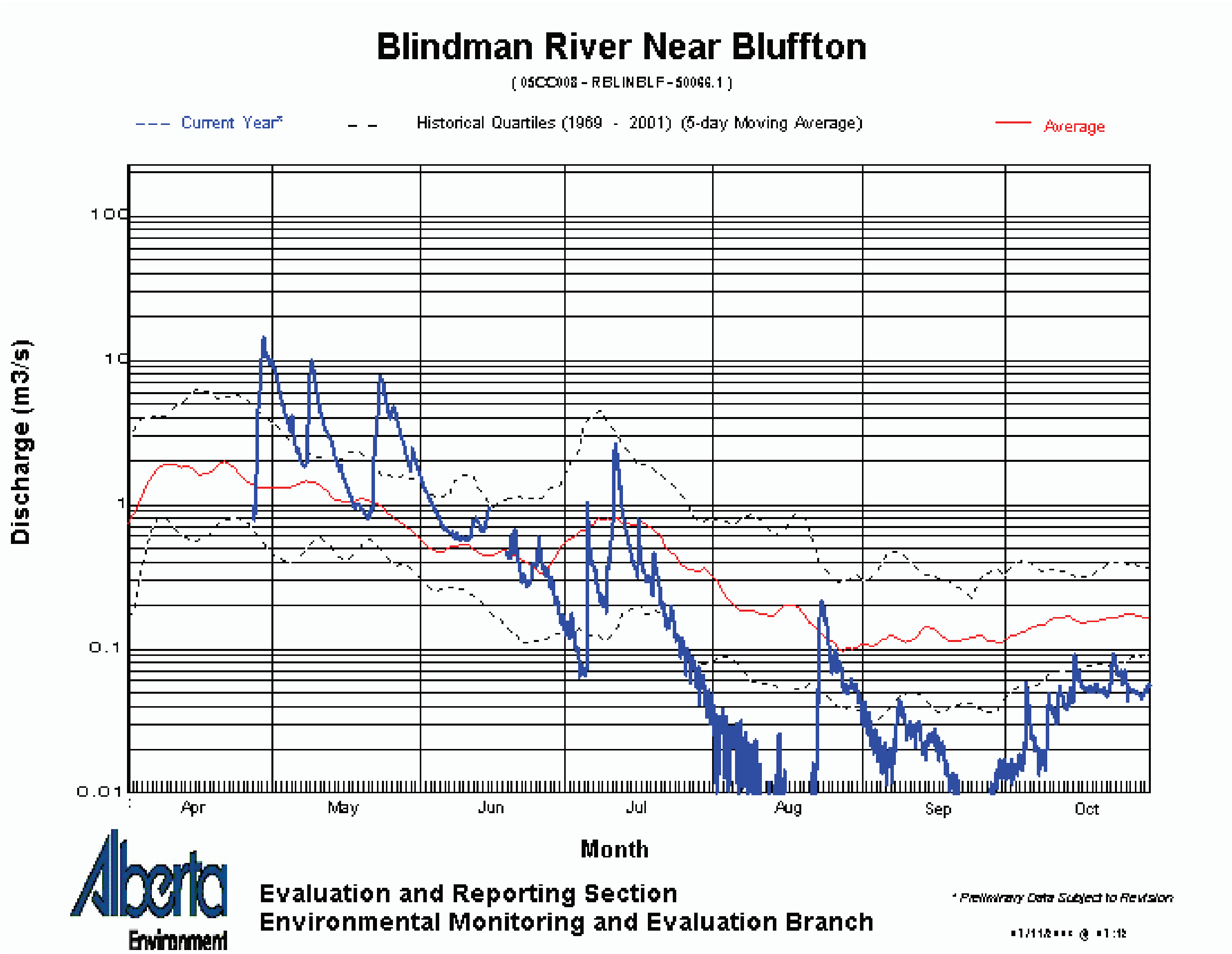



**Figure 188.** Discharge rates of the Blindman River near Bluffton (Government of Alberta, 2008c). "Current year" indicates water discharge rates in 2008.

Near Blackfalds, discharge rates of the Blindman River are also highest in spring, ranging from 2-5 $m^3$/sec (April-May) and then decline throughout the remainder of the year to about 0.4-1.0 $m^3$/sec (June-October). A mid-summer discharge peak in July reaches up to about 3 $m^3$/sec. Historically, discharge rates show a similar trend, but have reached maxima as high as 20 $m^3$/sec and minima as low as 0.2-0.3 m$^3$/sec (Figure 189). Overall, discharge rates are higher at Blackfalds than further upstream near Bluffton (Government of Alberta, 2008c).

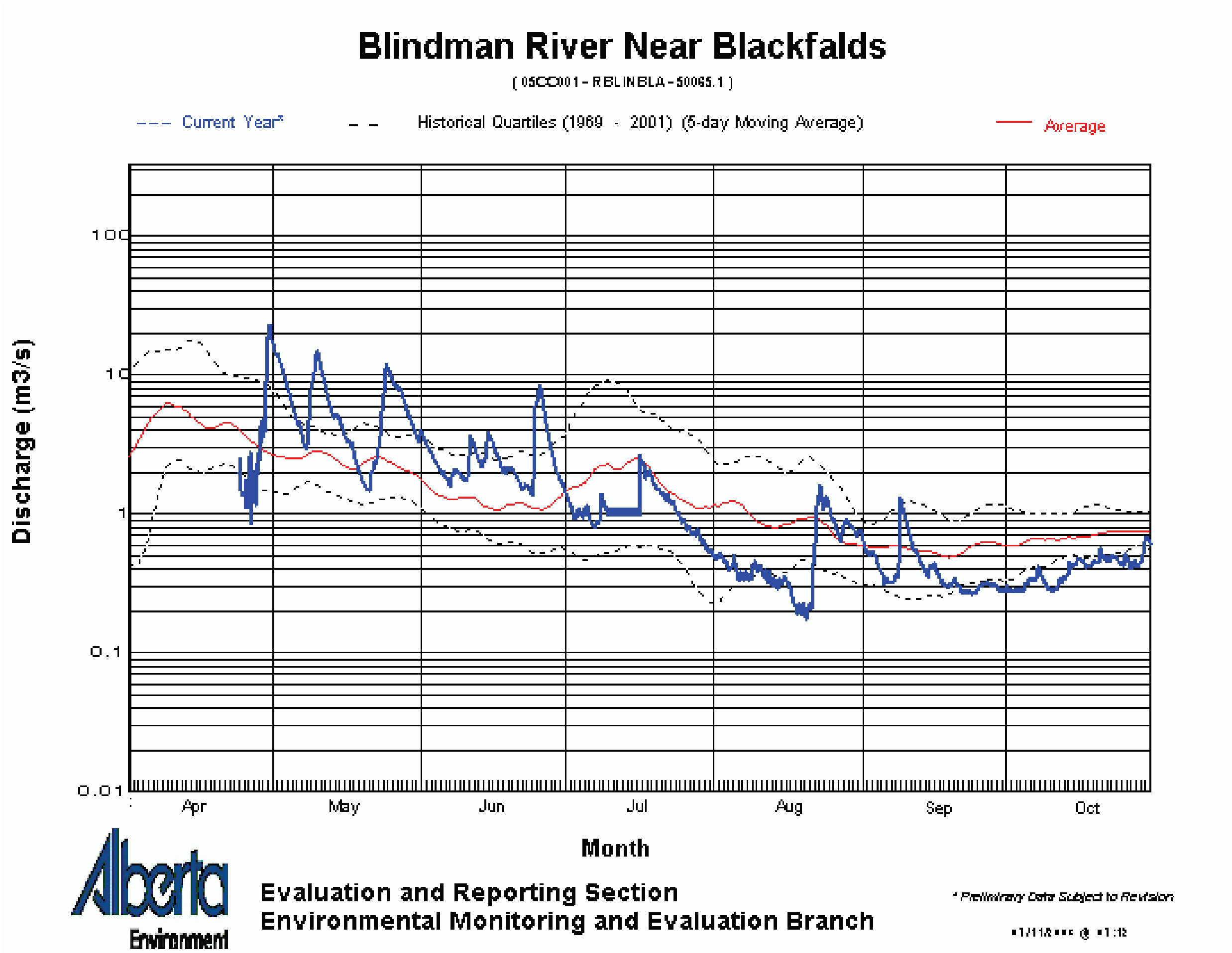



**Figure 189.** Discharge rates of the Blindman River near Blackfalds (Government of Alberta, 2008c). "Current year" indicates water discharge rates in 2008.

Water discharge rates at both Blindman River station were well above average levels in the spring and early summer 2008, when they exceeded 10 m$^3$/sec for short periods. Thereafter, discharge rates were similar to or substantially lower than average levels, e.g., near Bluffton (Figures 188, 189) (Government of Alberta, 2008c).

There are no major dams located in the Blindman River subwatershed; however, there are numerous smaller water infrastructures in the subwatershed, e.g., small dams, sluices, weirs and dykes, which control water flow.

4.6.4.2 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 Blindman River subwatershed.

#### 4.6.4.3 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 Blindman River subwatershed, 10,404 ha (or 4.9% of the total area of the subwatershed) of land does not contribute to the drainage of the subwatershed (Figure 190). These areas are located primarily in the southeastern area of the subwatershed, e.g., south and east of Gull Lake, south of Sylvan Lake and west of Red Deer and are areas of low relief and a flatter topography compared to the remainder of the subwatershed (Figure 191) (AAFC-PFRA, 2008).

The Blindman River has had two high streamflow advisories in response to high precipitation events. The first was issued on June 17, 2005, and the second was issued on June 23, 2005 (Alberta Environment, 2008c).

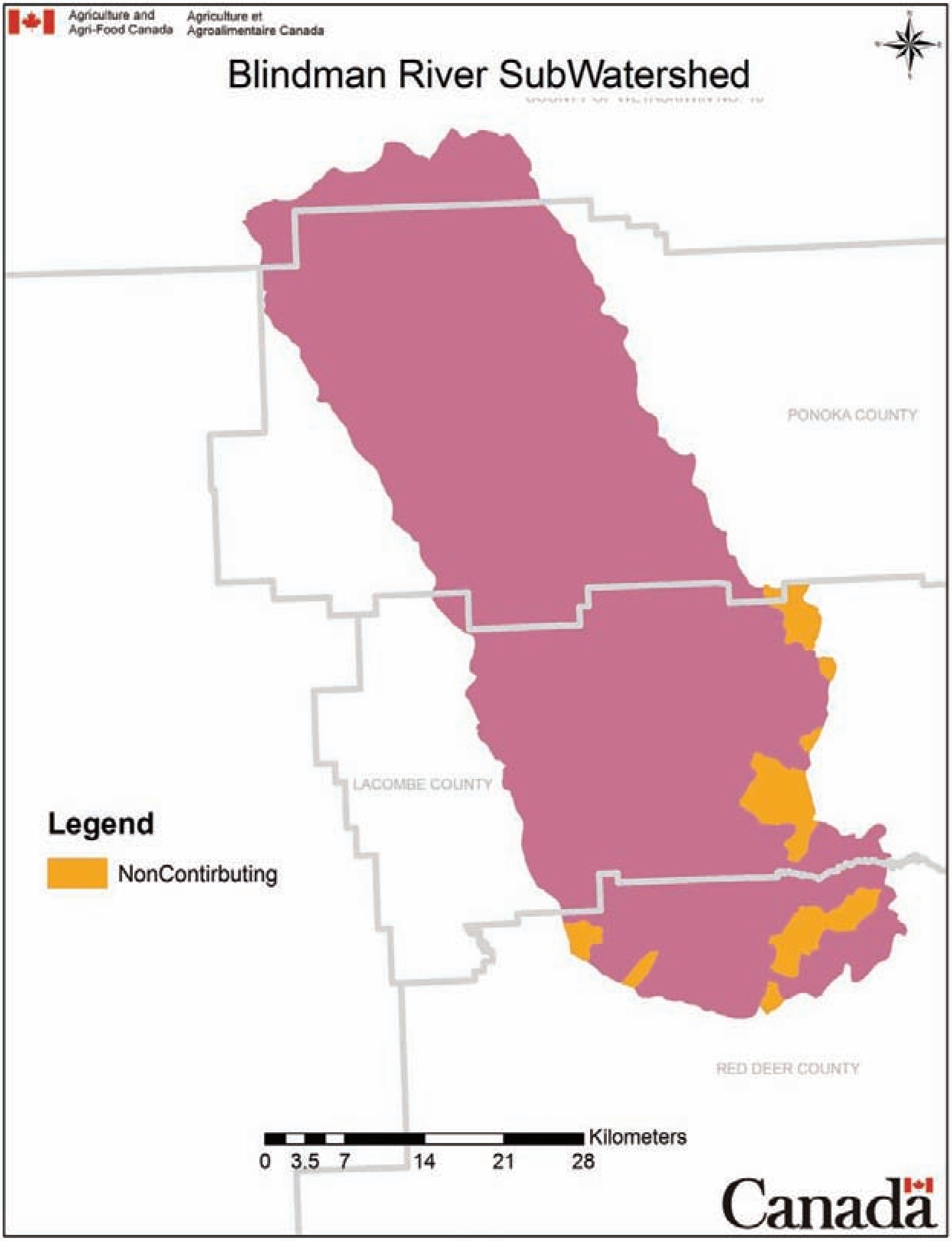



**Figure 190.** Non-contributing drainage area in the Blindman River subwatershed (AAFC-PFRA, 2008).

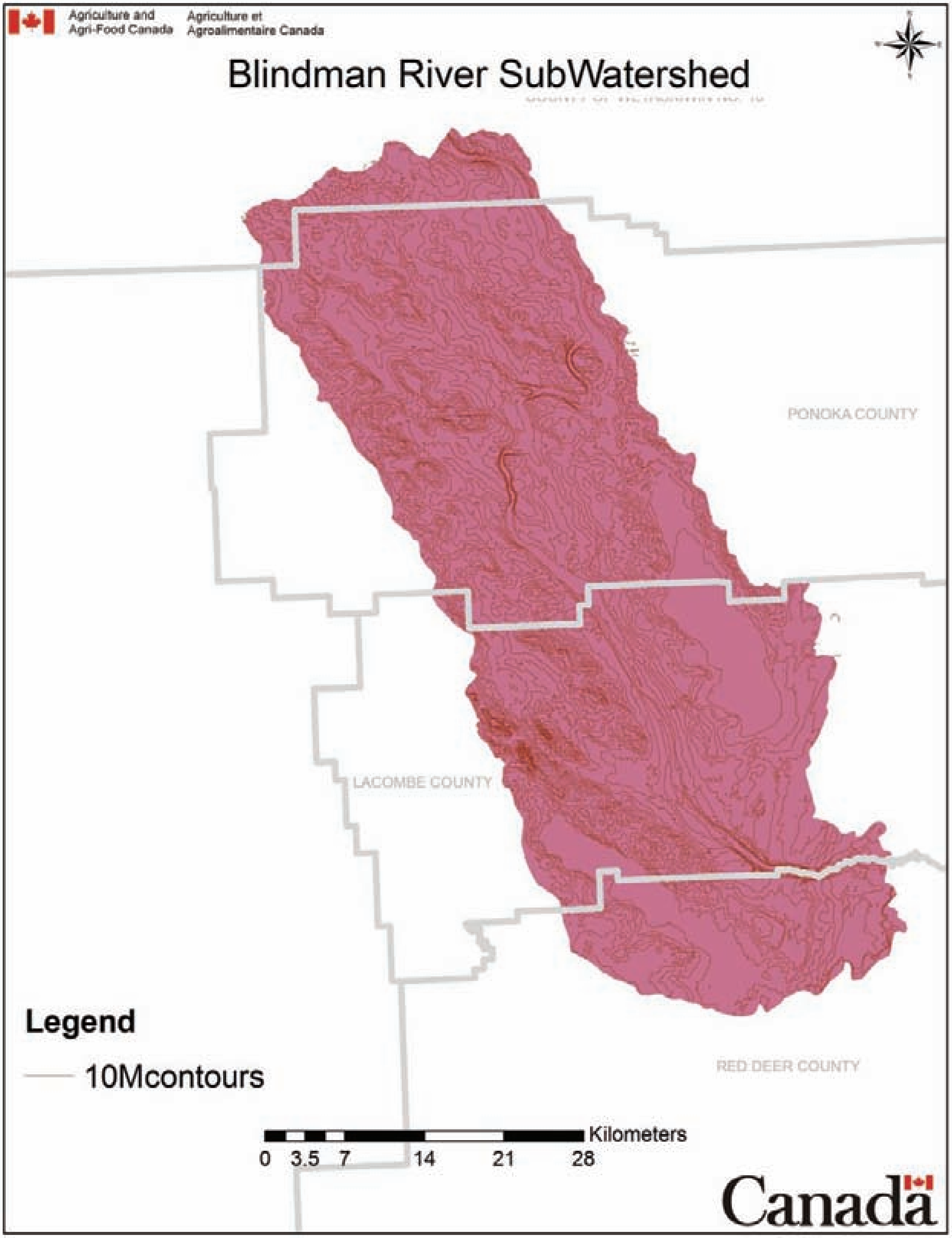



**Figure 191.** Topography (10-m contour intervals) of the Blindman River subwatershed (AAFC-PFRA, 2008).

#### 4.6.4.4 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 Blindman River subwatershed, 1,746 surface water licenses and 1,237 groundwater licenses have been issued for water diversion projects (Figures 192, 193, respectively) (AAFC-PFRA, 2008). They are distributed throughout the entire subwatershed.

About 12.96 million $m^3$ of surface and groundwater are diverted annually in the Blindman River subwatershed (Government of Alberta, 2008d). The most prominent use of surface water is water management (82% of total surface water diversions), irrigation (6% of total surface water diversions) and commercial operations (6% of total surface water diversions), while the most prominent users of groundwater are municipalities (50% of total groundwater diversions) and agricultural (22% of total groundwater diversions) and industrial operations (22% of total groundwater diversions) (Table 82). The majority of water diverted in the entire subwatershed comes from surface water sources, e.g., lakes, streams and rivers (60%) (Government of Alberta, 2008d). Additional groundwater diversion information is provided in HCL (2001a, 2003a, 2005).

**Table 82.** Surface and groundwater diversions in the Blindman River 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 | 228,542 | 1,147,260 |
| Commercial | 429,075 | 231,918 |
| Habitat enhancement | 225,730 | --- |
| Industrial | --- | 1,130,665 |
| Irrigation | 492,150 | --- |
| Management of fish | 1,230 | 6,170 |
| Municipal | --- | 2,631,316 |
| Other purposes specified by the Director | --- | 6,293 |
| Recreation | 2,000 | 62,515 |
| Water management | 6,361,940 | --- |
| **Total** | **7,740,667** | **5,216,136** |
| **Grand total** | | **12,956,803** |

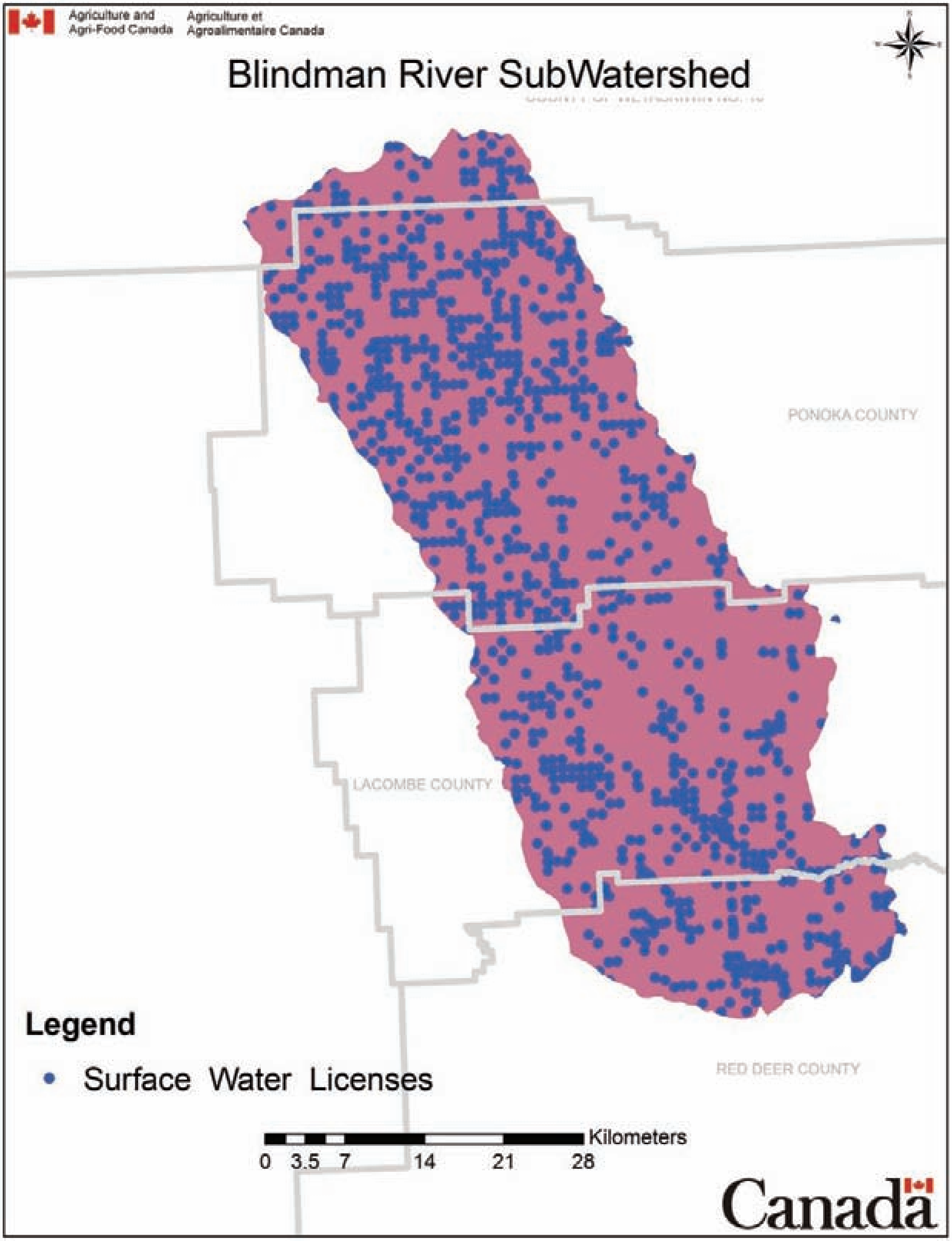



**Figure 192.** Surface water licenses in the Blindman River subwatershed (AAFC-PFRA, 2008).

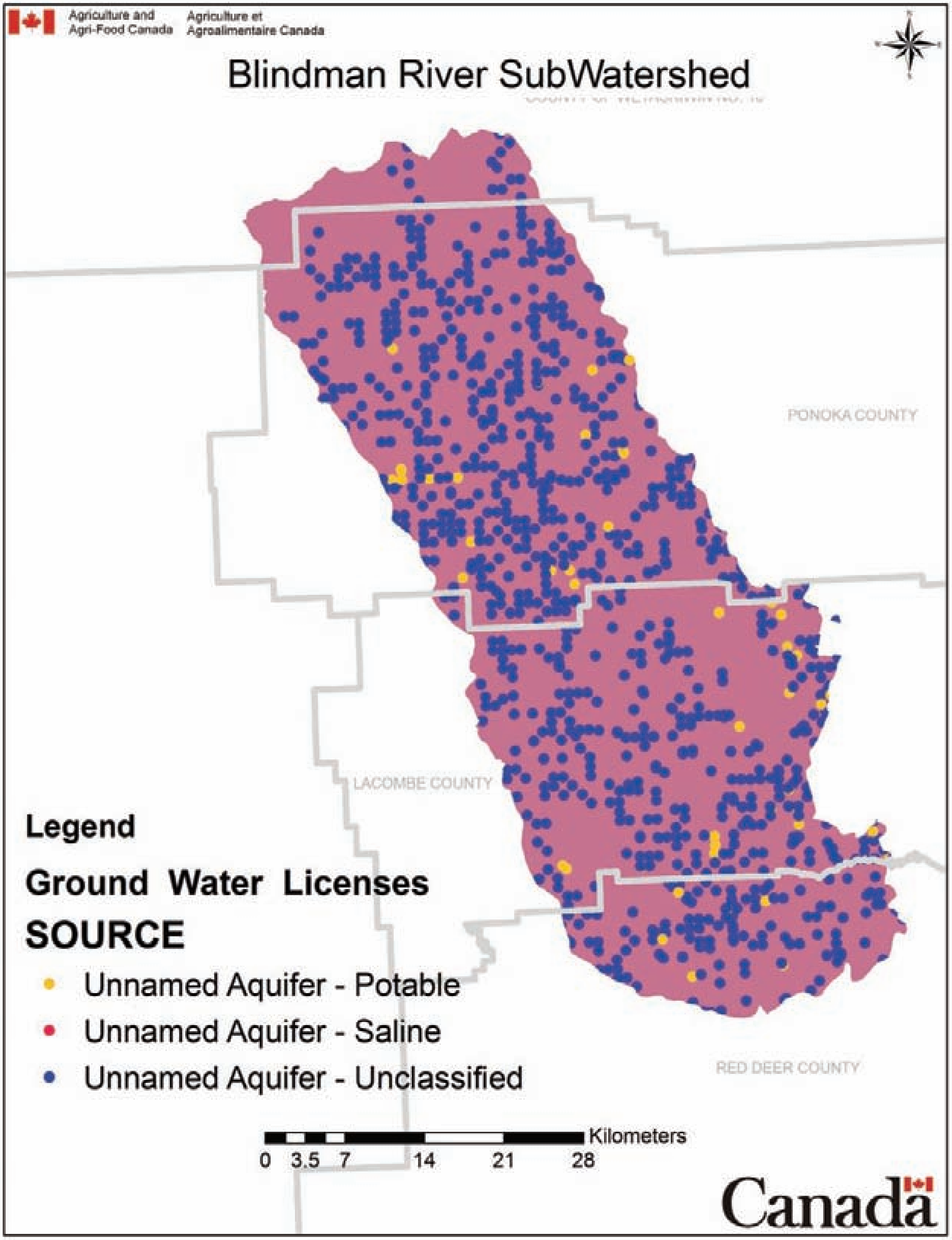



**Figure 193.** Groundwater licenses in the Blindman River subwatershed (AAFC-PFRA, 2008).

#### 4.6.4.5 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 Blindman River subwatershed has nearly 100 freshwater springs, most of which are located in the vicinity or along Boyd Creek, Lloyd Creek and the Blindman River (Bluffton-Rimbey-Bentley corridor).

The Blindman River subwatershed lies in the counties of Lacombe, Ponoka, Red Deer and Wetaskiwin No. 10. Groundwater assessments have been conducted in the first three of these counties by HCL (2001a, 2003a, 2005). The assessments indicated that most of the area in the headwaters of the Blindman River and Lloyd Creek is a groundwater discharge area (i.e., water moves from groundwater reservoirs to the surface), whereas the middle and lower reaches of the Blindman River towards the Red Deer River are primarily groundwater recharge areas (i.e., water moves from the surface into groundwater reservoirs). 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 (2001a, 2003a, 2005).

### *4.6.5 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.

#### 4.6.5.1 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 Blindman River subwatershed.

#### 4.6.5.2 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.

Fish populations have been assessed in one stream and two lakes in the Blindman River subwatershed: Blindman River, Gull Lake and Sylvan Lake. The predominant species in the Blindman River include longnose sucker, white sucker and mountain whitefish (Figure 194). There does not appear to have been a significant change in the populations of these species over this time period ($p > 0.9$); however, there may not be enough data replicates to provide an accurate analysis. The predominant species in Gull Lake are lake whitefish, yellow perch and northern pike. There have been no significant changes in the populations of these species over the sampling period ($p > 0.2$). Yellow perch were found the most consistently over the sampling period (Figure 195). The predominant species in Sylvan Lake are emerald shiner, lake whitefish and white sucker. There have been no significant changes in the populations of lake whitefish ($p > 0.3$) or sport fish populations (i.e., walleye, northern pike) ($p > 0.2$) over the sampling period. Of interest is the complete lack of emerald shiner captures until 2005, when over 11,000 specimens were collected (Figure 196). Lake whitefish and yellow perch were the only species collected consistently every year throughout the sampling program.

The mountain whitefish lives in mountain streams and lakes, favoring clear cold water and large deep pools at least 1 m deep. They are bottom feeders, stirring up the substrate with pectoral and tail fins to expose insect larvae and other invertebrates, including snails, crayfish and amphipods. Their main feeding time is in the evening, but they will also take drifting prey during the day. The mountain whitefish frequently feeds in the lower strata of streams, but populations may rise to the surface to prey on hatching insects, including mayflies. The spawning season is from October to early December, when water temperatures are 2-6 °C. The fish seek out areas of coarse gravels or cobbles at depths of at least 75 cm, and scatter the non-adhesive eggs so that they sink into the interstices. The eggs then develop slowly through the winter (6-10 weeks), hatching in the early spring. They are considered to be a barometer of good water quality (Nelson and Paetz, 1992; Scott and Crossman, 1998).

The longnose sucker inhabits cold, clear waters. It is a bottom-feeding fish, eating aquatic plants, algae and small invertebrates. They are preyed upon by larger predatory fish, such as bass, walleye, trout, northern pike, muskellunge and burbot. They are fished for game and food and also used as bait to catch the larger predators (Nelson and Paetz, 1992; Scott and Crossman, 1998).

The white sucker is a bottom feeding fish and spend most of its time in shallow, warm waters, where it searches for aquatic plants, algae and small invertebrates, particularly worms and crustaceans. It makes its homes in holes and areas around windfalls or other underwater obstructions. White suckers lay their eggs among pebble and gravel beds in lake and river shallows during the spring. They have been accused of consuming large quantities of eggs from more desirable food and sport fish species, but there is no conclusive evidence to support this contention (Nelson and Paetz, 1992; Scott and Crossman, 1998).

Yellow perch inhabit lakes, ponds, pools of creeks and rivers and is also found in brackish water and in salt lakes. Most commonly found in clear water near vegetation; tends to shoal near the shore during spring. It feeds on immature insects, larger invertebrates, fishes and fish eggs during the day. Yellow perch are preyed upon by fishes and birds. It spawns from February-July (Nelson and Paetz, 1992; Scott and Crossman, 1998).

Northern 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).

Lake whitefish inhabit large rivers and cold freshwater lakes. It is a cool-water species that moves from shallow to deep water as warming occurs and back to shallow water in the cooler months. Primarily bottom feeders, lake whitefish eat crustaceans, snails, insects and other small aquatic organisms. Lake whitefish spawn in the fall. Its major predators are lake trout, northern pike, burbot, yellow walleye and even whitefish themselves (Nelson and Paetz, 1992; Scott and Crossman, 1998).

The emerald shiner is found commonly in large, deep lakes and rivers, though sometimes in smaller bodies of water as well. It is pelagic and avoids areas with aquatic vegetation. The emerald shiner feeds on small organisms, such as zooplankton and insects, but some algae and terrestrial insects have been found in their stomachs as well. It is a common fish and is often used as bait (Nelson and Paetz, 1992; Scott and Crossman, 1998).

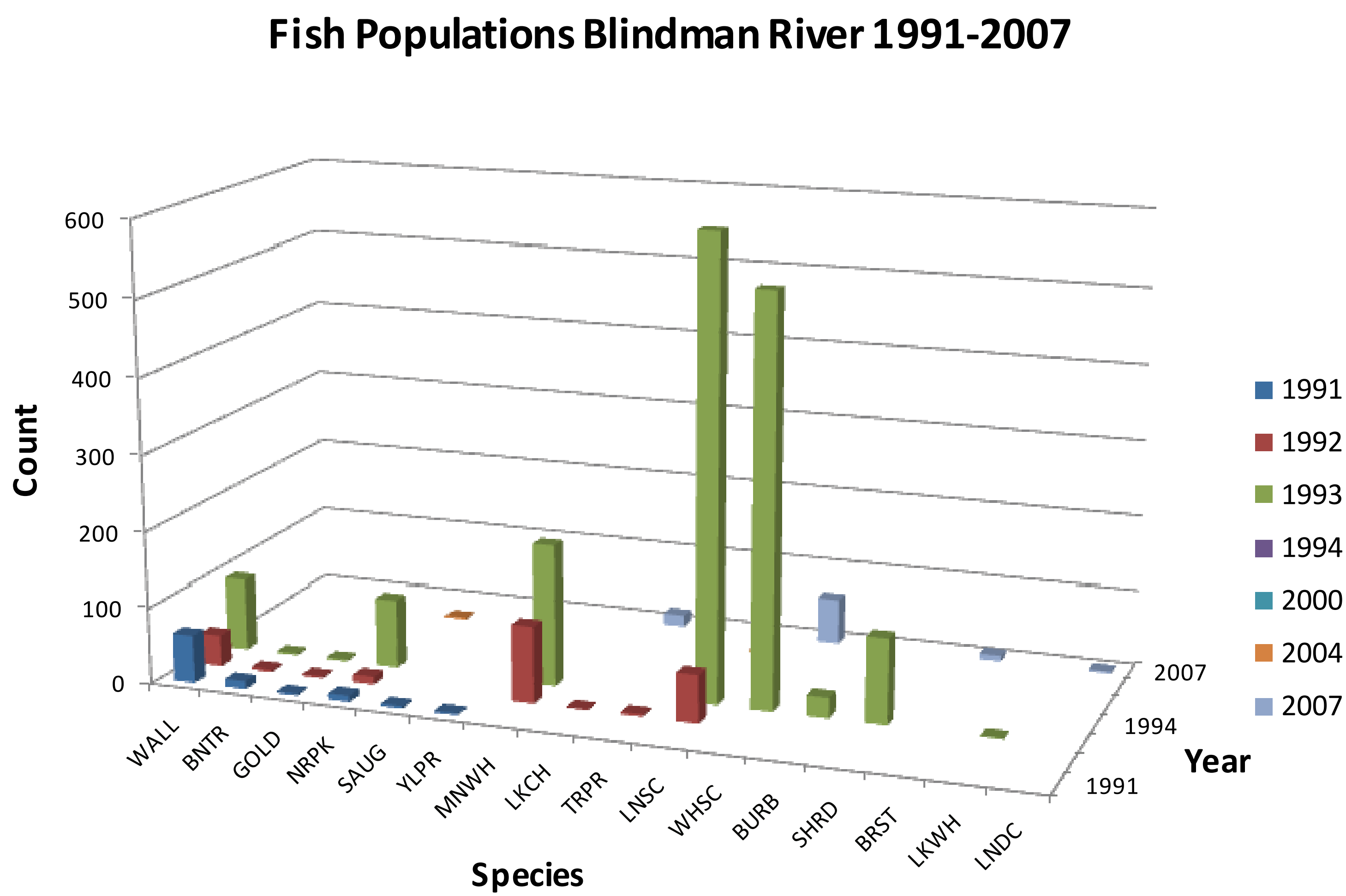



**Figure 194.** Fish populations in the Blindman River from 1991-2007 (data from Alberta Sustainable Resource Development, 2008). For full species names, please refer to Table 23.

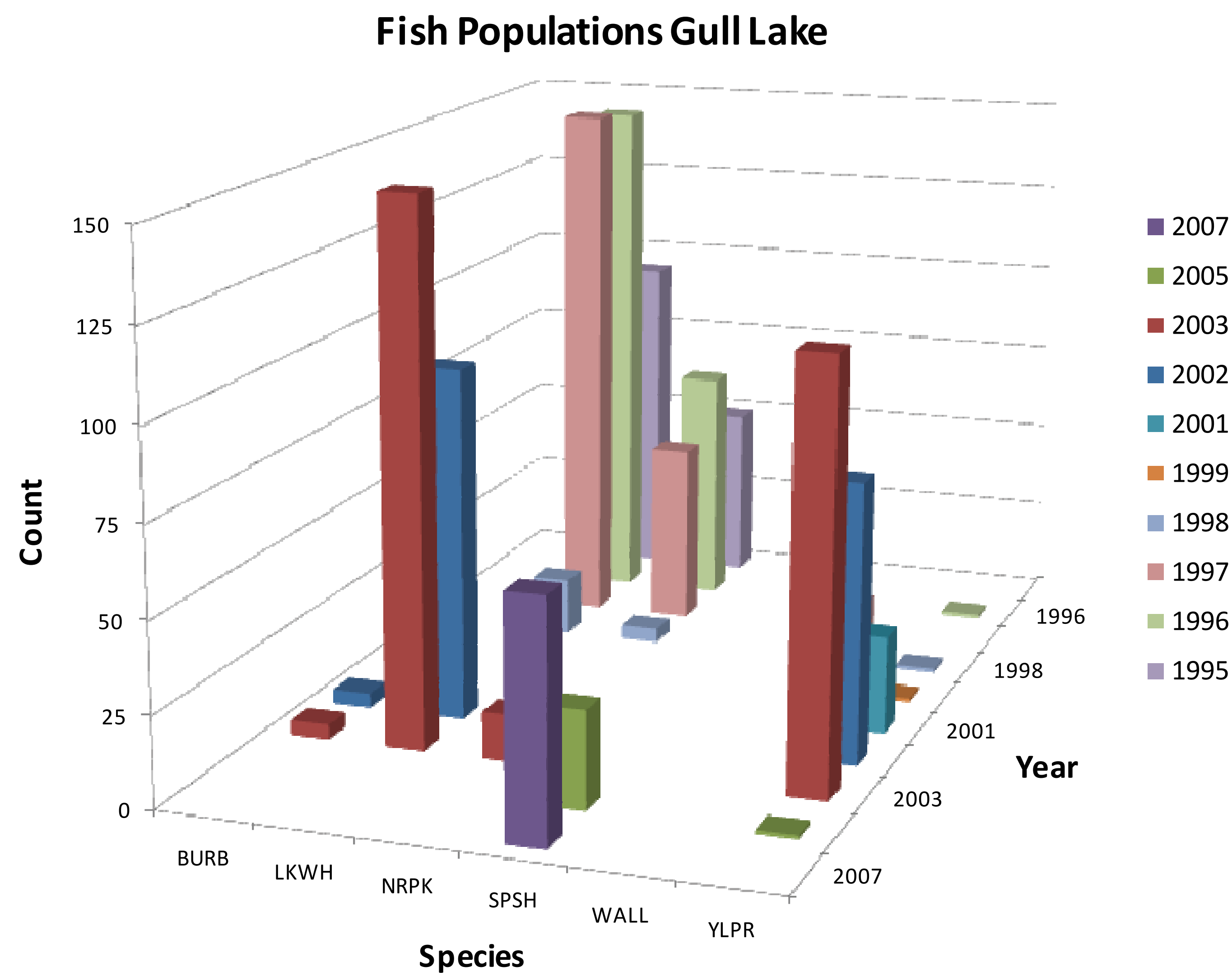



**Figure 195.** Fish populations in Gull Lake in 1995-1999, 2001-2003, 2005 and 2007 (data from Alberta Sustainable Resource Development, 2008). The y-axis has been modified for better data representation. For full species names, please refer to Table 23.

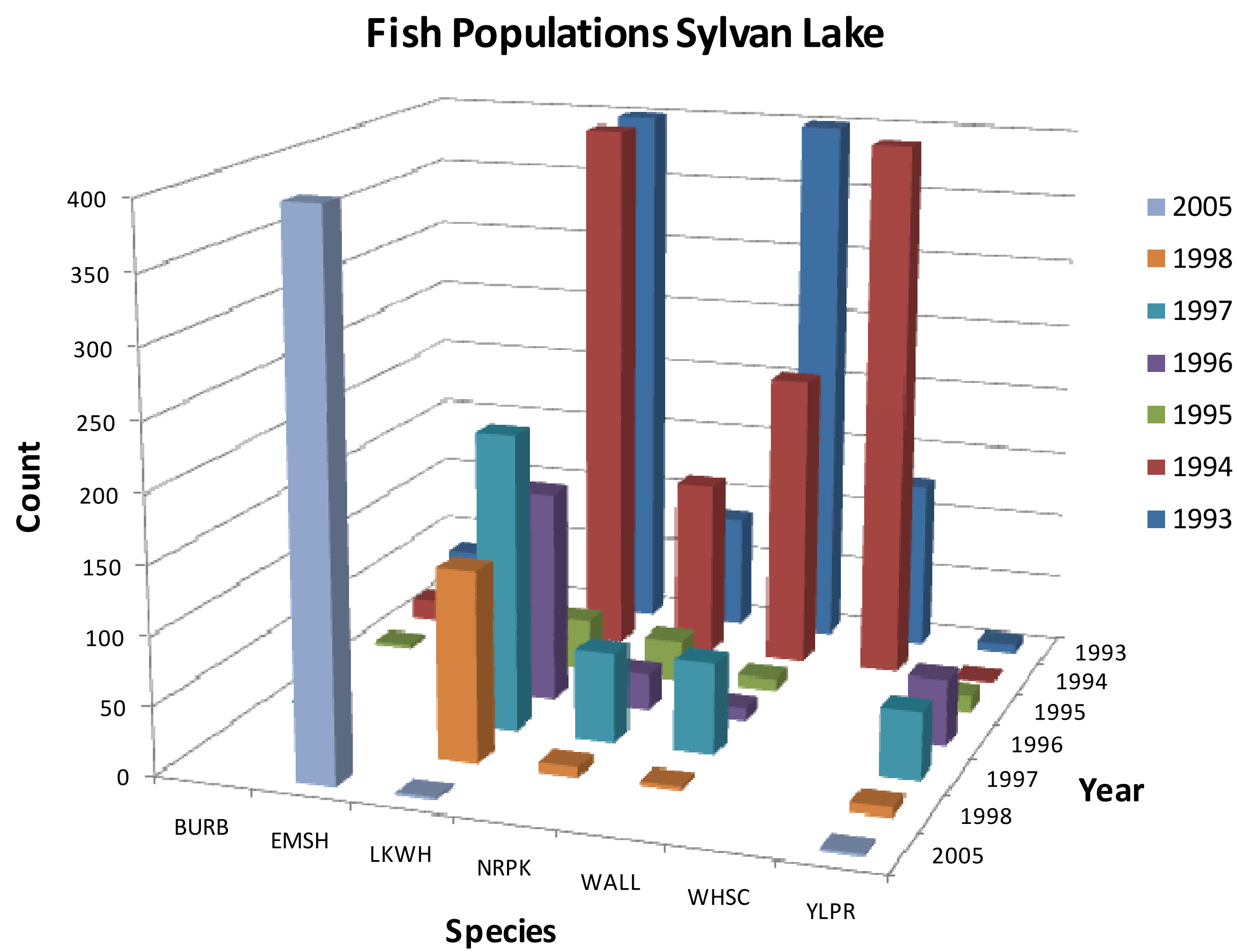



**Figure 196.** Fish populations in Sylvan Lake in 1993-1998 and 2005 (data from Alberta Sustainable Resource Development, 2008). The y-axis has been modified for better data representation. For full species names, please refer to Table 23.

4.6.5.3 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 Blindman River subwatershed is covered by annual and perennial croplands/pastures (26% and 39%, respectively). Deciduous forests cover about 11% of the land base, while exposed and developed lands, shrublands, grasslands, wetlands and mixed forests are uncommon (Figure 197, Table 83) (AAFC-PFRA, 2008).

**Table 83.** Land cover in the Blindman River subwatershed (AAFC-PFRA, 2008). The most prominent land cover types are highlighted.

| Land cover type | Area (ha) | Proportion of subwatershed area (%) |
|---|---|---|
| Waterbodies | 13,747 | 5.98 |
| Exposed land | 493 | 0.21 |
| Developed land | 4,740 | 2.06 |
| Shrubland | 3,168 | 1.38 |
| Wetland | 5,744 | 2.50 |
| Grassland | 1,549 | 0.67 |
| Annual cropland | 58,960 | 25.65 |
| Perennial cropland/pastures | 89,357 | 38.88 |
| Coniferous forests | 7,744 | 3.37 |
| Deciduous forests | 25,324 | 11.02 |
| Mixed forests | 1,051 | 0.46 |
| No data | 17,961 | 7.81 |
| **Total** | **229,837** | |

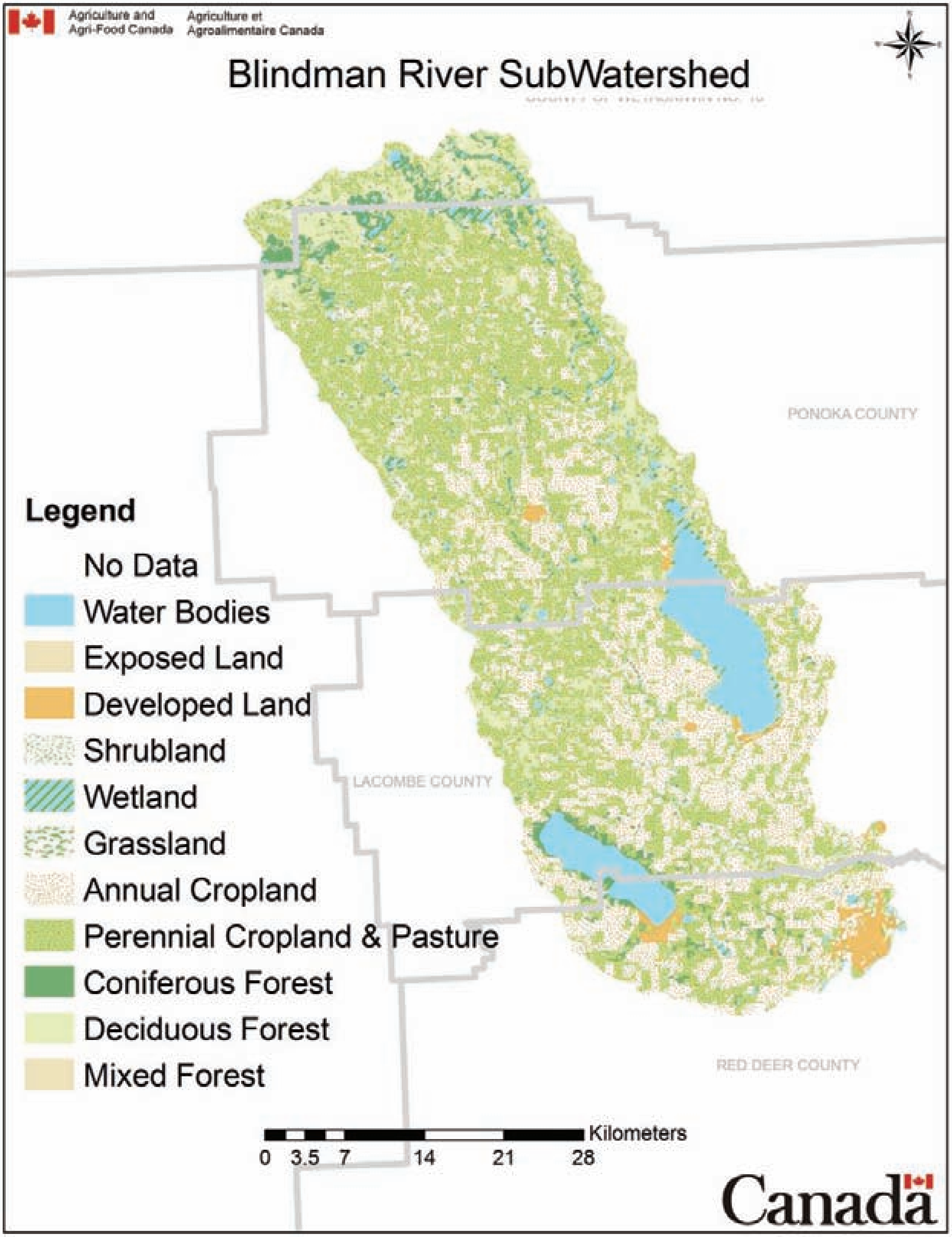



**Figure 197.** Land cover of the Blindman River subwatershed (AAFC-PFRA, 2008).

One Ecologically Significant Area has been identified in the Blindman River subwatershed: Gull Lake (Twp. 40-42, Rge. 28, W 5 to Rge. 1, W 5) (Alberta Environmental Protection, 1997). It is located in Ponoka County and Lacombe County and covers an area of 10,282 ha. The following factors make Gull Lake a provincially significant area:

- one of the largest and most productive water bird lakes in the Dry Mixedwood Subregion of Alberta
- large, relatively deep lake
- includes adjacent wetlands and natural shoreline, backshore willow, poplar and meadow habitat (particularly well-developed along the west-central and east sides of the lake)
- spawning, rearing and overwintering area for several fish species, including lake whitefish, northern pike, walleye, burbot and sauger; locally significant sport fishing lake
- large marshy pond in Secs. 11-13, Twp. 41, Rge. 1, W 5, and productive ponds in Secs. 24-25, Twp. 41, Rge. 28, W 4
- significant staging and production wetland for waterfowl, marsh birds and shorebirds
- great blue heron and large gull colonies located just outside study area boundary
- large esker adjacent to eastern shoreline
- former nesting area for piping plover (a COSEWIC endangered species in Canada and a red-listed species in Alberta)
- American white pelican (a blue-listed species in Alberta) foraging and loafing habitat; apparently increasing in numbers, expanding range into this part of Alberta

There are no nationally or internationally designated Ecologically Significant Areas in the subwatershed (Alberta Environmental Protection, 1997).

#### 4.6.5.4 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 Blindman River subwatershed is home to three species of special concern, i.e., native species, sub-species or ecologically significant units that warrant special attention to ensure their conservation. These are the monarch butterfly (*D. plexippus*), western toad (*B. boreas*) and yellow rail (*C. noveboracensis*). There are no endangered or threatened species in the subwatershed. Detailed descriptions of these species can be found in section 3.1.3.7.

### *4.6.6 Subwatershed Assessment*

The Blindman River subwatershed lies in the Lower Foothills, Central Mixedwood, Dry Mixedwood and Central Parkland Subregions and is biogeophysically complex. Livestock and agricultural intensities are low to medium and medium, respectively, relative to the Alberta average, and there are over 40 feedlots in the subwatershed. Most of them are located near urban centres, including the city of Red Deer and several towns. The Blindman River subwatershed has three provincial parks, two of which are located on Sylvan Lake and one on Gull Lake, the two largest waterbodies in the subwatershed. Resource exploration and extraction activities have created a complex network of linear disturbances (primarily roads) and contributed to the establishment of 2,670 active wells, most of which are natural gas wells. These land use practices along with encroachments by residential developments, the establishment of private beaches, boat lifts and marinas, as well as ATV trails and livestock grazing have significantly impaired riparian zones. For example, 49% of the riparian zones on Sylvan Lake are impaired (42% highly impaired), while those of Gull Lake are in even worse condition (64% impaired, 29% highly impaired). The degradation of riparian zones along waterbodies has contributed to the decrease in water quality. TP and TN concentrations in most streams/rivers in the subwatershed are above CCME PAL guidelines, and most have elevated fecal coliform bacterial concentrations. Generally, lake water quality is higher than streams/river water quality. In addition, 14 different pesticides have been detected in waterbodies in the subwatershed, although none exceeded current water quality guidelines. Parasite data were not located for any waterbody in the subwatershed. Sylvan and Gull Lakes are the two most prominent waterbodies and provide water resources for numerous activities. Altogether, 2,983 water diversion licenses have been issued in the subwatershed, which permit the diversion of 12.96 million $m^3$ of water annually. Most of this water is being used by municipalities and for water management activities. While no biodiversity assessment data were located for the Blindman River subwatershed, longnose sucker, white sucker, lake whitefish and mountain whitefish are the most common fish species. In addition, three SARA species of special concern inhabit the mostly perennial and annual cropland and pasture-dominated subwatershed.

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 Blindman River subwatershed receives a rating of "poor" for the condition indicators and a rating of "medium" for the risk indicators (Tables 84, 85). Overall, this subwatershed receives a ranking of "C-". There are 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) the extensive network of linear developments (roads), primarily due to natural resource exploration and extraction activities throughout the subwatershed, (2) nutrient and bacterial concentrations that occasionally exceed water quality guidelines, likely due to impaired riparian area health conditions and excessive agricultural runoff, municipal effluent and urban runoff that reach waterbodies throughout the subwatershed, (3) conversion of the land base from its natural state into annual and perennial croplands and pastures and (4) 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.

**Table 84.** Condition and risk indicator summary for the Blindman River subwatershed. Gray logos indicate data gaps.

**Condition Indicators**

**Risk Indicators**

**Table 85.** Condition and risk assessments of the Blindman River subwatershed. Indicators with a "poor" or "high" ranking are highlighted.

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