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LAC LA NONNE

Lac La Nonne Watershed
Stewardship Society

STATE OF THE WATERSHED REPORT
2006

Lac La Nonne State of the Watershed Report

Prepared for:
Lac La Nonne Watershed Stewardship Society and Partners
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Project Area:

Lac La Nonne Watershed

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2.0 Executive Summary

The Lac La Nonne watershed includes Lac La Nonne, Nakamun and Majeau Lakes that straddle both Lac Ste. Anne County and the County of Barrhead in central Alberta. Lac La Nonne is a popular recreational lake that experiences numerous blue-green algal blooms and has extensive aquatic vegetation growth, both of which are of concern to local residents and lake users.

The purpose of this report is to summarize and document all of the current environmental information for the Lac La Nonne watershed. This is an initial step that can be used for the development of a Lac La Nonne Watershed Management Plan in the future.

There is currently quite a bit of information available about the environmental status of Lac La Nonne but there are substantial information gaps that need to be filled, including environmental data on Nakamun and Majeau Lakes. These gaps need to be filled in order to develop the best and most comprehensive management plans for this watershed.

Based on the information gathered for this report, we conclude that overall the watershed health is good, with some obvious problem areas. Streams in the area are inputting excess nutrients into all three lakes, and will continue to reduce lake water quality.

A watershed management plan needs to be undertaken for the Lac La Nonne watershed.

Recommendations for this watershed fall into the following four categories:

1. Planning – This is an ongoing, regulatory approach which will include the watershed management planning process, and the municipal process (intermunicipal development plans, bylaws, others)

2. Stewardship – This is ongoing as well, and requires community involvement. Components of this step are education and awareness, use of cottage owner BMP's provided by organizations such as Living by Water and ALMS, better animal husbandry and agricultural land use practices, nutrient and manure management, and others.

3. Reclamation and restoration – This is the most invasive of all of the steps. This would involve activities such as fencing of riparian areas, off site watering, riparian restoration and revegetation, and others.

4. Data gaps – Significant data gaps will need to be filled to move forward with a Watershed Management Plan. These gaps include paleolimnology studies on the lake, an overall nutrient budget for each lake, and riparian health information.

The LWSS, municipal, provincial and federal governments must work together in order to improve the health and functionality of the Lac La Nonne watershed. Their efforts should include stewardship initiatives, education of residents, improvement of water quality in the lakes and tributaries, changes to the land use bylaws and continued improvement in sewage management practices.

3.0 Introduction

The purpose of this report is to summarize all available current and historic information on the Lac La Nonne watershed. The watershed includes Lac La Nonne as well as Nakamun and Majeau Lakes and straddles Lac Ste. Anne County and the County of Barrhead. It includes information on the watershed, stream and lake water quality/quantity, land-use and the potential effect of resource and land-use practices. In many cases, lake and tributary water quality data has been used as an indicator of the overall health of the watershed. Each section of this report is intended to provide and summarize known social, physical and environmental information. The report begins by summarizing public perceptions and concerns as to the status of their watershed, and then considers the physical aspects of the entire watershed, first at a broad scale, then focussing on the specific land and water resources. The report also identifies the jurisdictions of the various Federal, Provincial and Municipal regulators in an effort to decipher roles and mandates.

The report then outlines how state of the basin reporting fits into the greater context of watershed management planning in Alberta under Alberta Environment's *Water for Life* Strategy, and identifies legislation and policies affecting watershed management in Alberta. A special emphasis has been placed upon the role of this document in future planning in the Athabasca River basin, and how the report can aid local municipal planning.

This report will provide a benchmark against which the effectiveness of future stewardship activities and best management practices aimed at improving watershed health can be assessed. The information will provide landowners, stakeholders, municipalities and stewardship groups the information needed to make sound management decisions aimed at implementing beneficial management practices and developing possible solutions to protect and/or enhance their land and water resources. This report prioritizes the issues to be addressed and makes recommendations toward the development of strategies to address those issues and opportunities.

4.0 Public Perception and Concerns

4.1 Lac La Nonne Area Structure Plan Review Survey (1999)

In 1999, a survey was sent to Lac La Nonne residents asking for their input into the area structure plan review. Questions centered on perceived problems with the lake itself, land ownership, planning and development, recreation and environmental concerns. Areas of the survey dealing primarily with the lake itself and the surrounding environment are summarized below.

4.1.1. According to the survey respondents, things that are considered unpleasant about the Lac La Nonne area include:

- Algae
- High speed boats
- Dirty lake
- Poor water quality
- Unclean shorelines, no beach areas
- Lack of respect for nature
- Limitations on fishing
- No fish
- Poor water levels
- Weeds
- Too many geese
- Smell from lake
- Number of seadoos
- Sewage

Water quality and algae were identified as a common problem with the lake.

Things that are considered positive about the Lac La Nonne area include:

- Birds
- Waterfowl
- Deep lake
- Little commercial development
- Public boat dock
- Recreation
- Relatively undeveloped
- Wildlife
- Good fishing
- Public beach
- Scenery
- Snowmobile trails
- Winter access
- Sparse population

4.1.2. Lake Concerns

- Problems with property – Many people had concerns and/or problems with wave erosion on their property.
- Aesthetic condition and water quality of the lake for recreational use – The majority of responses dealt with weed and algal problems, and many listed lake odour as an issue.
- Issues of most concern regarding lake levels – Most respondents were concerned with the effect of lake levels on fish populations. Lake water levels were of moderate concern.

4.1.3. Recreation

- Problem areas in the physical condition of the lake – Again, many residents are concerned about weeds and algal growth. Some feel that the lake water is dirty and polluted.
- Problems with property – Many listed a soft or mucky bottom in the lake, along with poor beach quality.
- Common recreational activities around the lake include swimming, fishing, snowmobiling, ice fishing, cross country skiing, and boating.
- Most respondents felt that the current level of lake use was within an acceptable range.

4.1.4. Environmental Concerns

- Generally, respondents felt that a poor job has been done to protect environmentally sensitive regions of the lake area.
- Suggested protection measures included protecting marshlands, restricting cottage development, and placing restrictions on livestock operations.
- Most respondents have noticed a change in the water quality over time. Generally, the changes seen include algal growth and weed problems.
- Most respondents were not in favour of commercial fisheries on the lake.
- Most people feel that the dumping of sewage into the lake and agricultural operations have negatively impacted the sport fish populations in the lake.
- Most feel that Crown land should be used for wildlife habitat, hunting, watershed protection and bird watching, rather than for activities such as hiking and cross country skiing.

4.1.5. Zoning and Infrastructure

- Many respondents felt that weed control, water quality improvement, and protection of wildlife habitat were necessary measures for the management of the Lac La Nonne area.

- Sewage – Most common responses for the question regarding what residents used for sewage facilities included holding tanks and pumpouts. The majority used septic tanks or "other" for grey water disposal, but some responded "poured on ground". The "other" methods were not specified in the survey summary.

The results listed above were from a preliminary report only; no statistics were provided as to how many people received the survey, how many completed it, or the response percentage for each question.

4.2 Water's Edge Resource Group Watershed Survey (2003)

A toxic blue-green algal bloom in Lac La Nonne in August 2002 prompted public concern over water quality and lake health. In response to these concerns, Alberta Environment and the Water's Edge Resource Group (WERG) conducted a watershed stewardship survey in March 2003. Surveys were sent to approximately 1400 landowners, and 251 completed surveys were returned (WERG, 2004), the results of which are summarized below.

4.2.1 General Results

For a mail-out survey, the number of responses received back was very good. Out of the 251 respondents, over half were cottage owners, while others were acreage residents and agricultural producers. The vast majority of respondents supported the idea of establishing a multi-stakeholder watershed stewardship group in order to improve the quality of water within the Lac La Nonne watershed, and many were satisfied with the proposed committee structure that was provided for their review.

4.2.2 Public Perceptions of Water Quality

Overall, the survey respondents felt that the water quality in Lac La Nonne, Majeau Lake, Nakamun Lake and their associated tributaries had deteriorated with time, and rated lake water quality as poor (31%) to very poor (56%) during the 2002 season. The majority of respondents felt that the quality of the water flowing into Lac La Nonne through creeks and tributaries was poor (25%) to very poor (43%).
The main concerns identified included:

- Lake water level
- Algae
- Concern for birds, fish, wildlife and pets
- Concern for continued recreation
- Shoreline/aquatic vegetation
- Odour
- Contaminants
- Overuse of lake

4.2.3 Perceived Concerns and Opportunities

Survey recipients were asked to identify conditions or activities perceived to impact watershed health. The conditions and activities are listed below, and are ranked in order of importance or impact:

1. Low water levels
2. Application of agricultural fertilizers and/or other chemicals
3. Livestock grazing and/or manure management practices

4. Cottage septic/wastewater systems
5. Application of lawn fertilizers and/or other chemicals
6. Upstream on-farm/private/municipal drainage
7. Annual agricultural cropping practices
8. Water allocations or withdrawals
9. Lakeshore cottage/beach development
10. Clearing of riparian (streamside) and/or shoreline areas
11. Removal of lakeshore and aquatic vegetation
12. Local oil and gas activity
13. Erosion/sedimentation/runoff
14. Recreational activities (boating, swimming, others)
15. Other (included road construction and oiling, obstructions on inflow/outflow streams, high volume of public traffic, others).

68% of respondents also felt that the current quality of groundwater is a concern that should be addressed.

This section of the survey lists many stakeholder and resident concerns regarding the lake and what issues they feel should be addressed in a watershed management plan. This information should be consulted if terms of reference and a watershed management plan are written for the area.

4.2.4 Watershed Management Activities

When asked if they were aware of any water monitoring activities within the watershed, 74% stated they were not aware of any activities, and 86% stated they would be willing to make simple changes to their landscape and/or current land use practices to reduce nutrient inputs into the lake.

This survey was a valuable tool in soliciting many of the issues and concerns that watershed residents have. Overall, the comments provided by the respondents provide insight into their concerns regarding water quality, and may be a valuable resource in future watershed management planning.

5.0 Institutional and Regulatory Authorities

This section will provide a regulatory overview of the main legislation that impacts lakes and surface waterbodies in Alberta.

5.1 Federal Government

The *Canadian Environmental Protection Act* (CEPA) is the main federal law to protect the environment. With respect to water resources, CEPA empowers the federal government to create and enforce regulations regarding toxic substances, fuels, and nutrients. CEPA enables the federal government to undertake environmental research, develop guidelines and codes of practice, and conclude agreements with provinces and territories. Environment Canada administers CEPA, but assesses and manages the risk of toxic substances jointly with Health Canada.

Fisheries and Oceans Canada has the authority to protect fish and fish habitat under the guidelines of the *Fisheries Act* and the *Species at Risk Act*. Fish habitat by definition includes spawning grounds and nurseries, rearing, food supply and migration areas on which fish depend to carry out their life processes (Fisheries Act, 1985). It is their mandate to preserve healthy marine and freshwater aquatic ecosystems

in support of scientific, ecological, social and economic interests. The *Fisheries Act* prohibits any activity that results in the harmful alteration, disruption or destruction of fish habitat, protects fish populations from pollution and recommends mitigation measures where loss of habitat is unavoidable. Work carried out near a fish-bearing watercourse must have the approval of Fisheries and Oceans Canada, and failure to comply with the Act may result in fines or imprisonment.

5.2 Provincial Government

The Government of Alberta is committed to sustainable development through an integrated resource management (IRM) approach to protect the environment and manage Alberta's resources (Alberta Environment, 2002). IRM requires a comprehensive, interdisciplinary approach to the management of water, timber, air, public land, fish, wildlife, range, oil, gas and mineral resources. The Alberta Government recently initiated a province-wide comprehensive strategy called *Water for Life: Alberta's Strategy for Sustainability*. The purpose of the Strategy is to identify short-, medium- and long-term plans to effectively manage the quantity and quality of the province's water systems and supply. The three main goals of the strategy are to ensure that Albertans have a safe and secure drinking water supply, healthy aquatic ecosystems and reliable, quality water supplies for a sustainable economy (Alberta Environment, 2003). The provincial government uses both the *Water Act* and the *Environmental Protection and Enhancement Act* (EPEA) in order to enforce regulations regarding the preservation of Alberta's water supplies.

The *Water Act* supports the conservation and management of water, and allows for regional differences in water management to be reflected through the development of water management plans, as outlined in the *Framework for Water Management Planning,* released in 2002. The *Environmental Protection and Enhancement Act* is intended to support and promote the protection, enhancement and sustainable use of all aspects of the environment, from land to water. It covers conservation, reclamation, pesticide use, waste control and wastewater and storm drainage.

Other provincial acts that can be utilized to protect Alberta's water resources include the *Agricultural Operations Practices Act* (AOPA); *Safety Codes Act* (Municipal Affairs); *Regional Health Authorities Act*; *Wildlife Act* (Sustainable Resource Development (SRD)); *Public Lands Act* (SRD); *Provincial Parks Act*; *Wilderness Areas, Ecological Reserve, Natural Areas and Heritage Rangelands Act*; and policies such as the Wetlands Policy (SRD). Brief descriptions of these acts are provided in Table 1.

- AOPA provides guidelines and regulations regarding environmental management in livestock operations. It allows the province to be able to manage issues such as manure runoff, odour, noise, dust, smoke or other disturbances resulting from an agricultural operation, and provides clear manure management standards.

- The *Safety Codes Act* applies to the construction, installation and maintenance of septic systems. It ensures that septic systems follow minimum engineering standards for manufacture and installation, and that their integrity is preserved through regular maintenance. Leaking septic systems are a concern throughout the province. In particular, private septic systems seen in lakeside properties and recreational sites can cause contamination of groundwater and surface water bodies.

- The *Regional Health Authorities Act* ensures the preservation of the health and safety of Albertans, and can be used along side the *Safety Codes Act* in ensuring water supplies are kept free of sewage contamination.

- Alberta Sustainable Resource Development is responsible for enforcing many acts which can be used in the protection of aquatic resources. These acts include the *Wildlife Act*, which governs the management of wildlife as a Crown resource, enables the hunting and trapping of wildlife, and addresses the conservation of species at risk (endangered, threatened). The *Public Lands Act*

deals with the selling and transferring of public land, riparian rights, access to bed and shores and environmental reserves, as well as the management of rangeland and activities permitted on designated land.

- The *Provincial Parks Act* and the *Wilderness Areas, Ecological Reserve, Natural Areas and Heritage Rangelands Act* ensure the preservation and conservation of natural areas as parks or reserves. These Acts prohibit development and limit access to protected areas in order to preserve their natural state and ecological integrity.

- The Wetlands Policy was developed in 1990 by Alberta Environment, and is currently under review. The original policy mainly examines preservation of wetlands in settled areas (white zone) and recommends a No Net Loss policy for wetlands.

5.3 Municipal Governments

The following guiding documents can be used by municipalities in order to protect and maintain their watershed health and integrity:

- The *Municipal Government Act* (MGA) provides municipalities with authorities to regulate management of private land to control non-point sources. It also provides municipalities with the authority to enact bylaws and municipal land use to ensure that land use practices are compatible with the protection of aquatic environment.

- Land Use Bylaws divide the municipality into land use districts and establishes procedures for processing and deciding upon development applications. It sets out rules that affect how each parcel of land can be used and developed and includes a zoning map.

- An Area Structure Plan or Land Use Plan is a plan adopted by Council as an area structure plan bylaw pursuant to the *Municipal Government Act* that provides a framework for future subdivisions and development of an area.

- A Municipal Development Plan is a plan adopted by Council as a municipal development plan pursuant to the Municipal Government Act. It is a policy document that clearly states how land will be used and how future developments will be zoned.

Current and past land use plans, guiding documents and bylaws enacted for the Lac La Nonne watershed include:

- *Lac La Nonne Intermunicipal Development Plan* (2003)
- *Lac La Nonne Background Information and Management Issues* (1980)
- *Lac La Nonne Management Study* (1981)
- *Lac La Nonne Area Structure Plan* (1982)
- *Summer Village of Nakamun Park Land Use Bylaw and General Bylaws* (1997)
- *Nakamun Lake Area Structure Plan* (1981)
- *Nakamun Lake: Options for a Management Direction* (1979)

Table 1 summarizes the applicable acts and legislation available to assist with watershed management planning initiatives.

Table 1. Legislation and policy involving water and watershed management.

Legislation/Policy	Description
Federal *Fisheries Act* - Department of Fisheries and Oceans Canada (DFO)	Regulates and enforces on harmful alteration, disruption and destruction of fish habitat in Section 35.
Provincial *Water Act* – Alberta Environment (AENV)	Governs the diversion, allocation and use of water. Regulates and enforces actions that affect water and water use management, the aquatic environment, fish habitat protection practices and in-stream construction practices.
Provincial *Environmental Protection and Enhancement Act (EPEA)* – AENV	Management of storm water, contaminated sites, storage tanks, landfill management practices, hazardous waste management practices and enforcement.
Provincial *Agricultural Operations Practices Act* (AOPA) – Natural Resources Conservation Board (NRCB)	Regulates and enforces on confined feedlot operation and environment standards for livestock operations.
Provincial *Municipal Government Act* (MGA) – Municipal Affairs	Provides municipalities with authorities to regulate water on municipal lands, management of private land to control non-point sources, and authority to ensure that land use practices are compatible with the protection of aquatic environment.
Provincial *Public Lands Act* - Sustainable Resource Development (SRD)	Regulates and enforces on activities that affect Crown-owned beds and shores of water bodies and some Crown-owned uplands that may affect nearby water bodies.
Provincial *Safety Codes Act*- Municipal Affairs	Regulates and enforces septic system management practices, including installation of septic field and other subsurface disposal systems.
Regional Health Authorities Act – Alberta Health	RHA have the mandate to promote and protect the health of the population in the region and may respond to concerns that may adversely affect surface and groundwater.
Wildlife Act - SRD	Regulates and enforces on protection of wetland-dependent and wetland-associated wildlife, and endangered species (including plants).
Provincial Parks Act & Wilderness Areas, Ecological Reserve and Natural Areas Act – SRD and Community Development	Both Acts can be used to minimize the harmful effects of land use activities on water quality and aquatic resources in and adjacent to parks and other protected areas.
Provincial Wetlands Policy (expected September 2006)	This policy will be used to protect wetlands and mitigate losses through a No Net Loss policy.
Land Use Bylaws (Municipal)	The bylaw that divides the municipality into land use districts and establishes procedures for processing and deciding upon development applications. It sets out rules that affect how each parcel of land can be used and developed and includes a zoning map.
Area Structure Plans (Municipal)	Adopted by Council as a bylaw pursuant to the *Municipal Government Act* that provides a framework for future subdivisions, development, and other land use practices of an area, usually surrounding a lake.
Municipal Development Plans	The plan adopted by Council as a municipal development plan pursuant to the *Municipal Government Act*.

6.0 History

6.1 Lac La Nonne

The lake's name, which means "the nun" in French, has an uncertain origin dating back to the early 1800s. The Cree name for the lake, *mi-ka-sioo,* means "eagle". It is speculated that the lake may have been named for the white-winged scoter, a duck that is common on the lake and is similar to an English duck known as "the nun". The bird's colouring, which is black with white wing bars and a white spot on the head, suggests a black-robed nun (Mitchell and Prepas, 1990). Another suggestion is that the lake was named for the nuns at nearby Lac Ste. Anne Mission, though the mission was not founded until 1878.

The Hudson's Bay Company established a trading post at Lac La Nonne in the early 1800s. The post was used to pasture the pack horses needed to portage goods from Edmonton House to Fort Assiniboine on the Athabasca River (ERPC, 1980). By the 1830s, there were considerable numbers of Métis living by the lake. Missionaries arrived in the 1870s, and in 1878, the Oblate Fathers established a mission on the southeast shore at the site of the present-day Catholic Church at Camp Encounter. When the fur trade declined, the Métis moved away and the trading post and mission were closed (Mitchell and Prepas, 1990). Six Hudson's Bay Company land reserves were set aside in 1873, totaling approximately 500 acres northeast of Lac La Nonne. By the 1890s, several white families had settled around the lakeshore, and by 1912, most of the available land had been home-steaded. Horse and cattle raising were important occupations, and sawmills operated periodically near the lake. The first summer cottages were built on the eastern shore in the early 1900s.

By the 1970s, cottage development had increased to the point that most of the shoreline was privately owned (ALMS, 2002). Due to concerns expressed over water quality in the lake, further development was halted in 1977 through the Lake Shoreland Development Operation Regulations put in place by Alberta Environment (Mitchell and Prepas, 1990). This allowed preparation of the Lac La Nonne Management Plan, which was completed in 1980 (ERPC, 1980; ERPC, 1981). This plan determined the extent of future land developments, allocated land use and determined ways to minimize environmental impacts and conflicts in uses of the lakeshore. It also recommended preferred lake uses and ways to minimize lake-user conflicts. Subsequently, an area structure plan was adopted by the counties of Lac Ste. Anne and Barrhead in 1982 (ERPC and YRPC, 1982). The area structure plan defines land-use and development policies for the area and classifies parcels of land for various uses. The area structure plan has since been updated in 2003, and is now titled the Lac La Nonne Intermunicipal Development Plan. This plan includes a brief biophysical analysis of the lake and its surroundings, as well as lake and land use policies, land use classification, development policies, and implementation and administration of the plan.

Today, Killdeer Beach Resort, Willowbend Resort, and Elksbeach Campground are the three main commercial facilities at the lake (ALMS, 2002). There are no provincial or municipal campgrounds at the lake.

6.2 Nakamun Lake

Nakamun is a Cree word for "song of praise" or "songbird" (Mitchell and Prepas, 1990). Settlers arrived in the area at the end of the nineteenth century and began clearing land for agriculture to the east and northeast of the lake. Most of the land around the lake is privately owned and the south shore is extensively developed. The first subdivision was established in 1960; it was incorporated as the summer village of Nakamun Park in 1966. Four Oakes subdivision was founded in 1962 about 400 m east of Nakamun Park, and Nakamun Court subdivision (also called Losie Glade) was built in 1975 adjacent to the west side of Four Oakes. The north shore is mostly undeveloped except for a Bible camp and a few cottages.

6.3 Majeau Lake

Historical information regarding Majeau Lake is not well documented and no published information was found during the research stage of this report.

7.0 Watershed Characteristics

For the purposes of the current report, an innovative approach using Geographic Information Systems (GIS) and watershed delineation experts from PFRA, Alberta Environment and Aquality were used to establish a custom, improved watershed boundary for the Lac La Nonne watershed and the subwatershed catchments of Lac La Nonne Lake, Nakamun Lake and Majeau Lake (Figure 1). Where possible, we try to use our improved watershed boundary areas to avoid reader confusion. However, some older data and maps used in this report may still reflect the old boundary areas.

7.0.1 Description of Lac La Nonne Watershed

The watershed is part of the Athabasca River Basin in the Counties of Barrhead and Lac Ste. Anne, and lies approximately 100 km northwest of Edmonton, Alberta, Canada. It has a drainage basin area of approximately 299.128 km^2 (PFRA, 2006) and includes the Majeau Lake and Nakamun Lake subwatersheds (Figure 1). The region is part of the Moist Mixedwood Subregion of the Boreal Mixedwood Ecoregion, which means the area is dominated by aspen (*Populus tremuloides*) and balsam poplar (*Populus balsamifera*), with predominantly grey luvisol soils (Mitchell and Prepas, 1990). Some white spruce (*Picea glauca*) stands are present around the edge of depressional sites or wetland areas (Bentz and Wells, 1990).

7.0.2 Lac La Nonne Subwatershed

Lac La Nonne is a highly developed and popular recreational lake located approximately 90 km northwest of the City of Edmonton, in the counties of Barrhead and Lac Ste. Anne. Lac La Nonne has an area of 12.28 km^2 (Table 2), which is approximately 4% of its drainage basin area. Mean depth of Lac La Nonne is 7.8 m (Mitchell and Prepas, 1990), and the subwatershed area is approximately 129.906 km^2 (PFRA, 2006). The water residence time of Lac La Nonne is approximately 6.5 years and the maximum depth of the lake is 20 meters (Hamilton, 1980). This water residence time is relatively short for a prairie lake, and may help the lake respond more quickly to management activities. A detailed bathymetry map appears in Figure 2. The large drainage basin area to lake volume ratio would suggest that Lac La Nonne is eutrophic due to activities on the land that contribute nutrients (Alberta Environment, 1985a). The large subwatershed area of Lac La Nonne affords more opportunity for nutrients to runoff into the lake from point and non-point sources.

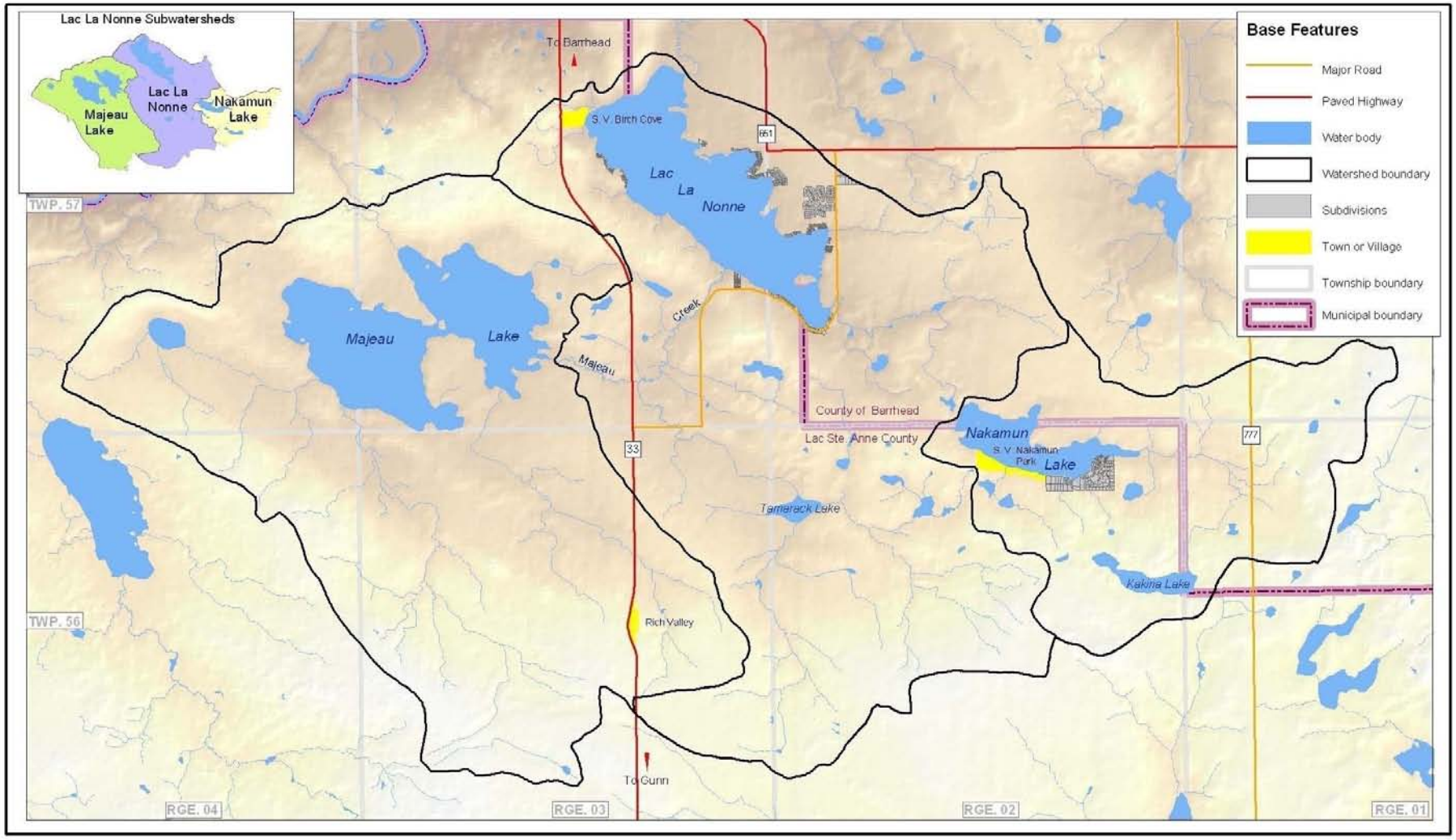

Figure 1. Overview of the Lac La Nonne watershed, showing the Lac La Nonne Lake, Nakamun Lake and Majeau Lake subwatersheds. Watershed boundaries delineated by PFRA, Alberta Environment and Aquality (PFRA, 2006).

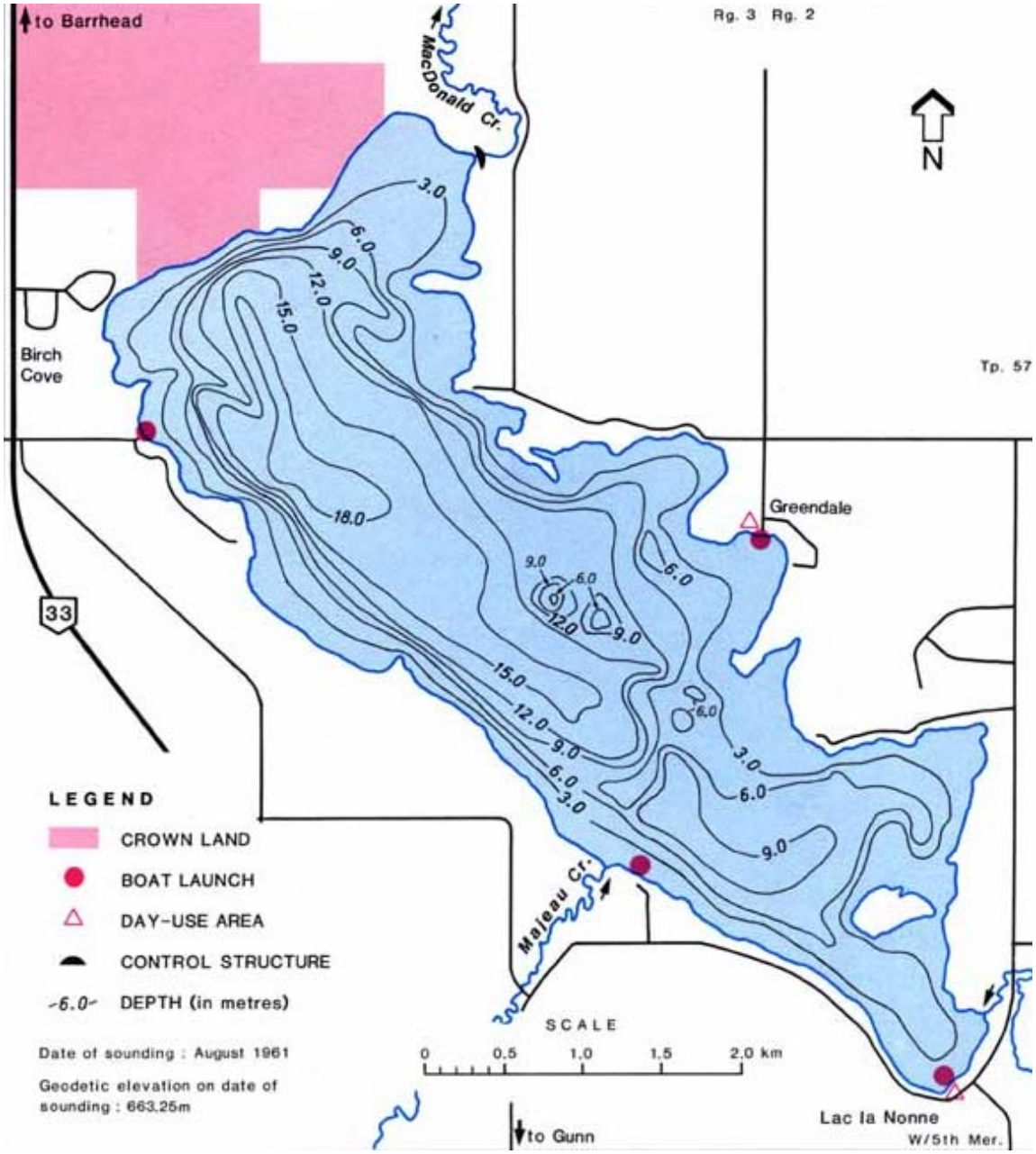

Figure 2. Bathymetry of Lac La Nonne. Adapted from Mitchell and Prepas, 1990.

7.0.3 Nakamun Lake

Nakamun Lake is located 95 km northwest of Edmonton and 28 km south of Barrhead. It is a headwater lake, with no major inflows into it aside from nearby Kakina Lake. The outflow of Nakamun Lake flows infrequently into Lac La Nonne when water levels are high. Nakamun Lake has an area of 3.54 km^2, a mean depth of 4.5 m and maximum depth of 8 m (Table 2). A detailed bathymetry map appears in Figure 3. It has a length of 2.2 km and a maximum width of 0.8 km. The Nakamun Lake subwatershed includes Kakina Lake and has an area of 48.579 km^2 (PFRA, 2006), which is about 13 times the size of the lake and is large for a prairie lake. The majority of land around the lake is privately owned, and the south shore is extensively developed.

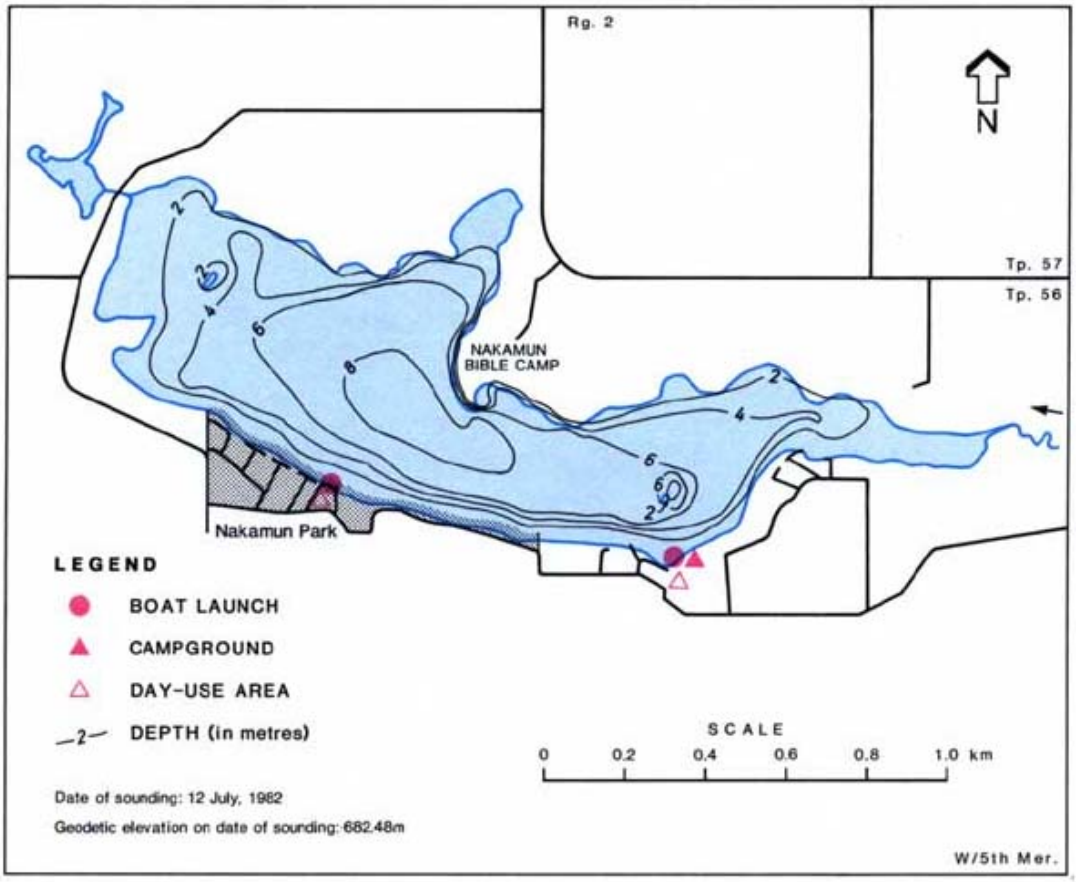

Figure 3. Bathymetric map of Nakamun Lake. Adapted from Mitchell and Prepas, 1990.

Table 2. Physical parameters of Lac La Nonne, Nakamun and Majeau Lake.

Parameter	Lac La Nonne[1]	Nakamun Lake[2]	Majeau Lake
Drainage Basin Area	129.91 km^2	48.58 km^2	102.64 km^2
Lake Area	12.28 km^2	3.54 km^2	12.14 km^2
Drainage Basin/Lake Area	10.5	13.7	8.45
Volume	95,956 dam^3	15,800 dam^3	N/A
Maximum depth	20 m	8 m	1.2m
Mean annual inflow	14, 241 dam^3	1,320 dam^3	N/A
Mean annual outflow	6,399 dam^3	N/A	N/A
Residence time	6.5 years	21 years	N/A

[1] Data from Alberta Environment (1980).
[2] Data from Mitchell and Prepas (1990).

7.0.4 Majeau Lake

Majeau Lake has an area of 12.14 km^2 (Table 2) with a maximum depth of 1.2 m (Rhude, 1979). The Majeau watershed has an area of 102.643 km^2 (PFRA, 2006). There is little other physical data available for Majeau Lake at this time and bathymetry has not been established. The major outflow from Majeau Lake is Majeau Creek, which flows into Lac La Nonne, and there are numerous other inflows and outflows around Majeau Lake, predominantly to the west.

7.1 Climate

In 2004, temperatures in the nearest weather station with long term data, which is Slave Lake, reached a mean maximum of 22.2^oC in July, and a mean low of -13.3^oC in January, and had a mean annual temperature of 1.8^oC (Environment Canada, 2004). The region received 414.4 mm of rain and 127.5 cm of snow, for a total of 533.9 mm of precipitation (Environment Canada, 2004). For perspective, long term climate averages for the Slave Lake station are compared to a southern Alberta station (Medicine Hat) and a northern Alberta station (High Level) in Table 3.

Rainfall in the region is generally highest in July through September, and snowfall generally begins in October and can carry through until April (Environment Canada, 2004).

Table 3. Long term climate normals for the Lac La Nonne area. The closest monitoring station is Slave Lake, which has data from 1994-2005. Climate data for Medicine Hat and High Level are given for comparison. Adapted from Environment Canada Climate office website, 2004.

Parameter	Slave Lake 1994-2004	Medicine Hat 1994-2004	High Level 1994-2004
Mean annual temperature (^oC)	1.9	5.8	-0.9
Mean annual maximum temperature (^oC)	7.3	12.4	5.3
Mean annual minimum temperature (^oC)	-3.6	-0.8	-7.0
Rainfall (mm)	305.6	235.4	230.7
Snowfall (cm)	83.7	96.4	126.1
Precipitation (mm)	385.7	316.8	317.9

7.2 Geology, Soils and Topography of the Watershed

The topography around Lac La Nonne is variable, ranging from level lacustrine and till plains to undulating and moderate to strongly rolling glacial moraine areas (ERPC, 1980). Gently undulating to level topography occurs to the northeast of the lake, and strongly rolling topography occurs to the west and south of the lake (Twardy, 1977). Relief is approximately 50 meters, with the lowest elevations on the east side of the lake (670 m above sea level) and the highest elevations to the west and south (720 m above sea level) (Twardy, 1977) (Figure 4).

Lac La Nonne is underlain by the Edmonton Formation of the Late Cretaceous age, and is composed of bentonitic clays and sandstones, sandy shales and coal seams (Twardy, 1977). Soils that have developed from outcrops of this parent material are weakly to moderately saline in nature. Site-specific sampling would be required to assess whether soils around the lakes are contributing a significant phosphorus loading.

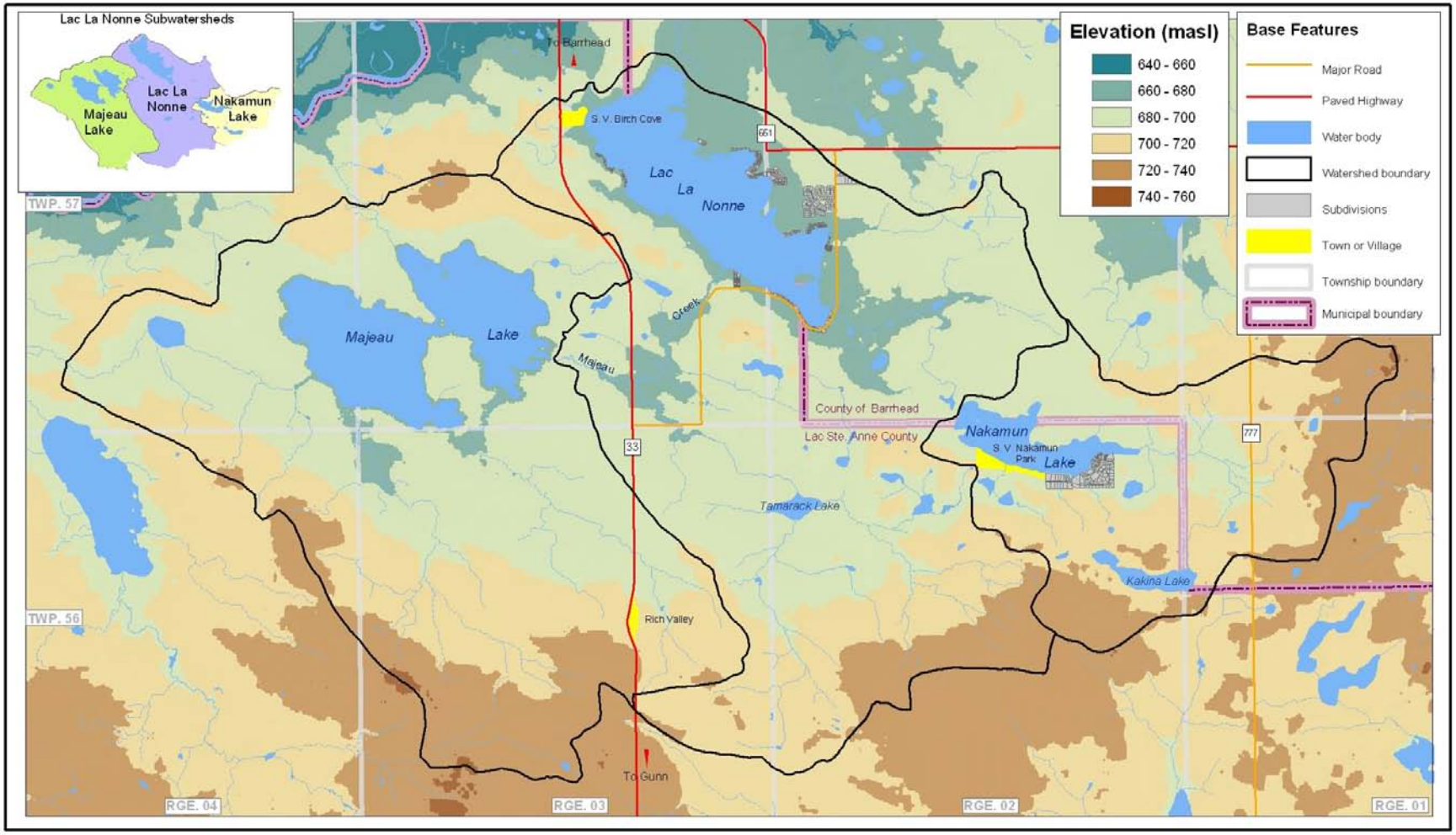

Figure 4. Overview of Lac La Nonne watershed topography, showing heights of land at the south and eastern portions of the watershed. Watershed boundaries delineated by PFRA, Alberta Environment and Aquality (PFRA, 2006).

7.2.1 Lac La Nonne Subwatershed

Soils have been mapped and described in general for the drainage basin and in detail for an area within 1.6 km of the shoreline (Twardy and Brocke, 1976; Twardy 1977). Adjacent to the lake, the predominant soils are moderately well-drained to well-drained gray luvisols that developed on lacustrine material or glacial till. Regosolic soils are present on the beach sands near parts of the lakeshore and on the floodplains of creeks. Imperfectly to moderately well-drained solonetzic soils that developed on moderately fine-textured till, weathered bedrock material, and fine-textured lacustrine material are located northeast of the lake. Throughout the remainder of the drainage basin, orthic and solodic gray luvisols and solonetzic soils are common and organic deposits are significant. The organics are characterized by accumulations of moss or sedge peat in depressional and poorly drained areas.

7.2.2 Nakamun Lake Subwatershed

The topography of the Nakamun drainage basin is quite varied. To the south and west, the land is gently rolling to rolling, with slopes from 5 to 15%; frequently, sloughs have formed in depressions. To the northwest, the terrain is undulating to gently rolling, with slopes from 1 to 8%, and to the northeast the land is gently rolling to rolling, with some slopes greater than 15% (Mitchell and Prepas, 1990). The elevation of the land ranges from 732 m at the northeastern and southern edges of the drainage basin to 683 m at the lakeshore (Mitchell and Prepas, 1990).

Soils around the lake are well-drained to moderately well-drained orthic gray luvisols and moderately well-drained to imperfectly drained solodic gray luvisols. Soils are overlain by moderately fine textured and medium textured glacial till. Large areas of poorly drained mesisols are located around the watershed. These wet depressions contain peat, sedges and slough grass (Twardy and Brocke, 1976).

7.2.3 Majeau Lake Subwatershed

Topography and soil types in the Majeau subwatershed have not been formally reported, but appear to be similar in nature to what is found in the Lac La Nonne subwatershed.

Soil types in the Lac La Nonne watershed may help with indicating what land use activities may be suitable or unsuitable. For instance, poorly drained, sloped and depressional areas would not be suitable for agriculture or housing development. In particular, sloped areas should be avoided due to the potential for runoff of stormwater and agricultural fertilizers into the lake. Poorly drained areas may indicate an interaction with groundwater, and may also be a source of runoff to the lakes.

7.3 Hydrology, Groundwater and Lake Levels

The main inflow into Lac La Nonne is Majeau Creek, which runs from Majeau Lake and drains the central and western portions of the watershed, a drainage area of 129.91 km^2; as well, there are two other inflows on the southeast shore and a number of small intermittent inflow streams accounting for a drainage area of 111.84 km^2 (Hamilton, 1980). These inflows account for approximately 81% of the drainage into Lac La Nonne. Only 38% of the watershed drains directly into the lake, while the remaining 62% flows into Nakamun or Majeau lakes. Inflows to Lac La Nonne from Nakamun Lake are rare, and occur only during instances of high precipitation (Mitchell, 1991). The outflow is MacDonald Creek, which flows into the Pembina River about 3 km north of Lac La Nonne. Currently there is a rock and timber weir on the outlet, which was originally installed by the Provincial Government in 1939 in an effort to control water levels.

Groundwater well records indicate good yields from the bedrock of this area. The majority of the watershed shows good yields of 5-25 Imperial gallons per minute (igpm). Only a small area in the southwest had lower yields around 1-5 igpm (ERPC, 1981a). Groundwater is alkaline and high in total dissolved solids. Alkalinity increases with well depths, and in relation to variation in bedrock strata. Figure 5 shows the groundwater recharge areas for upper bedrock aquifers in the watershed. Large recharge areas exist around Majeau Lake and Nakamun Lake, and the southern and northern shores of Lac La Nonne are recharge areas. Certain developments in these areas could pose a significant risk to groundwater contamination.

Surface permeability data and presence of sand or gravel within one meter of the ground surface were combined from groundwater surveys for both Counties (Hydrogeological Consultants, 1998a; Hydrogeological Consultants, 1998b) to establish a risk of groundwater contamination for the watershed (Figure 6). There are several areas of high groundwater contamination risk within the watershed, namely in the Lac La Nonne and Majeau subwatersheds. Future development in these areas should be closely monitored in order to prevent contamination of groundwater sources. Additional groundwater mapping and monitoring could be performed in the area in order to track changes and to implement protective measures as required.

7.3.1 Lac La Nonne Water Levels

Water levels have been recorded intermittently since 1940 (ERPC, 1981a) with variations around 1 meter (Figure 7). Lows were recorded in 1940, 1961, 1967-8 and 2003, with highs recorded in 1971 and 1974 (ALMS 2003). As shown in Figure 7, water levels have been steadily decreasing in the last10 years, and this may become an area of concern for Lac La Nonne. Low water levels can severely impact fish and wildlife populations as well as lake water quality.

7.3.2 Nakamun Lake Water Levels

Water levels in Nakamun Lake have been monitored since June 1968. Water levels have remained relatively stable, with a noticeable decline starting in 1997 (Figure 8). As of 2005, water levels were approximately 1 meter below 1997 levels.

7.3.3 Majeau Lake Water Levels

Majeau Lake is experiencing the same drop in lake elevation as seen in Nakamun and Lac La Nonne. Levels from 1969 to 1999 were relatively stable, while levels from 1999 to 2005 have seen a large drop, in the order of 1 meter (Figure 9).

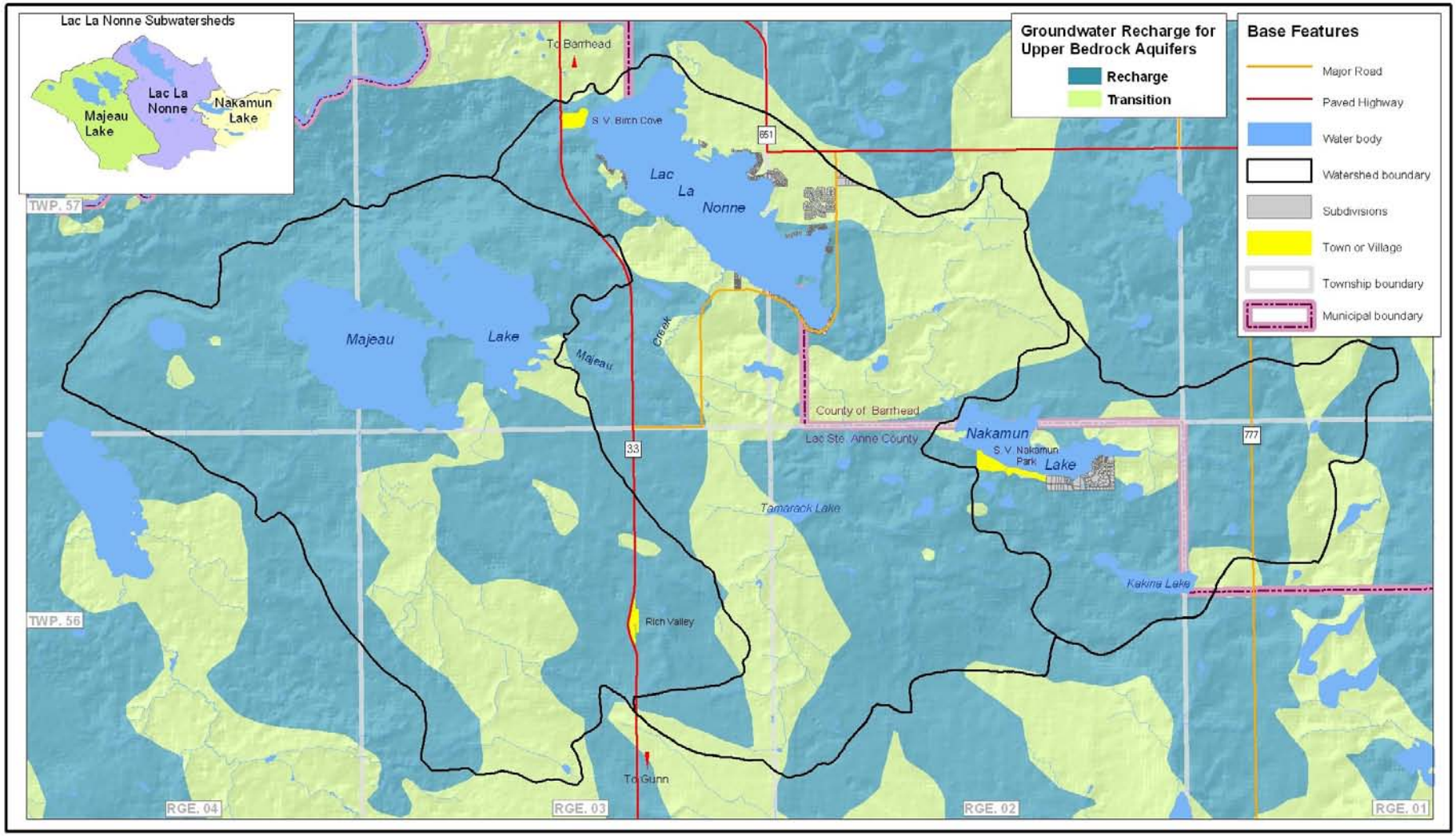

Figure 5. Lac La Nonne Watershed Groundwater Recharge Areas for Upper Bedrock Aquifers. Watershed boundaries delineated by PFRA, Alberta Environment and Aquality (PFRA, 2006).

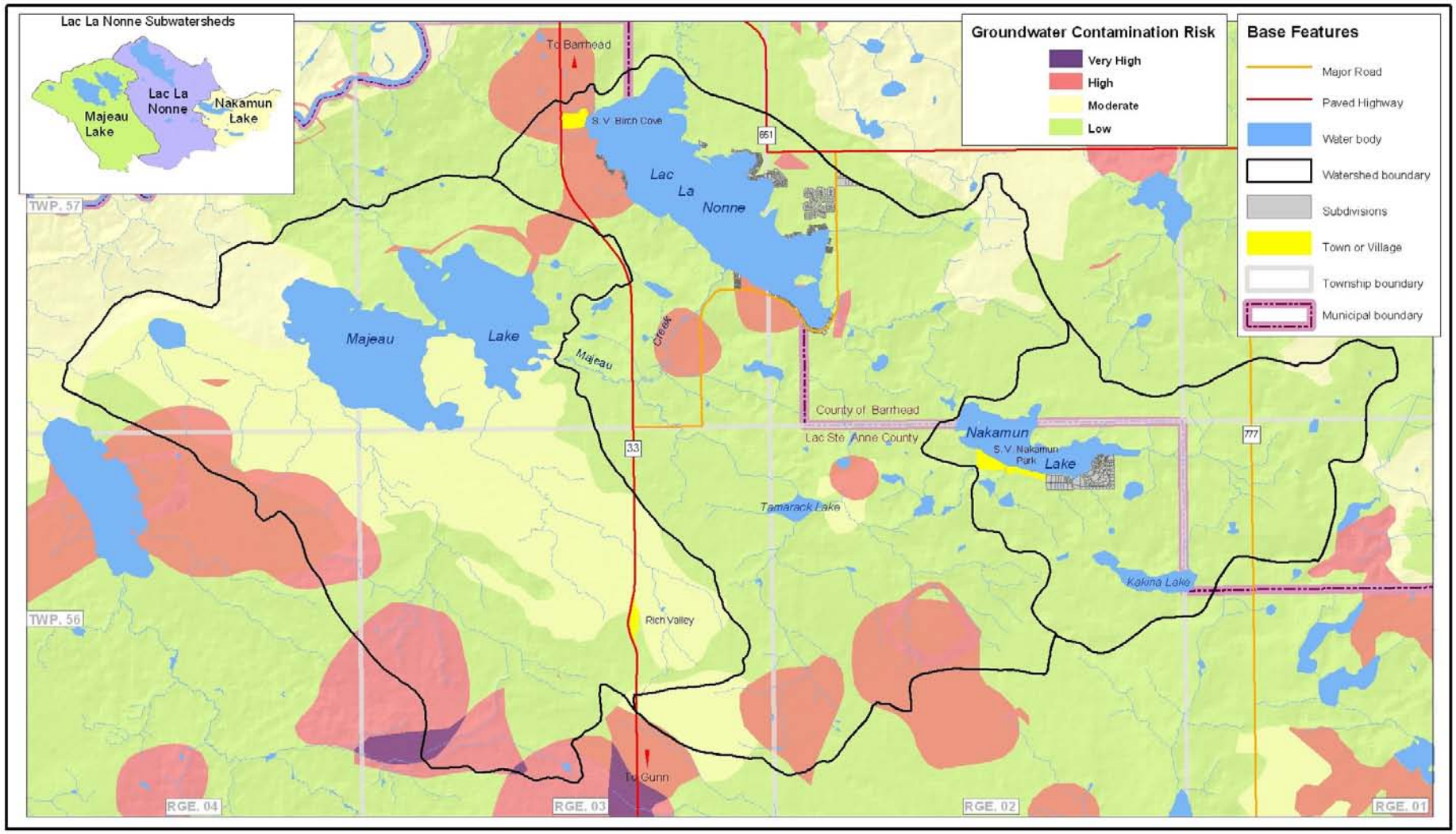

Figure 6. Lac La Nonne Watershed Groundwater Contamination Risk. Watershed boundaries delineated by PFRA, Alberta Environment and Aquality (PFRA, 2006).

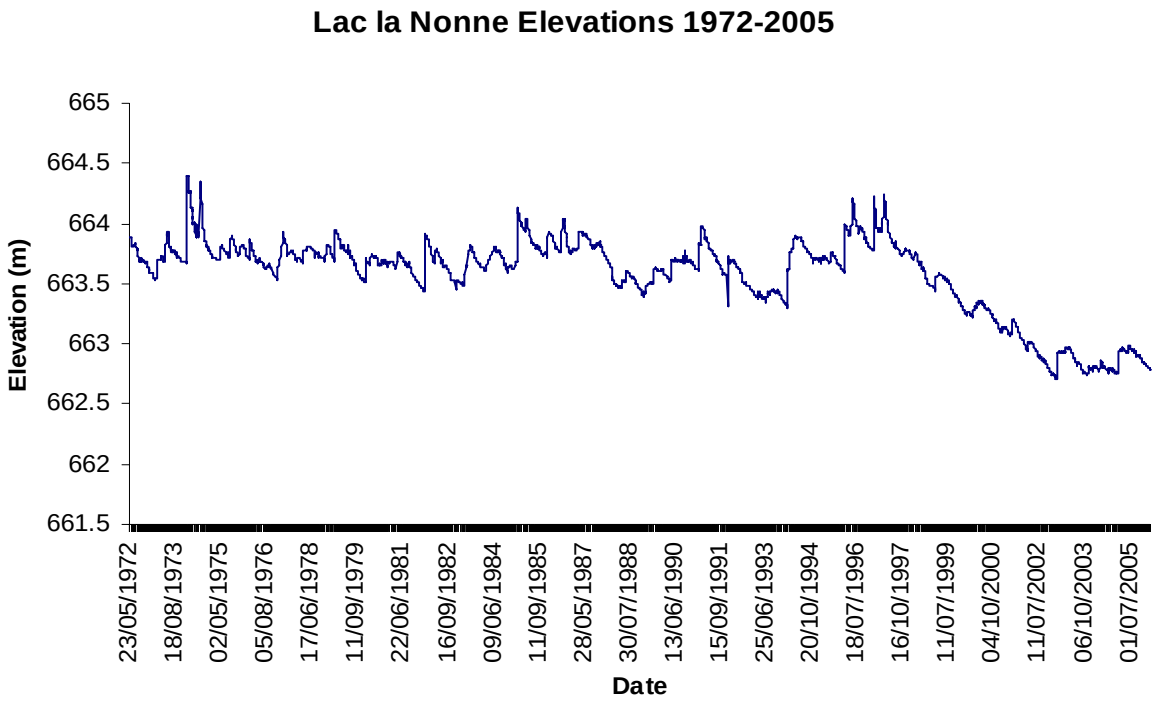

Figure 7. Water levels in Lac La Nonne from May 1972 to October 2005 (AENV, 2006a).

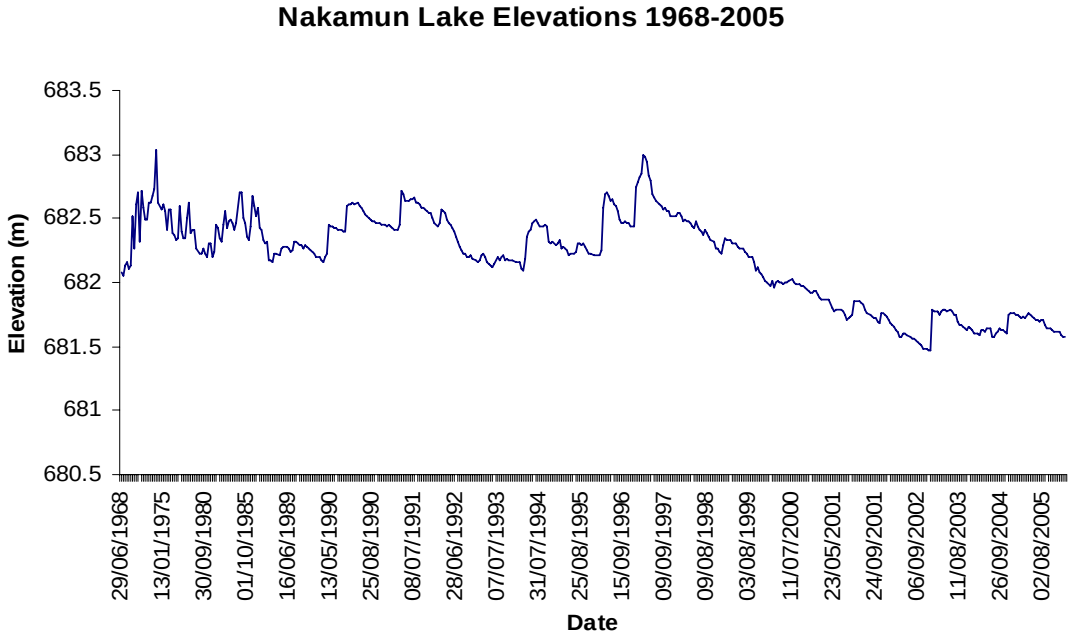

Figure 8. Water levels in Nakamun Lake from June 1968 to October 2005 (AENV, 2006a).

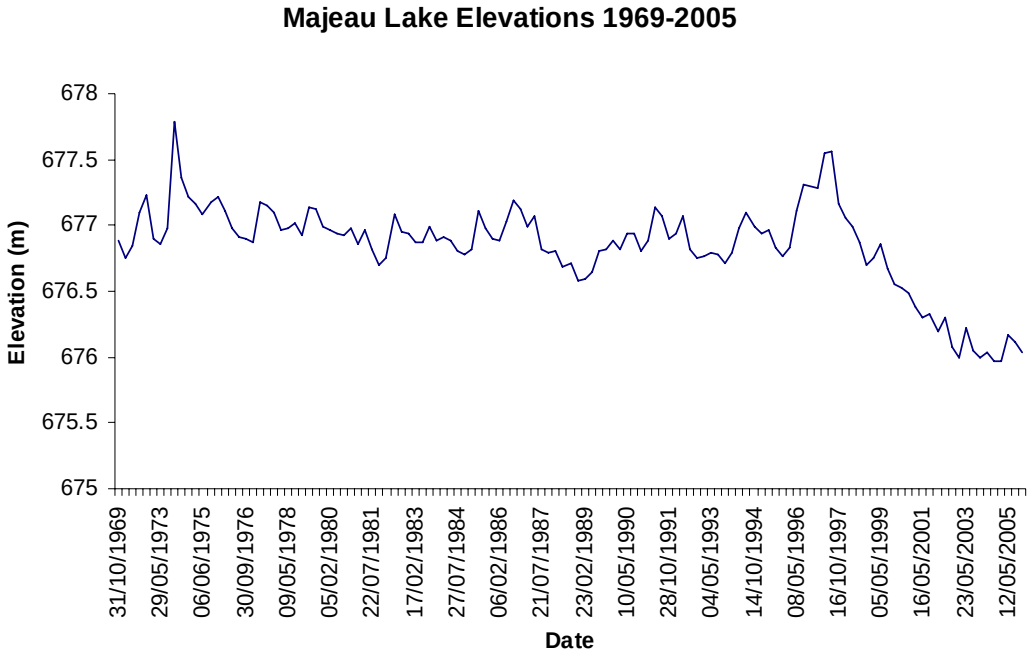

Figure 9. Water levels for Majeau Lake from October 1969 to May 2005 (AENV, 2006a).

7.4 Water Withdrawals and Consumption (including domestic use)

There are a total of 17 licensed water allocations and withdrawals currently on record for the Lac La Nonne watershed; 12 for withdrawals from Lac La Nonne, one for Nakamun Lake, and four for Majeau Lake. These licensed withdrawals are directly from the lakes themselves, and from the records obtained, only 3 out of 17 allocations are being currently being used, all from Majeau Lake. The allocations used from Majeau Lake amount to approximately 30,600 L/yr, with no return volumes (Alberta Environment, 2006b). Not enough data exists about lake volume, or inflow and outflow volumes, to determine if these withdrawals are detrimental to Majeau Lake water levels.

8.0 Water Quality (Lake and Streams)

8.0.1 Lac La Nonne

Lac La Nonne is the most researched lake in the watershed, with water quality studies dating back to 1978. The deepest areas of the lake thermally stratify in the summer months, resulting in oxygen depletion in the deeper waters of the lake, also known as the hypolimnion (Figure 10). Numerous water quality studies have been performed on the lake, but no continuous, long term monitoring has ever been done. Alberta Environment monitored the water quality in Lac La Nonne from the 1960's to 1990, and then again in 2000 (Table 4). The Alberta Lake Management Society (ALMS) sampled Lac La Nonne in 2000, 2001, and 2003. The 2000 ALMS report stated that the phosphorus levels in the lake published by Alberta Environment were hypereutrophic and were likely due to cattle operations in the Majeau subwatershed that were exporting more than five times more phosphorus than cottages (ALMS, 2000; Mitchell & Hamilton, 1982). Total phosphorus concentrations averaged 187 µg/L in 2000, and peaked in mid summer (ALMS, 2000). The trophic status of Lac La Nonne compared to other Alberta lakes is shown in Figure 11.

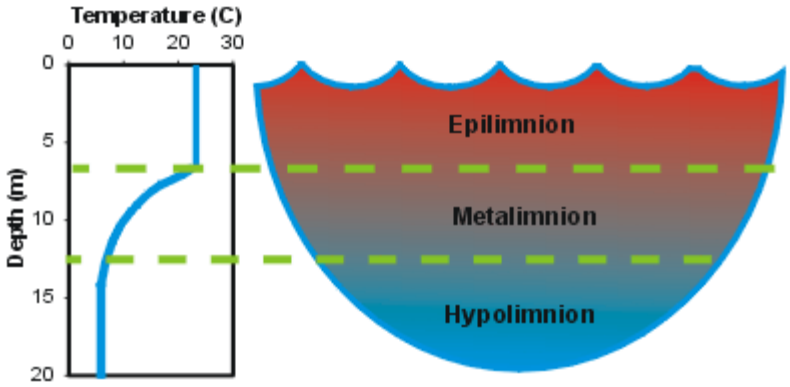

Figure 10. A schematic of thermal stratification and the associated layers of water which commonly occur in Alberta lakes (Central New York's Near-Real-Time Surface Water Quality Network, 2006).

Summer oxygen levels in Lac La Nonne are typically uniform, but the lake does stratify in summer (ALMS, 2000; ALMS, 2002; ALMS 2003). Despite its depth, Lac La Nonne is warm with typical summer surface temperatures of > 22º C and bottom temperatures of 12º C (ALMS 2000). The water column dissolved oxygen concentrations are typically highly oxygenated at the surface (> 10 mg/L) and declining with depth below the thermocline (also known as the metalimnion) at 4-6 m depth (the thermocline being the area in the water column where there is a rapid decrease in temperature with depth). Sampling was limited to 11 m, where oxygen concentrations remained above 4 mg/L through the summer. Previous AENV data suggests this is typical, with much of the bottom remaining oxygenated until mid-July when anoxic conditions prevail below 15 m (Mitchell, 1991).

Winter oxygen conditions for Lac La Nonne are depleted below 10m yearly. Since the lake is fairly deep, the risk of winterkill is likely low (Alberta Environment, 1985a).

Bacteriological data on 53 samplings provided by the Aspen Regional Health Authority for Lac La Nonne for five beach sites sampled between June, 2002 and September, 2005 were all below CCME Recreational Guidelines (200 CFU / 100 mL). However, bacteria data collected by Aquality

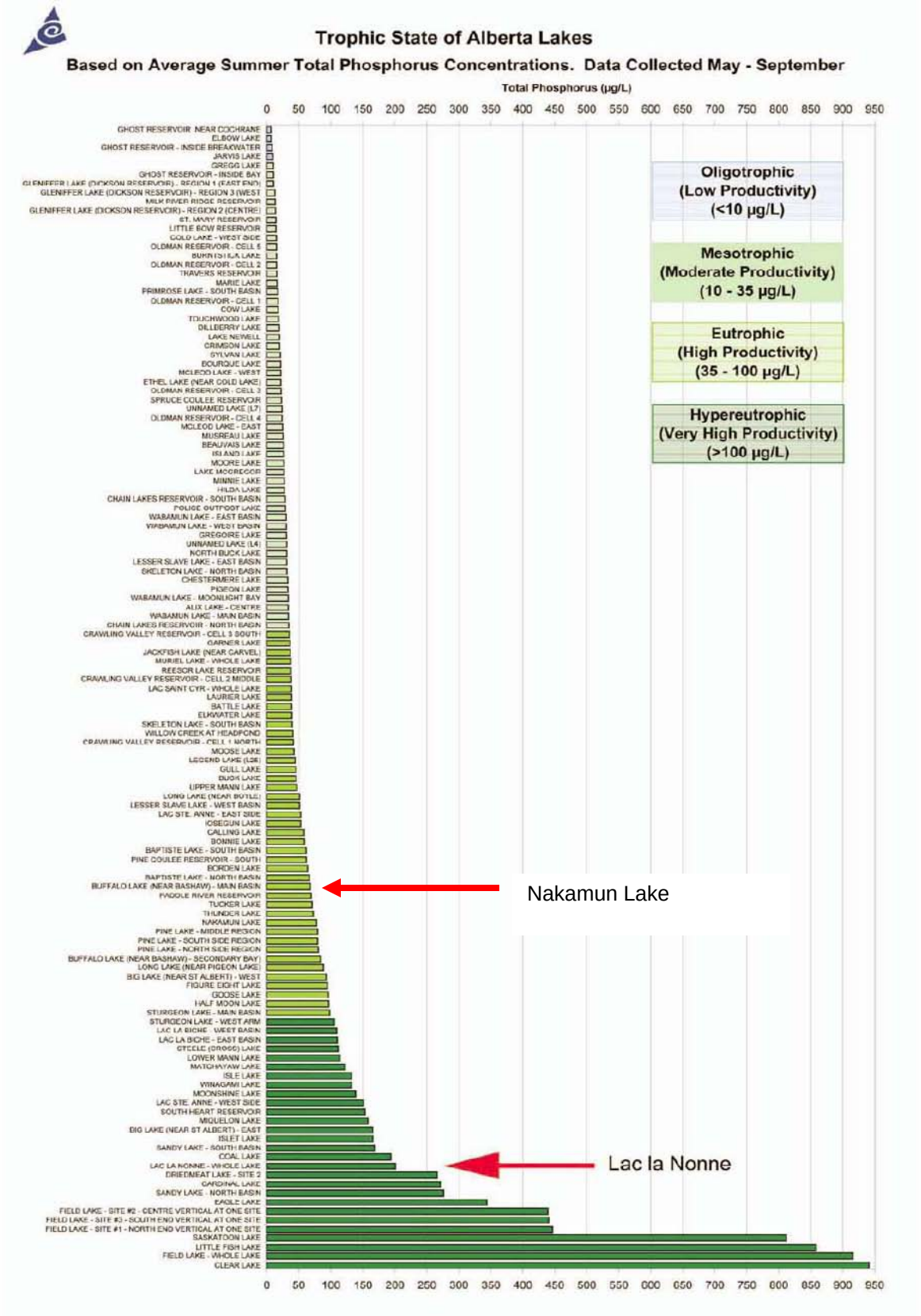

Figure 11. A comparison of trophic status of Alberta lakes. Alberta Environment (2004).

(2005) in March 2005 at two sites exceeded the Guideline with counts of 360 and 340 CFU / 100 mL. The exact location of the Aspen beach sampling sites was not provided due to confidentiality reasons, and the sites used by Aquality were chosen by LEPA to target shoreline developments and inflows to Lac La Nonne.

Table 4. Select water chemistry parameter means for Lac La Nonne, Nakamun and Majeau Lake.

Mean Parameter[1]	Lac La Nonne	Nakamun Lake	Majeau Lake
Total Phosphorus (µg/L)	260 (hyper)[2]	77 (eutrophic)	540 (hyper)
TDP (µg/L)	N/A	24	396
Total Nitrogen (µg/L)	2339	1780	3875
Nitrate + Nitrite (µg/L)	107	14	76
Period of Record	May 78 – Oct 79	May 83 – Oct 03	Mar – Jun 81
# of Observations	48	91	125

[1]Data from Alberta Environment (2006).
[2] Hyper = hypereutrophic (see Figure 11 for Alberta Lake trophic status definitions).

Fifteen sites on Lac La Nonne were sampled by LEPA for caffeine, an indicator of human sewage during 2004-2005; there were 3 positive hits in 2004, and none in 2005 (Aquality 2004, 2005). The positive hits could be an indicator of a recent sewage release, and a negative hit could mean that sampling occurred too long after release, caffeine levels were below current detection limits, or that there is no human sewage present. Future samplings may identify the exact sources of sewage dumping into the lake.

8.0.2 Nakamun Lake

Nakamun Lake has a historical water quality database dating back to 1977. Both the University of Alberta and Alberta Environment have collected extensive water quality samples. The lake is hyper-eutrophic, and frequent algal blooms are of concern. The lake only weakly stratifies in early summer, but is usually well-mixed due to its shallow depths. Under winter ice cover, the dissolved oxygen levels decrease to zero in the deeper areas of the lake (Mitchell and Prepas, 1990).

A detailed phosphorus budget, including internal loading estimates has been completed for Nakamun Lake. An estimated 779 kg/year of phosphorus enters the lake from external sources (precipitation, dustfall, runoff and sewage) and approximately 60% of this external load is from agriculture and cleared areas (Riley, 1983). Almost twice that number, 1,468 kg/year of phosphorus, was released from the sediments from May to November in studies (Riley, 1983; Riley and Prepas, 1984). Approximately 80% of the annual loading of phosphorus in Nakamun Lake originates from the sediments. Scientists call this phenomenon “internal loading” and little can be done to manage this nutrient source. Nakamun Lake was one of the lakes used to prove the significance of internal loading in shallow, productive Alberta lakes. A report written in 1979 by the Water Control Branch of Alberta Environment had recommended possible macrophyte harvesting as a method of improving water quality (Mitchell, 1979), but this has not worked in other lakes. The trophic status of Nakamun Lake compared to other Alberta lakes is shown in Figure 11.

Summer oxygen levels for Nakamun bottom waters are very low, despite mixing on windy days (Alberta Environment, 1985b). Nakamun is likely too shallow, and too wind-blown to thermally stratify for the entire summer.

Observations by SRD support the theory that Nakamun Lake goes almost completely anoxic during winter months. Dissolved oxygen profiles performed during the winters of 2003, 2004 and 2005 all recorded dissolved oxygen levels below the Alberta Surface Water Quality Guidelines for Protection of Aquatic Life (5.0 mg/L) (Hildebrand, 2006). If low dissolved oxygen conditions persist during winter months, it is unlikely that Nakamun Lake will be capable of supporting a sport fishing population.

8.0.3 Majeau Lake

Water quality data on Majeau Lake is limited. The majority of sampling in the Majeau subwatershed has been performed on Majeau Creek, and not the lake itself.

Mitchell and Hamilton completed an assessment of the phosphorus export from the Majeau Creek in 1981. Average phosphorus export in Majeau Lake streams was 0.904 mg/L, and they calculated an export coefficient of 0.51 kg/ha/yr (Mitchell and Hamilton, 1982). Majeau Lake itself retains approximately 53-93% of the phosphorus it receives from the surrounding watershed (Mitchell and Hamilton, 1982). There appeared to be an increase in phosphorus levels corresponding with increasing numbers of cattle in the watershed (Mitchell and Hamilton, 1982).

No summer or winter dissolved oxygen data were found for Majeau Lake.

8.0.4 Streams in the Lac La Nonne Watershed

Two major stream water quality studies have been performed in the Lac La Nonne watershed. In 1981, Hamilton and Mitchell sampled several streams in the watershed to gauge the impact of livestock density on water quality in streams. In 2004 and 2005, the Lac La Nonne Enhancement and Protection Association and Aquality Environmental Consulting Ltd. sampled Lac La Nonne inflows, Nakamun Lake inflows and Majeau Creek, a total of eight streams (Table 5).

Two sites from the Hamilton and Mitchell (1982) and LEPA stream survey 2004 - 2005 were compared to determine if there had been any changes in nutrient input from Majeau Creek over the past 25 years (Table 6). These sites were Site 4: Majeau Creek at the culvert under Highway 33, and Site 6: Majeau Creek at the Lac La Nonne Road culvert. Almost all of the parameters sampled had increased between 1981 to 2005. Phosphorus results for both sites were very high for agricultural streams.

Table 5. Select water chemistry parameter means for Lac La Nonne streams taken during the 2004-2005 LEPA sampling (Aquality, 2004;2005).

Mean Parameter	Lac La Nonne Streams
Total Phosphorus (µg/L)	415
TDP (µg/L)	N/A
Total Nitrogen (µg/L)	3065
NO_2-N (Nitrite) (µg/L)	16
Period of Record	March-April

Table 6: Average total phosphorus and total dissolved phosphorus (µg/L) values for two sites in Majeau Creek. Site 4 is located at the culvert for Majeau Creek running under Highway 33, Site 6 is located just upstream of Lac La Nonne.

	Hamilton and Mitchell (1981)		LEPA Stream Study 2004		LEPA Stream Study 2005	
	Site 4	Site 6	Site 4	Site 6	Site 4	Site 6
TP	342	536	266	335	529	731
TDP	148	341	174	278	373	589

The 2004 sampling program was also designed to detect caffeine, an indicator of human sewage. Samples were taken on major lake inflows on Lac La Nonne and Nakamun Lake. There was one positive hit for caffeine in Majeau Creek in May 2004, and none in September 2004. Negative hits could indicate that there is no sewage present, that dilution was too great for detection limits, or that the caffeine had already degraded in the environment. Positive hits may indicate recent releases of human sewage into the receiving waterbody.

The 2005 sampling program was expanded to include nutrients and bacteria from 8 different streams within the watershed. Overall, nutrient levels were high in all streams, with many exceeding the Alberta Surface Water Quality Guidelines (ASWQG) for the Protection of Aquatic Life (PAL). Caffeine detections were negative in 2005; however, bacterial results showed two streams in the watershed with *E. coli* counts exceeding the ASWQ Recreational Guideline (Table 7). This is a sign of fecal contamination, and future monitoring in the area should include methods such as microbial source tracking to help identify sources of contamination in the watershed.

Table 7. Alberta and CCME Surface Water Quality Guidelines for Recreation and Aesthetics, Agricultural Uses and Protection of Freshwater Aquatic Life.

Parameter	Recreation and Aesthetics	Agricultural Uses	Protection of Aquatic Life
E. coli (#/100 mL)	200	100	N/A
Total Phosphorus (µg/L)	N/A	N/A	50
Total Nitrogen (µg/L)	N/A	N/A	1000
Nitrate + Nitrite (µg/L)	N/A	100000	N/A
Nitrite (µg/L)	N/A	10000	60

The streams sampled were ranked according to the Alberta Agricultural Water Quality Index (AWQI). All streams sampled rated either poor or marginal in 2004 (Figure 12, Table 8) and 2005 (Figure 13, Table 9) (Aquality, 2004; Aquality, 2005).

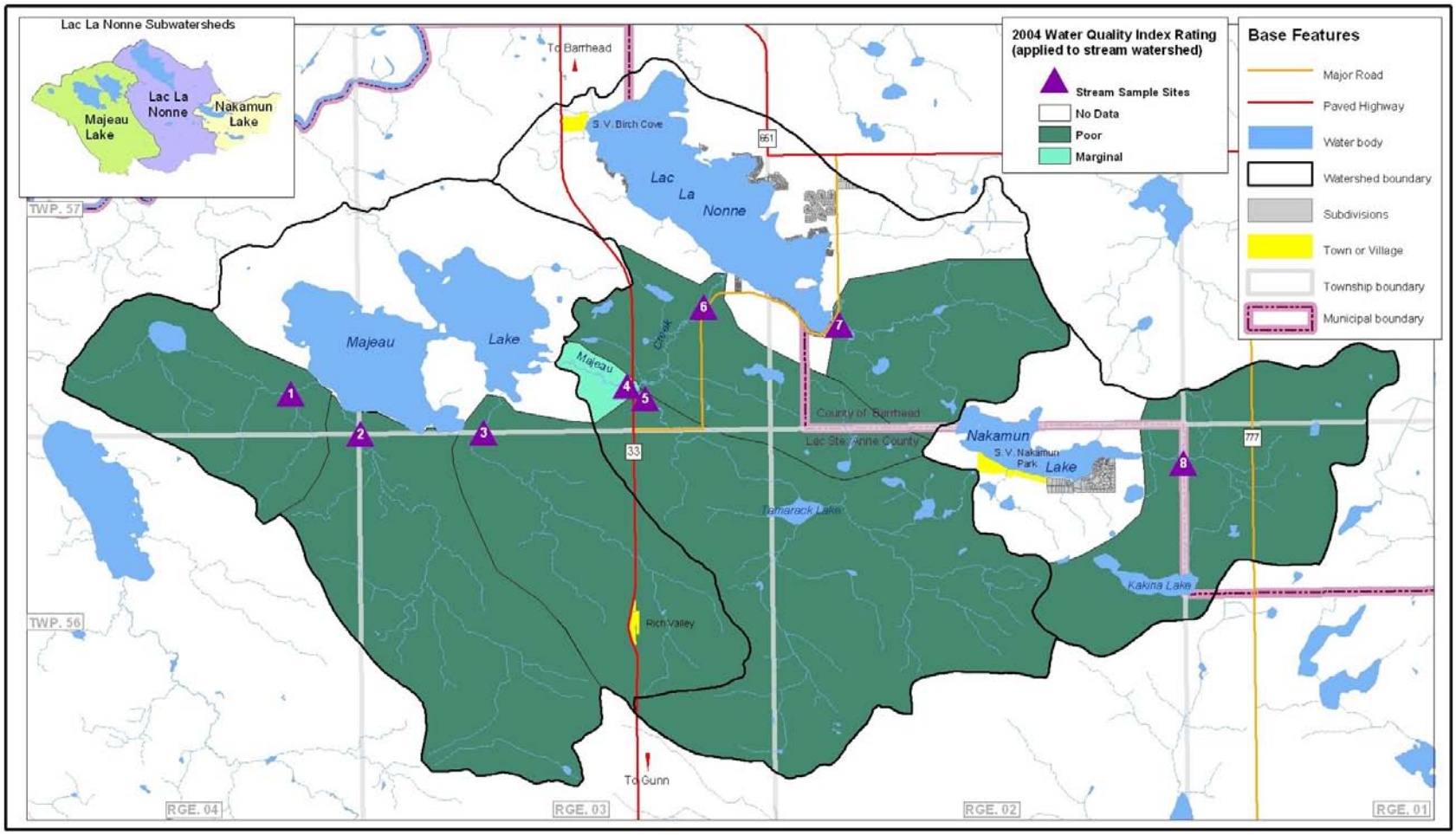

Figure 12. Lac La Nonne Watershed 2004 Water Quality Index Ratings. Data from PFRA (2006).

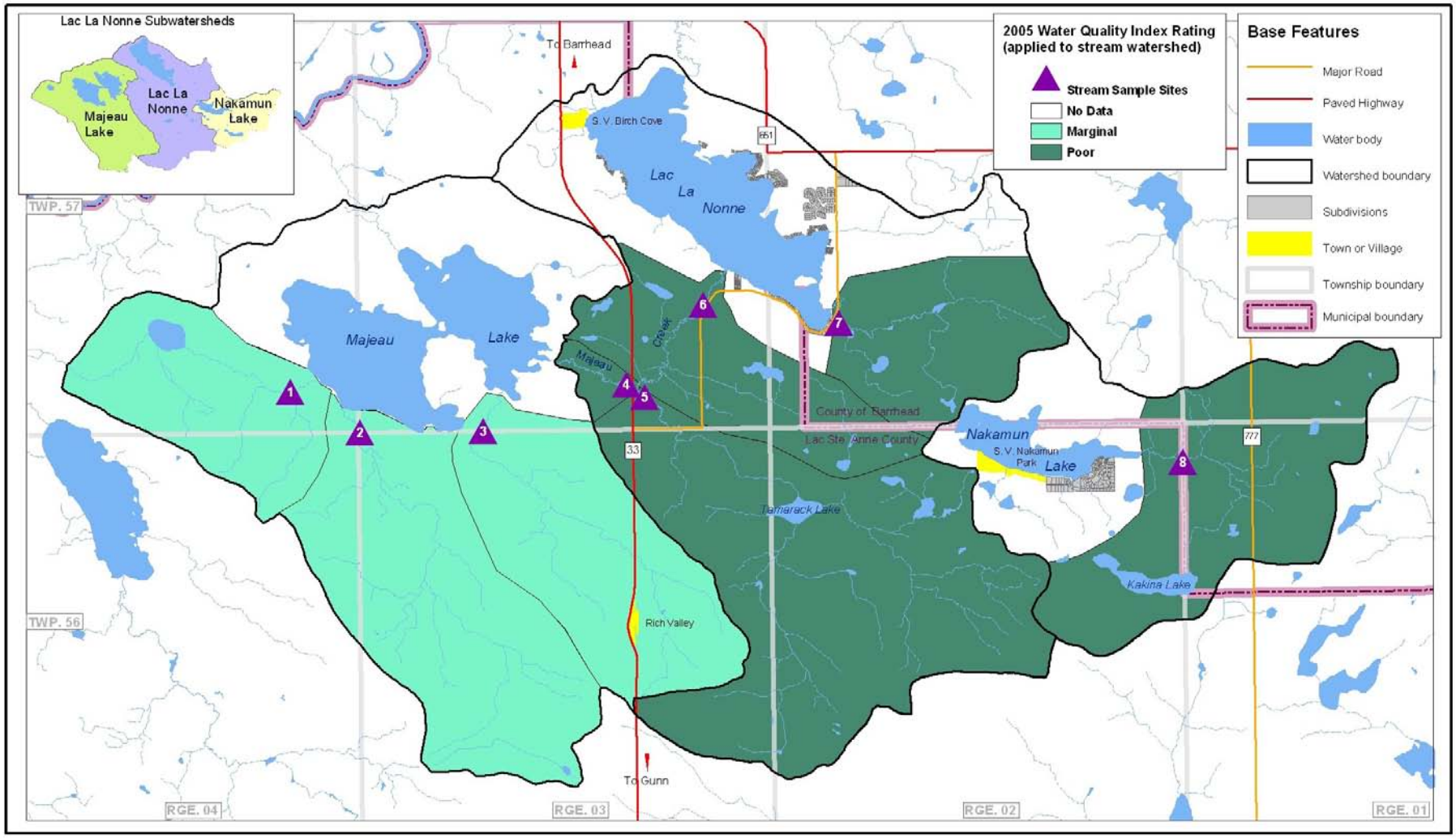

Figure 13. Lac La Nonne Watershed 2005 Water Quality Index Ratings. Data from PFRA (2006).

Table 8: Alberta Agricultural Water Quality Index scores for streams in the Lac La Nonne Stream Water Quality Survey 2004. Scores from 100-95 are Excellent, 94-80 Good, 65-79 Fair, 64-45 Marginal and 44-0 Poor. Data courtesy of Sarah Depoe, Alberta Agriculture Food and Rural Development.

Site No.	AAWQI Nutrient Sub-Index Score	Ranking
1	24.5	Poor
2	17.0	Poor
3	13.3	Poor
4	53.3	Marginal
5	15.6	Poor
6	23.0	Poor
7	19.7	Poor
8	8.8	Poor

Table 9: Alberta Agriculture Water Quality Index scores for streams in the Lac La Nonne Stream Water Quality Survey 2005. Data courtesy of Sarah Depoe, Alberta Agriculture Food and Rural Development.

Site No.	Score	Ranking
1	52.6	Marginal
2	45.5	Marginal
3	50.2	Marginal
4	34.2	Poor
5	39.3	Poor
6	39.4	Poor
7	41.6	Poor
8	39.8	Poor

8.0.5 Lac Ste. Anne Private Sewage Inspections

In 2004, 182 private sewage system inspections were carried out in Lac Ste. Anne County, and 181 sewage systems were inspected in 2005. Table 10 lists a summary of the results. 180 lots were selected for inspection in 2006, but the results were not available at the time of this report.

Table 10: Summary of sewage system inspections in 2004/2005 in Lac Ste. Anne County (Lac Ste. Anne, 2006).

Year	Number of systems inspected	% in compliance with Safety Codes Act	% not in compliance with Safety Codes Act
2004	182	72	28
2005	181	91	9

Non-compliant owners were sent a letter in the spring of 2005 to address the issue, and 35% of the recipients did not respond to the letter. By the end of 2005, however, the County saw a compliance rate of 90% (Lac Ste. Anne, 2006). Non-compliant owners in 2005 would have been sent a letter in the spring of 2006 to address the issue.

Leakage of sewage from faulty private sewage systems could definitely pose a problem for lake water quality, introducing bioavailable nutrients, fecal bacteria and parasites to the water. We recommend that Lac Ste. Anne County proceed with their private sewage system inspection program, and that the County of Barrhead adopt a similar program.

8.1 Biotic Indicators

8.1.1 Fish Populations - Lac La Nonne

Lac La Nonne has a high capability (Class 2) for warm water sport fish such as northern pike (*Esox lucius*), walleye (*Stizostedion vitreum vitreum*), and yellow perch (*Perca flavescens*). Historically, there was a high density of Cisco (*Coregonus artedi*) that have decreased substantially (Stephen Spencer, pers. comm., 2006). Commercial fishing for whitefish occurred prior to 1975 on Lac La Nonne, and used for mink food. Controversy between sports and commercial fishermen over walleye resulted in the closure of the commercial fishery in February 1975 (ERPC, 1981a).

In 1996, the walleye population was considered vulnerable, and a 50 cm length catch limit was imposed. In 1997, creel surveys by Alberta Sustainable Resource Development staff captured 12 walleye, 8 of which were smaller than the minimum length. Catch rates were recorded at 0.005 walleye per angler hour. Based on the criteria used to classify walleye stocks in Alberta, the walleye population in Lac La Nonne was identified as "collapsed" (Stephen Spencer, Pers. Comm., 2006). Catch and release policies were later implemented for the lake.

In 2001, additional creel surveys were performed once again to assess walleye populations. During the summer, over 108 walleye were captured, ranging from 230 mm to 560 mm fork lengths. The most numerous size of fish were those with 320 mm fork lengths (11 caught) followed by 340 mm and 410 mm fork length fish (Figure 14). The population seems to be fairly normally distributed, and would appear to be healthy. Of all fish captured, four were older than four years, the typical age of fertility for walleye.

Creel surveys in 2001 also assessed northern pike populations (*Esox lucius*) in Lac La Nonne. During the survey period, a total of 109 northern pike were captured, ranging from 410 mm to 910 mm fork lengths. The most common size class for northern pike was 500 mm fork length (Figure

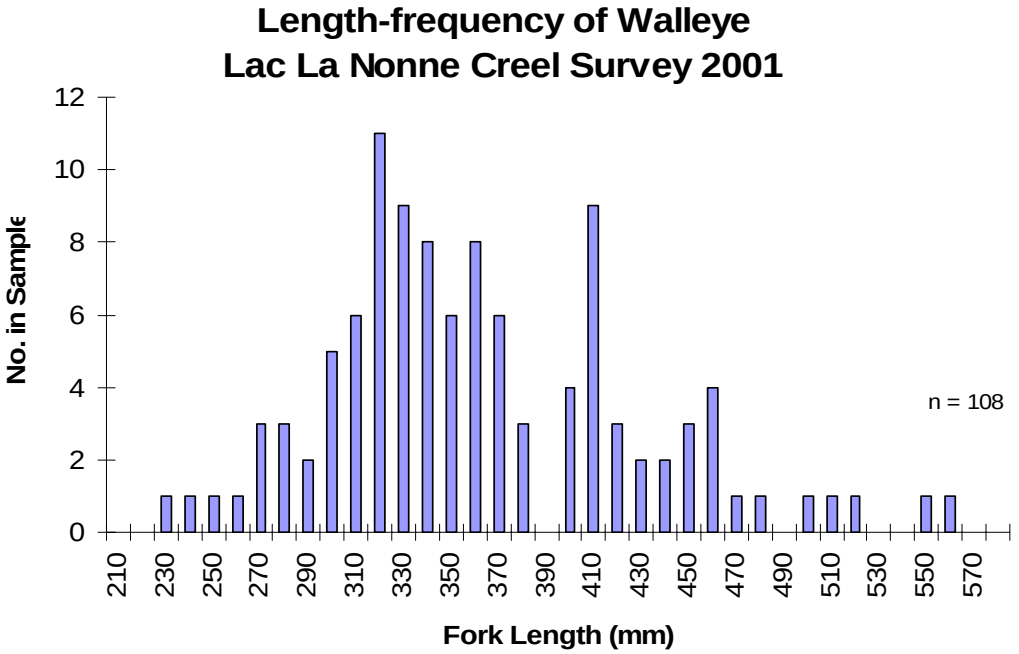

Figure 14. Length frequency of walleye, Lac La Nonne, 2001.

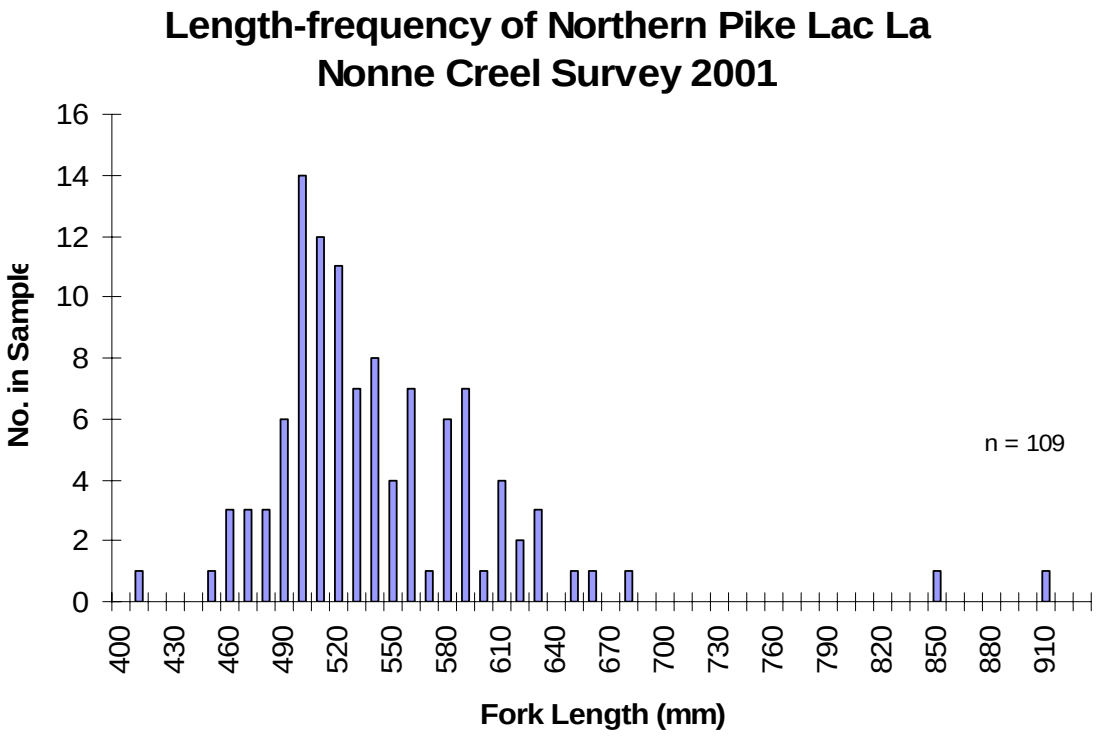

Figure 15. Length frequency of northern pike, Lac La Nonne, 2001.

15). The population seems to be fairly normally distributed, and would appear to be healthy. In total, 43 fish were aged older than 5 years, the typical age of reproduction in most northern populations of northern pike (Scott and Crossman, 1973).

As mentioned earlier, winter oxygen conditions for Lac La Nonne are depleted below 10m yearly but since the lake is fairly deep, the risk of winterkill is likely low (Alberta Environment, 1985a).

8.1.2 Fish Populations - Nakamun Lake

During the winter of 2002-2003, citizens of Nakamun Lake reported an extensive winterkill to Alberta Sustainable Resource Development (SRD). In order to investigate these reports, SRD staff performed test netting in the lake. After setting the test nets for approximately 23 hours, no pike were captured. This has led SRD to conclude that the 2002-2003 winterkill was extensive, if not complete, and that winter dissolved oxygen levels should be monitored in 2003/2004 to determine the likelihood of further fish kills before restocking was attempted (SRD memorandum, 2003). Subsequent monitoring has confirmed the lack of winter oxygen and halted any restocking efforts.

8.1.3 Fish Populations - Majeau Lake

No fish data was found for Majeau Lake when researching this report.

9.0 Land Cover and Land Use

9.1 Land Resources Overview

A large part of the drainage basin, particularly in the southern and central portions, has now been cleared of forest (Figure 16 and Figure 17). A land cover comparison of data from 1992-1995 against data from 2001-2003 would suggest that much of this change has been recent. Over that time period, tree cover loss was 41% for the Lac La Nonne subwatershed, 52% for the Majeau subwatershed and 39% for the Nakamun subwatershed. Presumably, this loss has been due to the substantial increase in forage and cropland cover during the same time period, as Lac La Nonne cropland increased by 174%, Nakamun increased by 105% and Majeau increased by 65% (PFRA, 2006).

Soils with the best agricultural rating (fairly good to good arability) are located south of Majeau Lake. The soils around Nakamun Lake and in the central part of the drainage basin have a poor to fair arability rating. Around Lac La Nonne, large areas that are rated as suitable for pasture and woodland are interspersed with lands that have poor to fair and fair to fairly good ratings (Lindsay et al. 1968). The main agricultural activities in the watershed are cattle and forage production (Mitchell and Hamilton 1982).

Land use in the Lac La Nonne watershed ranges from residential to commercial and industrial, agricultural and recreational (please refer to the Lac La Nonne Municipal Development Plans and Intermunicipal Development Plans for further details on development restrictions and zoning designations). As seen in Figure 18, there are numerous oil and gas wells in the watershed, some still in use and many are abandoned. The Majeau subwatershed contains the majority of the wells in the watershed, but most are abandoned. There may be a risk to groundwater from abandoned wells that are not properly decommissioned (sealed). Land use planning from the Lac La Nonne Intermunicipal Development Plan is shown in Figure 19.

Linear disturbances within the watershed are displayed in Figure 20. The majority of the linear disturbance arise from pipelines, trails and roads, with some power lines present. An ATCO gas pipeline passes between Lac La Nonne and Majeau Lake that connects Swan Hills to the Edmonton area. Utility services to the Lac La Nonne area are provided by the Lac Ste. Anne Natural Gas Co-op, Enmax and Telus.

Protected areas, including environmental reserves[1], historical sites, conservation easements and protected areas are shown in Figure 21. There are large historical areas at the southern end of Lac La Nonne, and in the southeast portion of the Majeau subwatershed. Small conservation easements exist on the western shore of Lac La Nonne, and around a small lake southeast of Lac La Nonne. Larger protected areas can be found in the northern section of the Majeau subwatershed, and smaller areas exist on the northern shore of Lac La Nonne and in the southern portion of the Nakamun subwatershed.

9.2 Agricultural Resources

Agricultural land census data was not available at the time of this report, and is identified as a data gap. General agriculture data for Barrhead County No. 11 and Lac Ste. Anne County was obtained, but information specific to the Lac La Nonne watershed was not provided. Generally speaking, there are 1,139 farms in Lac Ste. Anne County and 895 in Barrhead County (Statistics Canada, 2001). The average farm size is approximately 500 to 600 acres. Approximately 60% of the farms in both counties are cattle operations, with the remainder being field crops, grain and oilseed, hog operations and other miscellaneous specialty farms (i.e. vegetable farms) (Statistics Canada, 2001). As of 2001, in Barrhead

[1] **environmental reserve** - land dedicated to a municipality during the subdivision process because it is considered undevelopable for environmental reasons in accordance with Section 664 of the Municipal Government Act. This may include areas such as wetlands, ravines, drainage courses and steep slopes.

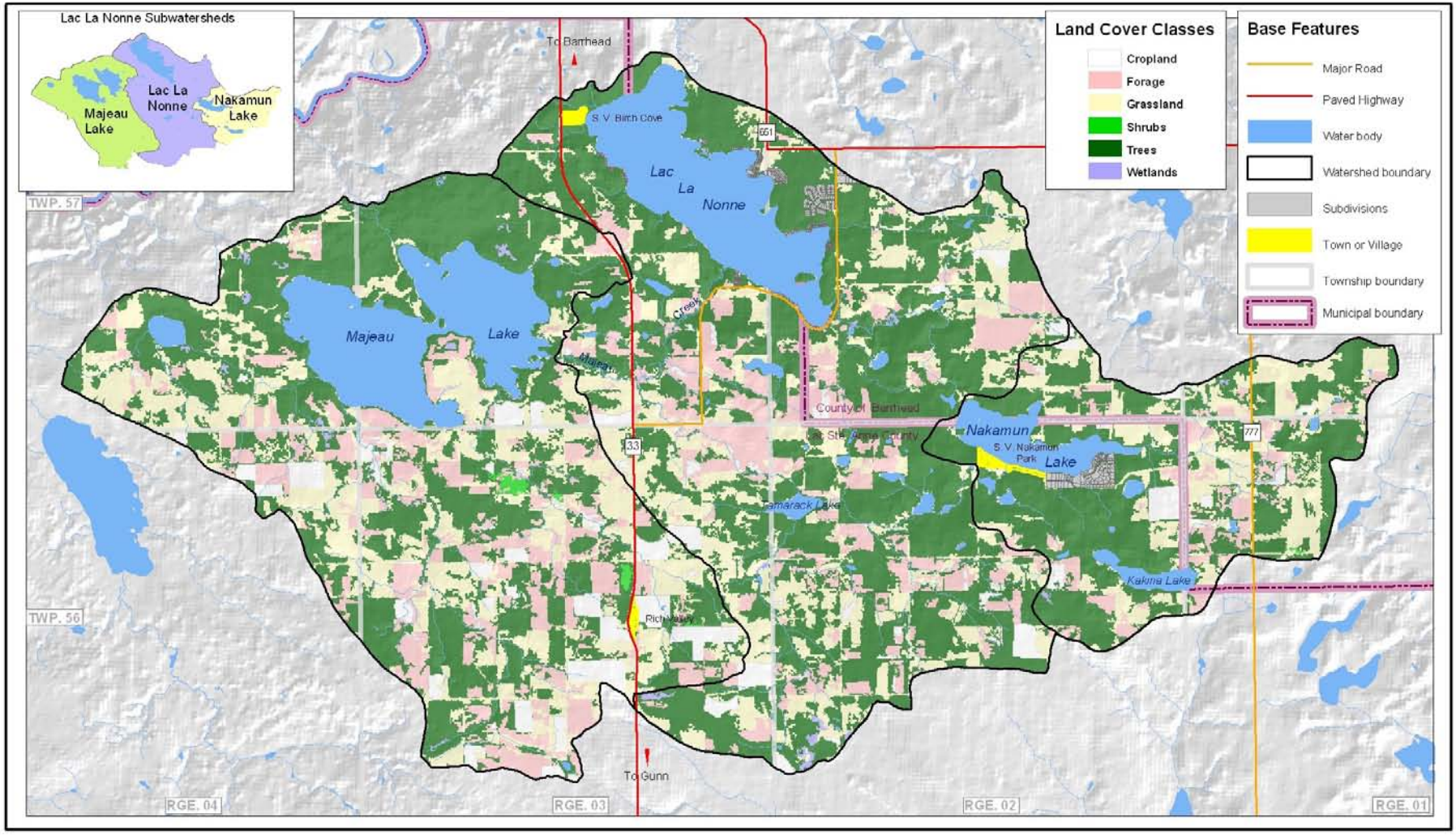

Figure 16. Lac La Nonne Land Cover Map, circa 1990s. Data from PFRA (2006).

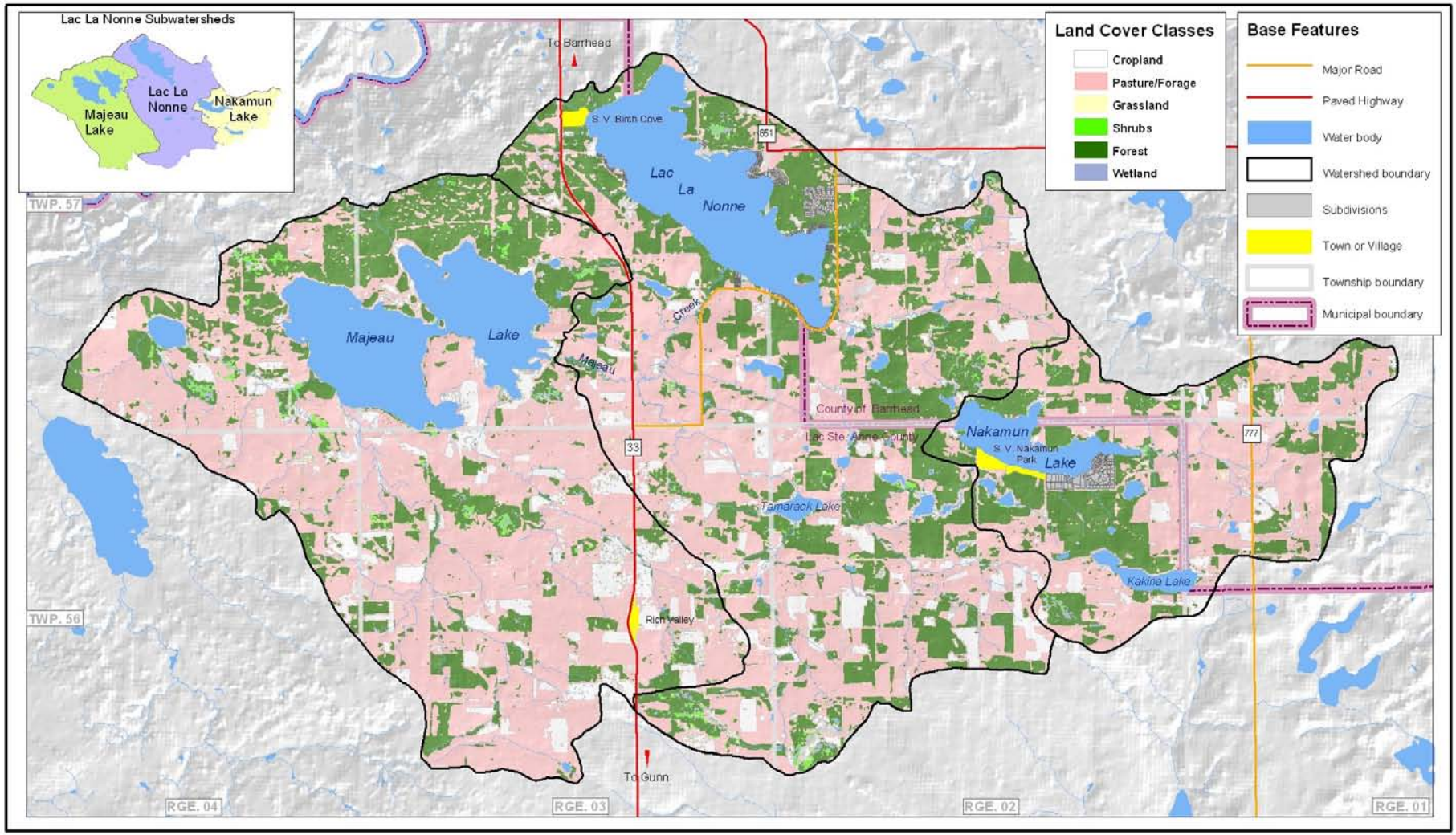

Figure 17. Lac La Nonne Land Cover Map, circa 2000. Data from PFRA (2006).

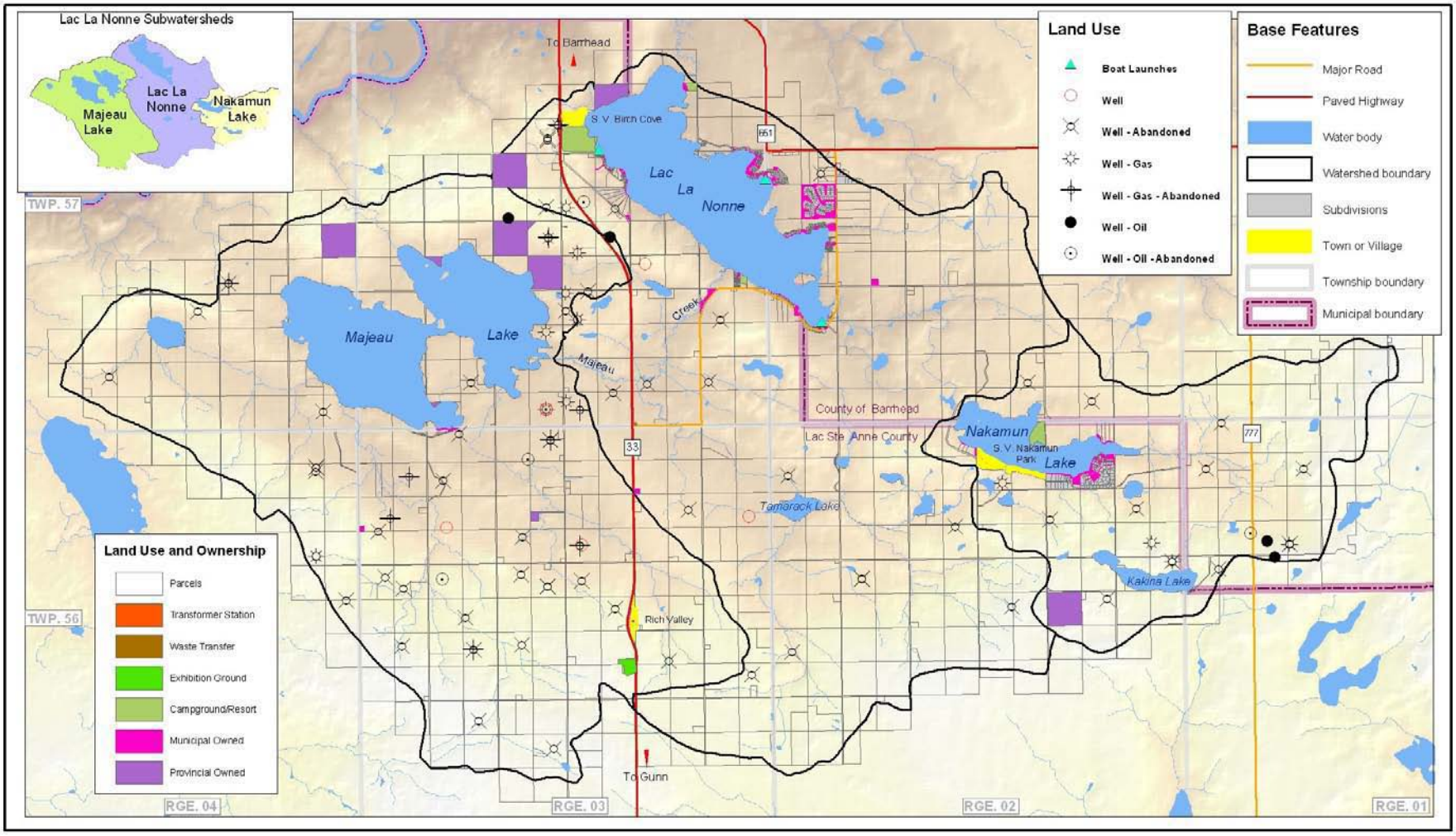

Figure 18. Lac La Nonne Watershed Land Use and Ownership Map. Features identified include oil and gas wells, municipal land, crown land, towns and subdivisions. Data from PFRA (2006).

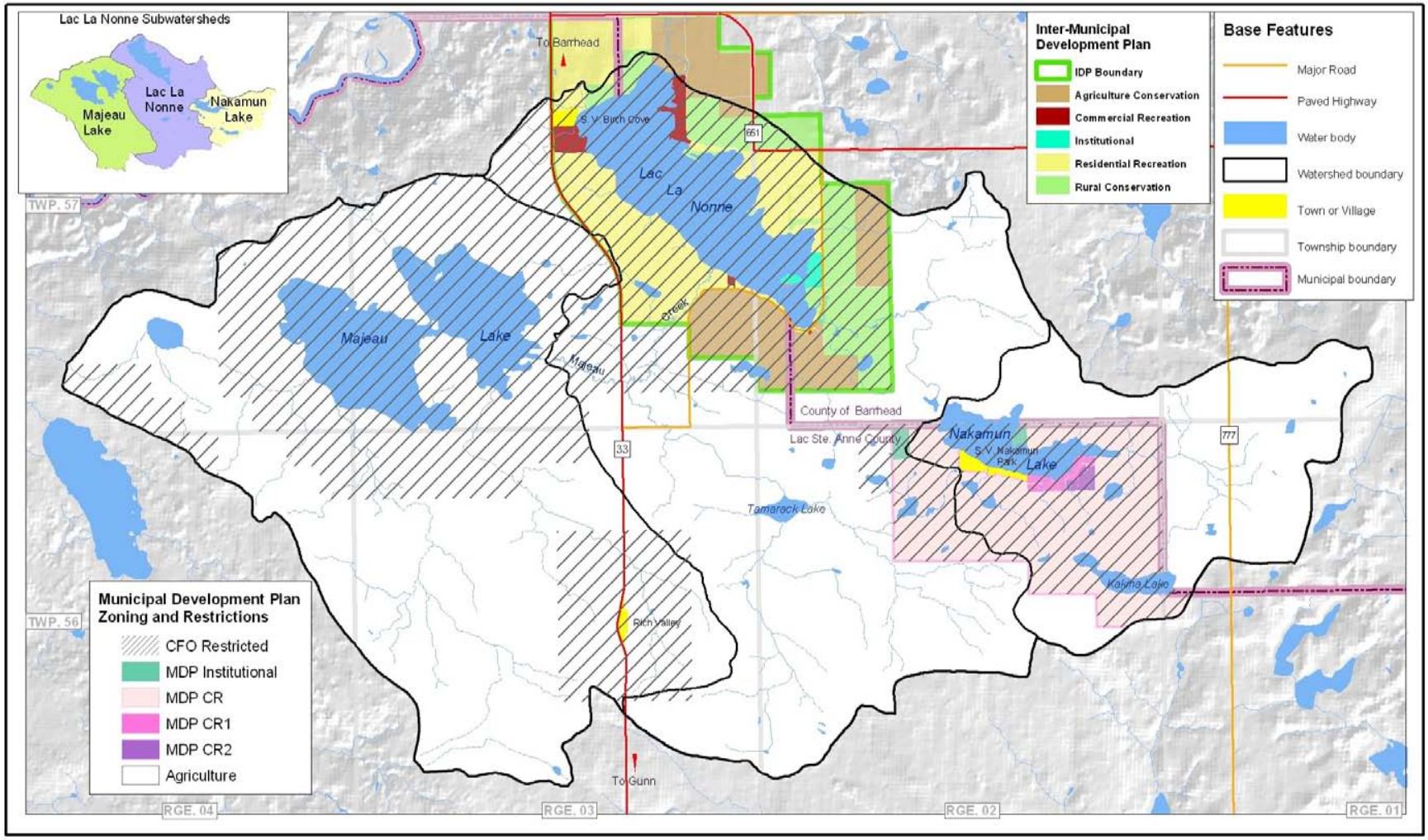

Figure 19. Lac La Nonne Intermunicipal Development Plan (IDP) – Land Use Planning. Key features identified include Confined Feeding Operation (CFO) restrictions, IDP for Lac La Nonne and Municipal Development Planning for both Counties. These include land zoning for environmentally sensitive areas, agriculture conservation, rural conservation, commercial recreation, country residential (CR1 and CR2) and residential recreation areas. Refer to the IDPs and County MDPs for more details. Data from PFRA (2006).

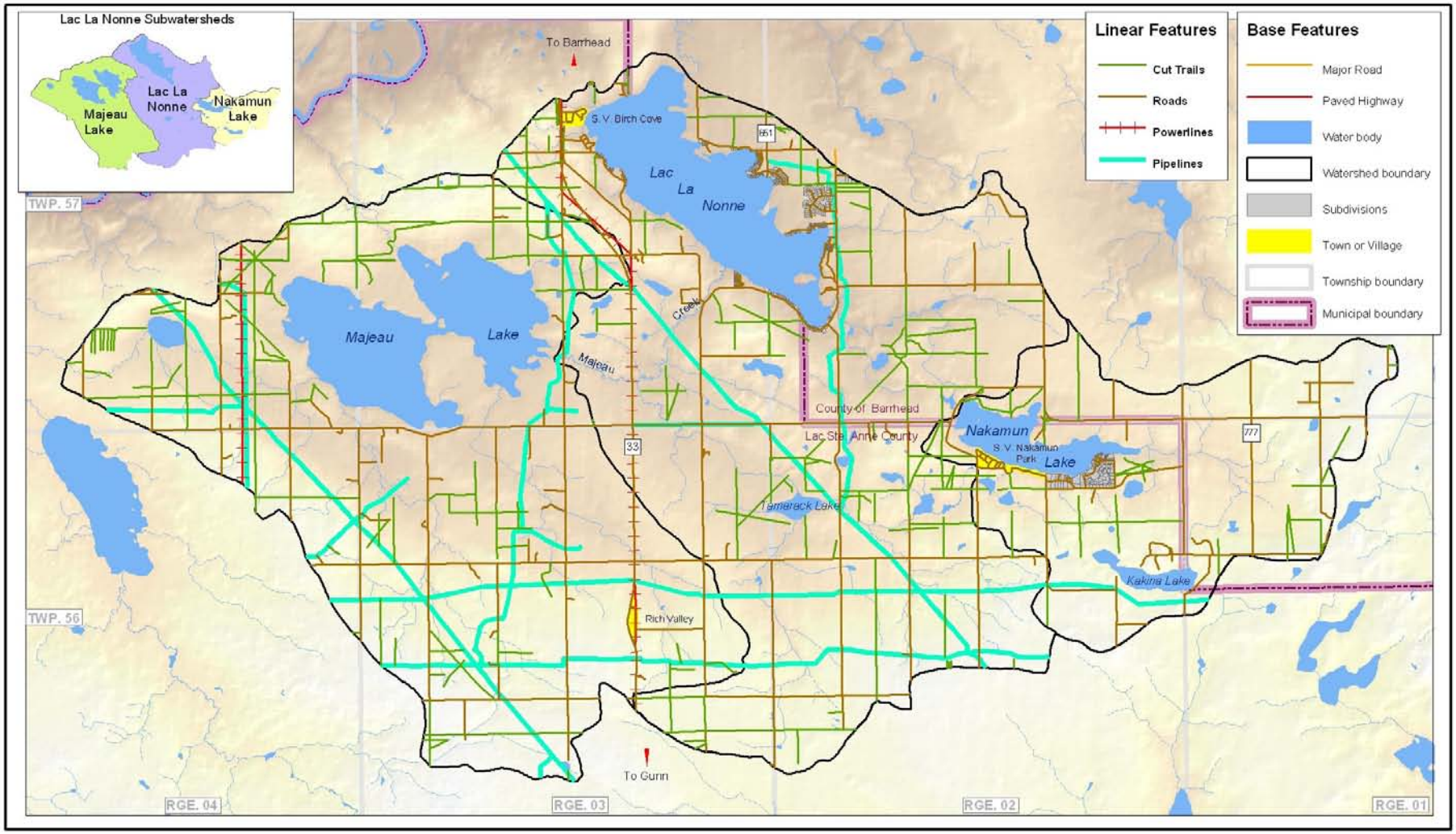

Figure 20. Lac La Nonne Watershed Linear Features. Key features identified include pipelines, powerlines, roads and cut trails. Data from PFRA (2006).

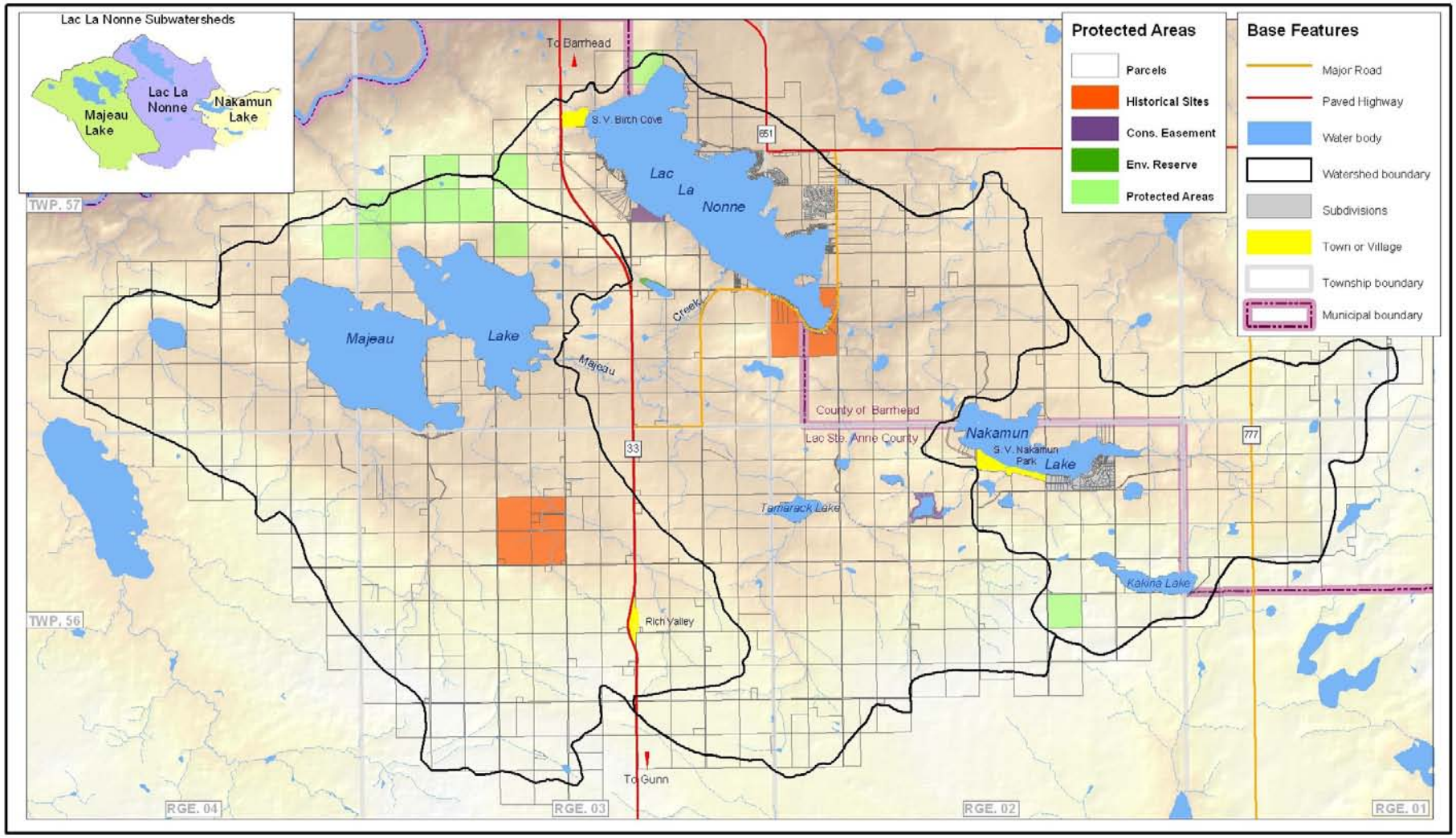

Figure 21. Lac La Nonne Watershed Protected Areas. Key features identified include conservation easements, environmental reserves, historical sites and protected areas. Data from PFRA (2006).

County, there were 117,064 head of cattle, and 105,632 head of cattle in Lac Ste. Anne County (Statistics Canada, 2001). Commercial fertilizers are used by approximately 32% of farms in Lac Ste. Anne County, and by approximately 47% of farms in Barrhead County; herbicides are used by 20% and 39% of farms, respectively (Statistics Canada, 2001).

Although undesirable soil structure, adverse topography and, in some areas, excessive moisture, have limited agriculture in parts of the Nakamun subwatershed, more than half of the land has been cleared for agriculture. The predominant agricultural activity is beef production and most of the cleared land is used for either improved pasture or forage production (Twardy and Brocke 1976; ERPC, 1979).

Impacts to water quality are largely from certain agricultural practices including tillage practices, manure management and animal management. Zero-till practices are preferred to heavy cultivation, as are best management practices for manure. Off-site watering that restricts cattle access to sensitive riparian areas is also preferred to prevent riparian damage and erosion.

9.3 Recreational Resources

Non-agricultural development, such as residential and commercial areas, can pose a problem to aquatic health due to the poor quality of stormwater runoff typically associated with such areas, as well as the large amount of clearing, grading and paving that is required. Stormwater runoff from paved areas can include heavy metals, pesticides, nutrients, and fecal matter from pets, which typically gets funneled into a central collection system and directed towards the nearest waterbody, where it is released untreated. Clearing and grading of the land changes the natural topography of the area and removes valuable vegetation, consequently altering the pre-existing surface water runoff patterns and reducing groundwater recharge through percolation. There is extensive development throughout the Lac La Nonne and Nakamun subwatersheds, which could play a large role in the poor water quality seen in the area.

9.3.1 Lac La Nonne Subwatershed

Figure 22 demonstrates the land use types specified in the Intermunicipal Development Plan for Lac La Nonne. Some riparian areas around the perimeter of Lac La Nonne have been declared environmentally sensitive areas, and the land surrounding the lake has been parceled into agriculture conservation, residential recreation, rural conservation, institutional and commercial recreation uses. The vast majority has been assigned to residential recreation, agriculture conservation and rural conservation. Reserve land widths between developments and lakeshore have been set at 30.5 m, and at 55 m around creeks and watercourse slopes (County of Barrhead, 2003).

The first subdivision at Lac La Nonne of 23 lots was registered in 1947. In 1980, there were 13 resort subdivisions located on portions of 11 quarter sections, with 678 subdivided lots, 537 commercial recreation sites (i.e. lakeshore areas of high scenic value, meant for outdoor recreational activities) and 45 municipal reserves in 47 registered plans of subdivision (ERPC 1981a). There are three commercial campgrounds or trailer parks; Elks Beach, Willow Bend and Killdeer Beach (Figure 22). Nine quarter sections of Crown Land are owned by the Province of Alberta, and three of these are grazing leases (ERPC 1981a). The number of developments has not changed signficantly since the 1980s.

Currently, there are many residential developments around the lake, including Whiterock Beach, Greendale, Idlehours Resort, Moonlight Bay Estates, Moonlight Bay, Winkleman Beach, Williams Beach, Mortenson Beach, Chrystyna Beach, Killdeer Beach, Bearland Condominiums, Murray's Beach and the Summer Village of Birch Cove (Figure 23). There are boat launches at Willow Bend Beach, Idlehours Resort and at the southern tip of the lake. Over one hundred of these are beachfront properties.

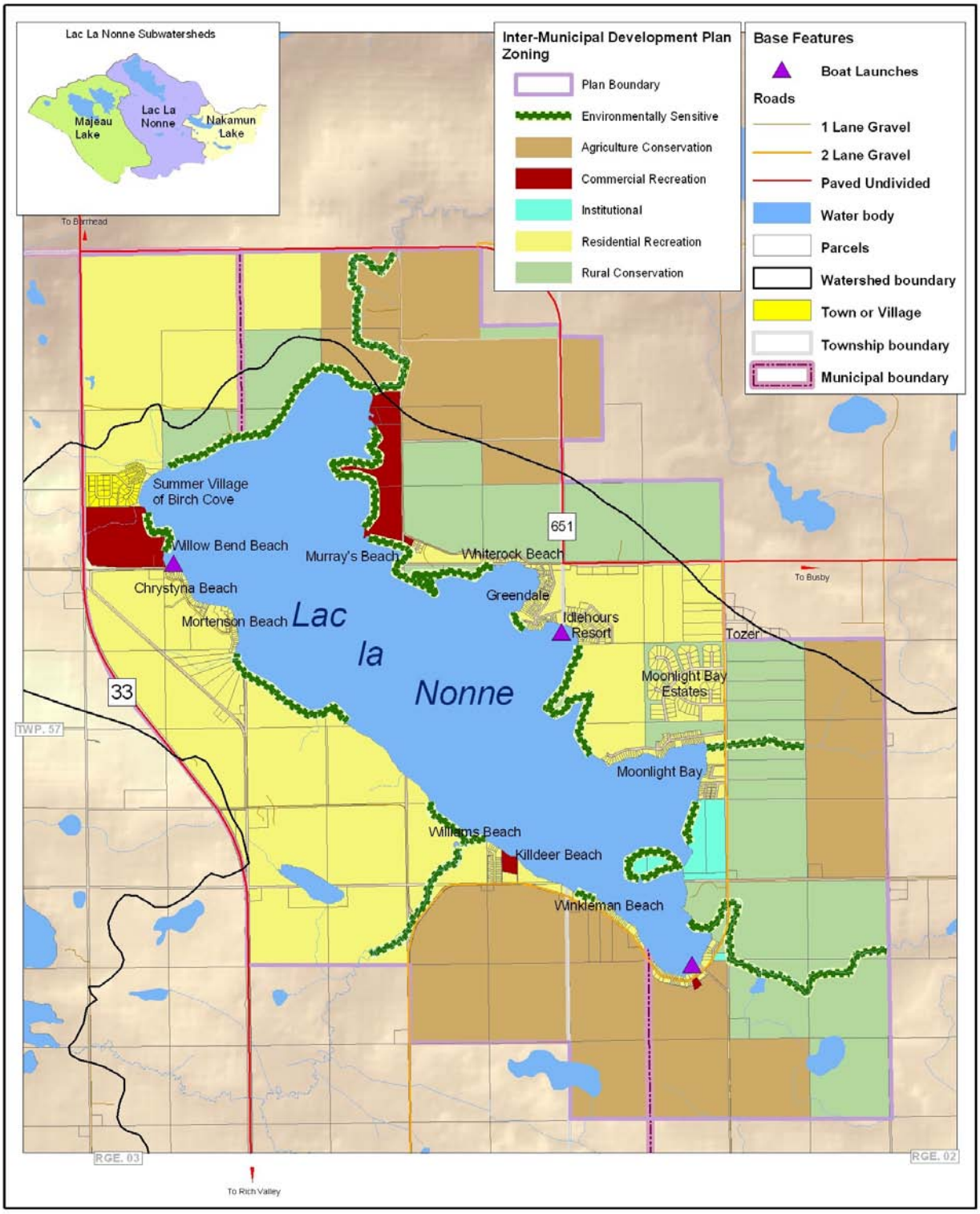

Figure 22. Intermunicipal Development Plan Zoning for Lac La Nonne. Data from PFRA (2006).

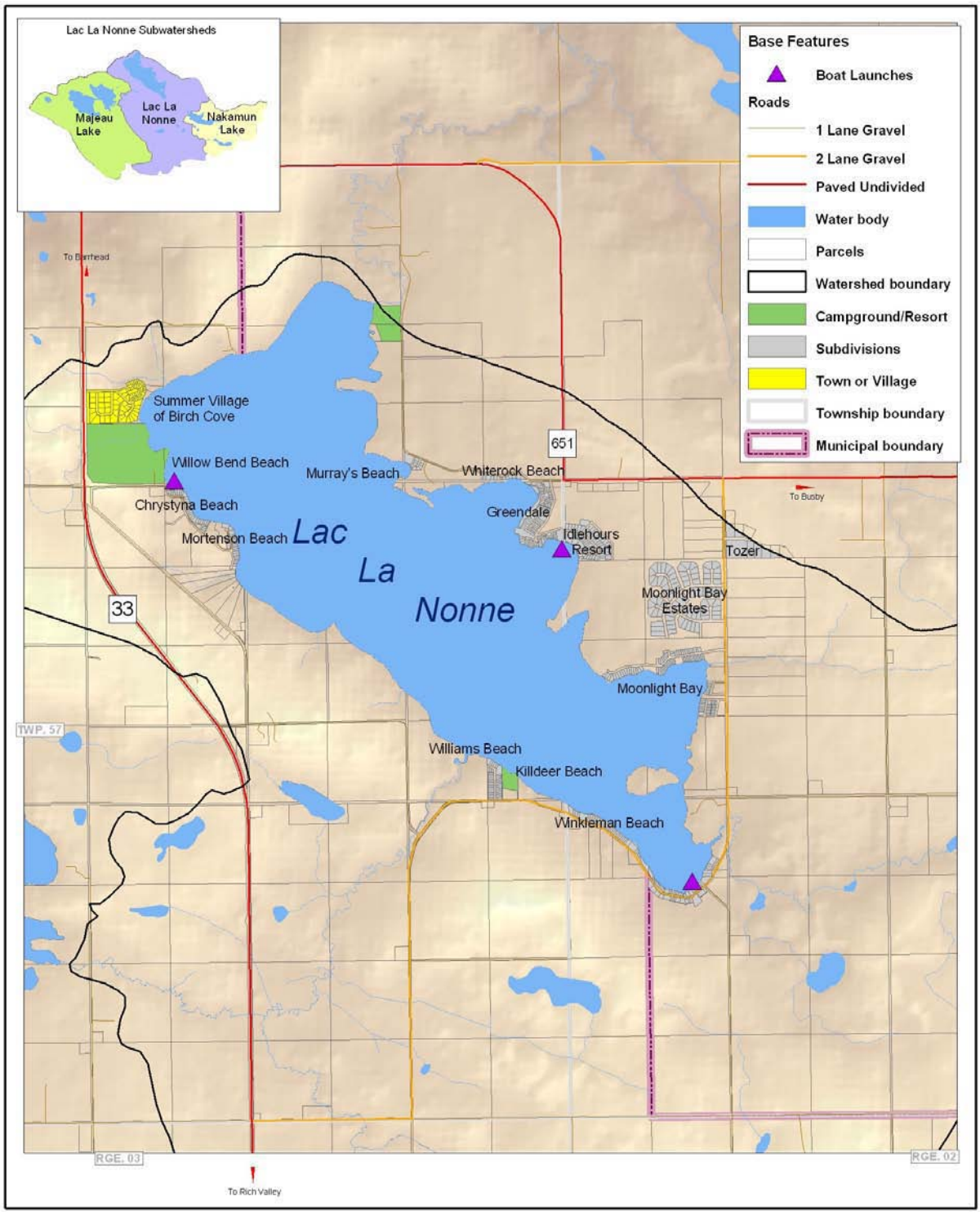

Figure 23. Lac La Nonne Lake Subdivisions. Several small subdivisions are scattered around the east, west and south portions of the lake. Data from PFRA (2006).

9.3.2 Nakamun Lake Subwatershed

The first subdivision at Nakamun Lake was registered in 1960, and became the Summer Village of Nakamun Park in 1966. This subdivision is on the southwest shore of the lake (Figure 24). Four Oakes subdivision was registered in 1962, and Nakamun Court (also called Losie Glade) followed in 1975, again on the south shores of the lake. There is a campground on the northern shore of the lake, and the majority of the surrounding lands on the north side are either treed or grasslands, mixed with agricultural lands. Much of shorelands around the south end of the lake have been developed for seasonal and permanent residences. As of 1990, 23% of the shoreline was developed, predominantly on the south shore (Mitchell and Prepas, 1990).

Areas to the north of Nakamun Lake have been identified as agricultural land in the future land use plans, and lands to the south have been designated as Inter-Municipal Development Plan Country Residential, with restricted development (Figure 19).

9.3.3 Majeau Lake Subwatershed

There is very little development on the shores of Majeau Lake. The land to the north of the lake is treed, and classified as a protected area (Figure 21). There is considerable forage land to the south of the lake, as well as grasslands. Although the County of Lac Ste. Anne has not completed an individual development plan for Majeau Lake, it has restricted development around it and all lakes in the Lac La Nonne watershed by not permitting Confined Feeding Operations (CFOs) within approximately a kilometer of all lakeshore (PFRA, 2006).

9.4 Other Human/Industrial Influences

Oil and gas exploration has occurred throughout the Lac La Nonne watershed, with the majority occurring south west of Lac La Nonne (Figure 18). There are no major sand or gravel pits in the area, and the area does not appear to have significant aggregate resources (ERPC, 1981a).

9.5 Riparian Health Status

Riparian vegetation disturbances on Lac La Nonne have been recorded as far back as 1980. The ERPC (1981a) noted that shrubs, trees and ground cover had been removed in the vicinity of resort cottage areas, while shoreline vegetation “has often been removed completely”. No riparian health data was found for Nakamun or Majeau Lakes.

Detailed riparian assessments have not been completed in the Lac La Nonne watershed, and this is a data gap which should be addressed before any decisions regarding watershed management are made. Healthy riparian areas are linked to benefits for water quality, water quantity, biodiversity, fish and wildlife habitat, and agricultural production. Currently, there are three riparian improvement demonstration sites, one on the west side of Lac La Nonne and two on the east side, and the health of these sites has been assessed to establish baseline data (K. O’Shaughnessy, pers. comm. 2006). Cows and Fish has flown the watershed in 2000 and 2004 to gather an aerial photographic record of the riparian areas and surrounding landscape in the watershed.

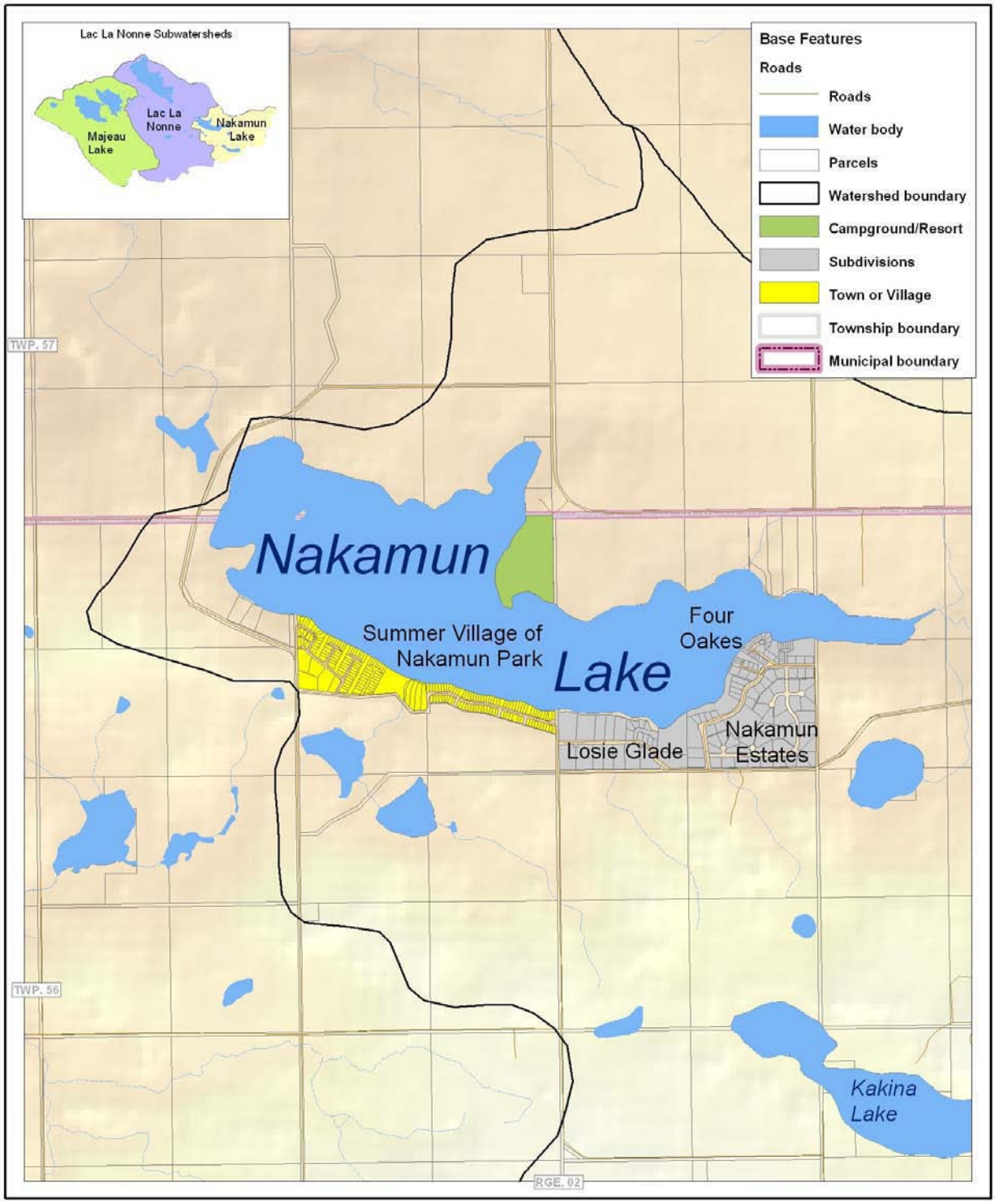

Figure 24. Nakamun Lake Subdivisions. Development of subdivisions has only occurred on the southern portion of the lake. Data from PFRA (2006).

10.0 Issues and Challenges

10.1 Validation of Issues

Based on the results of the water quality testing completed in the Lac La Nonne watershed, many of the public concerns over poor water quality in the lakes are certainly valid, and are issues that need to be addressed. Groups such as LWSS and LEPA continue to provide grassroots actions around the watershed, but larger planning programs need to be initiated by the stewardship groups and their partners. Smaller actions such as riparian demonstration sites with willing landowners, volunteer stream monitoring and lake water quality samplings for sewage testing have been undertaken with great success. Suspicion and mistrust between the local farming community and cottage community regarding their individual issues may undermine stewardship activities in the watershed. This will need to be overcome in future planning and stewardship initiatives, perhaps through the involvement of agricultural fieldmen and continued education and outreach initiatives for producers and cottage owners.

County involvement will be critical for input, issue identification, development and implementation of a plan, enforcement and fundraising. Financial support for some watershed undertakings may only be available to watershed stewardship groups through their County partners, to ensure accountability. Several other County-supported watershed projects around the province have been very successful at raising large grants for watershed management projects, such as Lakeland County (Lac la Biche), Northern Sunrise County (Heart River) and the M.D. of Bonnyville (Moose Lake). This money can be used to supplement funding for projects such as public outreach and education, water quality monitoring, and completion of a watershed management plan.

Education and awareness, behavioural change and enforcement are all tools that will need to be explored to address concerns. As well, all levels of government will need to support the planning efforts to have the political will to enforce environmental infractions to ultimately see changes. Enforcement of environmental regulations at the local level (i.e. the landowner) continues to be the most challenging of these tools. Staffing resources, cost and political will continue to undermine environmental enforcement actions, and this needs to be addressed by the municipalities involved (see section 10.2).

10.2 Data and Data Gaps

Several data gaps have been identified in the compilation of this report. These gaps include, but are not limited to:

- **Agriculture census breakdown** – Could be used to provide data on land use around the lake and point out any areas of high agricultural intensity
- **Drained wetland inventory** – This will highlight any pre-existing wetland areas that may need to be restored to improve watershed health and functionality, and will provide a background level to help determine the rate of wetland loss
- **Riparian health assessments** – This will demonstrate any riparian areas that are in need of restoration or improvement in order to help preserve the health of the lake
- **Water quality monitoring in Majeau Lake** – This will provide a picture of the condition of the lake as well as offer a background for comparison for performance monitoring of watershed initiatives
- **Long term water quality monitoring for Nakamun Lake and Lac La Nonne and tributaries** – This will provide a picture of the condition of the lake as well as offer a background for comparison for performance monitoring of watershed initiatives, as well as give an indication of the water quality entering through the streams
- **Groundwater mapping –** This will help identify recharge and discharge areas, and when used along side the groundwater contamination risk areas map in this report will assist with preservation of groundwater quality and quantity

- **Groundwater quality data –** This will provide a picture of the condition of the groundwater as well as offer a background for comparison for performance monitoring of watershed initiatives
- **Historical information on the Majeau subwatershed –** This would provide some historical context for land use around Majeau Lake
- **Palaeolimnological assessments of Lac La Nonne, Majeau and Nakamun Lakes –** Palaeolimnological assessments will provide a record of water quality changes in the lakes throughout the past 100 years or longer, which will allow a comparison of lake water quality change over time

Many of these data gaps can be filled through establishing partnerships with groups such as Ducks Unlimited, Cows and Fish, Alberta Agriculture, PFRA, Alberta Environment, the Alberta Conservation Association, and the University of Alberta. Fundraising opportunities should be considered on a project-by-project basis. The services of a professional fundraiser should be considered. Numerous federal (Federation of Canadian Municipalities, Department of Fisheries and Oceans) and Provincial (Alberta Lotteries, Alberta Stewardship Network) funding opportunities exist for a variety of projects.

11.0 Conclusions and Recommendations

11.1 Conclusions

Based on the information gathered for this report, we conclude that overall the watershed health is good, with some obvious problem areas. Streams in the area are inputting excess nutrients into all three lakes, and will continue to reduce lake water quality. Poor water quality will lead to increased algal blooms, increased aquatic plant growths, low oxygen levels, fish kills and degraded habitat. Land use practices and excess development, if left unchecked, will only exacerbate the problem due to the clearing of vegetation, stormwater inputs and demands on water supply. As seen in Figures 16 and 17, land cover has changed dramatically since the 1990's; continued alteration of the landscape in this fashion will negatively affect both groundwater and surface water supplies. A watershed management plan needs to be undertaken for the Lac La Nonne watershed.

The following sections identify stewardship opportunities, make recommendations for improving the water quality within the watershed, and direct future strategies for watershed management planning in the Lac La Nonne watershed.

11.2 Stewardship Opportunities

This report should be used by landowners, stakeholders, municipalities and government as a basis for future watershed management planning and for the implementation of BMPs. All regulatory agencies have a role to play in watershed management planning, and the Lac La Nonne Watershed Stewardship Society must work closely with Alberta Environment to ensure success. Financial and technical support will be required from project partners. Communication and outreach will continue to be an important role that the watershed stewardship groups play in educating local landowners and achieving local support and behavioural changes that benefit water quality.

Affected municipalities must be made aware of the importance of preserving watershed health, either through public consultation or advisement from the LWSS. Important points to make would include the cost of infrastructure and/or restoration to improve water quality, the loss of tax revenues from individuals no longer interested in living next to a "polluted" lake, the public health risks associated with toxic algal blooms and the subsequent loss of recreational value of the lake, among others.

Municipalities have a significant role to play in the protection and preservation of watershed health in many ways, including:

- Enforcement of Land Use Bylaws
- Creation of environmentally conscious Area Structure Plans and Municipal Development Plans
- Harmonizing bylaws with other municipalities and ensuring the highest standards are used from each
- Regular review and revision of bylaws as required
- Support watershed management planning activities, including staffing resources, establishing/maintaining ratepayer buy-in, continued education and awareness programs, newsletters and newspaper articles, and establishing a progressive approach with developers and realtors
- Considering wider environmental reserves, municipal reserves, and minimum setbacks from water bodies
- Stormwater management and low impact development initiatives
- Control development in sloped areas due to the potential for stormwater runoff.
- Encouraging the use of Environmental Farm Plans and Homesite Assessments.
- Continue private sewage inspections (Lac Ste. Anne County).
- Begin private sewage inspections (County of Barrhead).
- Undertake riparian health assessments on lakes and other waterways.

Cottage owners have many options available to them for helping to restore the health of the lake and watershed. Groups such as Living by Water and ALMS (among others) have many programs available for assisting cottage owners with improving their land use practices, from how to better manage vegetation to fertilizing practices and water management. A list of stewardship groups can be found on the Alberta Stewardship Network website, www.ab.stewardshipcanada.ca.

On a community basis, initiatives such as shoreline cleanup days should be initiated by the County or by the LWSS, and participation in program like Alberta Water Quality Awareness Day, and Farm WaterWatch should be promoted. Partnerships can be formed with the Alberta Fish and Game Association, Water's Edge Resource Group, the West Central Conservation Group, Alberta Riparian Management Society, Ducks Unlimited, the Alberta Conservation Association, and the Living By Water Project to host open houses, lake awareness days, riparian and wetland restoration sites, and other opportunities to increase the level of education and awareness in the Lac La Nonne watershed residents and stakeholders.

Associated with water quality improvement would be restoration and protection of wetlands and riparian areas, sewage and stormwater best management practices, nutrient management in residential areas, changes to the land use bylaws and IDP to further protect sensitive areas and limit development, and public education and outreach regarding watershed health and beneficial land use practices. A recommendation for future management initiatives would be to implement a long term, annual sampling program for Lac La Nonne in order to monitor lake water quality and as a performance measure for watershed restoration programs. Sources of fecal contamination should be identified and quantified with methods such as microbial source tracking.

A generic land use bylaw has been drafted by the Bow River Basin Council and is freely available for municipalities to review. It can be downloaded from the BRBC website (www.brbc.ab.ca).

11.3 Recommendations

Recommendations for this watershed fall into the following four categories:

1. Planning – This is an ongoing, regulatory approach which will include the watershed management planning process, and the municipal process (intermunicipal development plans, bylaws, others)

2. Stewardship – This is ongoing as well, and requires community involvement. Components of this step are education and awareness, use of cottage owner BMP's provided by organizations such as Living by Water and ALMS, better animal husbandry and agricultural land use practices, nutrient and manure management, and others.

3. Reclamation and restoration – This is the most invasive of all of the steps. This would involve activities such as fencing of riparian areas, off site watering, riparian restoration and planting, and others.

4. Data gaps – Significant data gaps will need to be filled to move forward with a Watershed Management Plan. These gaps include paleolimnology studies on the lake, an overall nutrient budget for each lake, and riparian health information.

Planning is a slow process but will be the most effective method to help preserve the health of the Lac La Nonne watershed. The main areas of concern that have been noted are listed in Table 11, along with the corresponding parties responsible for addressing these priorities.

Table 11. Priority Areas of Concern and Responsibilities

Priority Areas (Highest to Lowest Concern)	Lead Role	Contributors
Water quality of the lakes and tributaries	Provincial and Federal Governments	LWSS
Sewage inputs and concerns over lake recreational use	Municipal Government	Municipal Affairs, LWSS, Alberta Health
Education and Awareness	LWSS/LEPA	Municipal Government, Alberta Environment
Zoning and infrastructure, land use bylaws	Municipal Government	All Muncipalities
Improving land use practices	Municipal Government, Producers and General Public	All Municipalities

11.4 Future Strategies

To move forward, the Lac La Nonne Watershed Stewardship Society and their project partners should embark on the watershed management planning process to address some of the issues faced in the Lac La Nonne watershed. To start this process, a watershed advisory committee (WAC) should be formed, followed by technical advisory committees (TACs) as required. The WAC, once formed, will need to

formalize their mandate, include all involved municipalities and stakeholders, and identify grants or other funding and in-kind assistance in order to complete the watershed management plan and associated activities.

Planning initiatives with the two Counties should be undertaken to harmonize legislation to protect watershed health. For example, the County of Lac Ste. Anne has outlawed septic pits, but Barrhead County has not. Outreach and education programs should focus on nutrient management beneficial management practices for the agricultural and recreational cottage communities. Several data gaps should be filled. Environmental Farm Planning should be undertaken on a large scale and this will likely involve a significant commitment from county agricultural fieldmen. The watershed management plan for Lac La Nonne should be linked with the larger planning initiatives in the Athabasca River Basin in order to ensure consistency and harmony among plans.

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13.0 Listing of Acronyms Used in this Report

AAWQI- Alberta Agricultural Water Quality Index
ALMS - Alberta Lake Management Society
AOPA - Agricultural Operations Practice Act
ASWQG - Alberta Surface Water Quality Guidelines
BMP - Best management practices
CCME - Canadian Council of Ministers of the Environment
CEPA - Canadian Environmental Protection Act
Dam - Decameters
EPEA - Environmental Protection and Enhancement Act
ERPC - Edmonton Region Planning Commission
GIS - Geographic Information Systems
IDP - Intermunicipal Development Plan
Igpm - Imperial gallons per minute
IRM - Intergraded Resource Management
LEPA - Lac La Nonne Enhancement and Protection Association
LWSS - Lac La Nonne Watershed Stewardship Society
MDP CR - Municipal Development Plan Crown Reserve
MGA- Municipal Government Act
PAL- Protection of Aquatic Life
PFRA - Prairie Farm Rehabilitation Administration
ppm - Parts per million (mg/L)
ppt – Parts per trillion (µg/L)
REC - Recreation
SRD - Sustainable Resource Development
SWQI - Surface Water Quality Index
TAC - Technical Advisory Committees
TDP - Total Dissolved Phosphorus
TP - Total Phosphorus
WAC - Watershed Advisory Committee
WERG - Water's Edge Resource Group

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