COLD LAKE–BEAVER RIVER

SURFACE WATER QUANTITY AND AQUATIC RESOURCES

STATE OF THE BASIN REPORT

Alberta
ENVIRONMENT

In partnership with Lakeland Industry and Community Association
and the Cold Lake–Beaver River Basin Advisory Committee

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SECTION 1. PRELIMINARY INFORMATION

1.1 INTRODUCTION

This report is one of four State of the Basin reports described below. Each report gives specific information to provide a snapshot that illustrates the current condition of the Cold Lake–Beaver River (CLBR) Basin. The reports contain inventory and assessment information related to surface and groundwater quantity, quality and aquatic resources of the basin. Also identified are the management tools that are currently available to address water issues in the basin. In addition to providing background information and a knowledge base for the CLBR plan, the reports update information in the 1985 planning documents.

Developing the State of the Basin reports was a collaborative team effort using expertise from Alberta Environment, Sustainable Resource Development, Alberta Agriculture, Food and Rural Development, Prairie Farm Rehabilitation and Administration, Department of Fisheries and Oceans, and the Lakeland Industry and Community Association (LICA).

The four State of the Basin reports prepared for the CLBR Basin Plan Update are as follows:

- *Surface Water Quantity and Aquatic Resources State of the Basin Report*: This document contains an overview of regional hydrology, lake-based water balance studies, an assessment of current and historical surface water allocation and uses, and best management practices for municipal, agricultural and industry water conservation. The report also contains an assessment and update of fish and fish habitat, wildlife and recreation in the basin.
- *Groundwater Quantity and Brackish Water State of the Basin Report*: This document contains an assessment of fresh and brackish groundwater uses, groundwater/surface water interactions, and the geological/hydrogeological framework of the basin.
- *Groundwater Quality State of the Basin Report*: This document contains an overview of groundwater quality in the basin, including indicator parameters, potential contamination point sources and aquifer sensitivity maps. The report presents a summary of the groundwater quality database developed for the basin, and contains a summary of deep well disposal regulations and practices in the province and the basin.
- *Surface Water Quality State of the Basin Report*: This document contains an overview of regional water quality in lakes and the Beaver River at the Saskatchewan border. Also included is an assessment of surface water quality changes over the past two decades and reasons for the changes. In addition, the report contains an assessment of the sources of drinking water and identifies data gaps.

1.2 Need for The Plan Update

The Cold Lake–Beaver River Water Management Plan was adopted in 1985 to provide direction for managing water resources in the Cold Lake and lower Beaver River Basin. The plan's intent was to ensure an adequate quantity and quality of water to meet long-term user requirements of the basin. Since that time, however, the region has generally experienced below-average runoff as well as increased industrial development and population growth. This has resulted in the need to reassess the demands on the CLBR Basin and update the 1985 plan accordingly.

The update of the 1985 plan is occurring in consultation with stakeholders and the public, and in partnership with LICA and agencies that have an interest or mandate affected by the plan. The initiative undertaken in 1994 to update the 1985 CLBR Water Management Plan was never finalized. The 1994 initiative focused on industrial water supply and allocations due to increased industrial development in the basin.

1.3 Purpose of The Plan Update

Water management plans provide a framework for decision-making by the Alberta government. In particular, Alberta Environment uses the plans to make water management decisions under the *Water Act* and the *Environmental Protection and Enhancement Act*. This update will provide a current look at the state of the CLBR Basin, and a strategy will be developed to meet the current and future water needs of the basin. The updated plan will strive to balance community, economic and environmental issues and values with government legislation and policy for protecting and managing water resources in this area.

The Water Management Plan Update will assess the following:

- Groundwater quality and quantity
- Surface water quality and quantity
- Groundwater and surface water flows and interactions
- Aquatic resources.

The plan update will be guided by the following principles:

- ► Water must be managed sustainably.
- ► Water is a vital component of the environment; all life depends on it.
- ► Water plays an essential role in a prosperous economy and in balanced economic development.
- ► Water must be managed using an integrated approach with other natural resources, resulting in a healthy aquatic environment.
- ► Water must be managed in consultation with the public.
- ► Water must be managed and conserved in a fair and efficient manner.

1.4 Planning Area

The Cold Lake–Beaver River planning area is part of the CLBR Basin located approximately 300 km northeast of Edmonton. The Cold Lake River Basin drains to the outlet of Cold Lake, while the Beaver River Basin drains to the Alberta/Saskatchewan boundary.

The plan update study area focuses on the following lakes and downstream rivers:

- Jackfish Creek
- Manatokan Creek
- Marie Creek
- Moose Lake River
- Muriel Creek
- Reita Creek
- Sand River
- Wolf River
- Cold Lake
- Moose Lake
- Muriel Lake
- Marie Lake

The surface waterbodies supply most of the water used by the municipalities, of which the City of Cold Lake and the Town of Bonnyville are the largest. Cold Lake was incorporated in 1996 through amalgamation of Grand Centre, Cold Lake and 4 Wing Cold Lake (military base). It serves a regional trading area of approximately 50,000 people. Statistics Canada recorded an official population for Bonnyville of 5,710 in 2001, but the town serves more than 10,000 people living within a 10 km radius.

1.5 Plan Update Goals and Objectives

The plan update goals and objectives were laid out in the approved Terms of Reference, and are listed below.

Goals

- Assess the state of regional ground and surface water supply, quality, use, and their interactions in the basin based on the most recent information.
- Provide a strategy to meet current and future water needs in the region and ensure a sustainable water supply.
- Provide a strategy to protect and ensure a healthy aquatic environment.

Objectives

- Water Allocation — Review current and historical water allocation in the region.
- Water Use — Review current and historical water uses in the region and their potential impact on local water resources.
- Water Demand — Identify existing water demands in the region and forecast future short-term, medium-term (2010), and long-term water (2020) use.
- Water Supply — Establish quantity and distribution of surface and groundwater supply in the region.
- Water Interactions — Identify/investigate groundwater and surface water interactions.

- Legal Mandate — Identify all laws and legal agreements that are used to manage water in the basin, and ensure the plan is consistent with them.
- Water Conservation Objectives — Establish water conservation objectives to protect aquatic environments, regional tourism and recreation.
- Water Quality — Review regional surface and groundwater quality, and establish procedures to prevent pollution and degradation of water quality.
- Education — Engage the community, share information, and promote awareness of issues and solutions, as well as understanding about activities that impact the CLBR Basin water quantity and quality.

1.6 OVERVIEW OF ISSUES AND CONDITIONS

Key issues identified in the 1985 plan are listed below, along with their current status and related initiatives.

Industrial Water Supply

- Current industry use of freshwater is less than that predicted in 1985; however, allocation limits established in the plan are now being approached. *(Note: Allocation limits do not reflect actual use.)*
- Construction of a pipeline from the North Saskatchewan River was recommended as a way to secure a supply of freshwater for future use. This recommendation was based on a prediction that industrial freshwater requirements would become much larger than in 1985. Because of increased recycling of produced water and the use of brackish water by industry, the actual water use is only a fraction of the amount projected in the 1985 plan. Thus the pipeline has not been built. In addition, legislation now in place does not allow inter-basin transfer of water, which would be necessary should the pipeline be constructed. Some stakeholders, however, continue to view the pipeline as the preferred option for securing a long-term water supply for industrial use.
- Since 1985, industry has improved the efficiency of their operations through the use of produced water and recycling technology. Industry has also been supplementing make-up water needs by using brackish water for existing operations and future growth.
- Brackish water studies conducted by Imperial Oil and CNRL as part of their industrial expansions suggest the brackish water supply is sustainable and its use will not have a significant impact on fresh surface and groundwater resources.

Cold Lake Water Levels and Water Levels of Other Lakes in the Basin

- Cold Lake and Moose Lake are the water supply sources for the City of Cold Lake and the Town of Bonnyville, respectively. Cold Lake is also one of the water supply sources for CNRL's Burnt Lake operations, Imperial Oil's operations, as well as the Cold Lake Fish Hatchery.
- Cold Lake and other lakes in the basin are important recreational lakes and provide vital fish and wildlife habitat.
- The water flowing from Cold Lake into Saskatchewan is managed under the Apportionment Agreement between Alberta and Saskatchewan.

- There is ongoing concern related to securing municipal and domestic water supplies owing to fluctuating water levels.
- There is concern regarding potential decreases in water levels in local lakes, streams and wetlands due to diversions, particularly during periods of drought.

Effect of Industrial Groundwater Use on Quantity

- Historically, conflicts have arisen between local residents and industry over the perceived interference with water quantity, both as it affects lake levels and shallow groundwater levels.
- Several years of drought-like conditions related to low runoff levels in 1999-2002 resulted in low lake levels and local opposition to further industrial surface water withdrawals in the basin.
- Some local residents believe industrial pumping from deep useable aquifers has added to the impacts of the drought cycle, and point to the decline in some water levels as evidence of the interconnection between deep and shallow aquifer systems.
- Nine options for water supply alternatives were examined and evaluated in the 1994 Cold Lake–Beaver River Water Management Study Update using a number of criteria, including reliability of supply, economic factors, and impacts on other users and the environment. The preferred source for industrial water continued to be the proposed North Saskatchewan River water supply pipeline.
- The second, although less desirable, source of water was a system of weirs on Cold Lake or Primrose Lake and Wolf Lake, supplemented by the use of brackish water to the maximum extent possible. The reasoning at the time (1994) was that in the interim, while the long-term alternative (pipeline) was being constructed, industry could maximize its use of brackish water and continue using surface and groundwater within the existing license limits.

Groundwater Quality

- Groundwater protection is one of the most significant issues arising in the Cold Lake area. There is ongoing public concern that thermal, geomechanical or geochemical effects of oil production techniques may be releasing contaminants into useable aquifers.
- Available data for some contaminant indicators (e.g., arsenic, phenols, dissolved organic carbon) showed they tend to be clustered around industrial developments; little data are available for the rest of the basin. It should be noted that groundwater monitoring is most extensive near industrial developments, and measures additional and different chemical parameters than through standard water monitoring used in the rest of the basin.
- Residential well data tend to be clustered around Bonnyville and Cold Lake.
- No baseline groundwater quality data were included in the 1984 Cold Lake groundwater study for comparison purposes.
- Alberta Environment (AENV) contracted the Alberta Geological Survey (AGS) to compile a database of groundwater quality in the study area, including developing maps of all potential contaminant sources. This information will be used to help develop a comprehensive, long-term groundwater monitoring strategy that will address data gaps identified by AGS.

Protecting Sources of Drinking Water

- The potential impacts of industrial or other land-based activities on drinking water quality (both municipal and domestic wells) have been an ongoing concern in the CLBR Basin.
- Protecting the sources of drinking water was not specifically addressed in the 1985 plan or the 1994 study update.
- The Department of Environment is developing a provincial strategy to address "Protection of Sources of Drinking Water" as a follow-up action under the *Water for Life Strategy*.
- The CLBR Plan Update will assess municipal drinking water quality and general lake water quality. Investigation of private drinking water systems is outside the scope of this plan and is the responsibility of the individual owner. However, it must be recognized that private wells exist in large numbers and have the potential to serve as conduits for surface contaminants if they are not well maintained and abandoned correctly when no longer in use.
- Non-point source pollution is better assessed by monitoring runoff, identifying hot spots and developing management strategies at the watershed level through specific watershed management plans (e.g., the stakeholder-led *Water for Life* plan for Moose Lake).
- Contaminant prevention is the most effective strategy for dealing with water quality issues.

Surface Water Quality

- Some stakeholders in the planning area believe oil production is causing the following:
  - increased surface water salinity due to groundwater contamination; and
  - reduced water levels, which in turn are decreasing water quality.
- The increased shoreline and basin development is decreasing the quality of surface and drinking water, as well as recreation potential.
- There is a concern that water quality is negatively impacted by decreased water levels.
- There is a lack of water quality data prior to the 1980s. As such, comparisons with pre-development water quality cannot be made.
- There is a lack of water quality data for some lakes.
- Insufficient river/stream water quality data has made it difficult to detect change.
- Support of long-term monitoring sites for lakes and rivers is essential.
- Water quality in the CLBR Basin is above average compared to the rest of Alberta; however, areas of concern were identified in heavily developed sub-basins.

1.7 ORGANIZATION OF TECHNICAL STUDIES

Collecting and analyzing data is an essential part of updating the 1985 Plan. Four Technical Advisory Teams provided baseline information for the Cold Lake–Beaver River Water Management Plan Update: the Groundwater Quality Team, Groundwater Quantity Team, Surface Water Quality Team, and Surface Water Quantity and Aquatic Resources Team.

The technical teams reviewed existing information on water resources, identified information gaps, collected new information to address specific objectives, and provided advice on recommendations for the plan update. The teams and their responsibilities are listed below.

Groundwater Quality Team

- Evaluation of existing groundwater quality monitoring and data.
- Recommendations on a program to monitor and assess future groundwater quality.
- Overview of existing data on deep well disposal.

Groundwater Quantity Team

- Hydrogeological framework.
- Numerical flow model.
- Assessment of brackish water supply.
- Overview of groundwater flows and interactions with surface water.

Surface Water Quality Team

- Assessment of existing surface water quality monitoring data, including developing nutrient budgets for select lakes.
- Assessment of sources of drinking water quality.
- Assessment of municipal water quality data.
- Recommendations for long-term monitoring program.

Surface Water Quantity and Aquatic Resources Team

- Assessment of water availability at key locations (water balance).
- Assessment of actual regional water allocations and uses.
- Estimate of future water demands.
- Assessment of fisheries, water-based wildlife and recreation.
- Recommendations for water conservation objectives and strategies to protect the aquatic environments.

1.8 REPORT FOCUS

This state of the basin report describes surface water allocations and uses from 1985 to 2003, in addition to municipal, agricultural and industrial water conservation. Fish and fish habitat, as well as water-based wildlife and recreation are assessed.

Although this state of the basin report focuses on surface water quantity issues in the CLBR Basin, the issue of water quantity is intertwined with other basin issues such as groundwater quantity and quality, and surface water quality.

SECTION 2. OVERVIEW OF THE BASIN

2.1 PHYSICAL SETTING

The Cold Lake–Beaver River Basin is located approximately 300 km northeast of Edmonton (Figure 2-1). Most of the basin lies within Alberta, covering about 2% of Alberta's surface area, with a small portion extending into Saskatchewan. The basin is within the Boreal Forest Natural Region of Alberta, with undulating to moderately rolling topography and elevations ranging from about 500 m to 750 m above sea level (ASL). Boreal forest and aspen parkland vegetation communities dominate this region, consisting primarily of aspen, balsam poplar, white birch and white spruce. Jack pine is found in the more sandy areas, while black spruce and tamarack are found primarily in low-lying, poorly drained locations.

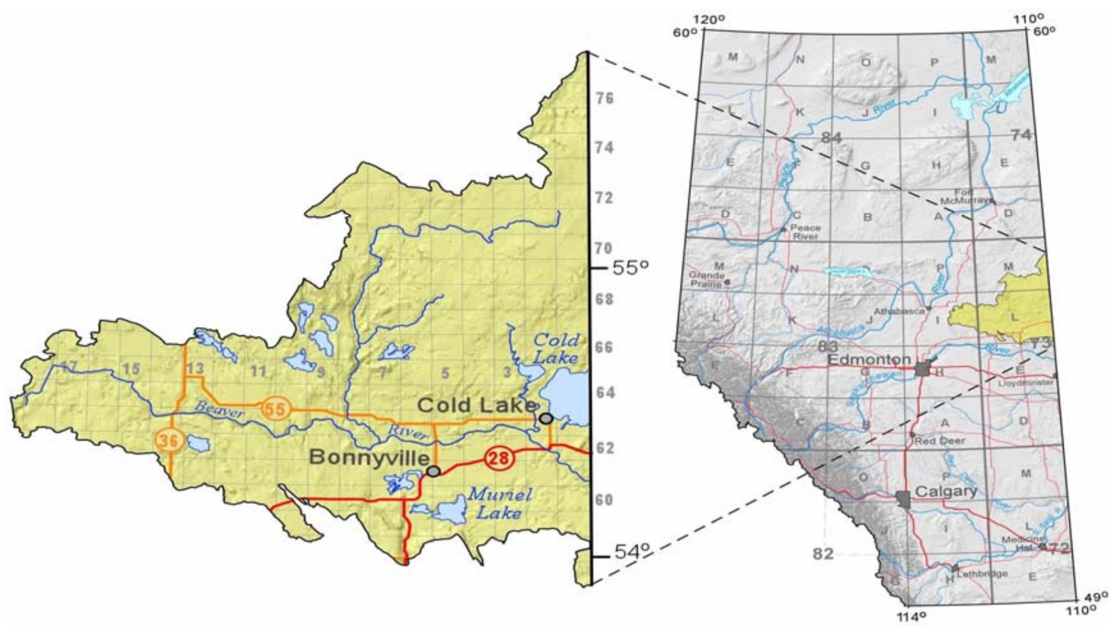


Figure 2-1. Cold Lake and Beaver River Basins within the Province of Alberta.

Figure 2-2 shows the entire basin has a total drainage area of 22,000 km^2, and comprises the Beaver River Basin (15,500 km^2) and the Cold Lake drainage system (6,500 km^2). The Beaver River originates near the Town of Lac La Biche as the outflow from Beaver Lake, and flows eastward. Cold Lake is the largest water body in the planning area, with a surface area of 350 km^2. A small portion of Primrose Lake falls within the planning area. Primrose Lake drains into Cold Lake through the Martineau River, and Cold Lake drains into the Beaver River through the Cold and Waterhen Rivers. The Cold Lake and Beaver River Basins then flow into the Hudson Bay through the Churchill River system.

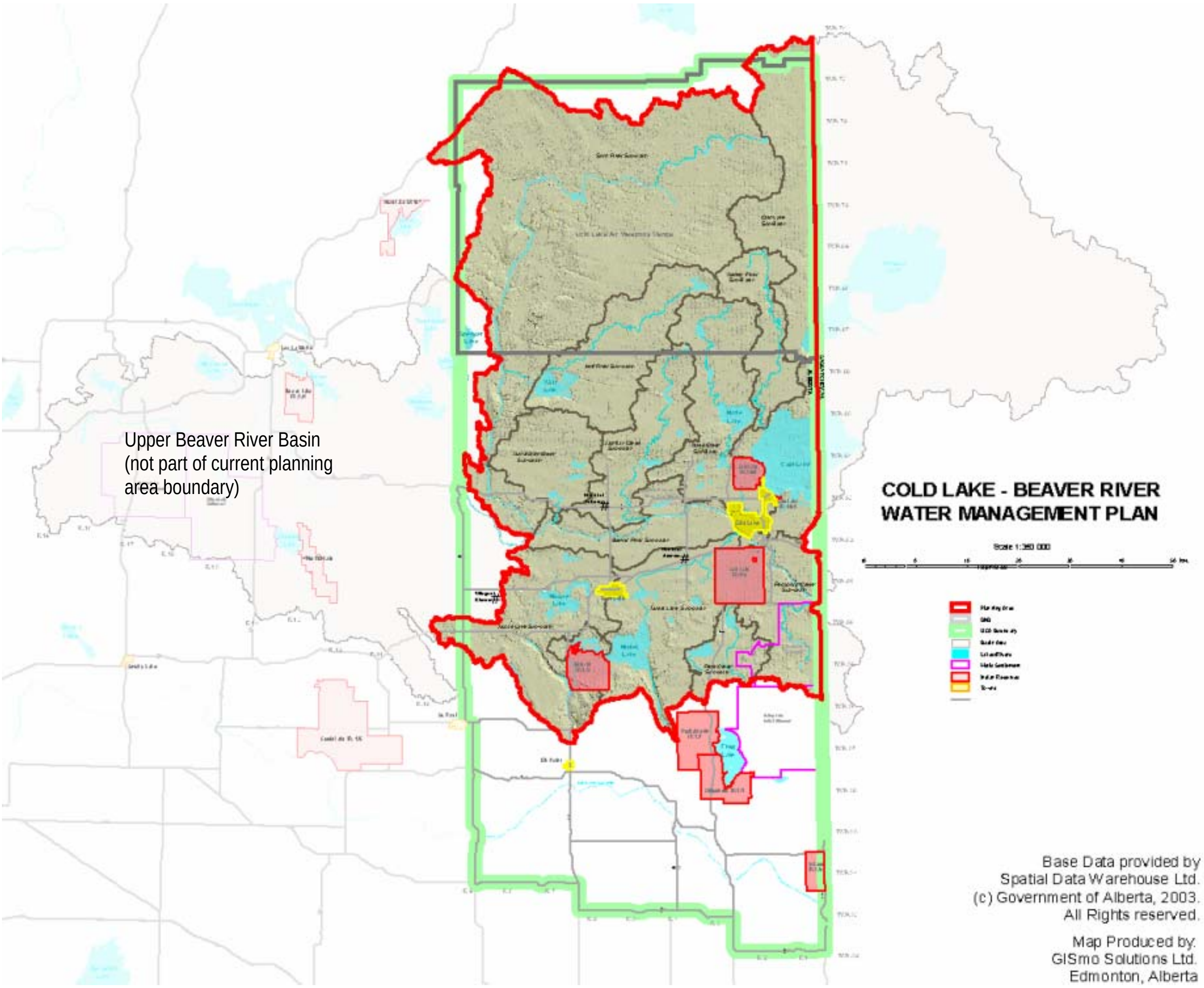


Figure 2-2 Cold Lake and Beaver River Basins with CLBRWMP Planning Area.

2.2 OVERVIEW OF BASIN WATER RESOURCES

In addition to the vital role of sustaining ecosystems, surface and groundwater in the Cold Lake–Beaver River Basin is used for many purposes including domestic and municipal uses, industrial and agricultural water supplies, and recreation. Understanding and managing regional water resources is essential in order to ensure the water resources are sustainable for both current and future uses. This section provides a brief overview of the basin's water balance, surface water and groundwater resources, regional hydrology and current water allocations. A general discussion on groundwater and surface water interactions is also presented.

2.2.1 Basin Water Balance

Figure 2-3 shows the average Cold Lake–Beaver River Basin annual water balance. The basin cycle is part of the global hydrologic cycle mediated by weather systems and predominantly driven by the sun. Solar power evaporates water from the oceans, and a portion of this water precipitates as freshwater in the CLBRB. On average, 8292 million m^3 (8.3 billion m^3) of water falls as rain and/or snow in the basin each year. Most of this water (7.6 billion m^3) evaporates or transpires through vegetation back into the air and leaves the basin. Some of the water drains from the land as surface water run-off into the Beaver River and some enters the subsurface as groundwater recharge.

About 650 million m^3 of water flows out of the basin through the Beaver River each year. The combined flow out of the basin, including Cold Lake/Cold River (about 350 million m^3), is about 1015 million m^3 (1 billion m^3) of water each year. This water ultimately flows toward the Churchill River system and back to the ocean.

An estimated 166 million m^3 of water enters the subsurface on the Alberta side of the basin as groundwater recharge each year. This water slowly percolates into the ground over time and results in fresh groundwater aquifers. It also discharges to lakes and streams in about the same amount each year. In other words, the amount of water entering as groundwater recharge equals the amount flowing into streams and lakes less the small amount pumped by groundwater users.

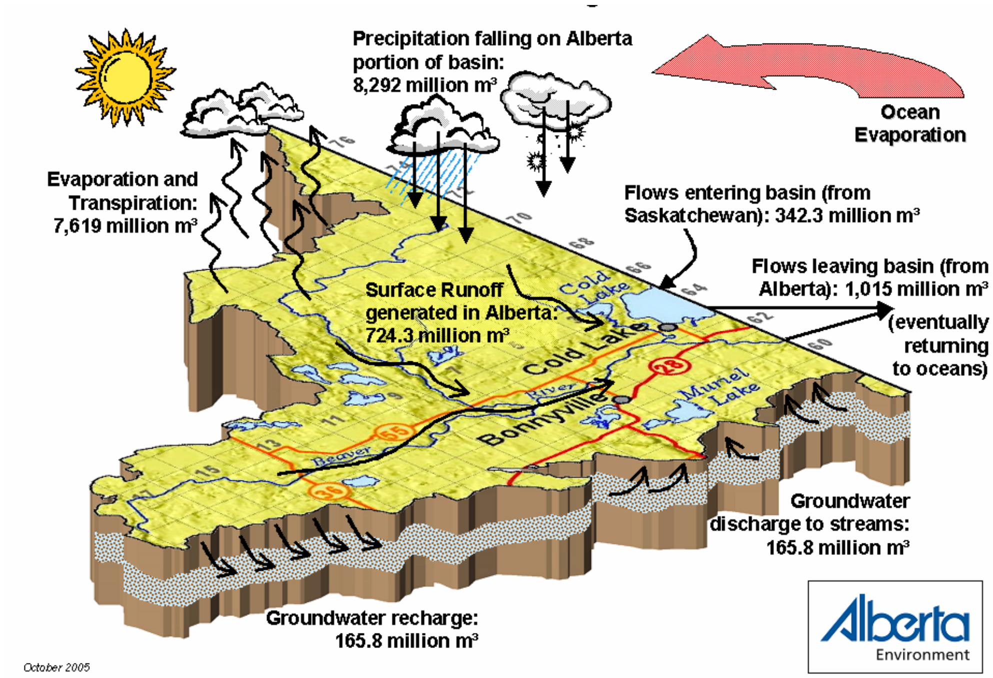


Figure 2-3. CLBR Basin average annual water balance.

2.2.2 Surface Water Resources

The Cold Lake–Beaver River Basin is well known for its abundant surface water resources that have supported a strong recreation and tourism industry for many years. The combined drainage area of the Beaver River and Cold Lake Basins is about 22,000 km^2 (about 8,500 sq. mi.). Compared to other major river basins in the province, the Beaver River is a relatively small river with a mean annual discharge of about 650 million m^3 per year. From the north, the Beaver River drains the Sand and Amisk Rivers as well as Manotokan, Jackfish and Marie Creeks. Tributaries from the south include Moose Lake River and Muriel and Reita Creeks.

The Cold Lake drainage system includes the Martineau River and the Medley River. Flow through the Cold Lake drainage portion of the basin (342 m^3) does not flow into the Beaver

River within Alberta. The majority of the flow in this basin is surface water from Saskatchewan, which flows into Cold Lake and drains from the lake eastward via the Cold River. The combined total average discharge from the Beaver River and Cold Lake Basin is approximately 1 billion m^3.

There are over 2000 lakes in the CLBR Basin. Many of these lakes are popular recreational destinations, and all are important elements of the basin's aquatic ecosystem. Table 2-1 summarizes the characteristics of some major lakes in the basin. These lakes contain over 20 billion m^3 of water.

Table 2-1. Characteristics of major lakes.

	Cold Lake	Moose Lake	Marie Lake	Muriel Lake	Wolf Lake	Ethel Lake	Moore Lake
Drainage Area (km^2)	6140	775.2	380.6	384	693	542	37.12
Lake area (km^2)	373	40.8	34.6	64.1	31.5	4.90	9.28
Ratio of drainage area and Lake area	16.5:1	19:1	11:1	6:1	22:1	110:1	4:1
Volume (m^3)	$18600x10^6$	$230x10^6$	$484x10^6$	$424x10^6$	$289x10^6$	$32.2x10^6$	$77.4x10^6$
Max. depth (m)	99.1	19.8	26	10.7	38.3	30	26
Mean depth (m)	49.9	5.6	14	6.6	9.2	6.6	8.3
Shoreline length (m)	90	64	29	50	49.8	11	16.7
Mean residence time (years) [1]	33	7.5	47.5	>100	6	2.5	>100

Source: Atlas of Alberta Lakes

[1] Average time required to completely replace the total volume of the lake with inflowing water.

The lakes in the basin have three distinct origins. The first type are typical prairie lakes characterized by shallow depth and a gently-dipping lake-bottom. These lakes are sensitive to seasonal and climate variations. The second type is deep lakes with steep sides. In general, these lakes do not tend to fluctuate widely in lake levels from year to year. They are also likely to intersect and interact with some groundwater aquifers. Cold Lake is an example of this kind of lake since it is about 100 m deep in places. The third group is formed by impoundments of surface water in the bottom of abandoned glacial melt water channels.

The ratio between drainage area to lake surface area is also an important indicator of how lakes will respond to local climate fluctuations. Typically, lakes with a small drainage area are more sensitive to climate variations. This is because these lakes have lots of area for water evaporation but do not drain very much land. These lakes are also more sensitive to land clearing and changing land practices within the lake's drainage area. The table above shows that Muriel Lake has a small drainage area compared to the size of the lake. Muriel Lake has been steadily declining during the last 25 years and did not respond substantially to the high precipitation events of 1996-97. In comparison, Moose Lake, which has a relatively large drainage basin, recorded its highest water levels in 1997. In some cases, groundwater inflows also play a role in lake level. For example, the water level of Moore Lake does not fluctuate substantially despite having a relatively small drainage basin. In this case, it is possible that Moore Lake receives substantial inflow from groundwater.

2.2.3 Groundwater Resources

Groundwater is an important component of water resources in the CLBR Basin. While groundwater volumes do not fluctuate from year to year as much as surface water, there are vast quantities of stored groundwater beneath the ground. A detailed assessment of regional geology and groundwater flows was conduct by Alberta Geological Survey (2005). The findings of this study are summarized in the *Groundwater Quantity and Brackish Water State of the Basin Report*. This section presents a brief overview of the regional geology and groundwater resources.

The subsurface beneath the CLBR Basin consists of a succession of geological units. From deeper intervals to shallow intervals, these include Cambrian sandstone and Devonian limestone and evaporates overlain by Cretaceous sands and shales and Quaternary sand and gravel glacial deposits. Fresh groundwater resources are shown in the Quaternary aged strata in Figure 2-4. These six main aquifers are listed on the right side of the diagram. Groundwater is mostly used in the basin by domestic/livestock users and by industry. Typically, domestic users are concentrated in the medium to shallower aquifers while industry mainly uses the deeper aquifers. Water below the Quaternary aged aquifers is usually saline. The deepest water used in the basin is from the McMurray Formation, which is a saline source.

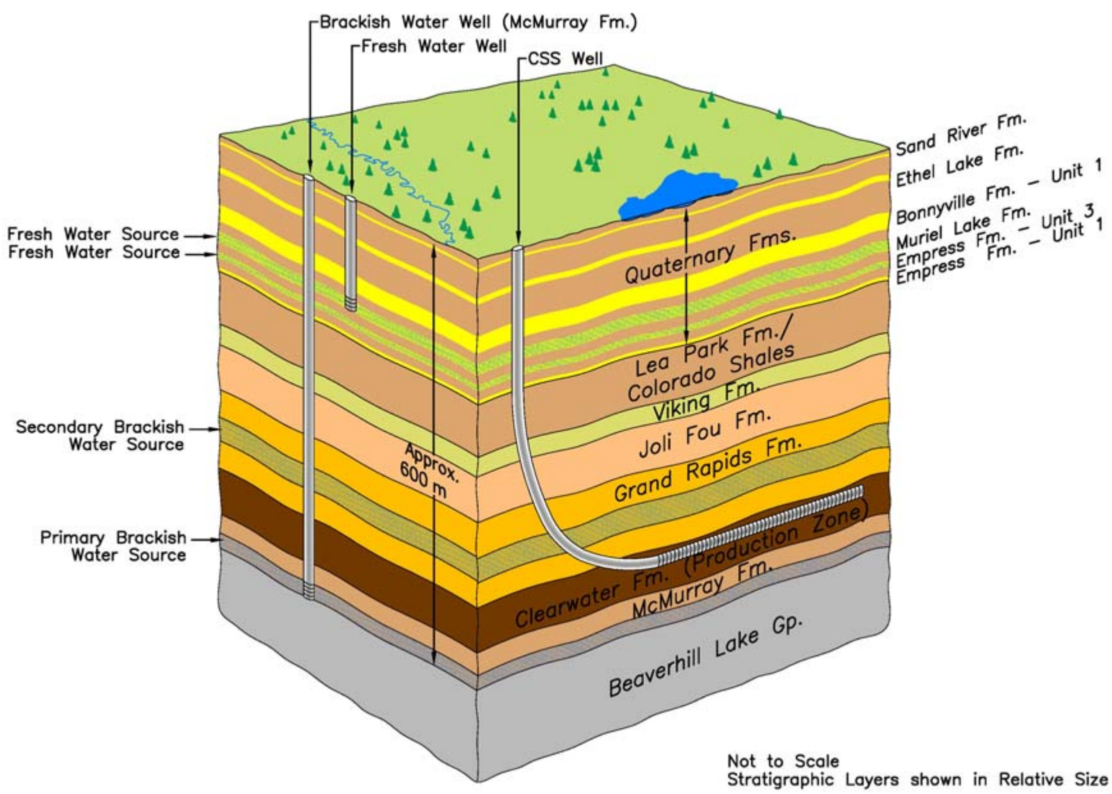


Figure 2-4. Schematic diagram of Cretaceous, Tertiary and Quaternary stratigraphy in the Beaver River Basin.

An estimated 166 million m^3 of water recharges groundwater resources each year. This amount may vary from year to year depending on climate. The amount of water estimated to be present as groundwater within Quaternary and Tertiary aquifers in the basin is an estimated 50 billion m^3 (AGS 2005).

2.2.4 Surface and Groundwater Interactions

The interaction between groundwater and surface water has become a public concern in the CLBR Basin, particularly during below normal run-off years. Some public and local stakeholders have become concerned that groundwater pumping has reduced the water levels of local lakes, streams and wetlands. In order to assess this concern, it is necessary to understand the volumes of water pumped in the context of the basin water balance. A summary of this water balance information is presented in this section.

Most surface water features, including lakes, rivers and wetlands, interact with groundwater to some extent. When lakes receive groundwater inflow via groundwater discharge, they are commonly called “gaining lakes”. The lakes referred to as “losing lakes” can lose water into the subsurface, thereby recharging groundwater. Many lake levels are not effected by groundwater influences. Although these lakes may receive water from or lose water to the subsurface, their water levels are generally not changed significantly due to the much larger influences of surface water flow.

Evaporation and precipitation have a greater effect on lake levels and for this reason, groundwater contributions are considered negligible in many studies. To put this in perspective, over 8 billion m^3 of water are in play in the basin each year. Of this amount, about 7 billion m^3 evaporates from lakes and the ground surface. One billion m^3 ultimately flows out of the basin through the Beaver River and Cold River. With respect to groundwater, 166 million m^3 enters the subsurface to become groundwater, and over time flows into the lakes and rivers. Thus while there are vast supplies of groundwater present in the basin, the amount that cycles annually is quite small compared to surface water.

Both natural processes (climate changes) and human activities (groundwater pumping, land use/land cover changes) affect the interaction mechanism of groundwater and surface water. For example, groundwater pumping initially captures water from aquifer storage. As pumping continues, the groundwater table declines and begins to affect the natural state of groundwater and surface water interactions by either decreasing the discharge to surface water bodies or inducing additional recharge until the pumping losses are balanced out.

Despite the connections between groundwater and surface water features, it is often difficult to determine the timing, location and magnitude of these interactions. At this time, an accurate assessment of groundwater and surface water interactions at specific locations is not possible within the CLBR Basin. In part, this is due to the relatively small contributions of groundwater cycling in the basin compared to surface water cycling. A regional groundwater numerical model, developed by the Alberta Geological Survey (AGS 2005) has been used to simulate groundwater and lake interaction in the basin. The model has the capacity to show general trends that would occur during a pumping situation, and can indicate where more conservative management guidelines and more extensive monitoring might be required.

As suggested in the Komex reports of (2002) and (2004), climate changes alone may not be solely responsible for changes to the hydrological cycle in the basin. Human-induced factors such as water withdrawal and land use and land cover changes (from forest clearing) may also have the potential to affect localised or regional water balances. The southern portion of the Beaver River Basin has seen a large amount of forest clearing for agricultural development.

2.3 BASIN ALLOCATIONS AND COMPARISON TO OTHER ALBERTA RIVER BASINS

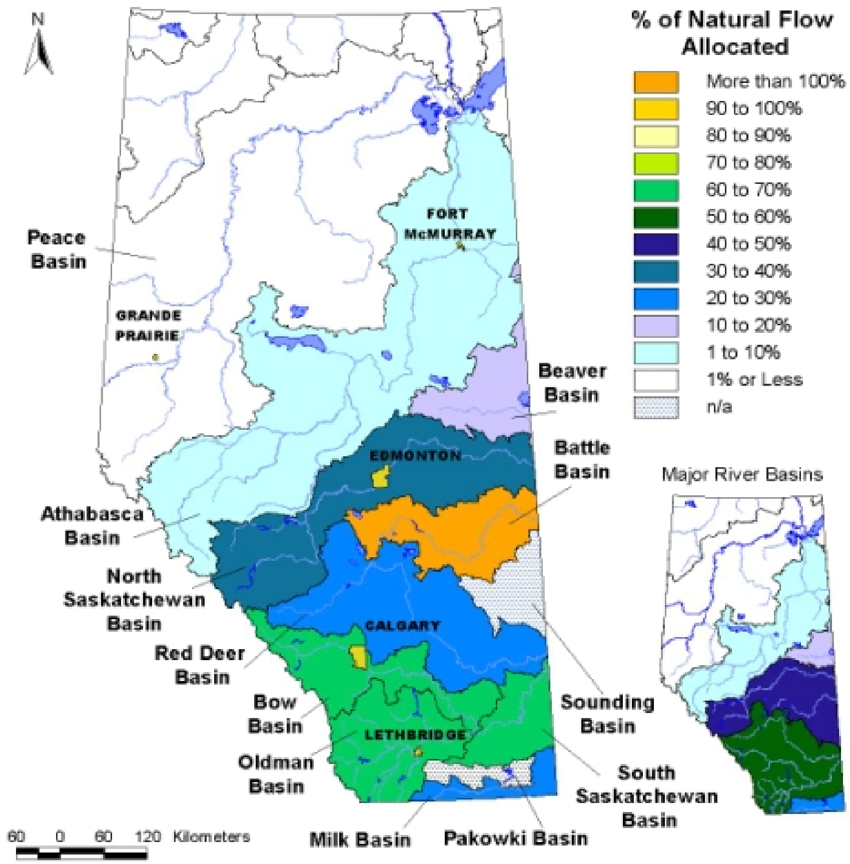
This section presents an overview of the current water allocations in the basin and makes comparisons with other major river basins in the province. It should be noted these gross allocations do not represent actual water use in the basin. Total allocations indicate the maximum amount of water that has been granted for use by Alberta Environment and are often double actual water use. In addition, some water license holders return water directly back to the environment. While allocations have risen with population growth, increased industry and increased agricultural activity, the allocation amounts are small in comparison to other basins in the province.

As of December 2003, a maximum of 44 million m^3 of groundwater and surface water were allocated in the basin. This represents about 4% of the average 1 billion m^3 of surface water that leaves the Beaver River Basin each year and about 0.5% of the average annual precipitation of the basin. Of the 44 million m^3 of allocations in the CLBR Basin, surface water allocations represent about 62% (27 million m^3) and groundwater about 38% (about 17 million m^3). Therefore, groundwater allocations are about 1.5% of the average annual flow that leaves the CLBR Basin each year. The actual use is about 0.5% the average annual flow.

On a provincial scale, about 9 billion m^3 of water are allocated for use in Alberta with less than 300 million m^3 of that consisting of groundwater. Thus the CLBR Basin allocations represent less than half of one percent of the water allocated for use in Alberta.

Figure 2-5 shows surface and groundwater allocations compared to average natural flow for Alberta river basins. With this update of the CLBR Basin plan, it has been determined the actual allocation in the Beaver River Basin is less than that shown in the figure since the allocation (as a percentage of the flow leaving the CLBR Basin) is about 4%. However, the figure generally shows the southern basins are more heavily used than the northern basins, and demonstrates the relative abundance of water in the Beaver River Basin compared to others in the province.

One difference in water use in the CLBR Basin compared to other basins is the percentage of groundwater compared to surface water used in the basin. In the CLBR Basin, groundwater is about 33% of the total water allocation compared to less than 3% at the provincial level. In a large part, this is due to low overall water usage and not due to large groundwater usage.



Alberta Environment

Note: allocations do not represent actual water use.

Figure 2-5. Surface and groundwater allocations in 2004 by river basin compared to average natural flow.

2.4 CLIMATE AND RECENT REGIONAL HYDROLOGICAL TRENDS

2.4.1 Climate

The climate in the CLBR Basin is generally described as continental with short, cool summers and long, cold winters. The weather patterns are usually influenced by maritime air masses moving east from the Pacific Ocean, and continental air moving south from the Arctic. In winter, the westerly winds are pushed southward, allowing cold arctic air to invade the region. These cold, heavy air masses frequently stagnate over this area for weeks at a time, often causing fog or ice fog.

Continuous year-round regional climate data has been recorded at the Cold Lake weather station since 1951. A detailed assessment of regional climate changes was conducted by Alberta Environment (1997), and in a Komex study (2003) commissioned by LICA. The mean annual temperature measured at the Cold Lake station from 1956 to 2003 was 1.65°C. The mean annual temperature observed at the same station from 1986 to 2003 was 2.2°C. This suggests the annual mean temperature in the last 20 years has increased by 0.6°C compared to the longer–term average temperature. The Komex (2002) study found a temperature correlation with an El Niño-like phenomena in the North Pacific called the Pacific Decadal Oscillation (PDO) which cycles every 20-30 years. The PDO had a warming effect in the Cold Lake region from about 1980-2000. There is some evidence to suggest this warming trend is beginning to enter a cooler and therefore wetter cycle. Warm and cool periods not only affect the amount of precipitation in the region but also the amount of evaporation in the basin.

The average annual precipitation measured at Cold Lake station from 1953 to 2003 was 433.5 mm. Between 1986 and 2003, the average annual precipitation was 15 mm less than the long-term average, and 22 mm less than the average amount for the previous 15-year period (1970-1985). It is interesting to note the record high annual precipitation of 1997 (record wet year) was 64 mm higher than the long-term average annual precipitation. Conversely, the record low precipitation of 1992 (driest year) was 62 mm lower than the long-term annual amount. In 1997, the majority of the lakes and streams in the basin recorded historical high water levels while in 1992, the water levels were the lowest recorded. This suggests that climate and precipitation have the greatest long-term direct impact on the fluctuation of local lakes and groundwater levels.

2.4.2 Regional Hydrological Trends

There has been a warming trend in the CLBR Basin over the last 20 years. With the exception of 1996-97, the basin has, on average, experienced an increase in temperature and decreased flow in the Beaver River. These changes have an impact on other components of the regional hydrological cycle. Generally, increased temperature leads to changes in evaporation and precipitation that result in changes to lake levels, regional stream flows, runoff and groundwater recharge and discharge.

A detailed assessment of lake water balances is presented later in this report. This section presents only an overview of historical streamflow trends to determine the response to recent climate variations. Figure 2-6 shows the total average annual runoff of Beaver River at Cold Lake in cubic meters per second compared to total annual precipitation (in mm). Both precipitation and runoff shows a declining trend, particularly in the past 20 years. The slope of the annual runoff decline is more pronounced than the precipitation-declining rate. This demonstrates there may be other factors such as increased evaporation or land use/land cover changes in the basin that might also affect the flow of the Beaver River. The total allocated water withdrawals represent only 1.4 m^3/s and could not be responsible for this change, especially if one considers that only about one third of the allocation is being used (<0.5 m^3/s).

Table 2-2 compares average annual flows with precipitation, evaporation from the Cold Lake surface and temperature. Under natural conditions, the regional hydrologic cycle tends to balance out. The difference between water input (precipitation) and water output (evaporation and runoff) provides an indication of moisture conditions in the watershed. During dry periods, the water output exceeds the water input, thus creating a natural “deficit” that will be balanced by the removal of water stored in lakes, streams, wetlands and soil in the watershed.

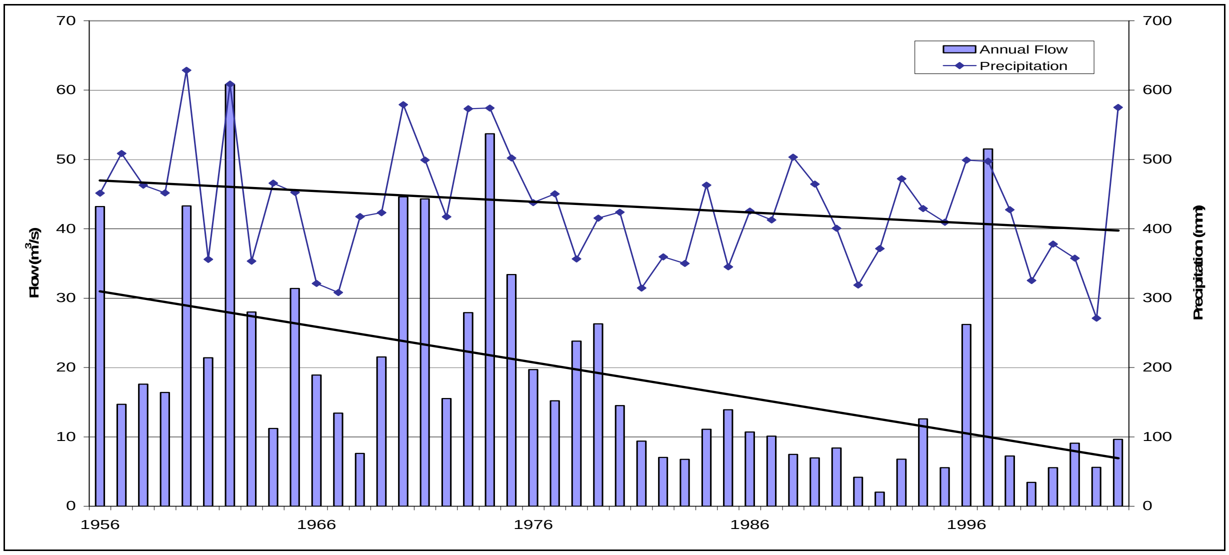


Figure 2-6. Annual flows of Beaver River and annual precipitation at Cold Lake.

Table 2-2. Cold Lake hydrological data.

Period	Average Annual Flows Beaver River at Cold Lake (m^3/s)	Average Annual Precipitation	Average Annual Evaporation (mm)	Average Annual Temperature (^0C)
1956 to 2003	18.90	433.5	618	1.65
1970 to 1985	22.90	441.3	630	1.37
1985 to 2003.	10.70	418.8	608	2.21
1996 – 1997	51.50	497.4	606	2.63
1991 – 1992	2.02	371.5	588	2.24

At first glance, this table suggests there is not a good relationship between precipitation and outflows. During the 1985 to 2003 period, annual average flows were reduced by 43% from 18.9 m^3/s to 10.7 m^3/s. In absolute terms, this represents an average reduction of about 260 million m^3 of water. Mean annual precipitation was only reduced from 433.5 mm to 418.8 mm (3.4%), which represents a reduction of about 280 million m^3 of water. The average evaporation from Cold Lake did not change much over this period. On average, the reduction in the amount of precipitation equalled the reduction in streamflow.

Groundwater levels also fluctuate with the climate over some time frame. Depending on how directly connected water wells are to the surface, they will respond to climate variation on different time scales. Surficial water levels sometimes respond almost immediately to large precipitation events. Other aquifers (e.g., Figure 2-7) show seasonal responses with a typical rise in levels around June followed by slowly decreasing levels until the next spring melt. Deeper aquifers may show less or delayed seasonal response, and demonstrate long-term variations from climate effects.

Figure 2-7 indicates water levels from a monitoring well completed across the water table in the area of Borque Lake, which shows clear seasonal responses due to groundwater recharge from precipitation.

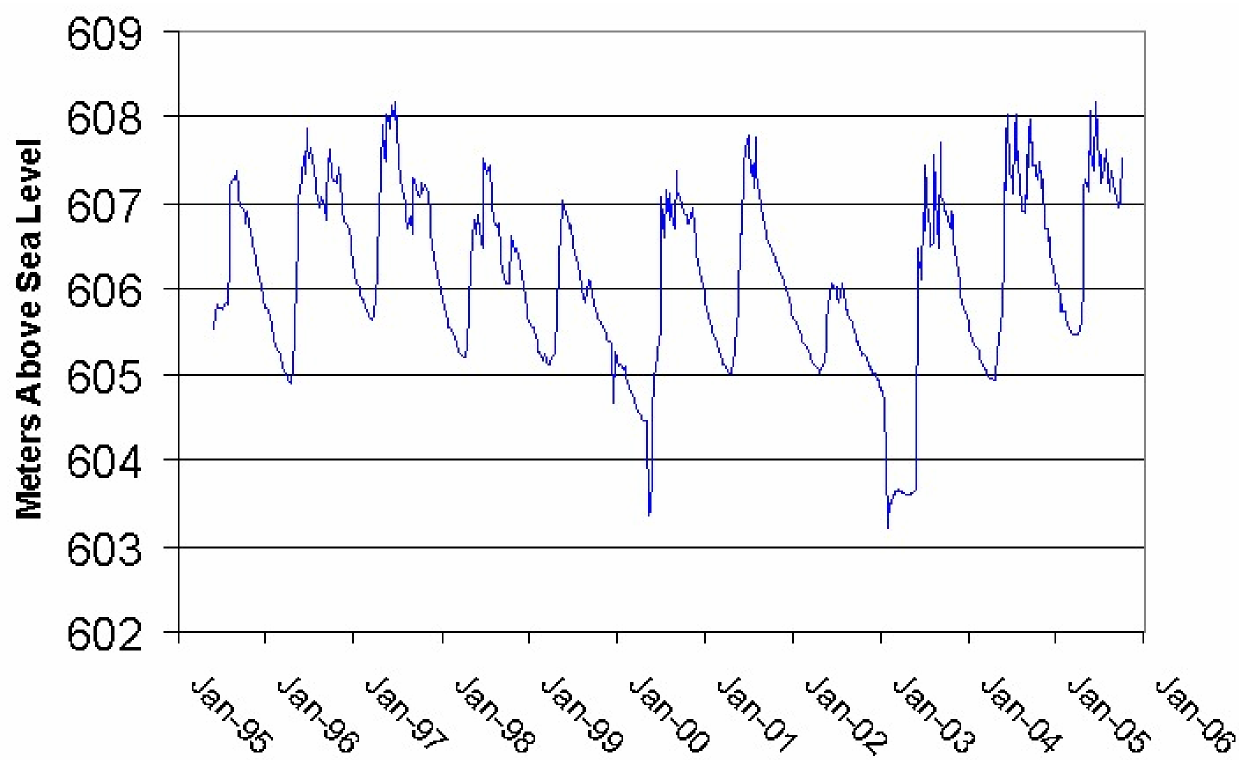


Figure 2-7. Hydrograph for monitoring well MAS92-1 (WT).

SECTION 3. LAKE WATER BALANCES

In 1985, the Cold Lake–Beaver River Water Management Plan was approved by Alberta Environment. A complex water balance model (Streamflow Synthesis and Reservoir Regulation model [SSARR]) and a water accounting model (Water Resource Management Model [WRMM]) were used to evaluate water supply under natural and future scenarios, respectively. These models involved a network of interconnected points throughout the southeastern part of the basin. Recommendations from that plan included:

- A maximum withdrawal limit for Cold, Wolf, Moose, Burnt, Angling, Caribou, Ethel and Marie lakes.
- Moratoriums on withdrawals from May, Manatokan, Muriel, Reita and Tucker lakes.
- A total limit of withdrawals for the basin of 19 million m^3/yr.

The updated plan includes a water balance analysis on key lakes—Cold, Moose, Marie and Muriel lakes for the following reasons:

- Cold Lake is a relatively major surface water source in the basin;
- Moose Lake currently has municipal withdrawals;
- levels for many lakes are declining, which is most noticeable at Muriel Lake; and
- of the recreational lakes, Marie Lake is closest to industrial development.

There are no current or planned permanent withdrawals from the Beaver River, so it was not included in the modelling study.

Water balance models were created by Stantec Consulting Ltd. The simulated lake levels presented by the model data correlated well visually with the observed lake levels. There are no simulated lake levels for the Cold Lake graph since a water balance model was used for this lake.

3.1 Overview of Regional Hydrologic Regime

A hydrologic regime is made up of the components of the hydrologic cycle and the variations on the land surface that may affect those components (Figure 3-1).

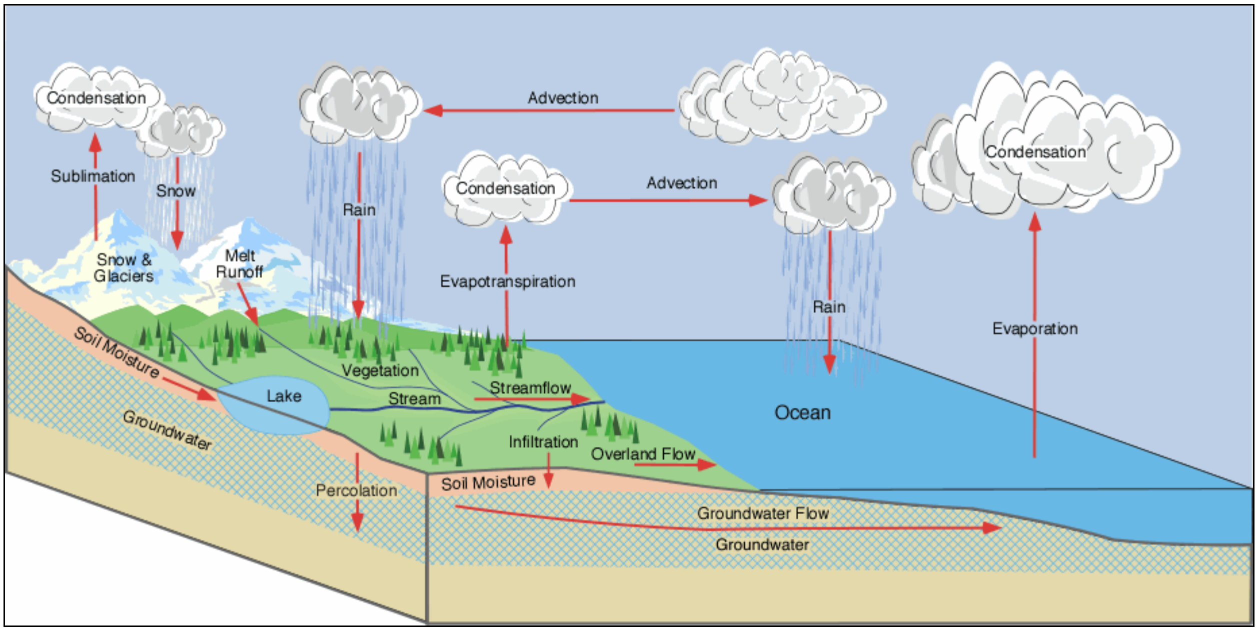


Figure 3-1. Hydrologic cycle.

3.1.1 Precipitation, Evaporation and Evapo-transpiration

Precipitation is the primary element entering the hydrologic cycle. A portion of precipitation is intercepted by trees and other vegetation, as well as other surfaces, and eventually evaporates. Evaporation occurs from any open water such as lakes, rivers, storage ponds or dugouts. Water absorbed by plants can be transpired through the leaves and evaporated back to the atmosphere. For most applications in hydrology, evaporation and transpiration are grouped together as "evapo-transpiration".

Measuring precipitation as liquid collected is fairly simple; however, measuring evaporation—the amount of moisture in the air in gaseous form—is more difficult since it cannot be measured directly. One way to estimate evaporation is to calculate the difference in the amount of liquid remaining in an evaporation pan over time. Since the amount of evaporation depends on the surface area of water available to evaporate, as well as the air temperature and humidity above the waterbody, an adjustment factor must be applied to more accurately represent evaporation from a larger waterbody such as a lake.

Evaporation can also be estimated by establishing a relationship between the climatic parameters on which the evaporation depends. These are equations/formulas (i.e., simple models) that allow evaporation to be estimated based on measured parameters (e.g., temperature, wind speed, solar radiation, sunshine duration, relative humidity).

In most areas of Alberta, including the Cold Lake area, the climate is such that the annual amount of lake evaporation in millimetres almost always exceeds the annual precipitation. Figure 3-2 compares the precipitation measured for the years 1954-2003 at the Cold Lake climate station to the evaporation estimated based on climate data from Cold Lake and Edmonton. Cold Lake evaporation data are available from 1974-1994. In years when Cold Lake data were not available, an estimate was made based on a relationship between Edmonton and Cold Lake data.

The figure shows evaporation exceeded precipitation in all years except 1954, 1960 and 1962. Therefore, for an individual waterbody such as a lake, the precipitation falling directly onto the lake is normally exceeded by the amount of water lost from the lake through evaporation. The average deficit from 1954-2001 was 173 mm. This deficit can be offset by surface runoff and groundwater contributions to the lake.

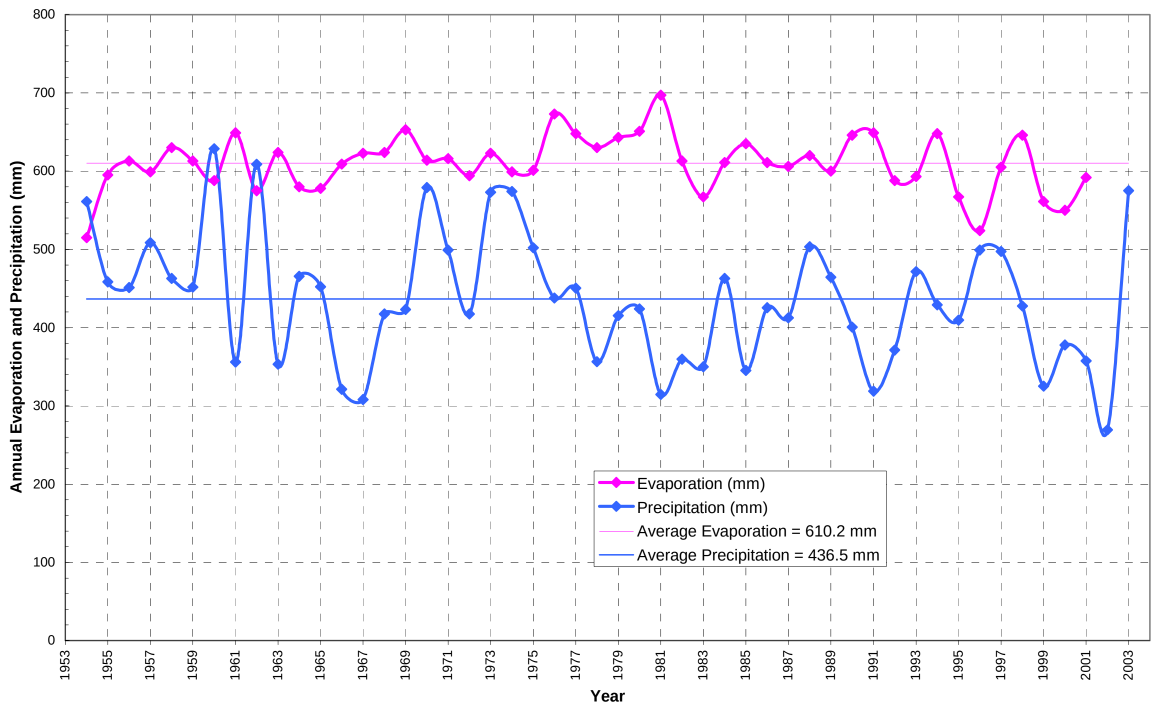


Figure 3-2. Cold Lake annual precipitation and evaporation comparison.

Figure 3-3 shows data for precipitation and evaporation at Edmonton City Centre (Municipal) Airport. Precipitation data are available from 1883 to the present time; evaporation data are available from 1912-2001. Long-term precipitation data are also available at Elk Point from 1914-1996; however, the station is no longer active. There are no evaporation data from Elk Point. Figure 3-4 shows a comparison of the Elk Point, Edmonton and Cold Lake data for the period in which their records overlap. The relationship between evaporation data at Edmonton and Cold Lake can be observed visually. Since precipitation can differ greatly between local areas, it is much more difficult to correlate between locations.

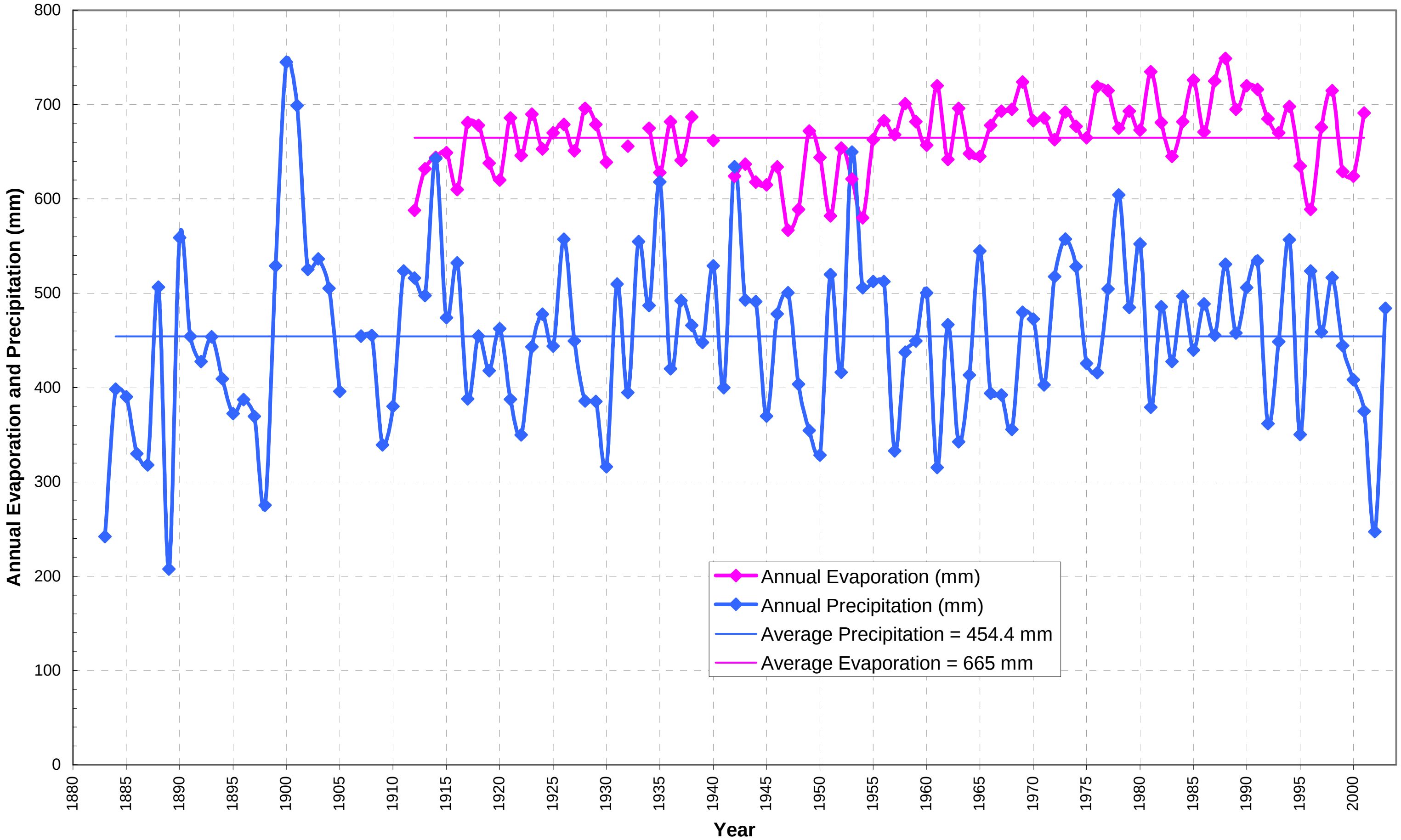


Figure 3-3. Edmonton Annual precipitation and evaporation comparison.

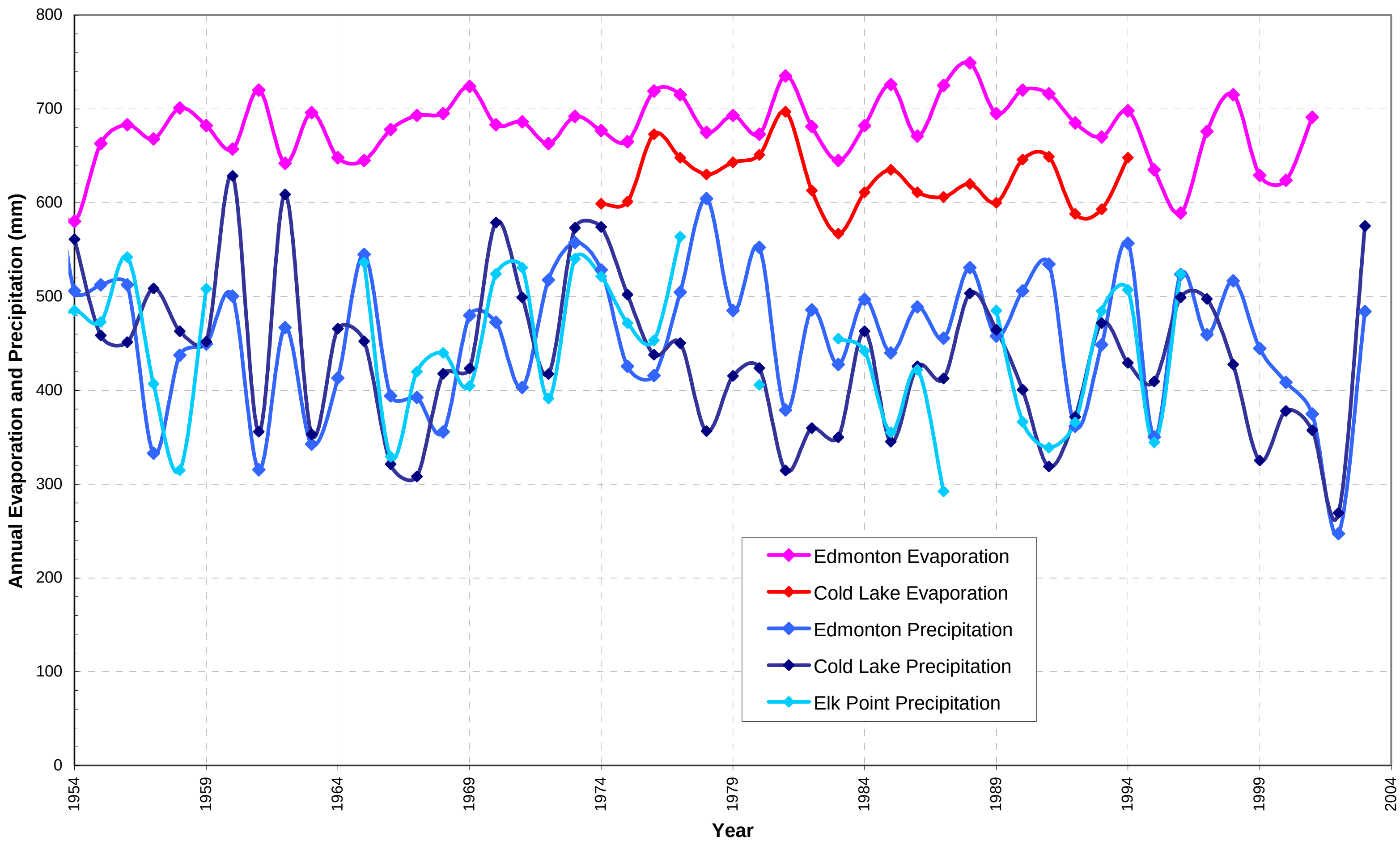


Figure 3-4. Edmonton and Cold Lake Annual precipitation and evaporation comparison.

3.1.2 Surface Runoff and Groundwater

As noted previously, precipitation is the primary source of water for the hydrological cycle (see Figure 3-1). A portion of this water is lost to evapo-transpiration. Precipitation that reaches the land surface as rain saturates soils and fills land depressions first, and then flows overland as surface runoff. If soils are already saturated, there will be more runoff.

Precipitation falling as snow and accumulating follows the same cycle. Snowmelt will first saturate soils and then flow overland as surface runoff. Soils that were saturated during freeze-up will generate more snowmelt runoff. Whether or not soils are frozen will also affect surface runoff. Different soils have differing properties and capacities for water; therefore, runoff volumes will vary. Precipitation infiltrating the soils can be absorbed by vegetation and the remaining moisture can percolate downward to recharge groundwater.

Surface runoff flows from higher to lower topographical areas. The high ground boundaries define the basin and the direction of the runoff. The edge of the basin is at a relatively high level in the topography. On each side of the edge, surface runoff drains from the edge toward a point of interest. For example, part of the boundary of the CLBR Basin lies between Beaver Lake and Lac La Biche. The boundary is determined as such because the topography is sloped toward Lac La Biche on one side of the boundary and toward Beaver Lake on the other. The entirety of the CLBR Basin comprises all lands with runoff that is directed toward the Beaver River near the Alberta-Saskatchewan border, as well as lands with runoff directed toward Cold Lake.

The terms *basin*, *drainage basin, sub-basin* or *watershed* are often used interchangeably, but all refer to an area of land that drains toward a point of interest. The basin could be defined as all land draining toward a certain lake, or all land draining to the mouth of a river (or a combined basin as in the case of the CLBR Basin). The boundaries of the basin are also referred to as drainage boundaries.

Surface runoff can be measured by a streamflow gauge. Direct measurements of flow and the corresponding water level are taken periodically to establish a relationship between the two. Once this is established, real-time flow information can be gathered by measuring the water level only, and using that relationship (called a rating curve) to generate flow. The flow measurement at the gauge is a direct indication of the amount of surface runoff generated from the basin upstream of the gauge. Any groundwater contribution to streamflow is also included in the measurement. There are several streamflow gauges in the CLBR Basin as well as the surrounding areas. Table 3-1 summarizes the gauges, their contributing basins and the period of record that is available.

Table 3-1. Streamflow gauges in the CLBR Basin and area.

Station No	Station Name	Location (legal land description	Gross Area	Effective Area	Major Basin	Station Type	Start Year	Finish Year	Years of Data
07CA010	Piche River near Imperial Mills	SW 28-69-12 W4	1030.00	984.00	ATH	Flow	1984	1986	3
07CA013	Owl River below Piche River	SW 36-69-13 W4	3080.00	3040.00	ATH	Flow	1984	2001	18
07CA011	La Biche River at Highway 63	NE 34-68-17 W4	4860.00	4740.00	ATH	Flow	1982	1995	15
07CA005	Pine Creek near Grassland	SE 26-67-19 W4	1450.00	933.00	ATH	Flow	1966	2001	36

Station No	Station Name	Location (legal land description	Gross Area	Effective Area	Major Basin	Station Type	Start Year	Finish Year	Years of Data
06AF008	Martineau River above Cold Lake	NW 01-66-01 W4	5350.00	5340.00	BEA	Flow	1981	1995	15
06AB002	Wolf River at outlet of Wolf Lake	NE 16-66-07 W4	725.00	564.00	BEA	Flow	1968	2001	34
06AF001	Cold River at outlet of Cold Lake	NE 27-64-26 W3	6515.10	6257.10	BEA	Flow	1952	2001	50
06AC901	Marie Creek below Ethel Lake	SE 12-64-03 W4	595.00	0.00	BEA	Flow	1981	1982	2
06AB003	Punk Creek near the mouth	NW 13-64-09 W4	395.00	384.00	BEA	Flow	1981	1990	10
06AB001	Sand River near the mouth	NW 20-63-08 W4	4910.00	4730.00	BEA	Flow	1967	2001	35
06AC001	Jackfish Creek near LaCorey	NE 09-63-05 W4	489.00	333.00	BEA	Flow	1972	2001	30
06AC009	Manatokan Creek near Iron River	SW 13-63-07 W4	449.00	359.00	BEA	Flow	1981	1990	10
06AA002	Amisk River at Highway 36	SW 26-63-14 W4	2510.00	1890.00	BEA	Flow	1971	2001	31
06AA001	Beaver River near Goodridge	NE 12-63-10 W4	4710.00	3780.00	BEA	Flow	1967	2001	35
06AD006	Beaver River at Cold Lake Reserve	NE 10-62-02 W4	14500.00	11600.00	BEA	Flow	1955	2001	47
06AA004	Columbine Creek near the mouth	SE 16-62-08 W3	241.00	229.00	BEA	Flow	1979	1996	18
06AC006	Mooselake River near Franchere	NE 34-61-07 W4	1010.00	627.00	BEA	Flow	1980	1993	14
06AD013	Reita Creek near outlet of Angling Lake	SW 36-60-03 W4	161.00	161.00	BEA	Flow	1981	1991	11
05EC002	Waskatenau Creek near Waskatenau	SE 28-59-19 W4	312.00	205.00	NSA	Flow	1966	2001	36
05EC006	White Earth Creek near Smoky Lake	NW 23-59-16 W4	1000.00	934.00	NSA	Flow	1985	1995	11
05ED001	Stony Creek near Saddle Lake	SW 23-58-12 W4	543.00	217.00	NSA	Flow	1972	1977	6
05EC004	Namepi Creek near the mouth	NE 23-58-20 W4	720.00	586.00	NSA	Flow	1975	1995	21
05ED003	Moosehills Creek near Elk Point	SE 23-57-06 W4	36.50	36.50	NSA	Flow	1978	2001	24
05ED002	Atimoswe Creek near Elk Point	NW 36-56-07 W4	364.00	250.00	NSA	Flow	1975	2001	27

Streamflow gauges are not available in every location of interest. Therefore, to estimate the amount of surface runoff that contributes to an "ungauged" basin, a "gauged" basin is used as a proxy. The flow data are obtained from a streamflow gauge whose contributing basin has similar characteristics to the contributing basin for the point of interest. The streamflow is scaled linearly by the ratio of basin size of the gauged basin to the basin size of the point of interest.

When deciding on a representative streamflow gauge, several factors need to be considered, such as the following:

- the gauged basin is of similar size (a much larger basin could have delayed runoff, or positive or negative storage effects at the gauge);
- the gauged basin is in fairly close proximity or is known to have similar climatic conditions;
- the gauged basin has similar terrain;
- the gauged basin has similar storage characteristics (e.g., number of lakes);
- the gauge is not located at the outlet of a lake, where the flows would be representative of outlet flows rather than surface runoff.

The advantage of using measured streamflow data is it provides a direct measurement of the actual surface runoff. The disadvantage is the effects of any land use changes or diversions over time are inherently included in the data. There is also likely some error associated with transferring data from the gauged basin to the ungauged basin.

Another way to estimate surface runoff is to simulate it by modeling the physical processes taking place as precipitation falls, infiltrates, evaporates and runs off. These models are called rainfall runoff models.

The advantage of a rainfall runoff model is that terrain characteristics (land-use changes) can be changed and the effects then modelled. The disadvantage of rainfall runoff models is they require accurate local precipitation data as well as data on, and an understanding of, the parameters that can affect runoff (e.g., type of soil or vegetation cover). These data are not usually readily available and can be difficult and time consuming to gather. When data are unavailable, the model can end up being based on many assumptions. Local precipitation data can especially be a problem since it is the primary input to the hydrologic cycle and has a large effect on model results.

3.2 LAKE WATER BALANCE MODELS

Lake water balances, or water budgets, are an accounting of the hydrologic inputs and outputs to an individual lake. As part of updating the CLBR Plan, water balance models were developed for Moose, Marie, Muriel and Cold lakes.

The time frame selected for carrying out a water balance varies depending on the level of detail needed. The inputs and outputs on a yearly, monthly, weekly or daily basis, as well as the resulting changes in lake levels, can be accounted for. Finer time-steps such as hours or minutes may be desired in some applications. The finer the time-step of the model, the more data required. In some cases, it may be desirable to have a less-detailed understanding of the average long-term water balance of the lake.

In this study, Marie, Moose and Muriel lakes were modelled on a monthly basis, while Cold Lake was modelled on a weekly basis. All the models started with 1981 and ended at 2000, except the Cold Lake model that ran from 1974 to 2001.

The climate in the Cold Lake area (as in much of Alberta) is such that evaporation is almost always greater than precipitation, resulting in a net evaporation deficit. The average evaporation deficit from 1954-2001 was 173 mm. If the lake is to sustain its levels, this deficit must be made up by surface runoff and groundwater contribution to the lake. The larger a lake’s contributing basin, the larger the volume of surface runoff that is directed toward the lake. In addition, runoff volume will have a greater effect on lake level if the lake's surface area is smaller.

As an example, the long-term average runoff yield for lakes such as Moose and Muriel is estimated at 10.4 mm per year, based on data available from 1977 to 2001. The corresponding average evaporation deficit from 1977-2001 was 206 mm. Moose Lake has a contributing basin of 755 km^2, which means an average annual volume of 7,852,000 m^3 of runoff would be contributed to Moose Lake (Figure 3-5). With a surface area of 41 km^2, that volume translates to 191 mm of the lake level. With a small amount of groundwater contribution, the net evaporation deficit can easily be made up. This shows up in the lake level records. In some years, the lake receives more than the average contributions and less in other years, but lake levels do not show a decline over the long term.

In comparison, the annual volume of runoff contributed to Muriel Lake from its 384 km^2 basin would be 3,993,600 m^3. With a surface area of 64 km^2, that volume translates to 62.4 mm of the lake level. This reduces Muriel Lake's net deficit to 143.6 mm, but it is too large to be made up by groundwater contributions. This is shown in the lake level records (Figure 3-6), which shows a decline over the period on record. The evaporation deficit has a large effect on Muriel Lake, since it has a small drainage basin contribution in comparison with its lake level. The lake levels show the greatest decline throughout the 1980s and 1990s, and little decline in the 1960s and 1970s. This correlates well with Figure 3-2. Throughout the 1960s and 1970s, there were only two years (1960 and 1962) in which there would have been no evaporation deficit; i.e., there was a net precipitation gain, and three years in which the lake would have had a very low deficit (1970, 1973, 1974). This compares to only one year in the 1980s and 1990s (1996) in which this occurred.

The above water balances are examples of long-term average water balances (time-step of 25 years). Although this is a very course time step, it does demonstrate the relative contributions of the different components of the lake balance over the long-term. These balances also show how the size of a lake's contributing basin has a strong influence on lake levels as compared to the lake's surface area. Table 3-2 shows the ratio of basin area to lake area for some lakes in the Cold Lake area.

Table 3-2. Drainage basin to surface area ratio for selected CLBR Basin lakes.

Lake	Drainable Basin Area (km^2)	Surface Area (km^2)	Ratio of Drainage Basin Area:Surface Area
Amisk	234.0	5.15	45:1
Beaver	290.0	33.10	9:1
Cold	6140.0	373.00	16:1
Ethel	542.0	4.90	111:1
Garner	25.5	6.19	4:1
Long (near Boyle)	82.4	5.84	14:1
Mann (upper and lower)	148.0	9.69	15:1
Marie	386.0	34.60	11:1
Moore	37.1	9.28	4:1
Moose	755.0	40.80	19:1
Muriel	384.0	64.10	6:1

Lake	Drainable Basin Area (km^2)	Surface Area (km^2)	Ratio of Drainage Basin Area:Surface Area
Skeleton	31.7	7.89	4:1
Tucker	312.0	6.65	45:1
Wolf	693.0	31.50	22:1

3.2.1 Methodology for Muriel, Moose and Marie Lake Models

The lake water balances for Muriel, Moose and Marie lakes were completed by estimating the individual components of the water balance model: runoff, precipitation and evaporation, inflow and outlet flow. The model uses these components to simulate lake levels. Once the water balance model is established and believed to accurately represent the lake levels through time, adjustments can be made to the components and the results modeled. For example, an additional water withdrawal could be modeled.

The basic equation of a water balance is: Inflow – Outflow = Change in Volume. The lake water balance models for Muriel, Moose and Marie lakes simulate lake levels on a monthly time-step. To perform this simulation, the following procedure is carried out:

1. The volume of the lake is calculated using the lake level at the start of the month. A relationship between lake level and lake volume (called a stage-storage curve) is required to estimate this volume.
2. The volume of runoff plus precipitation, minus evaporation, minus outlet flow is added/subtracted from the volume of the lake.
3. Based on this change in volume, the lake volume at the end of the month is calculated. The corresponding lake level is calculated from the stage-storage curve.

These steps are repeated for each month within the modeling period (1981-2000). The initial month requires a measured lake level; all subsequent months use the previous month's simulated lake level. The result from the model is a "time series" of simulated or modeled lake levels for the modeling period.

Runoff Component

Rainfall Runoff Model

Runoff can be estimated using a rainfall runoff model, which provides additional detail about factors (such as land use) that affect surface runoff. A rainfall runoff model uses precipitation as an input and attempts to simulate runoff (recorded streamflow) based on estimates of how much precipitation will infiltrate, evaporate, and/or be transpired. Once calibration and validation are achieved, the model is transferred to the basin of interest (e.g. the Muriel Lake basin) in order to simulate runoff there.

Since rainfall runoff models are very sensitive to the precipitation input, a good local representation of precipitation is necessary to provide confidence in the runoff simulation results for the basin of interest. Without sufficient data to calibrate and verify the model, the more uncertainty there is that underlying processes controlling runoff are accurately represented. Few streamflow and precipitation stations exist in the Cold Lake area that have long-term data, thus making it difficult to carry out rainfall runoff modeling. Thus this model was not selected.

Models Using Measured Streamflow

Measured streamflow was used to estimate the runoff component of the water balance for the Muriel, Moose and Marie Lake models. (Note: Measured data from an appropriate proxy station is considered to be an accurate representation of runoff.) The measured streamflow from a gauged basin was transferred to the ungauged basins of Muriel, Moose and Marie lakes. Streamflow from Atimoswe Creek was used for the Moose and Muriel lake balances, and streamflow from Jackfish Creek was used for Marie Lake. The main reason for choosing these stations was due to their proximity to each of the lake areas, thus making them the best locations for representing the climate conditions in the northern part of the basin, as opposed to the southern part.

In determining the water balances, there was an opportunity to compare two lakes that are in very close proximity, yet have very different lake level records/responses—Muriel and Moose lakes. For the water balance models, the same proxy streamflow station was used to represent runoff contribution to both these lakes. The only change made to the runoff from the proxy basin was to linearly scale it by the ratio of each lake's contributing basins to the proxy basin's area. Therefore, any effects of land use changes on runoff in the proxy basin are applied equally to both these lakes.

Precipitation and Evaporation

Precipitation measured in millimetres at Cold Lake was used for the Muriel, Moose and Marie lake balances. As well, the parameters measured at the Cold Lake climate station were used to estimate evaporation for these lakes. Data from Cold Lake were used for all lakes as this station provided a more continuous data set over the entire modeling period than was available at the Elk Point station.

Groundwater Inflow and Outlet Flow

Where a structure exists at the lake outlet, outflow can be estimated based on design curves for the structure. Otherwise, it can be estimated based on the channel shape at the outlet and the lake elevation. The amount of outlet flow increases as the lake level increases. Therefore a relationship between lake level and the corresponding amount of outflow is required in each case (i.e., stage–discharge relationship). A long-term value for net inflow or outflow to lakes from groundwater was estimated for each of the lakes in this study by Alberta Geological Survey (AGS)[1]. AGS found there was a net inflow of groundwater into Moose and Muriel lakes, and a net outflow from Marie Lake.

Estimates made by the AGS of groundwater flux to or from the lakes are steady-state fluxes and represent the long-term average flux on a daily time-step. The values of these numbers give an idea of the long-term situation at each lake. If the long-term average is used in a model that is operating on a finer time scale, then the natural yearly, monthly, weekly or daily fluctuations are not captured for that component and the model results do not match well with measured lake levels. The Muriel, Moose and Marie lake models were based on a monthly basis; therefore, the AGS groundwater fluxes were not included in the models.

[1] Regional Groundwater Resource Appraisal, Cold Lake Beaver River Drainage Basin, Alberta. Alberta Geological Survey, 2004.

3.2.2 Methodology for Cold Lake Water Balance Model

The water balance for Cold Lake was completed by estimating runoff, precipitation, evaporation, groundwater inflow/outflow, and lake inlet flow as one "lumped" parameter. This could be estimated accurately, since there are measured flows at the outlet as well as measured lake levels at Cold Lake.

This is different from the models used for Muriel, Moose and Marie lakes, which used estimates of runoff, precipitation, evaporation and outlet flow to simulate the lake levels through time. The result of the Cold Lake model is instead a time series of inflows to the lake. There are no measured inflows to the lake for comparisons with the model results. It is known that these lumped inflows are accurate because they are exactly what produces the measured outflow. The Cold Lake model can be used to test future scenarios that have changes to the inflow series, such as additional lake withdrawals or changes to lake cutoff levels below which withdrawals are not permitted.

3.3 Moose Lake Water Balance Results

The water balance model for Moose Lake covers the period from May 1981 to December 2000. The monthly contributions of local surface runoff into the lake were computed using the recorded streamflow data of Atimoswe Creek near Elk Point (Hydrometric Gauging Station No. 05ED002). Of the streamflow data available in this area, this streamflow gauge was considered to be the most representative of runoff yields to Moose Lake. The following modeling parameters were used:

- stage–storage relationship,
- stage–area relationship,
- stage–discharge relationship for the outlet,
- estimated monthly runoff inflows (based on Atimoswe Creek streamflow),
- monthly precipitation (measured at Cold Lake climate station),
- monthly evaporation (based on parameters from Cold Lake climate station),
- one known water level at the beginning of the simulation period.

The stage–storage and stage–area relationships were developed based on a Bathymetric Survey that was done for Moose Lake in 1962. The survey allowed the development of lake bottom contours, and these contours were used to calculate the surface area and volume of the lake for several different lake levels. The stage–discharge relationship for Moose Lake was developed based on the design stage–discharge rating curves for the weir at the outlet (reconstructed in 1985). There were no measured flows at the outlet of Moose Lake.

Simulated lake levels were produced as the outcome of the modeling exercise. The model provided a satisfactory simulation of the recorded water levels for most of the modelling period. Since the model uses the stage–discharge curve for the current outlet structure, the simulated lake levels prior to May 1985 do not match as well.

In general, the water balance simulation can explain the lake behaviour based on what is estimated for the modeling parameters listed above, which do not include groundwater. Therefore, groundwater contributions are likely small on a monthly time-step over the modelling period in comparison to other parameters. The net groundwater contribution was estimated by AGS on a long-term average basis, and it was found there was a net groundwater contribution into Moose Lake over the long term.

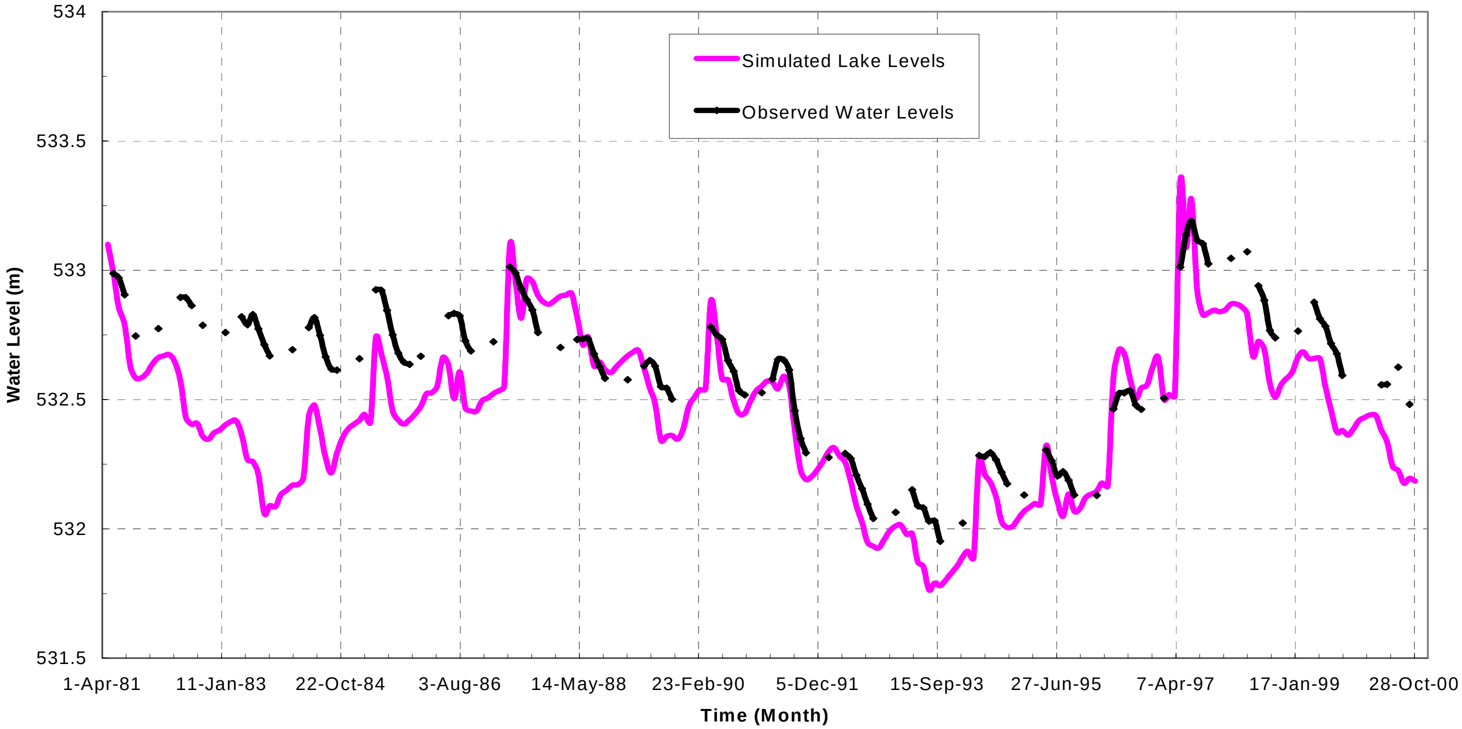


Figure 3-5. Comparison of Moose Lake levels.

3.4 MURIEL LAKE WATER BALANCE RESULTS

The water balance model for Muriel Lake covers the period from October 1981 to December 2000. The monthly contributions of local surface runoff into the lake were computed using the recorded streamflow data for Atimoswe Creek near Elk Point (Hydrometric Gauging Station No. 05ED002). Of the streamflow data available in the area, this streamflow gauge was considered to be the most representative of runoff yields to Muriel Lake.

The following modeling parameters were used in this study:

- stage–storage relationship
- stage–area relationship
- known zero lake outlet flow for the modelling period
- estimated monthly runoff inflows (based on Atimoswe Creek streamflow)
- monthly precipitation (measured at Cold Lake climate station)
- monthly evaporation (based on parameters from Cold Lake climate station)
- one known water level at the beginning of the simulation period.

The stage–storage and stage–area relationships were developed based on a hydrographic survey done for Muriel Lake in 1962. The survey allowed the development of lake bottom contours, and these contours were used to calculate the surface area and volume of the lake for several different lake levels. The spill elevation of Muriel Lake was estimated at 559.7 masl. Since measured lake levels at Muriel Lake over the modelling period did not reach this level, the outflow from the lake was assumed to be zero during this time.

The model provided a satisfactory simulation of the recorded water levels for the modelling period. In general, the water balance simulation explains the lake behaviour based on what is estimated for the modeling parameters listed above, which do not include groundwater. Therefore, groundwater contributions are likely small on a monthly time-step over the modelling period in comparison to other parameters. The net groundwater contribution was estimated by AGS on a long-term average basis, and it was found there was a net groundwater contribution into Muriel Lake over the long term.

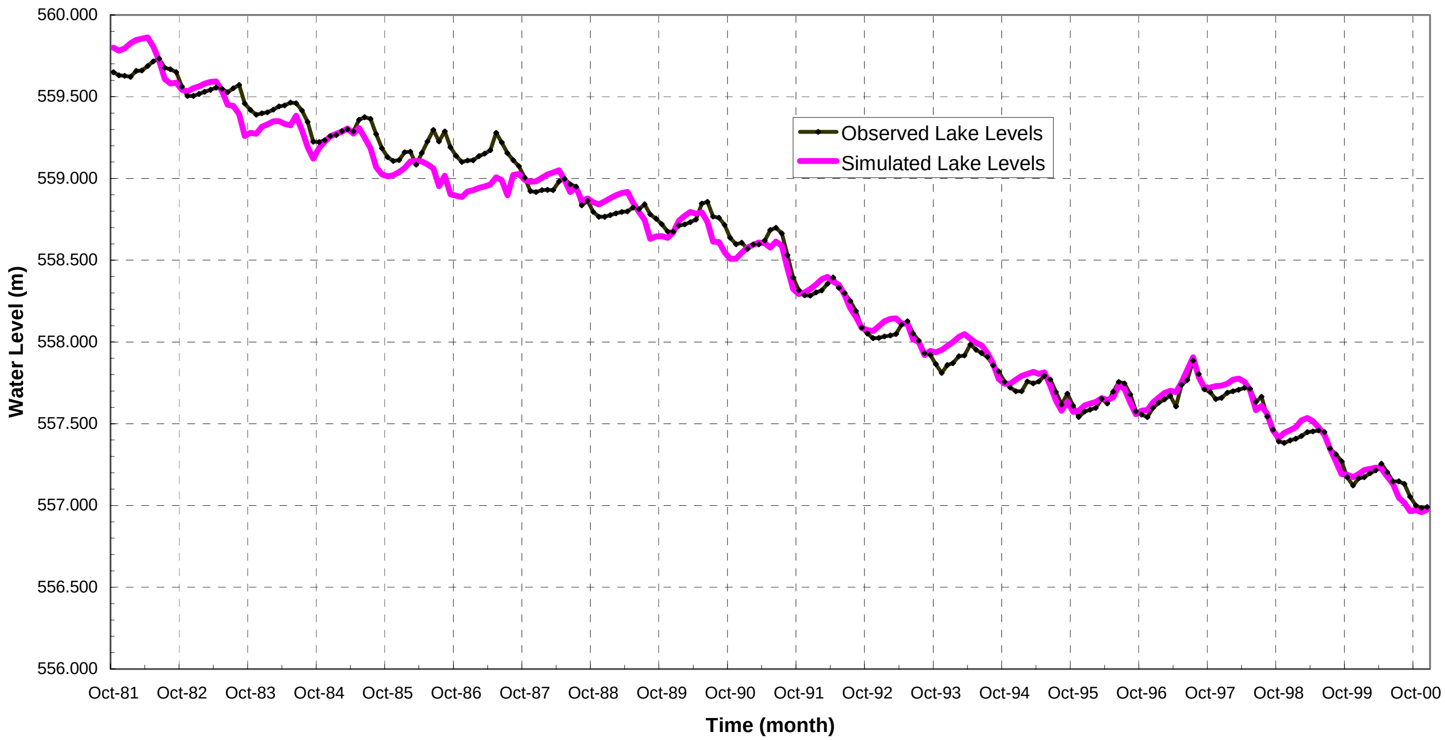


Figure 3-6. Comparison of Muriel Lake levels.

3.5 MARIE LAKE WATER BALANCE RESULTS

The water balance model for Marie Lake covers the period from June 1981 to December 2000. The monthly contributions of local surface runoff into the lake were computed using the recorded streamflow data for Jackfish Creek near La Corey (Hydrometric Gauging Station No. 06AC001). Of the streamflow data available in the area, this streamflow gauge was considered to be the most representative of runoff yields to Muriel Lake.

The following modeling parameters were used in this study:

- stage–storage relationship
- stage–area relationship
- stage–discharge relationship for the outlet
- estimated monthly runoff inflows (based on Atimoswe Creek streamflow)
- monthly precipitation (measured at Cold Lake climate station)
- monthly evaporation (based on parameters from Cold Lake climate station)
- one known water level at the beginning of the simulation period.

The stage–storage and stage–area relationships were developed based on a hydrographic survey done for Marie Lake in 1964. The survey allowed the development of lake bottom contours, and these were used to calculate the surface area and volume of the lake for several different lake levels. The stage–discharge relationship for Marie Lake was developed based on cross-section information on Marie Creek at the outlet of the lake, obtained from a Fish and Wildlife Division survey of the channel in 1983. There are no measured flows at the outlet of Marie Lake.

The simulated lake levels are an outcome of the modeling exercise. The model simulated the recorded water levels fairly well for most of the modelling period; however, there may be unidentified physical factors responsible for the discrepancy shown during some periods. Accounts of the existence of several beaver dams along the Marie Creek downstream of the lake have been recorded periodically. The beaver dam activities, which cannot be incorporated into the water balance model, can affect the water levels in the lake. Furthermore, the historical stage–discharge relationship was not verified, however, and this modeling parameter has a significant effect on the modeling results.

The net groundwater contribution was estimated by AGS on a long-term average basis, and it was found there was a net groundwater flow out of Marie Lake over the long term. The AGS-derived flux values out of Marie lake were quite small when compared to the other parameters in the water balance, and these values had no noticeable effect on the simulated lake levels (Figure 3-7).

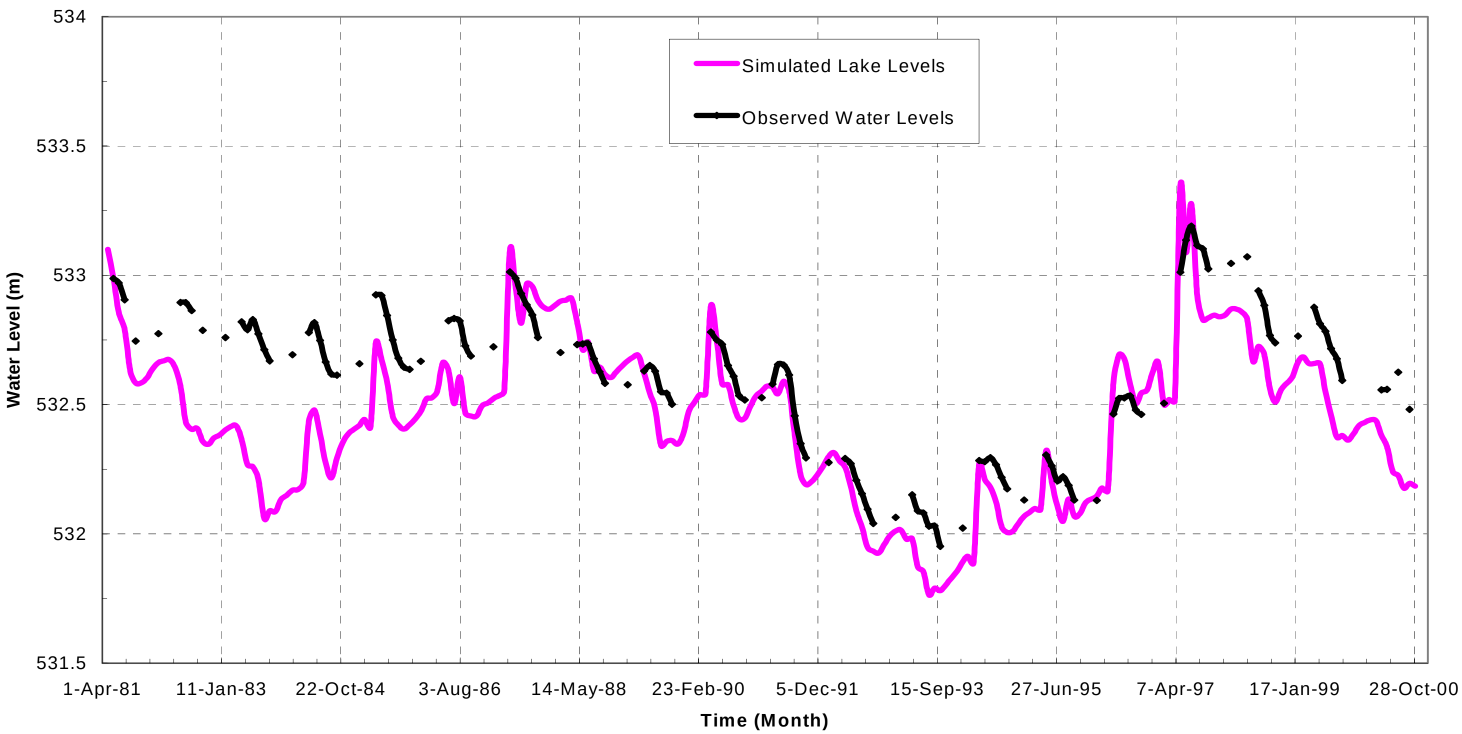


Figure 3-7. Comparison of Marie Lake levels.

3.6 COLD LAKE WATER BALANCE RESULTS

A different technique was used for the Cold Lake water balance model. This "backward routing" technique is sometimes used to obtain the inflow time series; it is based on the assumption that a linear relationship exists between all modeling variables. The measured outflow and water levels are used to compute the inflow time series. This method is selected when an accurate estimation of inflow is very difficult owing to the size of the contributing area and the historical fluctuations in lake levels, which are relatively small.

The water balance model for Cold Lake was done on a weekly time-step and covers the week of April 8, 1983 to the week of December 31, 2002. The following modeling parameters were used:

- stage–storage relationship
- stage–area relationship
- stage–outflow relationship
- known historical water levels.

The stage–storage and stage–area relationships were developed based on a Hydrographic Survey done for Cold Lake in 1969, which allowed lake bottom contours to be developed. The stage–discharge relationship for Cold Lake was developed based on measured flows on the Cold River at the outlet of Cold Lake. Because the stage–discharge relationship is based on both measured levels and outflows, there is a high degree of confidence in the relationship.

Using the above modeling parameters, the model calculated the inflows to the lake. These inflows included all forms of inflow—precipitation, evaporation, runoff and lake inlet flow and groundwater combined.

The computed historical inflows can be used to evaluate the effect of additional water withdrawal from Cold Lake. Using known current actual withdrawals from the lake, it is possible to incorporate any changes to the current situation into the inflow time series, and the resulting impact on lake levels can then be estimated. An example of the effect of a hypothetical increased withdrawal on the lake levels is shown in Figure 3-8. The example uses an increased withdrawal, over current actual withdrawal, of 35 million m^3 per year. This number was picked randomly for illustration purposes only. The current total allocation from Cold Lake is 15 million m^3; the actual withdrawal from Cold Lake varies, but on average it has been about 181,000 m^3 per year.

Currently, there is a two-step cut-off lake level applied to two industrial licences on Cold Lake—Imperial Oil Resources and Canadian Natural Resources Ltd. (CNRL). When Cold Lake reaches 534.62 metres above sea level (masl) the two industries must cut back use by 30%. When it reaches 534.55, they must cease withdrawals.

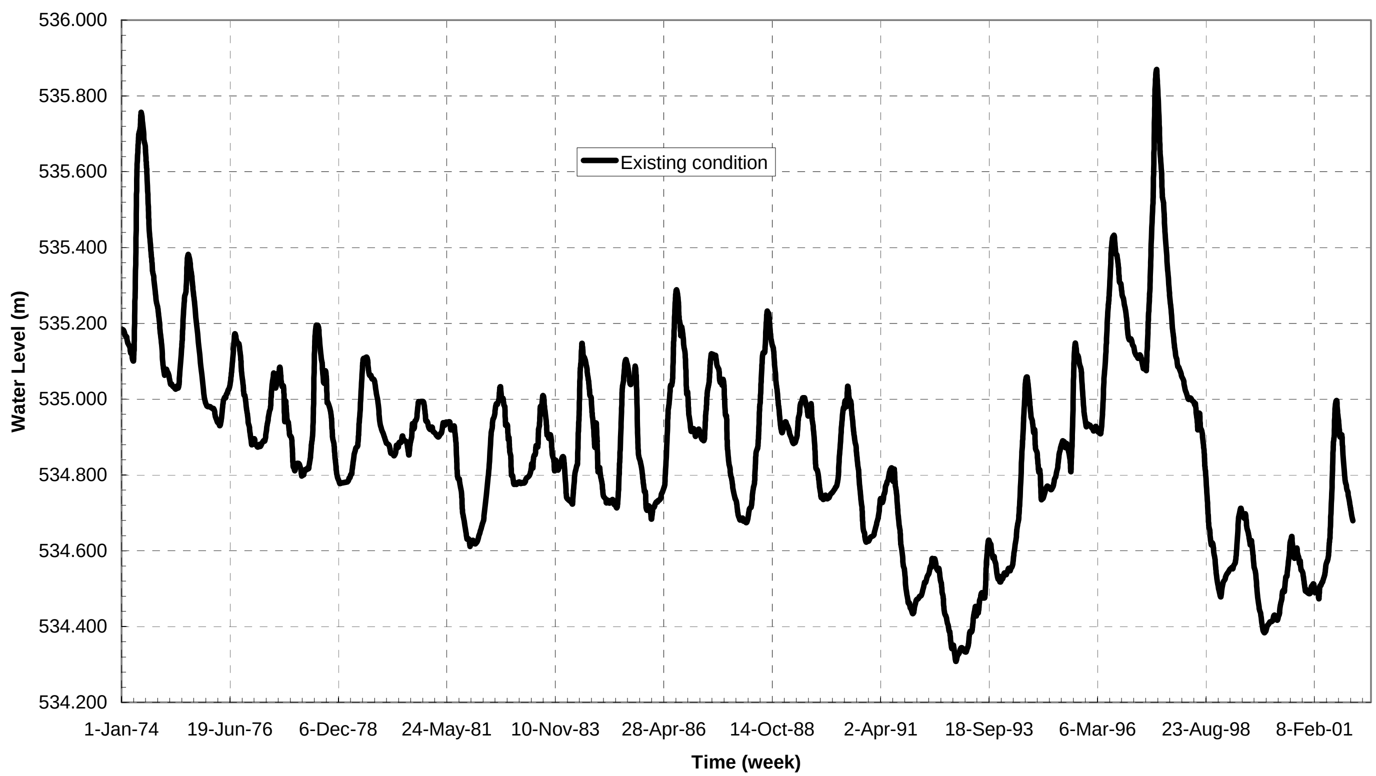


Figure 3-8. Cold Lake levels.

3.7 KEY FINDINGS

1. Loss of water through evaporation is almost always greater than gain of water from precipitation in the Cold Lake area (and in most areas of Alberta). This means lakes must have surface runoff plus groundwater contributions that are greater than or equal to that deficit in order to sustain their levels. This is a significant contributing factor as to why lakes with small drainage basins can have declining lake levels when compared to their surface area.
2. According to precipitation and evaporation records, there were five years with little or no net evaporation deficit during the 1960s and 1970s, whereas there was only one year that had little evaporation deficit during the 1980s and 1990s.
3. For the water balance studies on Moose, Muriel and Marie lakes, it was decided that measured streamflow from a proxy gauged basin was the most accurate way to estimate surface runoff. Although the use of measured streamflow inherently includes any effects of land use changes on runoff, these effects are applied equally to all lake balances using the same proxy streamflow gauge, as it was used for both Moose and Muriel lakes. Since both these lakes show a very good correlation between measured and simulated lake levels using the same proxy streamflow gauge, the effects of land use changes in both basins are likely negligible (very small in comparison with other factors).
4. The Cold Lake water balance was done using a different method than used for the other three lakes, since measured streamflow was available at the outlet of Cold Lake. This allows a very accurate representation of net or "lumped" inflows to the lake without estimating the inflows individually.
5. The key purpose of all the water balance models is to use them to evaluate possible water management scenarios for these lakes. Both methods of performing a water balance still enable this analysis. Likely future scenarios to be evaluated are the increases or decreases in water allocation or use, and changes to lake cut-off levels below which withdrawals are not permitted.

SECTION 4. WATER ALLOCATIONS AND USES

4.1 Introduction

The CLBR Basin is an important source of water supply for domestic, municipal, industrial, agricultural, irrigation and recreational uses. The basin also provides water for the aquatic environment and downstream users in Saskatchewan under the apportionment agreement between Alberta and Saskatchewan. Persistent low runoff levels combined with the increasing water demands over the past decade has resulted in a need to revisit the water management plan for the basin. Managing the demand for water has become a regional priority.

4.1.1 Purpose

This section describes the current and historical surface water allocations and actual uses in the Cold Lake–Lower Beaver River Basin from 1985 to 2004. Since groundwater allocations and uses are included in the Groundwater and Brackish Water State of the Basin Report, they will not be discussed here.

The amount of surface water allocated and actually used is of concern to stakeholders in the basin. The impact on local streams and lakes could be significant, particularly during extended periods of low runoff. Placing pressure on the aquatic environment and limiting water availability for downstream users is also a concern.

Developing a better understanding of the trends for water allocation and actual use in the basin is essential to ensuring adequate water levels and flows for the aquatic environment, protecting existing water licences and downstream users, and predicting future water demands. The information gathered in this section provides statistical support for the development of a strategy to meet current and future water needs within the basin.

4.2 Water Allocations

Several terms are used when describing water allocations and actual uses.

- Water allocation represents the maximum authorized annual withdrawal from the freshwater source.
- Licences authorize the maximum total annual water use, the maximum diversion rate and the timing of diversions. The water allocation data presented in this section was gathered from existing licences.
- Actual water use (also referred to as water use) is the actual volume of water taken from the water source at any given time. The licence holder is required to keep records of the actual amount of water diverted. In the case of large allocations, such as industrial and municipal water operators, annual water use reports must be submitted to Alberta

Environment. Terms synonymous with actual water use include water diversion, withdrawal and consumptive use. Consumptive use refers to the volume of water taken from freshwater, but not returned to its original source.

- *Return flow* is the volume of water from a licensed diversion that is returned to the source of the diversion. Return flows are specified in the water licence and the actual flow data are reported to Alberta Environment.

In the case of steam injection, water is recovered and recycled throughout the operating phase of the project. Upon decommissioning, water has to be injected to replace the void space, meaning the injection water is disposed into deep geological formations and not returned to the surface water source. Municipal water withdrawals in the basin are also not directly returned to their source of their diversion. Both Cold Lake regional utilities and the Town of Bonnyville return their wastewater directly through sewage treatment plants to the Beaver River. Together, industrial and municipal diversions represent a net consumption in the basin with no return flow.

The Government of Alberta owns all rights to water in the province. Water allocation licences in the CLBR Basin and elsewhere are regulated under the *Water Act* (see Appendix A). Under this Act, anyone wishing to divert water in the basin (other than for traditional agriculture uses or for household purposes) must apply for a water licence and obtain approval from Alberta Environment. After reviewing each application, Alberta Environment may issue a licence in accordance with the *Water (Ministerial) Regulation*.

The main provisions of the *Water Act* that affect water allocation licensing are as follows:

- Protect the right of existing water licences that are in a good standing.
- Prohibit inter-basin transfers from Alberta's major river basins.
- Protect traditional agriculture uses of water through a voluntary registration process.
- Protect statutory rights for household use of water and grant it priority over all other uses.
- Allow for flexible water management by permitting the transfer of water licences.
- The priority of licences is established based on the "first in time – first in right" principle.
- Protect the aquatic environment.
- Protect public safety.
- Protect against potential and cumulative effects on the hydrological, hydraulic and hydrogeological regime of the basin.
- Protect any applicable water guideline, water conservation objectives and water management plan.
- Provide opportunities for potentially affected individuals to provide input and advice regarding the water allocation application.

A water allocation licence under the *Water Act* may be issued to the applicant based on the above provisions and after any other matters relevant to the application have been considered. Unlike the old *Water Resources Act*, a licence under the *Water Act* is for a fixed term and has an expiry date. This licence is a public document that contains detailed terms and conditions which must be followed by the licensee, such as point of diversion, source of water, allocated volume, return flow, priority number and expiry date.

4.2.1 Surface Water Allocation

Based on records from up to December 2004, Table 4-1 and Figures 4-1 and 4-2 summarize the current and historical surface water allocations in the CLBR Basin. At this time, a total of 27 million m^3 of surface water is allocated in the CLBR Basin. This quantity represents approximately a 30% increase over 1985 surface water allocations.

Table 4-1. Current and historical surface water allocation in CLBR.

Statutory Purpose	1985		Existing Licences as of December 2004	
	Allocations (m^3)	(%)	Allocations (m^3)	(%)
Municipal	10,646,930	56.62%	10,735,090	39.60%
Industrial	7,739,000	41.16%	8,479,168	31.28%
Agriculture	131,970	0.70%	7,027,287	26.41%
Irrigation	170,210	0.91%	213,380	0.79%
Commercial	114,710	0.61%	205,810	0.76%
Registrations	0	0.00%	317,820	1.18%
Temporary Diversion Licence	NA	NA	0	0.00%
Total	18,802,820	100%	27,111,360	100%

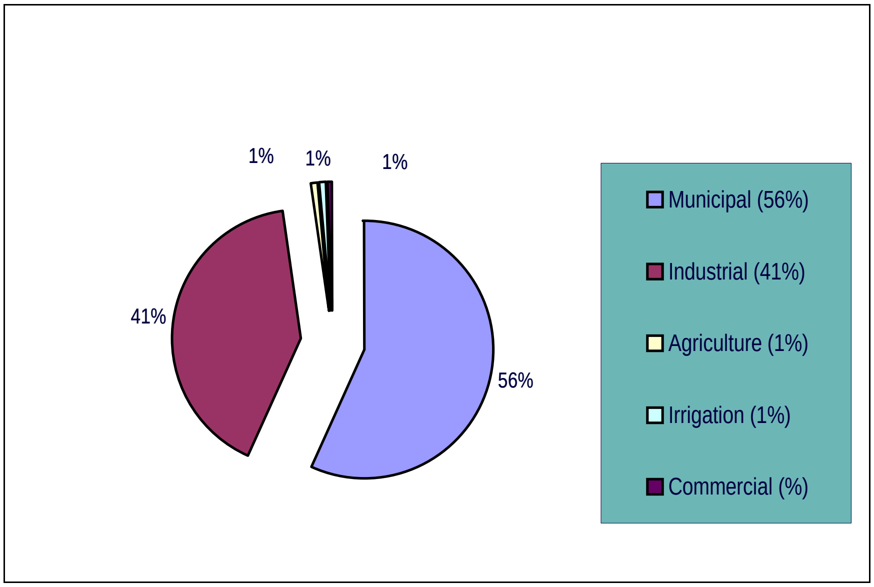


Figure 4-1. Surface water allocation as of December 1985.

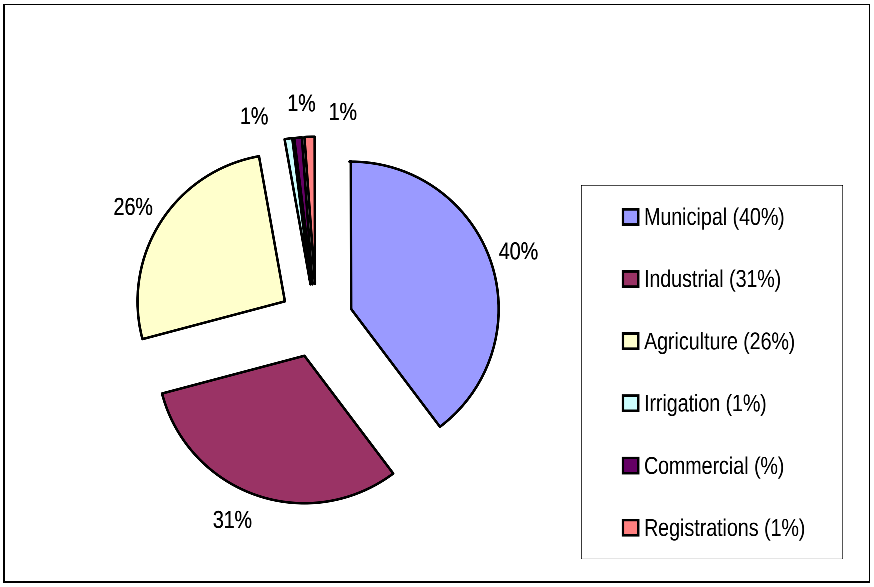


Figure 4-2. Existing surface water allocations as of December 2004.

Municipal Water Allocations

As of December 2004, the majority of surface water allocations were to municipalities and amounted to 10,735,000 m^3 per year, or 40% of the total surface water allocations. Municipalities within the CLBR Basin study area that use surface water allocations include the Cold Lake Regional Water Supply Authority, the Town of Bonnyville and the Kehewin Tribal Administration. The Bonnyville Rehabilitation Centre also uses surface water from Moose Lake.

- The Cold Lake Regional Water Supply Authority has the largest allocation, at 7,500,000 m^3 per year.
- The Cold Lake Regional Water Supply System conveys treated water from Cold Lake to the City of Cold Lake and the surrounding communities of 4 Wing Cold Lake and the Cold Lake First Nations. In 2002, Ardmore and Fort Kent began receiving their water supply from the Cold Lake Regional Water Supply System.
- The Town of Bonnyville has the next largest allocation at 3,100,000 m^3 per year. This water is diverted from Moose Lake and treated. The treated water is then delivered through a local water distribution system.
- The Kehewin Tribal Association has an allocation of 141,000 m^3 per year, which is significantly lower than either Cold Lake or Bonnyville. This water is diverted from Kehewin Lake and delivered through a local water distribution system.

The municipal population in the basin has increased by 23% since 1986. However, municipal water allocations have remained stable over the last 20 years. The existing allocations for the Cold Lake Regional Water Supply Authority and the Town of Bonnyville were issued in 1984, and no additional allocations have been requested in the last 20 years.

Industrial Water Allocations

Industrial surface water allocations account for approximately 8 million m^3, or about 31% of the total surface water allocations in the basin as of December 2004. This water is used primarily for industrial injection purposes, and none is returned to its source of diversion. Imperial Oil

Resources and Canadian Natural Resources Limited (CNRL) hold the largest surface water licences for industrial purposes, for a combined total of 7 million m^3 per year, or about 90% of the total industrial surface water allocation. Both licence holders divert water from Cold Lake, and are subject to specific conditions under the licences.

When Cold Lake water levels reach an elevation of 534.62 m, both licensees are required to reduce the amount of water pumped daily by as much as 30%, or otherwise modify the mode of operations of the water intake station upon notification from Alberta Environment.

If the level of Cold Lake is below or at an elevation of 534.55 m for two consecutive days at any time, both licensees must stop diverting water until water levels are at 534.55 m or higher for two consecutive days. This water loss is made up through the use of groundwater diversions. Both Imperial Oil and CNRL have contingency groundwater allocations that may be used only when the Cold Lake levels drops to 534.55 m for two consecutive days. Groundwater licences are discussed in the Groundwater Quantity and Brackish Water State of the Basin report.

Unlike the municipal water allocation process, industrial water allocations appear less predictable and depend on many factors such as general economic trends, oil prices, quantity of bitumen available, improvements in water recycling and reuse technologies, and availability of non-freshwater uses. Table 4-2 summarizes the existing and cancelled industrial surface water allocations since 1985.

A total of 12 million m^3 of water has been allocated for industrial purposes since 1985. Table 4-2 indicates 32% of these allocations have been cancelled in the last 20 years. The two main reasons for this change are:

1. The two largest producers in the basin, Imperial Oil and CNRL, have increased their use of brackish (saline) water and the ability to re-use produced water for steam injection. Recycling produced water has increased from a 20% recycling rate in 1985 to more than 90% in 2004. In addition, the current industrial expansion projects are all relying on the use of brackish water.
2. Some experimental (pilot) bitumen recovery projects that used mainly surface water in the late 1980s were shut down.

Table 4-2. Industrial surface water allocation (existing and cancelled licences).

Operator	Annual Allocation (m^3)	Project Location	Sources of Water	Issued Date	Expiry Date
Existing Licenses as of December 2004					
Imperial Oil	5,110,000	14-02-65-2-W4	Cold Lake	15 Jun 1983	12 Jul 2010
Imperial Oil	38,000	NE-16-65-4-W4	Surface runoff	17 Mar 1986	27 Jun 2012
Imperial Oil	36,000	SW-21-65-4-W4	Surface runoff	21 Feb 1991	In perpetuity
CNRL-Burnt Lake	2,628,000	NW-8-66-5-W4	Cold Lake	16 Dec 1985	In perpetuity
CNRL	64,000	NW-8-66-5-W4	Surface runoff	14 Jul 1999	In perpetuity
CNRL	25,900	NE-5-67-4-W4	Surface runoff	13 Jul 1999	In perpetuity
Talisman Energy	499,560	NW-12-65-2-W4	Cold lake	3 Oct 1976	In perpetuity
Imperial Oil	25,016	NE-12-65-4-W4	Surface runoff	16 Jun 2003	15 Jun 2028
Imperial Oil	52,692	N 1/2 –33-64-3-W4	Surface runoff	31 Jan 2003	28 Aug 2037

Operator	Annual Allocation (m3)	Project Location	Sources of Water	Issued Date	Expiry Date
Total	8,479,168				
Cancelled Industrial Licenses (1985-2004)					
Imperial Oil	431,720	NE-15-64-3W4	Ethel Lake	29 Mar 1976	02 Sep 1998
Imperial Oil	268,894	NE-15-64-3W4	Ethel Lake	2 Apr 1976	02 Sep 1998
Imperial Oil	44,410	SW-21-65-3-W4	Surface runoff	26 Jan 1987	27 Aug 1991
Imperial Oil	24,845	SW-33-65-3-W4	Surface runoff	07 May 2002	06 May 2003
Norcen Energy	230,666	SW-2-65-2-W4	Cold Lake	12 Dec 1988	4 Aug 1990
Murphy Oil	115,950	SW-18-58-4-W4	Bluet Lake	16 Oct 1975	20 Oct 1986
Canada Worldwide Energy	616,740	SE-24-59-5-W4	Muriel Lake	06 Jun 1983	09 Apr 1986
Suncor Energy	2,189,430	SW-10-61-5-W4	Sewage Effluent	21 Sep 1988	8 Sep 1990
Chevron Canada	172,690	SE-3-61-2-W4	Cold Lake	18 Mar 1983	31 Jan 1986
Total	4,095,345				

Commercial Licenses

Commercial licences account for less than 1% of the total surface water allocation. Three licences have been issued for commercial water use purposes: the Bonnyville Golf Course, Bonnyville Forest Nursery (tree farm) and the Cold Lake Skiing Society.

Temporary Diversion Licenses

A Temporary Diversion Licence (TDL) provides authority for diverting and using surface water on a temporary basis, for up to a maximum of one year (s. 62 *Water Act*). This licence identifies the source of water supply, point of diversion, the amount allowed for diversion, and the condition under which the diversion can take place. Since the *Water Act* came into force (January 1999), about 150 TDLs have been issued for surface water diversions in the CLBR Basin. This amounts to about 188,950 m^3 of water. TDLs were issued for industrial, municipal, commercial and agriculture purposes.

Agriculture

Agriculture licences account for approximately 7,159,257 m^3, or 26% of total surface water allocations in the study area. Agricultural licences are issued primarily for stock watering. The major user of surface water for agricultural purposes within the basin is the fish hatchery, operated by Sustainable Resource Development, with an allocation of 7,000,000 m^3 per year, or 98% of the total agriculture licences. More than 90% of the water used from this allocation is returned to Cold Lake.

Irrigation

There are seven licences for irrigation purposes in the study area. This accounts for less than 1% of the total surface water allocation.

Traditional Agriculture

The *Water Act* protects water that is used for traditional agriculture purposes (water used for raising animals or applying pesticides to crops—up to a volume of 6,250 m^3 of water per year). A licence is generally not required for this type of diversion under the *Water Act* (s. 19).

Registrations

The *Water Act* (s.73) contains a mechanism whereby someone could register and secure tradition agricultural use, with a priority number assigned that was grandfathered back to the date on which the water was first put into use. This was a voluntary program that extended from January 1999 to December 2001. About 887 traditional agriculture users for surface water sources have been registered in the CLBR Basin, with a total allocation of 317,820 m^3 of water per year.

As registration was voluntary, it is expected that some traditional agriculture users decided not to register. However, these users may continue to divert water and are exempted under the *Water Act*. The total number of non-registered traditional users is not known and no estimates have been made, but their cumulative water use in the basin is believed to be minor in comparison to the remainder of the surface water allocations.

Household Purposes

Water for household purpose is defined as a maximum amount of 1,250 m^3 used for the purposes of human consumption, sanitation, fire prevention and watering animals, gardens and trees. This allocation is exempt under the *Water Act* (s. 21) and has priority over all other users of water (s. 27). A licence is not required. The amount of water used for household purposes in the CLBR Basin is not known and was not estimated for the purposes of this study.

4.3 ACTUAL WATER USE

This section focuses on industrial and municipal water uses, which comprise the largest amount (70%) of surface water used in the basin. The agriculture sector also diverts large amounts of water, or about 26% of the total surface water allocation. About 90% of water diverted for the Cold Lake Fish Hatchery (considered to be within the agricultural sector) is returned to its source. Water allocations for irrigation, registration purposes, commercial and temporary diversion licences are very minor in terms of overall water use in the basin.

This section focuses on Cold and Moose lakes, which are the main sources of surface water diversions for industrial and municipal uses in the basin. It is expected these two lakes will continue to be a major source of water for industrial and municipal purposes in the future.

Table 4-4 documents current and historical industrial surface water diversions from all surface water sources, as concerns have been raised by the public regarding historical industrial water diversions in other lakes such as Muriel, Ethel and Bluet. Water use data were gathered from Alberta Environment files for the period of 1985-2003. This was possible owing to the condition placed on most licences issued to industrial users, municipalities and most agricultural users that water use must be metered and reported to Alberta Environment on an annual basis.

4.3.1 Cold Lake

Cold Lake is a water supply source for industrial operations, the City of Cold Lake and the surrounding communities. In addition, Cold Lake is an important recreational lake and habitat for aquatic resources.

The primary industrial users of surface water in the CLBR Basin study area are Imperial Oil and CNRL. Industry's use of freshwater is somewhat cyclical and related to project start-ups and various other stages. It is also affected by business climates. With the increase in industrial activity over the past 22 years, an increase in water use would be expected, particularly with the increase in freshwater allocations over that same time period. However, surface water use by industry has been lower in each of the past 13 years than it was from 1985-1990. This reduction is the result of industry improving recycling techniques and developing the ability to use brackish water.

As shown in Figure 4-3, surface water use by industry from 1985-2003 ranged from 0 million m^3 to 6.5 million m^3 (about 0-75% of their total allocation). Industry's use of surface water decreased from 1991-1993, followed by a sharp increase from 1994-1997. A period of significantly low use also occurred from 1998-2001, followed by a period of increased use until 2002. These two periods of decreased surface water use were due to Imperial Oil and CNRL implementing their contingency licences.

Historically, there were two industrial licences from Cold Lake for projects that were never developed. As a result, no surface water was diverted from Cold Lake under these licences from 1985 to 2003. These were held by Norcen Energy and Chevron Canada.

Municipal water use has remained relatively stable in the past 20 years. The municipalities have been diverting about 2.4 million m^3 of water per year, or 32% of the allowable diversions.

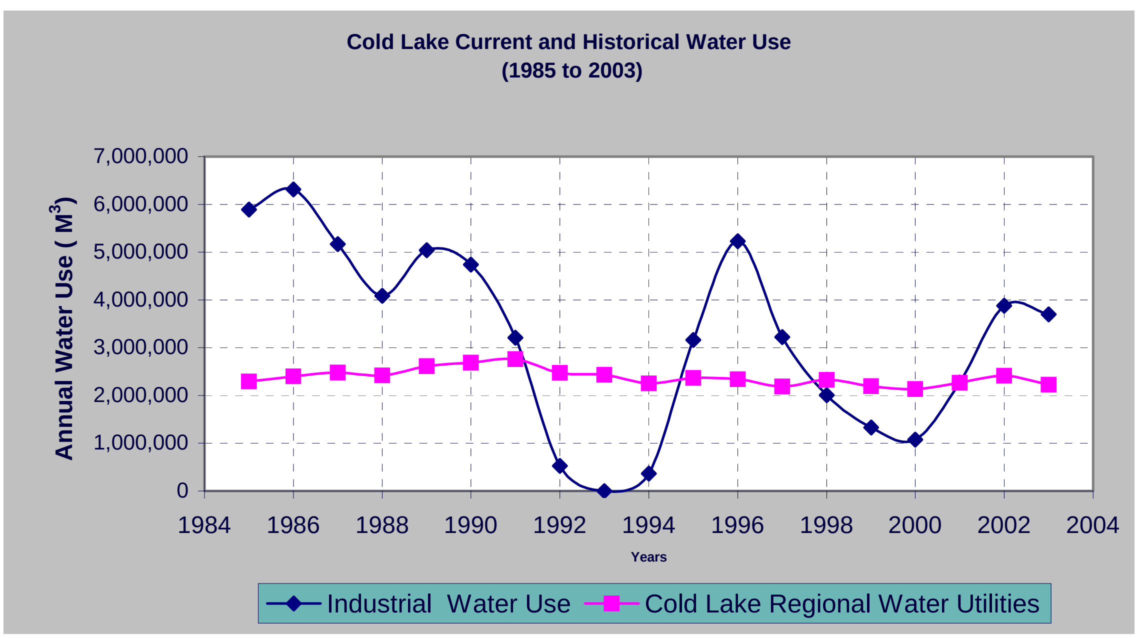


Figure 4-3. Cold Lake current and historical water use (1985-2003).

4.3.2 Moose Lake

Moose Lake is a source of water supply for the Town of Bonnyville. Current water usage is approximately 1,000,000 m^3 per year, an increase from approximately 850,000 m^3 per year in the late 1980s. Figure 4-4 shows the town's water diversion decreased significantly in 1992 and 1994, and was about 17% lower than the annual average diversions. The town's water diversion peaked again in 1998 and declined slightly by 2000. The town's water diversion has increased since 2000 to its current usage amount.

Decreased water use in the 1990s could be attributed to several reasons. Recorded water levels for Moose Lake and several other lakes in the region were at historical lows for the early 1990s. Many recreational campgrounds were closed in the early 1990s; as well, oil and gas exploration camps were also closed due to low-oil prices. The Town of Bonnyville formerly provided potable water, mainly through a trucking system, to recreational campgrounds and oil and gas exploration camps.

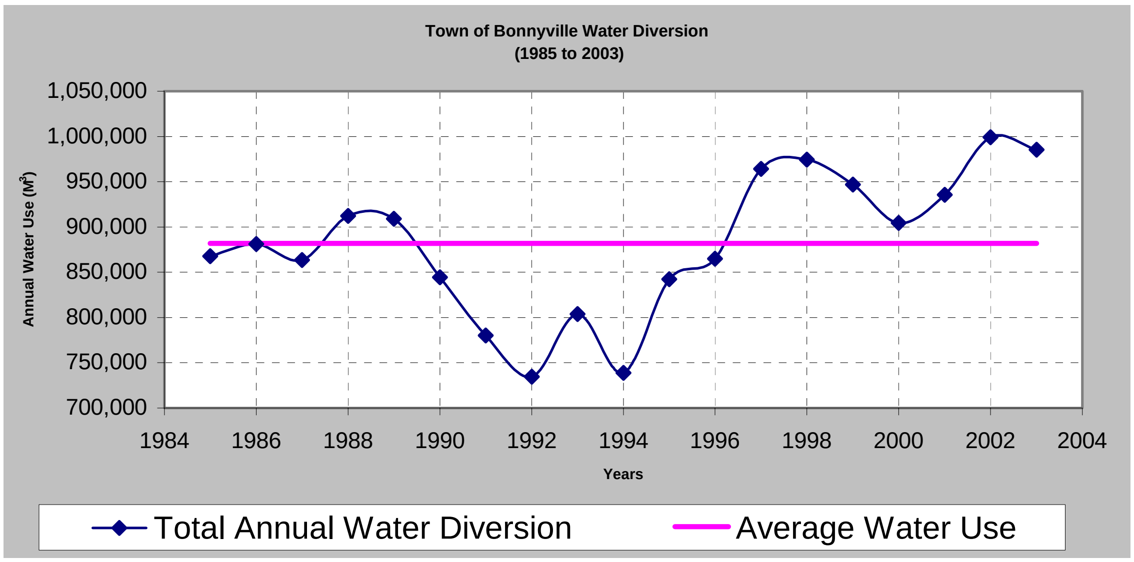


Figure 4-4. Town of Bonnyville water diversion (1985-2003).

Population and water use trends can be correlated, as shown in Table 4-3. Figure 4-4 shows the annual water use from Moose Lake dropped between 1990 and 1991, coinciding with a decrease in population from 5470 in 1986 to 5132 in 1991. The population numbers and annual water use remained low until 1996, after which time the population and water diversion amount began to increase.

Table 4-3. Historical per capita water use.

Years	Population	Reported Annual Water Use (m^3/year)	Per Capita Water Use (L/day)
1986	5470	881,020	440
1991	5132	780,017	416
1996	5100	864,850	464
2001	5397	895,571	454
2003	5709*	985,240	472

Source: Official population list, Alberta Municipal Affairs.

4.3.3. Historical Industrial Water Use From Other Lakes

The public has raised concerns regarding historical industrial water diversions in other lakes such as Muriel, Ethel and Bluet (the latter is a local name; Bluet Lake is located upstream from Muriel Lake). Table 4-4 documents historical industrial surface water diversions from all surface water sources.

The 1985 Cold Lake Water Management Plan established cut-off levels for both Ethel and Muriel lakes. The water management plan also established a moratorium on Muriel Lake in 1985, which meant water could no longer be diverted from the lake for industrial purposes.

Imperial Oil

Imperial Oil held a licence for surface water diversions from Ethel Lake from 1976-1998, with an annual allocation of 801,763 m^3. Two licences were issued initially, bit the amounts were later combined into a single annual allocation. One of the conditions of the licence was a cut-off level of 540.82 m, below which Imperial could not divert water from the lake. Average annual diversions were 485,693 m^3 from 1985-1992. No water has been used since 1992. In 1993, Imperial installed its first brackish water to supplement its water requirements for steam.

Murphy Oil

Murphy Oil held a surface water diversion licence for Bluet Lake from 1975-1986, with an annual allocation of 115,950 m^3. This licence also had conditions related to cut-off levels. Murphy Oil diverted water from Bluet Lake only in 1985.

Worldwide Energy

Worldwide Energy held a surface water diversion licence for Muriel Lake from 1983-1986, with an annual allocation of 616,740 m^3. The conditions of this licence also included a cut-off level that ranged from 559.643 m to 559.765 m throughout the year, depending on the month. Water was diverted in 1983, but conditions related to cut-off levels prevented water from being diverted in the years following. Therefore, no water was diverted from Muriel Lake in the time period considered for this update (1985-2003).

Table 4-4. Historical industrial surface water diversions from all surface water sources.

Company	Amount Diverted/Year (m^3)																		
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Imperial Oil Allocation: 801,763 Source: Ethel Lake Issued: 29 March 1976 Expired 2 Sept 1998	361760	570894	444293	628514	641924	440733	266228	531198	0	0	0	0	0	0	0	0	0	0	0
Murphy Oil Allocation: 115,950 Source: Bluet Lake Issued: 16 Oct. 1975 Expired: 20 Oct. 1986	115950	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Worldwide Energy Allocation: 616,740 Source: Muriel Lake Issued: 6 June 1983 Expired: 9 April 1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Norcen Energy Allocation: 230,660 Source: Cold Lake Issued: 12 Dec. 1988 Expired: 4 Aug. 1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chevron Canada Allocation: 172,690 Source: Cold Lake Issued: 18 Mar. 1983 Expired: 31 Jan. 1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

4.4 KEY FINDINGS

The following are some of the key findings of surface water allocations and actual uses in the CLBR Basin since 1985:

1. Industry in the Cold Lake Beaver River Basin is allocated a total of 8,479,168 m^3 surface water annually while municipalities are allocated 10,735,090 m^3 annually. This correlates to 31.28% and 39.60% respectively. Combined total water use in the basin for industry and municipalities combined is equal to 70%.
2. All industrial surface water diversion in the Cold lake Beaver River basin is currently provided by Cold Lake.
3. Total annual surface water use in the Basin is equal to 2,400,000 m^3 for municipalities and ranges from 5,000,000 to 6,500,000 m^3 for industry.
4. Only Imperial Oil and CNRL divert and use surface water for industrial injection purposes.
5. Since 1985, the total number of surface water diversion licences cancelled amounts to 9 licences, which is 4,095,345 m^3 less allocated annually as compared to 1985.
6. Total surface water allocations for municipal purpose have remained consistent since 1985.
7. The major change in allocations is in the agricultural section, where allocations have increased from 131,970 m^3 in 1985 to 7,027,287 m^3 as of December 2004. That correlates to an increase of agricultural water allocations as a percent of total surface water allocations from 0.70% in 1985 to 26.41% in 2004. However, 100% of the surface water used is eventually returned to the lakes.

SECTION 5. MUNICIPAL, AGRICULTURAL AND INDUSTRIAL WATER CONSERVATION

5.1 INTRODUCTION

This section documents and highlights the current water conservation practices for the municipal, agricultural and industrial sectors in the CLBR Basin.

The CLBR Basin appears to be going through an extended period of low runoff conditions, causing its water supplies to be even more valued than previously. Over the past few years, competition for surface water allocations has increased within the basin, likely owing to an increase in industrial and agricultural development and the associated population growth in the region.

Municipal water suppliers, in particular the Town of Bonnyville, are concerned about the declining lake water levels and the resulting need to replace their water intake structures. Agricultural water users and rural communities are also concerned about the availability of water and the need to retain their water resources in order to protect their livelihoods. Adequate lake water levels are needed by recreationists to allow them to pursue their activities and to protect the interests of the recreational industry. Most stakeholders, including environmental groups and people living in the area, are concerned about protecting the riparian areas and aquatic habitat, and want assurances that adequate water supplies will remain in the rivers and streams to protect the aquatic environment.

Water conservation is a priority for the basin, and emphasis will be placed on efficient and wise use as important components of the updated CLBR Basin Water Management Plan. This is consistent with Alberta's *Water for Life Strategy,* which focuses on ensuring safe, secure, reliable drinking water and a healthy aquatic ecosystem.

5.2 *WATER FOR LIFE* AND WATER CONSERVATION

With an increasing population, growing economy and periodic dry conditions throughout much of the province, considerable pressure is being placed on Alberta's water resources. Greater efficiency in water use and conservation is needed, as well as more effective management of the province's limited water supply.

Water for Life, Alberta's water strategy, outlines Alberta's plan to ensure safe, secure drinking water, healthy aquatic ecosystems, and reliable quality water supplies for a sustainable economy. A key area of focus for achieving these goals is improved water conservation.

5.2.1 Conserving Water

Water conservation includes all activities that reduce water demand and use, and improve the efficiency and productivity of water that is used for a variety of purposes. There are several positive outcomes of conserving water, including:

- Activities that reduce the amount of water removed directly from the environment help to maintain rivers, lakes and wetlands—habitats critical for fish and wildlife.
- Removing less water reduces the need for additional resources such as power for pumping water or chemicals for water and wastewater treatment.
- Improving productivity allows more of a particular product such as oil, crops, or electricity to be produced with less water.
- Becoming more efficient and using less water helps to ensure water is accessible for future uses and sufficient water is available for healthy aquatic ecosystems.

The water strategy identifies a number of short, medium and long-term actions to improve water conservation in Alberta. A significant target identified within the strategy is a 30% improvement in the overall efficiency and productivity of water use by 2015. This will involve preparing water conservation and productivity plans for all water use sectors including industry, agriculture and municipalities.

Using 2005 water use data, each sector will work with the Alberta Water Council to develop their plans, which will outline strategies and targets for improving conservation. A watershed approach will be considered in the development of these plans, since each major watershed faces different water use, supply and demand aspects.

Overall, *Water for Life* recognizes that all Albertans, citizens, communities, industries and governments share responsibility for the wise use and sustainability of water, and need to take action in the area of water conservation.

5.3 Municipal Water Conservation

Water conservation is any action or technology that reduces the amount of water diverted from source, reduces consumption, improves efficiency, reduces the loss of unaccounted water, and increases the reuse and recycling of water. Water conservation is essential to meeting the needs of existing and future demands, and ensuring the needs of aquatic systems are protected. This section contains a review of the current municipal water conservation best management practices.

5.3.1 Current Issues

Municipal water conservation is a relatively new concept in water management planning, and is becoming increasingly important due to the escalating costs of providing clean and safe drinking water. The provincial, and several municipal governments recognize that using water wisely and efficiently will conserve water, prevent pollution, and reduce costs associated with expanding the water supply and water system infrastructures. Alberta Environment and several municipalities are currently promoting efforts to use water efficiently and effectively, and encouraging ways to balance water demand and supply.

The CLBR Basin has a relatively abundant amount of water in its lakes, rivers and aquifers compared to other parts of the province. However, the availability of water for municipal purposes is diminishing owing to prolonged low runoff conditions over the past 20 years.

Major challenges facing the municipal water supply utilities in the basin that were identified by municipal operators and regulators, include:

- Moose Lake
  - Trihalomethane (THM), a disinfection by-product from using chlorine as a disinfectant. Production is near the guideline of maximum allowable concentration (MAC) in water treated and distributed from the lake.
  - Taste and odour problems during the algae season in water treated and distributed from the lake.
- Bonnyville
  - Cast iron distribution mains causing growth of iron bacteria and discolouration of water in water system.
  - Treatment and distribution costs in Bonnyville.
  - Source water protection/water conservation (Bonnyville and Cold Lake).
- Cold Lake
  - Asbestos Cement (AC) pipe in ground at Cold Lake.
  - Inefficient distribution to two of the lake's reservoirs.
  - Particle counts in the lake's water system.
  - Turbidity reduction in the lake's water system.

A survey conducted by the Alberta Northern Development Council also documented the increasing costs of replacing the aging infrastructure, the cost of implementing water safety and security supply regulations, and the inability to meet the federal drinking water standards for small communities. The initiation of major capital projects is also anticipated within the next 5-10 years.

Since the cost of providing municipal water supplies in the future are projected to become increasingly higher, and will have significant environmental impacts on the region’s fragile water resources, the best management practices for municipal water conservation will need to be investigated by both Alberta Environment and local municipal governments. This approach is consistent with the goals of Alberta’s sustainable development and the Provincial Water Strategy.

5.3.2 Benefits of Municipal Water Conservation

In 1994, Environment Canada released a *National Action Plan to Encourage Municipal Water Use Efficiency* (CCME Water Use Efficiency Task Group) based on the view that improved water efficiency practices are essential to sustainable development. The plan's goal is to achieve more efficient use of water in Canadian municipalities as a way to save money and energy, conserve water, and delay or reduce water system expansion costs.

In the past, municipal water management in Canada has focused on providing adequate supplies to meet municipal, domestic and industrial demands. Any increased demand has been met by expanding the existing water and wastewater delivery and treatment systems. The cost of this expansion has increased significantly as more distant and expensive sources must be tapped. In addition to the increase in use, more stringent standards and regulations have escalated the cost of providing improved water and wastewater treatment. Water-pricing policies in most municipalities do not encourage greater efficiency in water use, as they generally do not reflect the true cost of treatment and delivery.

All anticipated outcomes from the national action plan are beneficial to governments and consumers. One major benefit is the capital cost savings on the infrastructure needed to deliver water and treat wastewater. From an environmental perspective, there will be a decrease in the amount of water used, which means less energy is required to process, transport and treat potable water and wastewater. This reduction in water use will also preserve surface waters for fish and wildlife habitat. In addition, the move to water efficiency will trigger new economic activity for water-related industries.

By assisting municipal actions for increasing water efficiency, the provincial and federal governments will support municipalities in their efforts. This assistance may be in the form of policies such as:

- Integrating water efficiency criteria into infrastructure assistance programs, including incentives for water efficiency planning.
- Incorporating water efficiency initiatives into government policy and regulatory structures.
- Developing a generic water efficiency plan outline as a guide for municipalities.
- Developing municipal water efficiency plans.

Although Alberta did not participate in the national action plan in 1994, the City of Cold Lake and the Town of Bonnyville, as well as other municipalities in the province, are putting some of these recommended actions in place.

5.3.3 Municipal Water Uses

Environment Canada completed a study in 1999 that separated municipal water use into specific types (Figure 5-1). These numbers show the residential sector has the highest level of water use, making it important to ensure this type of water use is managed effectively.

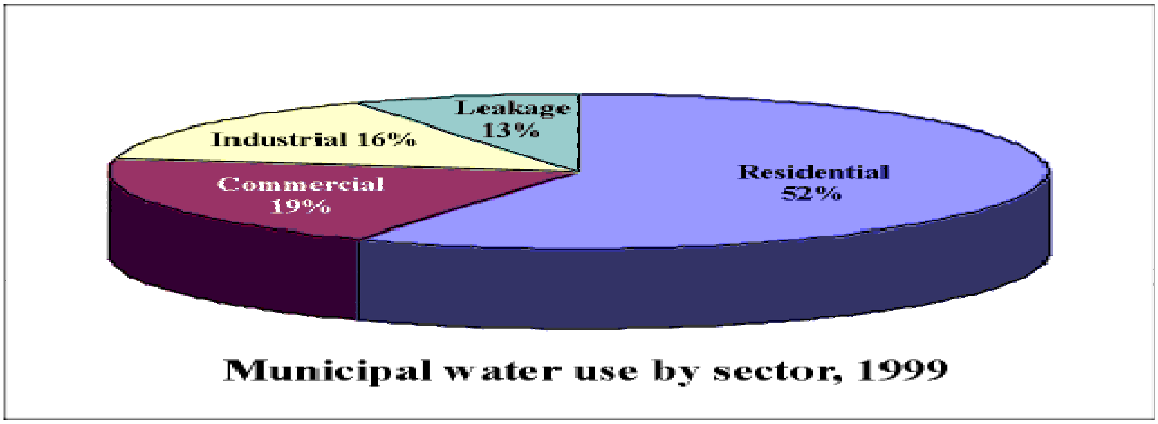


Figure 5-1. Municipal water use by sector, 1999.

Most of the water conservation activities undertaken by municipalities fall within the existing jurisdiction of municipal governments and/or public utilities. This includes metering, water recycling systems, wastewater re-use, flow control devices, rate structures, pricing policies, incentives through rebates, and sanctions (fines).

Common sources of residential water loss are leaking distribution lines, toilets and faucets, and inefficient use of appliances such as dishwashers and washing machines. The desire to maintain lush, green lawns and gardens also results in excessive water use. The frequency, duration and time of day are important factors to consider when watering lawns and gardens. Too often, watering occurs more frequently and for longer periods than necessary.

Metered households generally have lower water consumption than non-metered households. Water use in 1999 was 70% higher among consumers who paid flat rates irrespective of volume. The Indicator and Assessment Office of Environment Canada released the following numbers in 2000:

Table 5-1. Comparison of metering status and litres used, 1999.

Metering Status	Litres/person in 1999
Price by volume	287.90
Flat rate	433.10

Meters are generally an effective tool to encourage people to conserve water, since they provide an accurate account of how much water is being used. Meters are not mandatory in Alberta, although statistics show residents whose water is not metered tend to use more water than metered residents. When combined with a reasonable pricing policy, meters can reduce the demand for water.

In 2001, statistics showed 55% of Canadians paid for municipal water in ways that did not promote conservation:

- 43% of Canadians paid through a flat rate (water charges are fixed);
- 12% paid through a declining block rate (the more water used, the less the cost per unit).

Only 45% of Canadians were under a rate structure that promoted conservation:

- 36% were under a constant rate where the amount paid increased in conjunction with the amount consumed;
- 9% were under an increasing block rate where a successively higher price was paid with increasing water use.

Municipalities in Alberta that are on a pay-per-volume basis are Olds, Lethbridge and Edmonton. Calgary offers residents the choice of a flat or a constant metered rate, with general service rates calculated through a metered declining block rate. Increasingly, the trend across North America is towards universal water metering.

5.3.4 Municipal Water Conservation Practices Across Alberta

Public education plays an important role in water conservation and is an area supported by most municipalities. Metering water use has been employed as a water conservation method for some time; however, metering the return flow to the sewer system results in even greater water savings. For this reason, municipalities are beginning to include a sewer surcharge on residential water bills.

The Alberta Municipal Water/Wastewater Partnership (AMWWP) implemented a Water Conservation Initiative in April 1991. This is an ongoing initiative to encourage water conservation and consumption-based water rate schedules, and applies to both water and wastewater projects. Through this program, municipalities are encouraged to implement meter and consumption-based rate schedules if they are not already in place.

In 1989, Edmonton implemented a water conservation strategy through EPCOR, which provided water to 800,000 customers. A 4-phase, 15-year conservation program was implemented in the city, which was already fully metered and had relatively high water rates. Public education was used as the primary venue for change. The initial goal to reduce water use by 10% in 8 years was exceeded, with a 13% reduction shown within 6 years. Conservation initiatives focused on reducing peak demand as well as base load.

Strathcona County (east of Edmonton) is also serviced by EPCOR, using water supplied by Edmonton's treatment plants. When reservoir water quantities are low, water pressure is reduced, residents are asked to reduce water use (particularly lawn watering), the County stops high water use activities, and a ban may occur on lawn watering and other non-essential outdoor uses.

The Town of Okotoks has taken a proactive approach to managing water use, which includes:

- Setting a per capita water reduction target of 318 L/person/day (70 gal.)—the current water consumption rate is approximately 404 L/person/day (89 gal.).
- Providing "For Future's Sake" public information and education programs.
- Maintaining an active membership in the Bow River Basin Council (an advisory group to the Minister of the Environment).
- Developing a Geographic Information System (GIS) for the Sheep River Watershed.
- Owning and operating 10 water quality monitoring stations from the headwaters of the Sheep River to the confluence of the Highwood River.
- Implementing best management practices for stormwater runoff.
- Aggressive leak detection and maintenance programs.
- Upgrading the sewage treatment operations using advanced technologies.
- Upgrading water distribution systems and plans to expand the well fields and increase water storage through reservoir facilities owned and operated by the town.

The City of Lethbridge is using and encouraging xeriscaping, which is a different approach to water conservation. Xeriscape is based on sound horticultural practices and produces a sustainable landscape that conserves water. It uses seven common principles dealing with the following:

- Planning and design
- Soil analysis
- Appropriate plant selection
- Practical turf areas
- Efficient irrigation
- Use of mulches
- Appropriate maintenance.

5.3.5 Water Conservation Practices in the CLBR Basin

The City of Cold Lake and the Town of Bonnyville are the largest municipalities in the basin. The Beaver River Basin is one of the smaller basins within the province, covering 14,500 km^2. The water management practices for Bonnyville and Cold Lake are compared in Table 5-2.

Table 5-2. Water management comparison between the City of Cold Lake and Town of Bonnyville.

	City of Cold Lake	Town of Bonnyville
Metered water withdrawal from water source	No meter measuring water withdrawal from Cold Lake	A meter that measures water withdrawal from Moose Lake.
Metered water use	The south part was metered completely except for municipal buildings. The north side was not metered. When the towns of Grand Centre and Cold Lake amalgamated, residents were given a choice of a meter ($6.90/1000 gallons) or flat rate ($50/month). A bylaw now in place requires anyone moving into a new residence to be metered. Municipal buildings are being outfitted with meters. The metered rate includes a "Green Rate" for the months of June, July, and August, where sewer charges are capped at $10.50 regardless of consumption for residential accounts.	All residential and public buildings are metered with commercial and residential consumers paying the same amount per unit ($2.00/m^3). This is based on a user-pay system
Population served by water facilities	11,520 residents (includes the Air base), Cold Lake First Nations, Villages of Ardmore and Ft. Kent	5,709 residents, Tree Nursery
Water withdrawal in 2002	2,410,236 m^3	999,282 m^3
Water return in 2002 (not returned to the original source)	645,006 m^3 CFB and 1,417,875 m^3 SE lift station (total = 2,062,881 m^3)	989,598 m^3

The Town of Bonnyville is located within the CLBR Basin study area. Residents are on a metered system, which includes sewer collection and treatment. This is the primary method used by the town for encouraging water conservation.

The City of Cold Lake has a total of four reservoirs with a 2 million gallon capacity. Water demand and metering policies are now in effect, coinciding with upgrades to the water treatment facilities. The city is also addressing water management and conservation issues through media press releases and newspaper advertisements, as well as website updates. Residents are requested to use water at different times of the day to reduce peak load pressures. Other conservation measures include manipulating the water pressure in the distribution system. Plans are being developed for conservation practices that will follow water management and conservation practices in other municipalities.

5.3.6 Key Findings

1. Municipal water conservation measures result in a number of benefits, including:
    - Delaying or eliminating the need to expand potable water supply and water treatment facilities.
    - Lowering variable operating costs.
    - Ensuring maximum use of existing water infrastructure.
    - Improving drought and emergency preparedness.
    - Helping to ensure lake water levels and in-stream flows for the benefit of aquatic resources are close to natural.

- Preventing water pollution by reducing wastewater flows and chemicals used to purify and treat water.
- Reducing energy costs associated with water pumping, heating and treating wastewater.
- Helping to ensure water availability for down-stream users.

2. Based on current research, the water conservation measures used most often are listed below. They are consistent with Alberta's *Water for Life Strategy*.
   - Metering — Installation of meters at water sources, customer service connections, public buildings, parks and recreation centers. Metering provides opportunities to track water productions and deliverables and pinpoints any leakage in the system.
   - User pays based on volume — Consumers pay for water and wastewater services on the basis of measured actual use.
   - Full-cost pricing — Municipalities use water and wastewater rate structures that reflect the full costs of delivery and treatment.
   - Public education and information — The public is informed of the real costs of water use and the savings that can be achieved through water efficiency. Actions they can take to reduce usage are also provided.
   - In-school education — develop specific information-based programs for schools.
   - Record keeping and water audit — quantify and control water that is not accounted for.
   - Leak detection and repairs — detect and repair leaks to reduce distribution system losses.

5.4 Agricultural Water Conservation

Water is an essential and increasingly valuable resource for the agriculture community within the CLBR Basin. It is used for drinking by humans and livestock, growing crops, washing and cleaning, and heating and cooling.

As water use increases in the basin, a higher percentage of the natural flow will likely be consumed and the potential for water shortages during periods of low flow will increase. Water conservation measures are essential not only for agriculture producers, but for all water users in the basin. The focus of this section is on water conservation practices at the farm level, including some best management practices for the individual farmer.

5.4.1 Current Agricultural Trends in the CLBR Basin

The basin has experienced significant agriculture development since 1985. Agricultural water use in the study area is mainly for livestock production, with intensive livestock operations and larger farm units being the current trend. This growing demand for agricultural land poses environmental concerns and conflicts over water uses.

The CLBR Basin is a source of drinking water for local municipalities, and sustains important commercial and recreational fisheries. The potential for pollution from agricultural activities is of concern to the municipalities and fisheries managers. Demand for more agricultural and development land may bring pressure to drain wetlands in the basin, which would result in a loss of important waterfowl habitat and threaten the stability of the water resource.

5.4.2 The Need for Agricultural Water Conservation

The CLBR Basin has been experiencing periodic low runoff conditions for the past 20 years, which has resulted in record low water levels in many lakes and stream flows. The impacts of this prolonged drought are far reaching in the agriculture and farming communities within the basin.

In agricultural terms, the moisture deficit places farmland soils at risk of erosion, and poses a threat to both crop and livestock production. The existing water supplies have not met the demands placed on them during the extended dry periods. In many cases, water rationing has been necessary, as well as pumping water to fill dugouts, emergency drilling of new wells, deepening existing wells and trucking in water for stock watering. Agriculture production has been limited by the drought, which may become more frequent and severe in the future if current climatic conditions persist.

In addition to concerns over drought-like conditions brought on by lower than average runoff levels, there is an increased need for water by agricultural water users, as well as by other sectors that are experiencing growth. In terms of water use, agriculture competes with the oil and gas industry, municipal water utilities, and the protection of aquatic resources (e.g., recreation, wildlife and fisheries).

The rural population of the prairies relies heavily on groundwater for their domestic water supply. Increased environmental awareness in recent years by the public and all levels of government has resulted in vigorous attempts to protect and enhance this vital resource. Federal and provincial government agencies provide financial and technical assistance for locating and developing on-farm groundwater supplies. These agencies work in cooperation with provincial water well associations to develop and implement high-quality work standards and construction methods.

5.4.3 Benefits of Water Conservation

Water availability and quality are the most pressing social, economic and environmental issues in drought-prone regions like the CLBR basin. Water conservation by the agriculture sector is an important factor in mediating the water quality and quantity conflicts, thereby enabling the needs of the aquatic environment, human settlements, agriculture and industrial development to be met in a sustainable manner.

Frequent drought-like conditions and a growing demand for clean, safe and reliable sources of water, reinforce the need for water conservation. The following are some benefits of implementing agriculture water conservation practices:

1. Efficient use of water through conservation can assist in prolonging the life of water supplies, which may make farm operations more sustainable during periods of drought. Water conservation can also reduce costs, increase productivity and protect the farm water supply.
2. Agricultural water conservation practices prevent the loss or reduction of wetlands. Reducing the amount of water diverted from streams or waterbodies by implementing such practices reduces the need to construct new water supply storage facilities, and protects wetlands and riparian habitat.

3. Water conservation practices prevent the reduction of in-stream flows, which are necessary for sustaining aquatic and terrestrial ecosystems. Sufficient in-stream flows also mean stock water is available for diversion, downstream flows are protected, and aquifers recharged.
4. Efficient water use may reduce the need to impound water or regulate the natural free flow of streams. This helps aquatic and terrestrial resources, since changes to the natural flow in a stream results in degradation of fish and wildlife habitat.
5. Water use efficiency reduces the need to divert ground and surface water for municipal, industrial and environmental demands. This reduces the potential for conflict over water use.
6. Water conservation practices prevent or reduce non-source pollutants by reducing nutrient runoff, sediment discharge, and erosion of streambanks.

Effective water conservation occurs when each farmer or rancher makes the necessary changes and implements water conservation practices.

5.4.4 Best Management Practices for Water Collection and Storage

Best management practices are an integral part of water conservation. They can address all activities on a farm that may affect water quality and water use. Good planning is fundamental to implementing best management practices:

- plan before constructing dugouts to ensure contamination or leakage does not occur;
- plan and construct snow fences to retain as much water as possible from snowmelt;
- use groundwater as the water supply for a dugout to minimize evaporation.

Dugout Construction

Dugouts are earthen excavations designed to collect runoff and store it for use during dry periods. Typically, dugout capacity ranges from a few thousand to tens of thousands cubic metres. The most common types of dugouts are:

- one filled only by runoff from surrounding fields;
- one located next to a watercourse from which water is pumped or diverted.

These types of dugouts would fit in the best management practices for agricultural water conservation.

Two types of dugouts are generally not recommended. The first type is created directly through a watercourse, which requires provincial approval and is not likely to be approved due to downstream implications. A dugout in the middle of a watercourse will also fail prematurely owing to build-up of sediment and organic matter. The second type is one that is in contact with shallow groundwater. This leads to mixing of the groundwater (highly mineralized) with surface water (high microbial contamination), which results in water that is of lower quality and more costly to treat than either surface or groundwater alone. This type of dugout is discussed under the section on Groundwater-Supplied Dugouts.

If a dugout will be located on uneven ground, berms can be constructed on the lower sides of the dugout using the excavated dirt. This prevents seepage loss under the berm and reduces overtopping of the berm by wave action.

Since dugouts fill with water that is directed to them from the surrounding land (the dugout's basin or watershed), the size of the dugout is an important factor. A deeper dugout is more efficient because it has less surface area for the same capacity, so less water is lost to evaporation.

Snow Fences

About 75% of the annual surface water runoff into most water storage reservoir projects is from spring snowmelt. For small water storage reservoir projects such as dugouts, the water supply relies almost entirely on snowmelt runoff.

On average, only 25%-30% of annual precipitation across the Canadian Prairies falls in the form of snow. Redistribution of the snow by wind can reduce or increase the effect of this precipitation immensely. For this reason, trapping snow with snow fences can be useful in ensuring a water supply. To achieve the greatest benefits from a snow fence, it should be placed perpendicular to the direction of the prevailing wind (Figure 5-2). Ideally, the length of the dugout should also be perpendicular to the prevailing winds to maximize fence length and therefore snow accumulation.

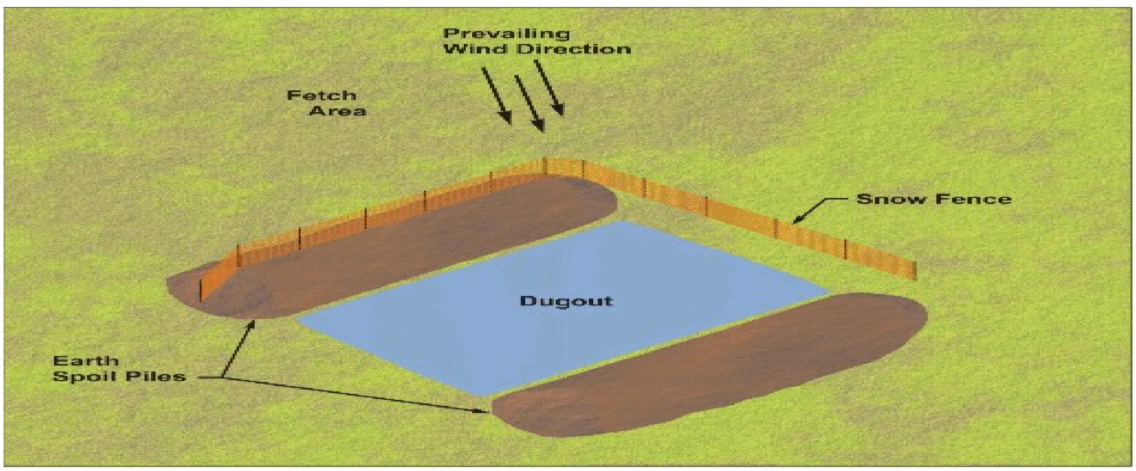


Figure 5-2. Example of a snow fence.

Wells

Best management practices for constructing and maintaining wells include the following:

- Wells must be properly constructed and sealed.
- Wells should be located up-slope, away from sources of contamination.
- Any old, unused wells should be properly plugged to prevent contamination of newer wells.
- Manure should not be over-applied to the surrounding land, since nitrate seepage can contaminate groundwater.
- Manure storage structures or catch basins should be constructed to prevent contaminated runoff from seeping into groundwater.

Storage Tanks

A proper intermediate storage tank is generally large enough to hold at least one day's supply of water. Water is pumped directly from a well through a flow-regulating valve and into the cistern and storage tank. The valve is throttled back to regulate the pumping rate to meet the capacity of the well. When a well is pumped too rapidly, the longevity of the well and pumping system are severely reduced. Therefore, this system works best by allowing water from several slow producing wells to be combined to fill the cistern and meet the demands of the farm.

Dugouts

- Dugouts should be constructed in proper drainage areas, away from potential sources of contamination.
- Groundwater-fed dugouts should not be shallow, nor should they use a combination of surface water and shallow groundwater input.
- Manure and fertilizers should be applied only to the point of meeting crop nutrient needs. Excess soil nutrient levels can lead to excess nutrient levels in the runoff water. This leads to increased algae and weed growth in dugout water.
- Manure cannot be spread on snow or frozen ground unless a manure handling plan is approved under the *Standards and Administration Regulation* (*AR 267/2001*) of the *Agricultural Operations Practices Act.*
- Manure storages, catch basins and sewage lagoons should be maintained to prevent runoff or seepage. Contact the local Alberta Agriculture, Food and Rural Development Water Specialist to develop a plan to protect the agricultural operation's water resource.

About 150,000 dugouts have been excavated in the Prairies and another 5,000 in British Columbia, mainly to supply rural domestic and livestock water needs. Dugouts are typically artificial ponds 4-6 m deep with a 2,000-6,000 m^3 capacity, designed to provide a 2-year water supply with allowance for evaporation losses and ice formation. Constructing larger dugouts is normally not practical, even though some regions frequently experience two or more consecutive years of low-runoff conditions. Annual net evaporation losses average 700 mm and are often the largest single demand on dugouts.

Groundwater-Supplied Dugouts

Groundwater is recharged by water that infiltrates into the zone of saturation, also called the water table. The sustainable yield of an aquifer is mainly controlled by the amount of recharge it receives. If total discharges (natural discharge plus water use for human activities) exceed recharge, water levels in an aquifer will decline. This decline will continue until a new balance is reached between total discharge and recharge, or the aquifer becomes depleted to the point where further withdrawals are no longer feasible.

If properly constructed and protected, groundwater-fed dugouts have proven to be a reliable source of water supply. This was shown in 2001, when runoff-filled reservoirs were often dry because of drought, whereas many subsurface-filled dugouts still contained water. Groundwater-fed dugouts can also conserve water by preventing water loss due to evaporation, since they can be significantly smaller than runoff-filled dugouts. This smaller surface area leads to decreased evaporation loss, which can be crucial during drought periods.

Groundwater-fed dugouts have a high potential for contamination if the source is not properly managed. The dugout should be protected from livestock. If groundwater yield is sufficiently high, consideration should be given to constructing an excavated or large-diameter bored well instead of a dugout. These wells are easier to protect from contamination than dugouts.

Dugout Maintenance

Once the dugout is constructed, it may need to be sealed to prevent seepage. This can be done through various means, including:

- using heavy clay to form an impermeable layer;
- using bentonite, which is an absorptive and colloidal clay used as a sealing agent;
- using plastic liners; or
- using gleization, which involves covering the bottom of the dugout with straw and then covering the straw with clay and packing it into a seal.

Dugout covers help prevent evaporation during periods of drought. A dugout cover also prevents sunlight from entering the dugout, which inhibits algae and weed growth and limits evaporation and water warming. Evaporation causes contaminants to concentrate in a dugout; therefore, controlling evaporation increases water quality. In hot years, even full dugouts can lose up to 50% of their water volume through evaporation.

Allowing animals to drink directly from a dugout degrades water quality and drastically shortens the lifespan of a dugout. The dugout should be fenced or otherwise protected from livestock, and water for livestock pumped into a trough away from the dugout. Placing berms around the dugout will prevent surface water runoff from entering the dugout.

5.4.6 Current Water Conservation Programs and Initiatives

There are many initiatives and programs in Alberta and elsewhere in Canada promoting agriculture water conservation. The following section provides a brief overview of the National Water Supply Expansion Program and Canada–Alberta Farm Water Program and the Canada-Alberta Farm Water Program.

National Water Supply Expansion Program: Canada–Alberta Water Supply Expansion Program

The National Water Supply Expansion Program (NWSEP) is administered by the federal government, in agreement and with additional funding contributions by provincial government across the country, to help farmers develop and enhance agriculture water supplies. NWSEP is a four-year program that was introduced in 2002 and ends March 31, 2006. The main purpose of the program is:

> "To provide assistance to the agriculture community across Canada to help reduce the risk of future water shortages, and to meet everyday growing needs of a vibrant Canadian Agriculture Sector, through planning and development of secure, healthy and reliable water resources".

The Canadian–Alberta Water Supply Expansion Program (CAWSEP) is the Alberta component of NWSEP and is carried out under the authority of NWSEP. Through this initiative, Alberta producers, agriculture groups and communities have access to both financial and technical support for planning and developing projects that will improve their ability to develop and enhance long-term, sustainable water supplies. Information about CAWSEP is available at all PFRA offices throughout the province and from the federal government program website at http://www.agr.gc.ca/env/index_e.php?section=h2o&page=apply-demande#ab.

Canada–Alberta Farm Water Program

The Canada–Alberta Farm Water Program (CAFWP) is an additional program (announced July 2003). Through this program, individual farmers can apply for technical and financial assistance to help develop on-farm water projects such as dugouts, wells and pasture pipelines, to target farm water supply needs.

Information on the CAFWP program is available from the local AAFRD Water Specialist or Program Administration at (780) 422-9167 (toll-free by dialling 310-0000 first and then entering 422-9167). Application forms are available from the provincial government website at http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/rsv7793?opendocument.

5.4.7 Key Findings

1. Agricultural water conservation has become an issue in the CLBR Basin area. Drought has been prevalent in the area for the past 20 years, and has had an impact on agricultural water use. Core to a successful water conservation program is an understanding of the following:
   - The water resource itself (baseline data and monitoring).
   - How, when and why water is used (water audits and metering).
   - The full cost of providing water of suitable quality and disposing of wastewater.
   - Alternative water-efficient technologies, processes and practices.
   - Positive attitudes and values related to water and the environment.
2. Agricultural water use in the study area is mainly for livestock production, as opposed to water use in the southern part of Alberta which is mainly for irrigation. To conserve water in the basin, appropriate management practices must be implemented. The following practices are relevant to water collection and storage:
   - Proper well and dugout construction to ensure there is no leakage and water quality remains acceptable.
   - Proper dugout construction to expand the lifetime of the dugout.
   - Well and dugout maintenance to increase the lifetime of the dugout and ensure there is no water contamination. This includes sealing the dugout and using a dugout cover.
   - Proper storage tank size and pumping system.
   - Using snow fences to collect snowmelt runoff as a source of water supply.
3. Groundwater can be a reliable water supply source for agricultural uses for the following reasons:
   - During a drought, runoff-filled dugouts may dry up, while groundwater-filled reservoirs remain filled.
   - Groundwater-filled dugouts have less evaporation since their surface area is smaller.

5.5 Oil/Gas Industry Water Use and Conservation

Since the CLBR Water Management Plan of 1985 and the 1994 plan update, industry has made significant progress in water conservation. Large increases in industrial water use were predicted to occur by 2000; however, this increase has not occurred despite increased bitumen production in the basin. Owing to improvements in water recycling and the development of alternative water sources, overall use of freshwater in the basin by industry has, on average, declined.

Future water use forecasts (2015) in the 1985 plan and 1994 update were high in estimating the amount of freshwater required for industry. At the time these two documents were produced, it would have been difficult to anticipate the progress made by the oil industry in using alternative water supplies to limit their requirement for freshwater. This success has led to increased productivity from freshwater use, as recommended by Alberta's Water for Life Strategy.

5.5.1 Oil and Gas Industry Overview

The oil and gas industry in the CLBR Basin consists of conventional and *in situ* oil sands production operations. Industrial use of water in the basin has been ongoing for nearly half a century. In addition to production, water is also used for operational purposes, including:

- utility water for boilers,
- fire fighting,
- showers and toilets,
- pump and compressor seal flushing,
- steam for heat tracing to prevent freezing, and
- hot water for thawing frozen equipment.

Water sources for industry include fresh surface and groundwater, brackish (saline) groundwater and produced water recovered with the oil. The largest water source now used in the basin by industry is recycled produced water. This water is saline and non-potable.

Conventional oil and gas developments focus primarily on shallow gas and oil reserves where the resource is sufficiently fluid that it can be pumped from the ground using only mechanical means. Mechanical screw pumps have now been developed to pump oil sands to the surface using "cold flow" technology. These methods require no water for production of the resources, and are not discussed further in this document.

Thermal oil recovery projects focus on recovering thick, tarry oil (bitumen) from oil sands. The Cold Lake and Athabasca oil sands deposits are among the largest deposits of bitumen in the world (Figure 5-3). Unlike the Fort McMurray area where bitumen is primarily excavated in open pit mines, the Cold Lake heavy oil deposits are buried too deep (400 m) and are accessible only through *in situ* production techniques.

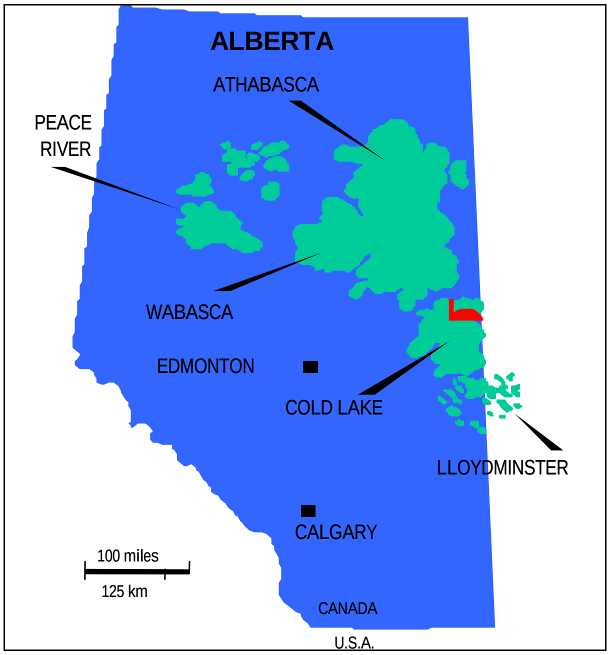


Figure 5-3. Map of Alberta showing the major oil sands deposits.

The most common recovery technique is thermal heating of bitumen, which changes its consistency from that of cold molasses to water and makes it possible to pump the oil from the ground. The two key techniques used are cyclic steam stimulation (CSS) and steam assisted gravity drainage (SAGD) (Figure 5-4). CSS (called "huff and puff") uses water to make steam, which is then injected into the oil reservoir to heat the bitumen. The bitumen and water are then both recovered from the same wellbores used to inject the steam (Figure 5-5).

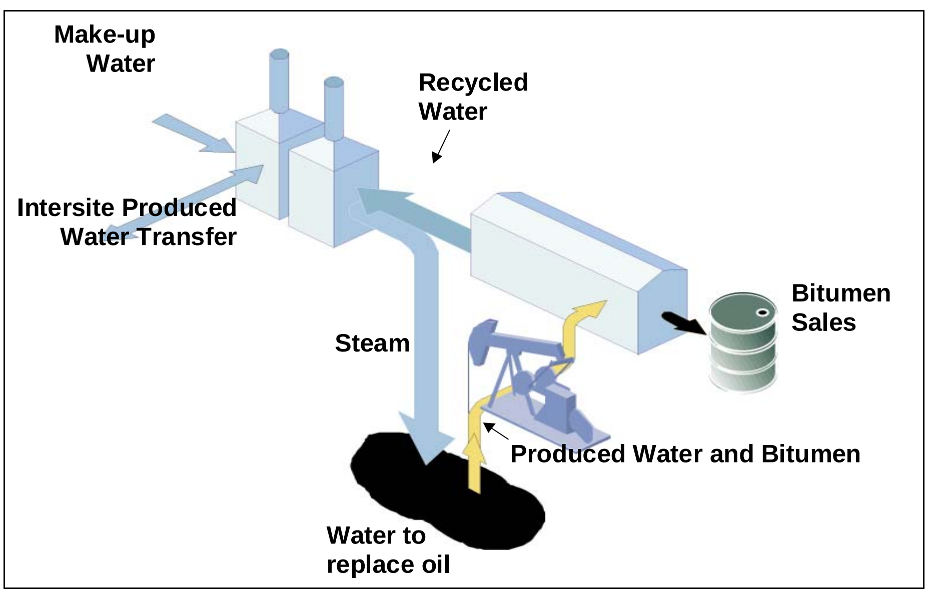


Figure 5-4. Schematic showing how water flows through a CSS or SAGD operation (diagram courtesy of Imperial Oil).

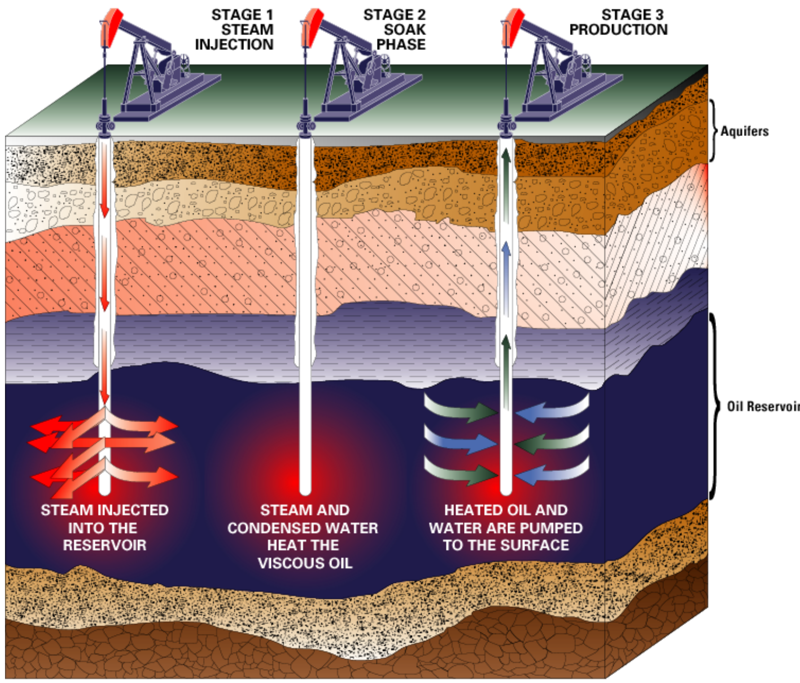


Figure 5-5. Typical cyclical steam stimulation process (diagram courtesy of Imperial Oil).

SAGD also involves injecting steam, but typically the steaming wellbore is drilled horizontally above a second wellbore, which is used to pump heated formation fluids (bitumen and water) that drain into it. A simplified view of how water is used in a typical steaming operation is shown in Figure 5-6.

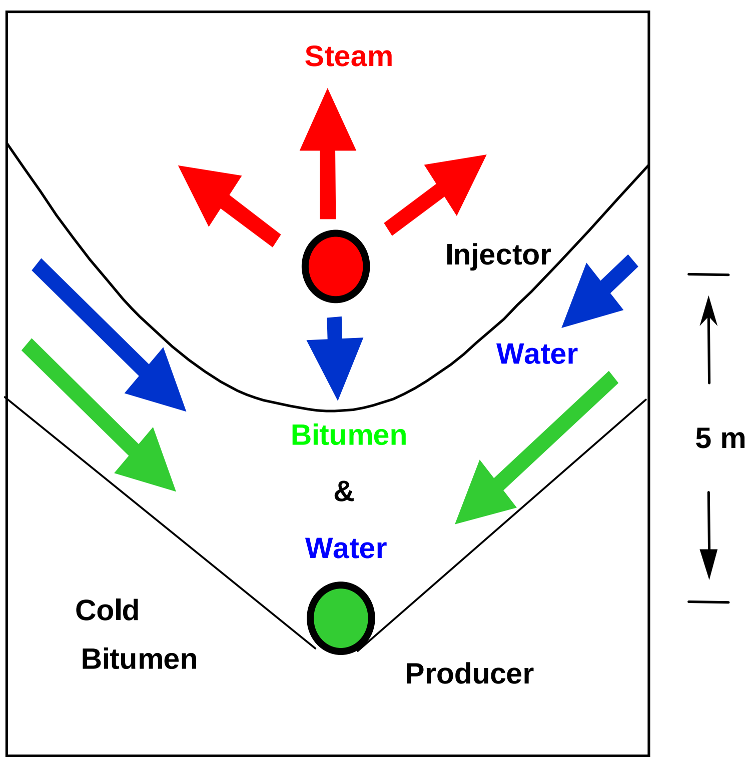


Figure 5-6. How water flows through a typical SAGD operation (diagram courtesy of Imperial Oil).

As shown in Figure 5-6, water is injected as steam into the oil reservoir. Hot bitumen and some of the water is then pumped from the reservoir. A portion of the injected water remains in the reservoir to replace the produced oil. Generally, approximately 7 barrels of condensed steam are needed to take the place of every 10 barrels of oil produced. Once in the plant, the produced fluids are separated into oil and produced water. The oil is sent to refineries and the produced water is recycled by treating it and re-injecting it as steam.

Since some of the water used in the process cannot be replaced, and companies also expand their operations where feasible, a replacement water supply is necessary. Replacement water consists either of fresh groundwater, fresh surface water, or saline (brackish) groundwater. Where excess produced water is available, little or no freshwater is necessary for steam injection.

If more produced water is available than can be injected as steam at any time, the company must dispose or store its produced water in deep geologic formations. Because of the large volumes of water handled each day, it is not possible to store the water above ground.

5.5.2 Industry Development History

The first oil and gas operations in the CLBR area began in the 1950s and 1960s, and involved drilling conventional oil and gas wells. During this period, oil sands in the Cold Lake area were mapped and studied by Imperial Oil, which led to the company obtaining four main leases between 1958-1962. Exploratory wells drilled in 1962 confirmed the presence of oil sands.

Three key pilot sites were constructed by Imperial Oil to develop and test bitumen recovery from the oil sands. In 1964, Imperial began constructing its Ethel Lake Pilot, followed by the 1972 May Pilot and the 1975 Leming Pilot projects. Using these experimental operations, Imperial Oil successfully developed CSS operations, as well as key water treatment and recycling operations to reduce the amount of freshwater required for oil recovery.

By 1985, there were 11 companies recovering bitumen either in pilots or commercial recovery schemes. Over the next two decades, however, difficult economic conditions caused some companies to leave the playing field. Companies with thermal bitumen recovery operations in the Beaver River Basin now include Imperial Oil, CNRL, BlackRock, EnCana and Husky. Although there are fewer companies, some operations are more extensive and integrated than in 1985.

5.5.3 Historical Water Use and Forecasts

Before 1978, most, if not all water used for steam generation and bitumen recovery was freshwater. As the technology for treating and recycling water was not available, all water produced with the oil was disposed in deep underground formations. During the late 1970s and early 1980s, efforts focused on developing technology that would allow produced water to be recycled. Current operations now show an efficiency of approximately 95% for recycling produced water.

By 1985, companies in the basin were using lake water and groundwater diversion licences to obtain water for commercial bitumen recovery. Based on the best available information, the 1985 CLBR Water Management Plan predicted substantial water withdrawals for future oil sands development (30,000 to 80,000 dam^3 by 2000). To ensure adequate water quality and quantities to meet the needs in the basin, a recommendation was included in the plan to construct a water pipeline from the North Saskatchewan River to transport water for industrial needs.

By 1989, it was apparent the increase in water demand was much less than anticipated (Figure 5-7) and the pipeline was not constructed. A Task Force was set up to update the water management plan. In the 1994 plan update, the pipeline remained a long-term supply alternative based on new industrial forecasts. However, with the substantial increase in conservation of freshwater by industry, the pipeline was not necessary. In 1999, the Alberta *Water Act* was enacted, which prohibited interbasin transfer of water, which would occur if the water pipeline from the North Saskatchewan River was constructed.

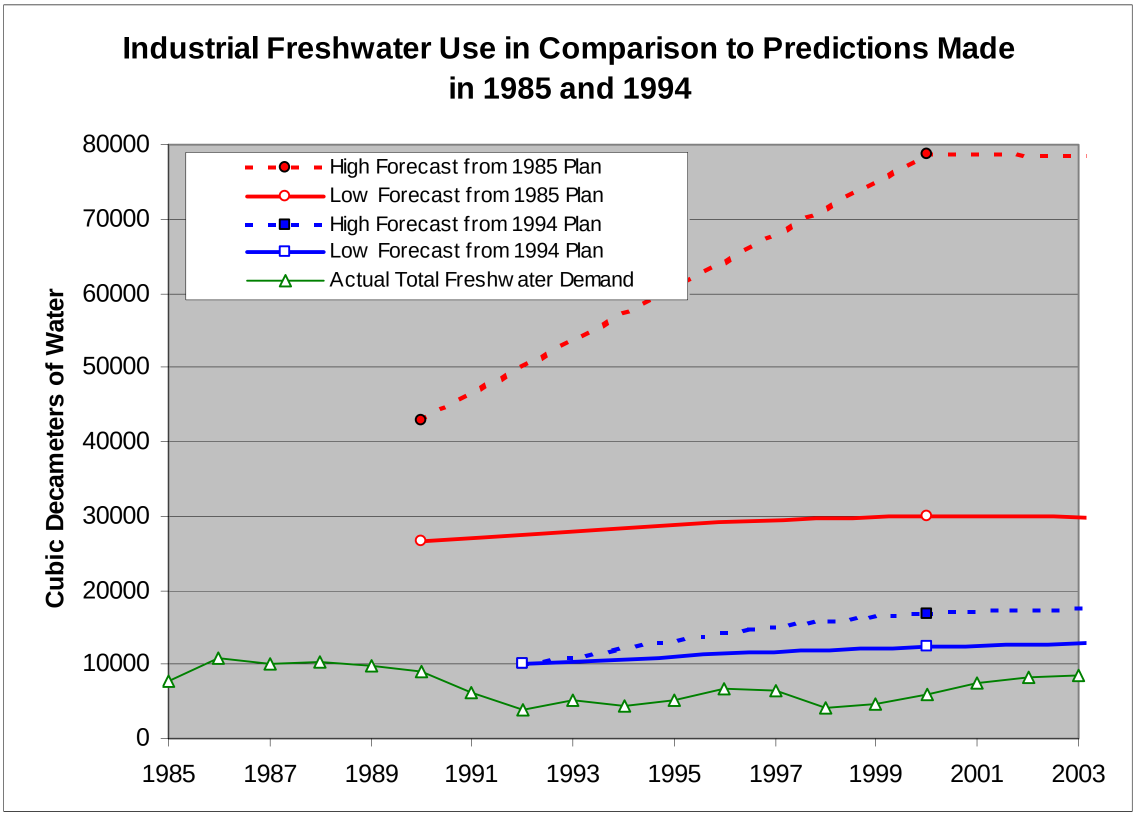


Figure 5-7. Comparison of actual water use by industry and forecasts made in the 1985 and 1994 water management plans.

5.5.4 Water Conservation

In situ thermal operations require substantial amounts of water to generate sufficient steam to heat the oil sands reservoir. Through continuous effort by industry, there has been a dramatic reduction in the amount of freshwater used for steam generation. Overall, the oil sands industry has made considerable progress in reducing its reliance on fresh surface and groundwater in the basin. As part of this ongoing effort, industry has continued to improve its environmental performance and water conservation techniques.

Core to these environmental achievements is the development and use of leading edge technology, and the ability to take advantage of synergies within the industry to reduce water use. This technology, combined with the knowledge gained from ongoing operations, has allowed industry to work toward its goal of increasing productivity at the lowest possible cost and least environmental impact.

Priorities for water use by industry include: (1) produced water, (2) brackish water, and (3) freshwater if the other sources cannot meet existing needs. Other aspects of a successful water supply strategy for industry include:

- Maximizing saline water use (produced and brackish water).
- Balancing surplus and deficit to minimize disposal.
- Minimizing freshwater use at existing facilities:
  - minimize the use of freshwater for utility needs;
  - modify selected plant equipment (e.g.. cooler water, slurry water and vapour recovery compressors to use produced water);
  - improve energy conservation to reduce utility steam; and
  - optimize water transfer capabilities between sites to meet future needs.
- Eliminating the requirement for freshwater in new industrial plants except for domestic and safety needs.

One of the goals of Alberta's *Water for Life Strategy* is to increase productivity of operations that use freshwater. The seven-fold reduction to date in the amount of freshwater required per unit of bitumen produced represents a 700% increase in productivity of freshwater since 1985. The amount of freshwater use as a percentage of total water use has dropped from 100% (before 1978) to approximately 10 to 20% of the steam demand at most commercial operations.

The main reason for the success in reducing industry's reliance on freshwater is its improved ability to recycle produced water for steam generation. This has increased from 0% recycled in 1978, to approximately 85% in 1990, and to more than 95% currently for CSS operations. SAGD operations are expected to recycle about 90% of their produced water. This is regulated by terms and conditions attached to AENV operating approvals.

In 1985, the two largest producers in the area (Imperial Oil and operations now owned by CNRL) required approximately 4 m^3 of freshwater to produce 1 m^3 of bitumen. This ratio has decreased over the years to 0.6 m^3 per 1 m^3 of bitumen in 2004, as shown in Figure 5-8.

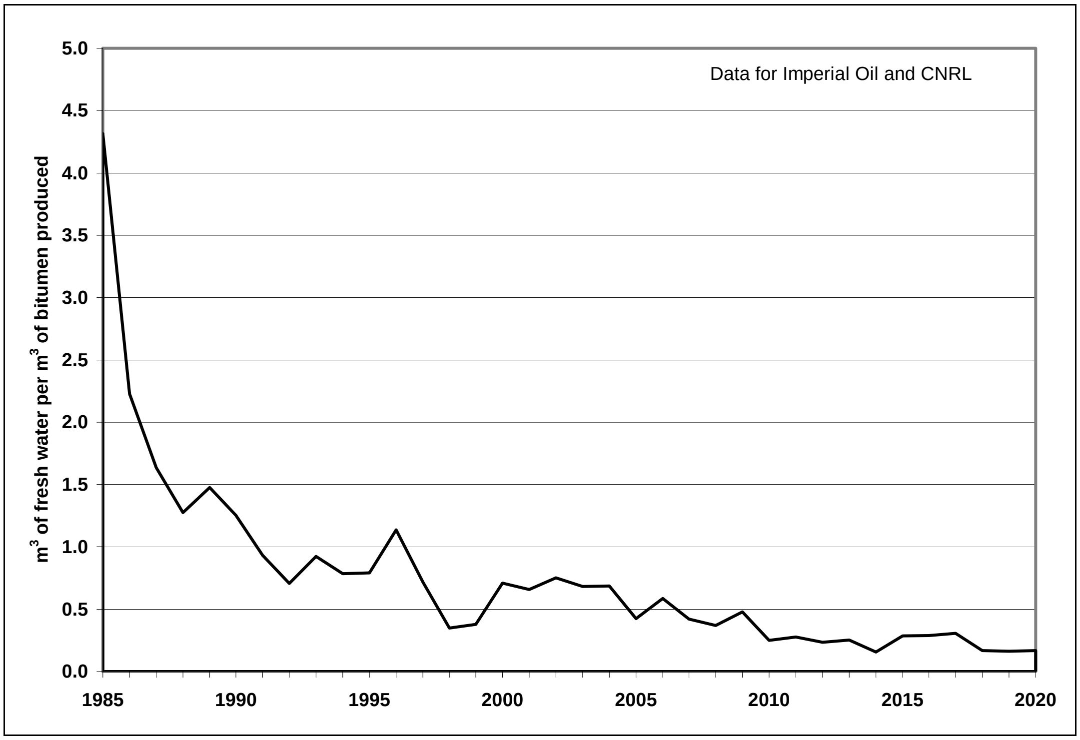


Figure 5-8. Conservation and productivity of freshwater use has increased over time, with a 7-fold reduction in the amount of freshwater needed per unit of bitumen produced.

Figure 5-9 shows the amount of each type of water that has been used in the operations since 1985, and the projections to 2020.

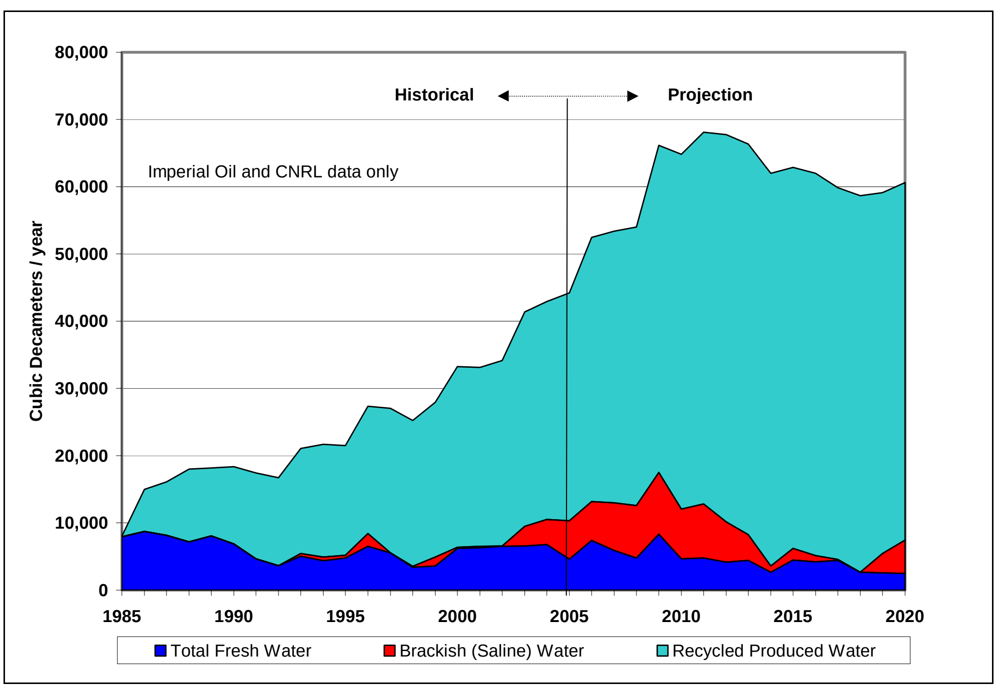


Figure 5-9. Historical and projected use of freshwater, brackish water and produced water in thermal operations.

As shown in Figure 5-9, recycling produced water and re-injected it as steam began in 1985, which reduced the amount of freshwater required. This type of water has become the largest source of industry water for bitumen recovery. Development of brackish (saline) water resources in the area started in 1993. While the overall quantities of brackish water use have only recently increased to volumes comparable with freshwater use, it has reduced the quantity of freshwater used during periods of peak make-up water requirements. Brackish water use will continue to increase as technology for its use improves.

5.5.5 Key Findings

1. Water conservation planning is a large part of future projects and expansions in the Cold Lake area.
2. Brackish water supplies are the predominant new sources of water being used by industry.
3. Freshwater use by the oil industry is not forecast to increase in comparison to alternate water sources.
4. Brackish (saline) sources of water are not always a clear environmental solution. In some cases, the additional waste products associated with saline sources, and the extra energy and emissions associated with treating this type of water, may indicate a greater environmental benefit in using renewable freshwater rather than saline. This is evaluated on a case-by-case basis, and is part of a balanced approach to ensuring protection of the overall environmental integrity of the basin.

SECTION 6. FISH AND FISH HABITAT

6.1 INTRODUCTION

The Cold Lake–Beaver River (CLBR) Basin is an important water supply source for aquatic resources—fisheries, wildlife and recreation. Managing the demand and use of water in the basin has become a priority owing to persistent low precipitation and increasing water demands over the past several years. This section summarizes fisheries management information and documents issues and concerns for lakes and streams in the basin.

The lakes support First Nations and Métis domestic, recreational and commercial fisheries. In addition, many of the larger lakes have attracted considerable shoreline cottage, rural residential and recreational facility developments. The rivers and streams in the basin are poorly studied compared to the lakes, but most are known to serve as spawning or migration routes for fish during periods of high water. They are also the key to watershed integrity and biodiversity. This is important for the genetic fitness of fish in the watershed, and re-colonization of waterbodies in which fish abundance has declined.

6.2 PURPOSE

The 1985 CLBR Water Management Plan concluded the shallow, productive lakes of the basin were sensitive to small changes in water levels, and water loss beyond natural fluctuations could be detrimental to many fish populations. This update presents new data accumulated since that time, reflecting the current fisheries management practices.

The information provides support for developing a strategy to meet current and future water needs within the basin in a way that protects and ensures a healthy fisheries and aquatic environment. References containing more detailed information and data are listed in the Bibliography (Appendix C).

6.3 OVERVIEW OF THE FISHERIES

The predominant fish in the basin are the cold-water species (lake whitefish, cisco and lake trout [Cold Lake]) and cool-water species (northern pike, walleye, yellow perch, white and longnose suckers and burbot). Small forage fish are also widespread and provide a food base for the major predator species. Walleye, northern pike, lake trout and yellow perch are the most popular species for the recreational fisheries, while lake whitefish are the primary target of First Nations domestic and commercial fisheries.

Except for the Beaver River mainstem, the streams in the study area that connect the lakes are generally small, shallow and slow flowing. In many cases, these streams become intermittent and stagnant, with low dissolved oxygen levels in summer. During periods of lower water levels, such streams favour beaver activity which helps to retain the water on the landscape. This maintains wetlands that improve water quality and provide important habitat for wildlife.

Lake level fluctuations have the greatest effect on the littoral zone (the shallow shoreline area of a lake). This zone is used by pike, walleye and perch as rearing habitat for young-of-year, and spawning and feeding habitat for adults. It also provides essential habitat for aquatic invertebrates and forage fish production, and maintains biodiversity of the aquatic environment.

Under low water conditions, the size and productive capacity of a lake can be greatly reduced; for shallower lakes, low water levels can seriously increase the risk of summer and winter fish kills. Low water levels in connecting streams can prevent fish passage to migration routes and isolate fish from their spawning areas.

6.4 FISHERIES MANAGEMENT

The fisheries and fish habitats within the CLBR study area have been subject to substantial change since the early 1980s. Factors that continued to drive the changes included the drought conditions of the late 1980s-1990s, and increased human activities within the watersheds.

The 1985 Water Management Plan, which reflected conditions in the early 1980s, indicated a degree of optimism and stated high-quality fishing opportunities existed for the region's many lakes, which had few limitations to fish production. By the mid-1980s, studies on many lakes showed most accessible fisheries were experiencing serious declines. The majority of evidence pointed to harvests well above sustainable production levels. This period of decline also coincided with the beginning of significantly less precipitation over the study area, resulting in decreased water levels in many lakes and their connecting streams.

Alberta favoured a simplified, province-wide application for its fisheries management and regulations in the early 1980s. When serious regional fisheries declines became evident, a change to a more complex, lake-by-lake and species-by-species management became necessary. As a result of these challenges, the province undertook legislative, policy and fisheries management initiatives to ensure appropriate action would be taken to deal with the declines and restore troubled fisheries to healthier levels.

6.4.1 Legislation and Policies Affecting the CLBR Basin

Natural Resources Transfer Agreement

When the 1985 Cold Lake–Beaver River Water Management Plan was written, fish and fish habitat management in Alberta was guided by the *Natural Resources Transfer Agreement* (1930). This agreement transferred resource management from the federal government to the province, but recognized it would be a shared responsibility. The provincial government managed the fisheries resources and the federal government implemented provincial recommendations under the *Fisheries Act (Canada).*

Fisheries Act

In 1997, the *Fisheries (Alberta) Act* gave the province the ability to implement regulation changes and have greater responsibility for the fish resources. Formal authority for the fish habitat provisions of the *Fisheries Act (Canada)* remained with the federal government and has led to a much higher profile in Alberta for the Department of Fisheries and Oceans (DFO) Canada (Appendix A).

Fish and Wildlife Policy for Alberta (1982)

Policy direction was provided in the *Fish and Wildlife Policy for Alberta,* as follows:

> "It is incumbent upon the Government, as the resource steward, to ensure that appropriate use is made of the fisheries resource and that it is passed on to succeeding generations as it was received. The primary consideration of the Government is to ensure that fisheries populations are protected from severe decline and that viable populations are maintained."

Fish Conservation Strategy for Alberta 2002-2005

In order to achieve the goals laid out in the 1982 Fish and Wildlife Policy in the face of declining fish stocks, and support lake-by-lake management, *A Fish Conservation Strategy for Alberta 2002-2005* was adopted. The mission and goals for fisheries management in Alberta were identified as follows:

- **Habitat Maintenance**
  - Fish Habitat Protection — maintain the productive capacity of aquatic habitats to support healthy and diverse fish resources.
  - Fish Habitat Rehabilitation — alleviate or reverse adverse impacts on the productive capacity of habitats and repair damaged habitats to restore their productive capacity.
  - Fish Habitat Development — enhance fish habitats in areas where the production of fish resources can be increased, but maintain the aesthetic quality of these sites.
- **Fish Conservation**
  - Fish Production — maintain the abundance and diversity of fish at the carrying capacity of the habitat.
  - Fish Production Restoration — restore diminished fish production to full production wherever possible.
  - Fish Production Enhancement and Development — enhance or develop new production wherever appropriate or possible.
- **Fish Use Allocation**
  - Fish Use Allocation Process — allocate fish production, beyond conservation needs, to achieve the greatest overall benefits, using a fair process that involves stakeholders, identifies users' expectations, and provides a basis for setting benefit priorities (in the following order).
    - Domestic Use — provide for domestic fishing by First Nations and Métis within the constraints of fish conservation and legislative obligations.
    - Recreational Use — provide for recreational fishing under an open-access policy and place no limitation on the number of general licences issued, within the constraints of fish conservation and subsistence fishing.
    - Commercial Use — provide for commercial fishing opportunities within the constraints of fish conservation, subsistence fishing and recreational fishing.

► **Guiding Principles**

- No net loss of the productive capacity of habitats.
- Fish populations are to be maintained by natural production wherever possible.
- The biological diversity of the fish fauna is to be maintained, and depletion or extirpation of the species, populations, sub-populations or unique strains must be avoided.
- The management of the fisheries will be conducted on the basis of fundamental ecological principles and factual information.
- There should be public involvement and education in the fisheries management process.
- The "user pays" philosophy should augment the financing of the stewardship and management resources.
- Public access to waters producing publicly owned fish should be provided and maintained.

6.4.2 Species Management Plans

Currently, there are two species management plans. Other species management plans for priority species such as yellow perch and lake trout are planned for development in the future.

Alberta's Walleye Management and Recovery Plan (1995)

The Walleye Management and Recovery Plan was produced following intensive scientific and public review and recommendations from the Walleye Task Force (an advisory group consisting of representatives from sportfishing organizations, university academics, commercial fishermen, Fisheries Management Division and the public). The plan describes walleye biology, distribution and limitations to natural production. It uses four categories (trophy, stable, vulnerable and collapsed) to describe the status of individual walleye stocks. Each status category has unique, recognizable population characteristics and unique sport fishing regulations that are designed to recover (over time) and maintain walleye stocks at either a stable or trophy status.

Field data collected from angler surveys and test netting programs are used to determine the status of the walleye population. Most CLBR lakes have vulnerable walleye populations that display narrow age-class distributions, low mean ages (4-6 years) and somewhat unstable age-classes. Growth rates are moderate, maturity is reached relatively early at 5-7 years for males and 7-8 years for females, and catch rates are low. The typical angling regulation applied is a daily limit of 1 walleye having a minimum length of 50 cm.

For a more detailed description of walleye management, please consult the Walleye Management and Recovery Plan.

Alberta's Northern Pike Management and Recovery Plan (1999)

The Northern Pike Management and Recovery Plan was produced after an extensive public process similar to the walleye management plan. Similar categories were developed for northern pike management (stable, vulnerable [no risk], vulnerable [low risk] and collapsed). These assessment categories are used to determine the appropriate sportfishing regulations, which in turn promote the recovery of depressed northern pike populations to a stable status or maintain stable populations.

6.4.3 Recreational Fishing

Sportfishing licence sales provide an indication of angler activity. The unavailability of regional sales information precludes a comparison of the number of angling licences sold within the study area. However, recent provincial figures show about 210,000 licensed anglers plus about 100,000 unlicensed youth and senior anglers fish annually in Alberta. In the latest federal survey (2000), the sportfishery in Alberta was estimated at contributing $660M to the provincial economy. The survey also stated that approximately 25% of the fish harvest in the province occurs in the northeast region. The lakes in the CLBR Basin are important components of the region's recreational fishery.

Since 1990, the number of Alberta non-resident sportfishing licences have remained relatively constant, averaging 2,118 licences sold each year. The 5-day non-resident sport licences have increased by 89% since they were introduced, rising from 2,704 in 1990 to 5,103 in 2002.

6.4.4 Commercial Fishing

The commercial fishing industry in Alberta has undergone many changes to the licensing and regulatory strategy over the past 20 years. Currently, commercial fishermen must purchase a $500 commercial fishing licence, plus a $1 net licence for each authorized net. From 1989 to 2002, commercial licence sales declined 31% and net licence sales decreased by 58%. These provincial declines reflected a greatly reduced commercial fish harvest for the industry.

Within the CLBR Basin, the total harvest for all species (including the targeted lake whitefish) has declined by about 87% (Figure 6-1). This has been largely due to reductions in sportfish tolerance levels during the commercial fisheries. The allowable limit set for commercially caught fish is based on the population status and productive capacity of the lake. Many of the basin's sportfish populations are classified as vulnerable and collapsed; therefore, much stricter angling and commercial regulations have been implemented to protect the recovering species.

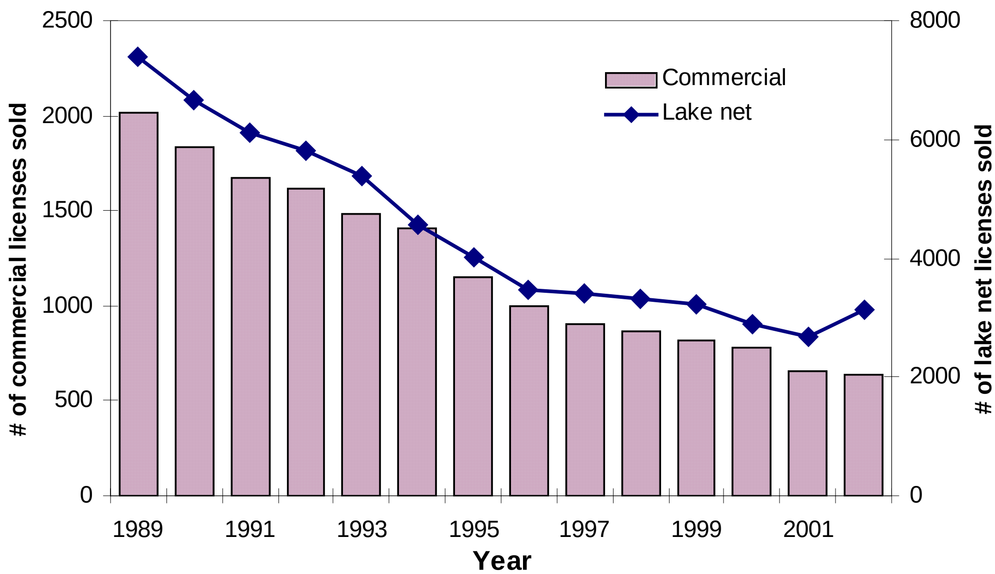


Figure 6-1. Number of commercial fishing and lake net licences sold in Alberta, 1989-2002 (Lovely 2004).

Guidelines used by fisheries managers to make decisions are included in *Alberta Guidelines Respecting Commercial Fishing*. This document bases allocation on the principle that priorities will be in the following order:

1. Conservation of fish stocks.
2. Domestic use by First Nations and Métis.
3. Residential recreational use.
4. Commercial fishing for an identified surplus.

In early 2004, a provincial *Commercial Fisheries Rationalization Plan* was implemented to reduce the number of commercial fishers to a level that is sustainable over the long term.

6.4.5 First Nations and Métis Domestic Fishing

Under federal law originating from Treaty Rights, First Nations people are entitled to harvest fish for subsistence purposes at any time of the year. A Domestic Fishing Licence is required by all First Nations wishing to fish for food with a net. This licence is free and can be obtained at any Fish and Wildlife office. Each domestic licence holder must also follow management regulations regarding net specifications.

For most lakes, the First Nations domestic harvest levels are largely unknown since harvests are generally reported on a voluntary basis. However, the number of First Nations domestic licences issued for lakes in the study area provides a general indication of fishing activity. The long-term average number of licences issued annually for these lakes is around 200. Although the number of licences has fluctuated considerably, the trend over the last 10 years has shown a gradual decrease in licences issued (Figure 6-2).

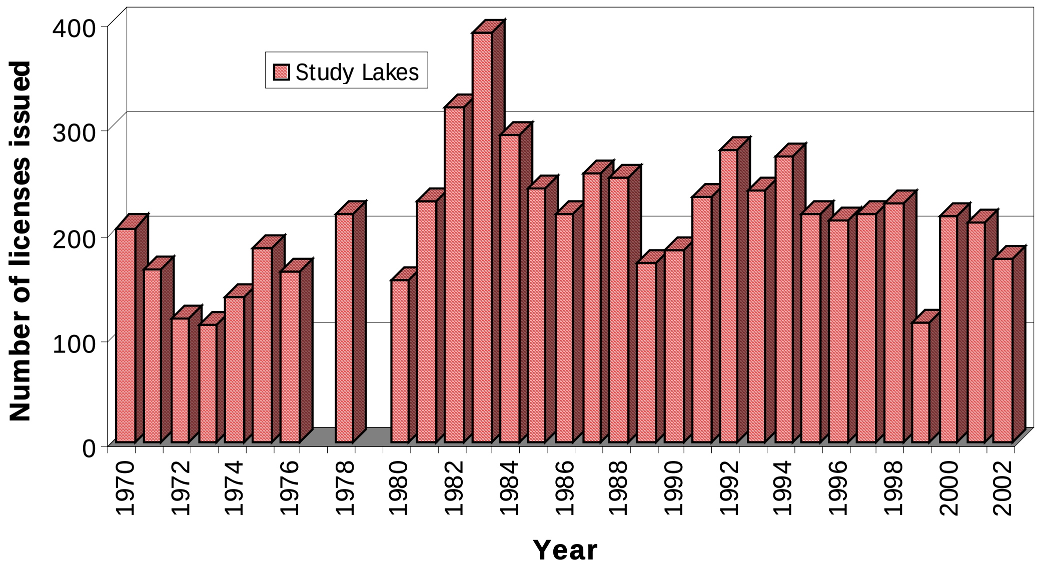


Figure 6-2. First Nations Domestic Licences issued for selected study lakes in the CLBR Basin, 1970-2002 (Lovely 2004). (Note: records were not available for 1977 and 1979.)

The Government of Alberta signed an interim agreement with the province's two Métis organizations effective October 1, 2004. This agreement allows Métis to fish, trap and hunt for subsistence purposes, at any time of the year, anywhere in Alberta where they have the right of access, and under similar processes as First Nations, subject to closures for conservation or safety purposes. These agreements were negotiated in response to R. v. Powley, a 2003 decision of the Supreme Court of Canada which held that among the Métis Aboriginal rights recognized and affirmed by the Constitution Act, 1982, there is the right to harvest wildlife. The Supreme Court also held this Métis right is not less than that of First Nations. Although the future impact of this agreement on this basin's fisheries is largely unknown, both Métis organizations have confirmed conservation is an overriding priority.

6.5 Water Body Summaries

Lakes that have water body summaries available include the following:

Angling Lake
Beartrap Lake
Beaver River
Bourque Lake
Burnt Lake
Chatwin Lake
Cold Lake
Ernestina Lake
Ethel Lake
Hilda Lake
Martineau River
May Lake
Medley River
Moore (Crane) Lake
Moose Lake
Mooselake River
Muriel Lake
Muriel Creek
Primrose Lake
Sand River

Jackfish Creek	Sinclair Lake
Kehewin Lake	Soars Lake
Leming Lake	Thinlake River
Little Bear Lake	Thompson Lake
Manatokan Creek	Tucker Lake
Manatokan Lake	Wolf Lake
Marie Creek	Wolf River
Marie Lake	

ANGLING LAKE	5-24-60-2 W4

Resident Fish Species

Northern pike	Spottail shiner
Yellow perch	Brook stickleback

Surface area (ha):	657
Maximum depth (m):	9.1
Mean depth (m):	
Trophic status:	Eutrophic

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Good	1 fish over 63 cm daily
Yellow perch	Considered Low	Good	15 fish daily

Current Use

Domestic	No current use.
Recreational	Insufficient information to quantify the sportfishing effort, but is considered low use.
Commercial	No commercial use.

Habitat Considerations

Land use activities, including cattle grazing, may contribute to poorer water quality. Low natural water levels increase this condition and reduce fish access to connecting streams, causing increased watershed fragmentation.

BEARTRAP LAKE	11-21-60-4 W4

Resident Fish Species

Northern pike	Yellow perch

Surface area (ha):	127
Maximum depth (m):	11.0
Mean depth (m):	
Trophic status:	Eutrophic

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Collapsed	Good	Limit 0 fish
Yellow perch	Considered low	Good	15 fish daily

Current Use

Domestic	None.
Recreational	Limited sportfishing use.
Commercial	None.

Habitat Limitations

Low natural water levels have increased the tendency for poor water quality and reduced fish access to connecting streams—increased watershed fragmentation and ecosystem isolation.

BEAVER RIVER	Sand River to Saskatchewan Border

Resident Fish Species

Northern pike	River shiner
Yellow perch	Brook stickleback
Walleye	White sucker
Burbot	Pearl dace
	Crayfish

The Beaver River is the most westerly branch of the Churchill River watershed and flows into the Hudson Bay. It provides the main connective waterway for most lakes in the study area, and gains most of its water from the Sand River. It is unique in having the only naturally occurring population of crayfish in Alberta. Sportfishing use is considered low and usually associated with access points.

Habitat Considerations

Land use activities, including some areas of intensive cattle grazing, may be affecting water quality.

BOURQUE LAKE	33-65-4 W4

Surface area (ha):	497
Maximum depth (m):	27.4
Mean depth (m):	8.4
Trophic status:	Meso-eutrophic

Resident Fish Species

Northern pike	Spottail shiner
Yellow perch	Iowa darter
Walleye	White sucker
Lake whitefish	Cisco
Burbot	

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Good	1 fish over 63 cm TL daily
Yellow perch	Considered Low	Good	15 fish daily
Walleye	Vulnerable	Good	1 fish over 50 cm TL daily
Lake whitefish	Unclassified	Good	
Cisco	Unclassified	Good	

Current Use

Domestic	3 licences (5 year avg.).
Recreational	Likely being over-harvested—no survey data available.
Commercial	Not since 1990.

Habitat Considerations

Summer stratification of the water column creates low oxygen conditions for fish and lowered productivity. Low flow in feeder streams over the last several years may be interfering with fish use as a travel corridor and walleye spawning. Uncontrolled camping on the west shore may be cause for riparian health concerns.

BURNT LAKE	20-67-3 W4

Surface area (ha):	438
Maximum depth (m):	9.1
Mean depth (m):	3.7
Trophic status:	Unspecified

Resident Fish Species

Northern pike	Burbot
Walleye	White sucker
Lake whitefish	Cisco

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Stable	Good	Closed
Walleye	Stable	Good	Closed
Lake whitefish	Unclassified	Good	
Cisco	Unclassified	Good	

Current Use

Domestic	No current use.
Recreational	No current use owing to access restrictions by Department of National Defence (DND).
Commercial	Bi-annual fishery harvests 49 kg northern pike, 60 kg walleye, 217 kg lake whitefish and 520 kg cisco (5 year avg.). Sharp declines in harvest since 1995.

Habitat Considerations

A decline in the water level in Burnt Lake and tributary streams may be creating difficulty for resident fish species owing to habitat loss and watershed fragmentation. Fish from Marie and May lakes may supplement Burnt Lake populations when migration becomes possible.

CHATWIN LAKE	11-4-61 W4

Surface area (ha):	71
Maximum depth (m):	15.8
Mean depth (m):	
Trophic status:	Hyper-eutrophic

Resident Fish Species

Yellow perch	

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Yellow perch	Considered low	Good	15 fish daily

Current Use

Domestic	No recorded use.
Recreational	Considered low. Annual stocking of rainbow trout was discontinued after 1999 owing to poor angler use. Yellow perch have been stocked in the last 2 years to establish a fishable population.
Commercial	No commercial use.

Habitat Considerations

Adjacent land use activities, including cattle grazing, along with lowered water levels due to drought conditions may be contributing to poorer water quality. Low natural water levels have reduced angler access. Poor water quality may be limiting fish production.

COLD LAKE	1-14-64-1-W4
Surface area (ha):	37,300
Maximum depth (m):	99.1
Mean depth (m):	49.9
Trophic status:	Oligo-mesotrophic

Resident Fish Species

Lake trout	White sucker
Lake whitefish	Longnose sucker
Cisco	Brook stickleback
Walleye	Ninespine stickleback
Northern pike	Emerald Shiner
Yellow perch	Spottail shiner
Burbot	Fathead minnow
Finescale dace	Log perch
Iowa darter	Trout perch
Lake chub	Longnose dace
Slimy sculpin	Pearl dace
Spoonhead sculpin	

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Lake trout	Recovering	Good	1 fish over 65 cm daily
Northern pike	Vulnerable	Good	1 fish over 63 cm daily
Walleye	Vulnerable	Good	3 fish over 50 cm
Yellow perch	Considered low	Good	15 fish daily
Lake whitefish	Stable	Good	
Burbot	Stable	Good	10 fish daily

Current Use

Domestic	60 licences/yr (5 year avg.). The 2002 winter domestic harvest estimates for lake whitefish and lake trout were 6,318 kg and 3,269 kg, respectively.
Recreational	Recovery of the collapsed lake trout population of the 1930s and 1940s was hampered by DDT use in the 1970s. Stocking over 2.3M lake trout between 1943 and 1987 supported the fishery and by 1982, the DDT contamination had diminished to allow the population to resume

	successful spawning. After 1995, substantial increases in lake trout catch rates were noted. Summer angler effort increased 35% from 0.40 angler-hours/ha in 1992 to 0.62 angler-hours/ha in 2000, and is considered to be much higher in 2004.
Commercial	Alberta commercial harvests for all species have declined 41% since 1980, primarily due to lowered sportfish tolerances. Since 2002, commercial trap netting in Alberta has replaced the traditional gill net fishery, dramatically reducing the sportfish by-catch. Saskatchewan continues their annual gill net fishery.

Habitat Limitations

Cold Lake habitat conditions remain good provided the water levels remain above 534.55 masl. This ensures fish access to the Long Bay complex (critical to the productive capacity for cool water species—northern pike, walleye and yellow perch) and access to the Cold River outlet for successful lake trout spawning.

ERNESTINA LAKE	SW 6-61-4 W4

Surface area (ha):	306
Maximum depth (m):	7.9
Mean depth (m):	3.5
Trophic status:	Eutrophic

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
None			

Current Use

Domestic	No current use.
Recreational	No recreational use at present owing to low water levels.
Commercial	No commercial use.

Habitat Considerations

Ernestina Lake has lost much of its water and major species have been extirpated. Even low dissolved oxygen tolerant species like stickleback experienced summer-kill in 1983 and 1986. Cattle grazing along the shoreline contributes to eutrophication.

ETHEL LAKE	6-14-64-3 W4

Surface area (ha):	467
Maximum depth (m):	30.0
Mean depth (m):	6.6
Trophic status:	Meso-eutrophic

Resident Fish Species

Northern pike	Spottail shiner
Yellow perch	Ninespine stickleback
Walleye	Iowa darter
Lake whitefish	White sucker
Cisco	Longnose sucker
Burbot	Brook stickleback

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Good	1 fish over 63 cm daily
Yellow perch	Unclassified	Good	15 fish daily
Walleye	Collapsed	Poor	0 limit
Lake Whitefish	Unclassified	Good	

Current Use

Domestic	8 licences issued (5 year avg.).
Recreational	A creel survey in 1997 indicated the fishery may be over-harvesting northern pike. The fishery also had a very low harvest of yellow perch.
Commercial	The alternate year commercial fishery was suspended in 2003-04 for a period of 6-7 years owing to an over-harvest of walleye in 2001-02.

Habitat Considerations

Severe oxygen depletion was recorded in the late 1980s, suggesting poor water quality.

Walleye recruitment failures are due to loss of adequate spawning habitat, caused by poor streamflow in the Marie Creek inlet owing to regional drought conditions. The weir and low-level crossing on the outlet are in the process of being removed and rehabilitated to a more natural state, thereby improving fish passage and spawning movement.

HILDA LAKE	5-8-64-3 W4

Surface area (ha): 337
Maximum depth (m): 12.2
Mean depth (m): 4.4
Trophic status: Meso-eutrophic

Resident Fish Species

Northern pike	Iowa darter
Yellow perch	Ninespine stickleback
Walleye	Spottail shiner
Cisco	White sucker
Lake whitefish	Longnose sucker
Burbot	

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Good	1 fish over 63 cm daily
Walleye	Vulnerable	Poor	1 fish over 50 cm daily
Yellow perch	Unclassified	Good	15 fish daily

Current Use

Domestic	2 licences issued in recent years.
Recreational	The 1997 summer angler survey indicated 6.3 anglers/ha harvesting approximately 282 kg of northern pike, 66 kg of walleye and 208 kg of yellow perch. A winter survey in 1994-95 indicated a catch rate of 5.94 fish/hr, harvesting 855 yellow perch.
Commercial	Commercial use was curtailed by 1989 owing to concerns for sportfish populations.

Habitat Limitations

Low natural water levels have increased the tendency for poor water quality and reduced access for fish to connecting streams. This has resulted in increased watershed fragmentation and habitat isolation.

JACKFISH CREEK	Bourque Lake to Beaver River

Resident Fish Species

Northern pike	Minnow species

Jackfish Creek connects and drains Bourque Lake and Tucker Lake to the Beaver River. It is a travel corridor for fish during higher water events and maintains low oxygen tolerant minnow species over the winter months..

Habitat Considerations

Land use activities, including some areas of intensive cattle grazing, may be affecting water quality in the lower reaches. The effectiveness of creek crossings and culverts should be evaluated. An old Ducks Unlimited control structure at the outlet of Tucker Lake has been removed and rehabilitated to a more natural state.

KEHEWIN LAKE	16-36-58-7 W4

Surface area (ha):	622
Maximum depth (m):	11.6
Mean depth (m):	6.7
Trophic status:	Eutrophic

Resident Fish Species

Northern pike	Burbot
Yellow perch	Spottail shiner
Walleye	Cisco

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Collapsed	Poor	0 limit
Yellow perch	Unclassified	Good	15 fish daily
Walleye	Collapsed	Poor	0 limit
Cisco	Unclassified	Good	

Current Use

Domestic	10 licences/yr (5 year avg.).
Recreational	The 1995 angler survey indicated very high summer angler effort of 21.9 angler-hours/ha. Walleye and northern pike populations were classified as collapsed in 1999 and 2000, respectively, due to low population levels. The 1995 summer yellow perch harvest was reported to be 250% of theoretical production.
Commercial	A very restrictive commercial fishery harvests 1,400 kg of cisco/yr (5 year avg.), with 100 kg/yr northern pike and 50 kg/yr walleye tolerances.

Habitat Considerations

Periodic fish kills indicate poor water quality and low dissolved oxygen levels. Natural low flow in feeder streams interferes with use as travel corridors and northern pike and walleye spawning.

LEMING LAKE	6-2-65-4 W4

Surface area (ha): 243
Maximum depth (m):
Mean depth (m):
Trophic status: Eutrophic

Resident Fish Species

Northern pike *	
Yellow perch *	

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike *	Unknown	Poor	
Yellow perch *	Unknown	Poor	

*No current data are available to confirm reports of population extirpation owing to water level declines.

Current Use

Domestic	No licences issued.
Recreational	Undetermined.
Commercial	No commercial use.

Habitat Considerations

Low water levels have likely disturbed critical fish habitats; however, recent evaluations were not available.

LITTLE BEAR LAKE	11-19-64-2 W4

Surface area (ha): 44
Maximum depth (m): 12.2
Mean depth (m): 5.4
Trophic status: Eutrophic

Resident Fish Species

Rainbow trout	Brook stickleback
	Lake chub

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Rainbow trout	Annual stocking	Good	15 daily

Current Use

Domestic	No recorded use.
Recreational	Annual stocking of rainbow trout since 1974 of approximately 34,600/yr has created an active summer and winter fishery. A 1999-2000 creel survey indicated a catch rate of 1.56 fish/hr.
Commercial	No commercial use.

Habitat Considerations

Eutrophic status and lack of wind exposure create conditions for poor water quality, low dissolved oxygen and periodic fish kills.

MANATOKAN CREEK	Manatokan Lake to Beaver River

Resident Fish Species
Northern pike

Manatokan Creek drains Manatokan Lake and may act as a travel corridor to and from the Beaver River when water levels are high. Intensive beaver activity during normal and low water levels maintains the creek as a wetland.

Habitat Considerations

A Ducks Unlimited control structure with a fish-way near the lake outlet should be evaluated to ensure its effectiveness. A hanging culvert (NE 24-62-7-W4) on a county road upstream of the Beaver River may be an impediment to fish passage and spawning access, and should be evaluated and replaced if necessary.

MANATOKAN LAKE	NW 23-63-7 W4

Resident Fish Species	
Yellow perch	Spottail shiner
Fathead minnow	Brook stickleback
Lake chub	Iowa darter

Surface area (ha):	438
Maximum depth (m):	6.7
Mean depth (m):	
Trophic status:	Eutrophic

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Yellow perch	Unclassified	Good	15 fish daily

Current Use

Domestic	No current use.
Recreational	Insufficient information to quantify the sportfishing effort, but considered high winter fishing use for yellow perch which have been successfully restocked since a major winterkill in 1994/95.
Commercial	No commercial use.

Habitat Considerations

Land use activities, including cattle grazing, may be contributing to poorer water quality. Low natural water levels increase this tendency and reduce access for fish to connecting streams, causing increased watershed fragmentation.

MARIE CREEK	Burnt Lake to Beaver River

Resident Fish Species

Northern pike	Lake whitefish
Walleye	Minnow species

Marie Creek mainstem connects Burnt, May, Marie and Ethel lakes to the Beaver River. A western tributary connects Moore and Hilda lakes to Ethel Lake. It is an important travel corridor and spawning area when water levels permit fish passage.

Habitat Considerations

Several impediments to fish passage need to be addressed. The old bridge/culvert (NW 1-63-3-W4) on DND property should be updated. The control structure, fishway and low-level crossing on the outlet of Ethel Lake requires removal and/or re-contouring. The old Ducks Unlimited control structure on the outlet to Moore Lake has been replaced with a more natural rock and rubble sill. This should be evaluated for effectiveness and modified if necessary.

MARIE LAKE	12-18-65-2 W4

Surface area (ha):	3,460
Maximum depth (m):	26.0
Mean depth (m):	14.0
Trophic status:	Meso-eutrophic

Resident Fish Species

Northern pike	Iowa darter
Yellow perch	Lake chub
Walleye	Ninespine stickleback
Lake whitefish	Spottail shiner
Cisco	White sucker
Burbot	

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Good	1 fish over 63 cm
Walleye	Vulnerable	Good	1 fish over 50 cm
Yellow perch	Unclassified	Good	15 fish daily
Lake whitefish	Unclassified	Good	
Burbot	Unclassified	Good	10 fish daily

Current Use

Domestic	9.6 licences/yr (5 year avg.). In 2002, a spring closure was extended to include domestic fishers to protect spawning fish.
Recreational	Sportfishing use (1.04 angler-hours/ha) was considered low during a 1996 summer angler survey but appears to be increasing in recent years. In summer 2004, a creel survey was undertaken to characterize the fishery.
Commercial	Marie Lake has not been commercially fished since 1981 due to high sportfish by-catch.

Habitat Considerations

Low natural water flows in connecting streams may be contributing to reduced access for fish, ecosystem isolation and watershed fragmentation.

MARTINEAU RIVER	Primrose Lake to Cold Lake

Resident Fish Species

Northern pike	Minnow species
Yellow perch	Lake whitefish
Walleye	Lake trout
Burbot	

The Martineau River is an important travel corridor between Primrose and Cold lakes, and important as a spawning site for lake whitefish and walleye. There is an active sportfishery where the river meets Cold Lake, especially for walleye.

Habitat Considerations

Fisheries habitat remains good.

MAY LAKE	12-16-66-3 W4

Surface area (ha):	301
Maximum depth (m):	14.5
Mean depth (m):	5.6
Trophic status:	Meso-eutrophic

Resident Fish Species

Northern pike	Iowa darter
Yellow perch	Spottail shiner
Walleye	White sucker
Lake whitefish	Cisco
Burbot	

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Good	1 fish over 63 cm daily
Walleye	Collapsed	Good	0 limit
Yellow perch	Unclassified	Good	15 fish daily

Current Use

Domestic	4 licences issued/yr (5 year avg.).
Recreational	A 1996 summer creel survey estimated anglers had a high northern pike catch rate (2.3 pike/hr) with an extremely low walleye catch rate (0.031 walleye/hr). Perch fishing was incidental. Sample angling in 1998 indicated declining northern pike catch rates. A trophy pike designation was dropped in 1999.
Commercial	No commercial use.

Habitat Considerations

Low natural flow in connecting streams over the past several years may be interfering with fish use as a travel corridor and for walleye spawning.

MEDLEY RIVER	Muskeg area north of Primrose Lake road to Cold Lake

Resident Fish Species

Northern pike	Rainbow trout
Walleye	Minnow species

The Medley River has been maintained as a "put-and-take" rainbow trout fishery through annual stocking since the mid 1960s, in its upper sections on either side of the Primrose Lake road. The lower section near Cold Lake supports a northern pike and a minor walleye fishery.

Habitat Considerations

Fish passage through the road culvert under the Primrose Lake road should be evaluated and maintained.

MOORE (CRANE) LAKE	14-3-64-4 W4

Surface area (ha):	994
Maximum depth (m):	25.9
Mean depth (m):	8.9
Trophic status:	Eutrophic

Resident Fish Species

Northern pike	Spottail shiner
Yellow perch	Fathead minnow
Walleye	Iowa darter
Burbot	White sucker

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Good	1 fish over 63 cm daily
Yellow perch	Unclassified	Good	15 fish daily
Walleye	Collapsed	Poor	0 limit

Current Use

Domestic	No licences issued.
Recreational	No survey data available, but considered a moderate yellow perch and northern pike fishery with a low catch rate for walleye.
Commercial	No fishery.

Habitat Considerations

The control structure at the outlet stream has been recently rehabilitated to a more natural state to ensure fish passage, and requires more evaluation. Low regional water levels have reduced water quality and poor stream flows have caused increased watershed fragmentation.

MOOSE LAKE	2-61-7 W4

Surface area (ha):	4,080
Maximum depth (m):	19.8
Mean depth (m):	5.6
Trophic status:	Hyper-eutrophic

Resident Fish Species

Northern pike	Brook stickleback
Walleye	Iowa darter
Lake whitefish	Spottail shiner
Yellow perch	White sucker
Burbot	Cisco

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Good	1 fish over 63 cm
Walleye	Vulnerable	Good	1 fish over 50 cm
Yellow perch	Unclassified	Good	15 fish daily
Lake whitefish	Unclassified	Good	

Current Use

Domestic	41 licences issued/yr (5 year avg.).
Recreational	Summer angler effort decreased 61% from 1986 to 2000 (15.6 to 6.07 angler hours/ha). This is likely a response to decreased sportfish catch rates and increasingly restrictive sportfishing regulations protecting the northern pike and walleye populations. Walleye populations recovered from a collapsed status in 1998 to a vulnerable status after 2000.
Commercial	Commercial harvests have declined 66% since 1980 due to incremental decreases in sportfish tolerances restricting the harvest. Commercial harvests of northern pike and walleye have remained below their tolerance limits (400 kg/yr and 250 kg/yr, respectively), while lake whitefish has remained relatively constant at 4,570 kg/yr (5 year avg.).

Habitat Considerations

Fish kills in Moose Lake River and low flows in other streams that isolate fish spawning habitats have been recorded. Land use practices associated with development are creating problems through alteration of shoreline (riparian and littoral) habitats. This contributes to poorer water quality, loss of fish spawning and rearing habitat, and loss of biodiversity. Recent data from the Alberta Conservation Association assesses Moose Lake's shoreline (riparian) habitat as 61% healthy, 13% somewhat impaired and 26% highly impaired.

Recent discussions with Alberta Environment indicated increasing salinity of Moose Lake water with some pH values as high as 8.9. (*Surface Water Quality Guidelines for Use in Alberta* 1999 state an upper pH limit of 9.0 for the protection of freshwater aquatic life.)

MOOSELAKE RIVER	Moose Lake to the Beaver River

Resident Fish Species

Northern pike	Minnow species
Walleye	

The Mooselake River drains the entire Moose Lake Watershed, including Bangs and Kehewin lakes. The river has traditionally been a fish travel corridor to and from the Beaver River, but is now characterized by very low flows and intense beaver activity. Water flow is influenced by a control structure with a fishway (SW 3-62-7 W4). This is an important spawning and rearing area for Moose Lake, especially in the upper reaches above the control structure.

Habitat Considerations

The control structure and fishway should be evaluated for effectiveness, environmental effects, and ability for migrating or spawning fish to pass through.

MURIEL LAKE	6-34-59-5 W4

Resident Fish Species

Northern pike	Iowa darter
Yellow perch	Spottail shiner
Walleye	White sucker
Lake whitefish	Burbot
Brook stickleback	

Surface area (ha):	8,550
Maximum depth (m):	10.7
Mean depth (m):	6.6
Trophic status:	Hyper-eutrophic

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Poor	1 fish over 63 cm
Yellow perch	Unclassified	Poor	15 fish daily
Walleye	Collapsed	Poor	0 limit
Lake whitefish	Unclassified	Poor	

Current Use

Domestic	5 licences/yr (5 year avg.).
Recreational	No current data for the fishery, but it is thought to be limited due to decreases in water level and poor sportfish catches.
Commercial	Commercial use has been curtailed since 1998 due to stresses on the fish population from loss of volume and habitat.

Habitat Considerations

Periodic fish kills indicate poor water quality creating low dissolved oxygen levels. Natural low water flow and poor culvert placement in connecting streams are interfering with use of these areas as travel corridors and spawning grounds for northern pike and walleye. Continued decreases in water level have created serious disturbances in fish habitat and lowered fish production. Recent littoral zone surveys indicate reductions in fish populations and a loss of species diversity.

Cattle grazing and manure runoff contribute to poor water quality. Recent information from Alberta Environment suggests increasing salinity, with pH values as high as 9.3 being recorded. (*Surface Water Quality Guidelines for Use in Alberta* 1999 indicate an upper pH limit of 9.0 for the protection of freshwater aquatic life.)

MURIEL CREEK	Muriel Lake to Beaver River

Resident Fish Species

Likely none

Water levels in Muriel Lake have decreased to where there is no outflow into Muriel Creek. Without a regular source of water, the creek has remained very small, influenced only by local runoff. Very poor for fish passage or support.

Habitat Considerations

Land use activities, including some areas of intensive cattle grazing, may be affecting water quality.

PRIMROSE LAKE	12-13-67-1 W4

Surface area (ha):	42,116
Maximum depth (m):	40.0
Mean depth (m):	
Trophic status:	Meso-eutrophic

Resident Fish Species

Northern pike	White sucker
Walleye	Longnose sucker
Yellow perch	Burbot
Lake whitefish	

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Stable	Good	Closed to angling *
Walleye	Stable	Good	Closed to angling *
Lake whitefish	Unclassified	Good	

*DND does not permit public access to the Cold Lake Air Weapons Range.

Current Use

Domestic	36 licences (5 year avg.).
Recreational	Closed to sportfishing due to DND access restrictions.
Commercial	The commercial fishery is managed under an inter-provincial agreement with Saskatchewan. Alberta’s commercial allocation is 17,100 kg/yr for lake whitefish, 4,800 kg/yr for northern pike and 6,400 kg/yr for walleye. The 5-year average Alberta commercial harvest has been 14,046 kg/yr for lake whitefish, 752 kg/yr for northern pike and 4,836 kg/yr for walleye.

Habitat Considerations

Habitat conditions remain good.

SAND RIVER	Western part of the Cold Lake Air Weapons Range to Beaver River

Resident Fish Species

Northern pike	Spottail shiner
Walleye	Brook stickleback
Yellow perch	Fathead minnow
Burbot	Longnose dace
Sucker spp.	Crayfish

The Sand River drains a large area of the western Cold Lake Air Weapons Range and is the main source of water for the Beaver River. It is an important fish travel and spawning corridor.

Habitat Considerations

Fisheries habitat conditions in the Sand River remain good.

SINCLAIR LAKE	12-23-66-5 W4

Resident Fish Species

Northern pike	White sucker
Yellow perch	

Surface area (ha): 174
Maximum depth (m): 14.3
Mean depth (m):
Trophic status: Eutrophic

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Uncertain	Closed
Walleye	Unclassified	Good	Closed

Current Use

Domestic	No current use.
Recreational	No current data available but thought to have low sportfishing effort.
Commercial	No commercial use.

Habitat Considerations

Too little information is available to provide comment.

SOARS LAKE	13-31-59-1 W4

Surface area (ha):	130
Maximum depth (m):	40.2
Mean depth (m):	
Trophic status:	Unclassified

Resident Fish Species

Northern pike	
Yellow perch	

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Good	3 fish over 63 cm

Current Use

Domestic	No recorded use.
Recreational	Considered low but no current data are available.
Commercial	No commercial use.

Habitat Considerations

Very little information is available. A narrow littoral zone will likely make the lake very sensitive to change as water levels fluctuate.

THINLAKE RIVER	Bangs Lake to Moose Lake

Resident Fish Species

Northern pike	Minnow species
Yellow perch	Walleye

The Thinlake River drains the Kehewin Lake and Bangs Lake valleys. It is a known spawning area for northern pike and walleye from Moose Lake, and an important fish travel corridor when water levels permit.

Habitat Considerations

Land use activities, including some areas of intensive cattle grazing, may be affecting water quality.

THOMPSON LAKE	7-3-60-2 W4

Surface area (ha):	483
Maximum depth (m):	3.5
Mean depth (m):	
Trophic status:	Eutrophic

Resident Fish Species

Northern pike *	White sucker *
Yellow perch *	

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike*	Vulnerable	Poor	
Yellow perch *	Unclassified	Poor	

* The fish populations have become extirpated possibly due to be severely low water levels and poor water quality.

Current Use

Domestic	No current use.
Recreational	No current data available.
Commercial	No commercial use.

Habitat Considerations

Thompson Lake was experiencing low oxygen levels by 1986. Its shallow nature has made it very susceptible to poor habitat impacts throughout the drought period of the 1990s.

TUCKER LAKE	18-64-4 W4

Surface area (ha):	627
Maximum depth (m):	8.2
Mean depth (m):	4.3
Trophic status:	Eutrophic

Resident Fish Species

Northern pike	Iowa darter
Walleye*	Ninespine stickleback
Yellow perch	White sucker
Lake whitefish*	Cisco*
Burbot	

*These species have historical records but are no longer considered to be viable populations.

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Poor	1 fish over 63 cm daily
Yellow perch	Unclassified	Poor	15 fish daily

Current Use

Domestic	No licences issued.
Recreational	A limited winter angler survey in 1995 estimated the harvest of pike and yellow perch may be near or exceeding annual production.
Commercial	Not commercially fished since 1990 due to conflicts with the recreational fishery.

Habitat Considerations

Low natural flow in connecting streams may be interfering with fish use as a travel corridor and spawning grounds. An old Ducks Unlimited control structure at the Jackfish Creek outflow has been replaced with a more natural rockfill sill to ensure fish passage.

WOLF LAKE	4-11-66-7 W4

Surface area (ha):	3,150
Maximum depth (m):	38.3
Mean depth (m):	9.2
Trophic status:	Eutrophic

Resident Fish Species

Northern pike	Brook stickleback
Walleye	Nine-spine stickleback
Yellow perch	Iowa darter
Lake whitefish	Spottail shiner
Cisco	White sucker
Burbot	Long-nose sucker

Major Species	*Population Status*	*Critical Habitat*	*Current Sportfishing Regulations*
Northern pike	Vulnerable	Good	1 fish over 63 cm
Walleye	Collapsed	Good	0 limit
Yellow perch	Unclassified	Good	15 fish daily
Lake whitefish	Unclassified	Good	

Current Use

Domestic	9 licences/yr (5 year avg.).
Recreational	Angler effort at Wolf Lake declined by 77% from 1992 to 1999 (9.1 to 2.12 angler-hrs/ha). This is a reflection of the walleye fishery collapse from over-harvesting and a zero catch limit that has been in place since 1995. Walleye studies in 2003 indicated recovery of the population is progressing. A stakeholder review is underway to develop regulations that will allow a limited walleye harvest for 2005.
Commercial	A very controlled commercial fishery with a tolerance of 200 kg/yr of northern pike and 50 kg/yr for walleye, produces 6,860 kg/yr (5 year avg.) of lake whitefish.

Habitat Considerations

Low flows in the connecting streams may be affecting consistent spawning success for walleye.

WOLF RIVER	Loseman Lake to Sand River

Resident Fish Species

Northern pike	Pearl dace
Yellow perch	Burbot
Walleye	

The Wolf River is an important travel corridor and spawning area, both upstream and downstream of Wolf Lake.

Habitat Considerations

The Wolf River upstream of Wolf Lake passes through an active area of oil development. It should be monitored regularly to ensure there is no degradation of water quality. In addition, all the many stream crossings should be monitored to ensure effective fish passage.

6.6 Key Points

1. The health of the basin's sportfish populations remains below optimum; however, there are some signs of improvement.
   - Of the 13 walleye lakes, 2 are classified as stable, 5 are vulnerable and 6 are collapsed. Recent improvement in Moose Lake can be noted. Wolf Lake's collapsed status is in the process of changing to vulnerable, and new regulations permitting harvest are forthcoming.
   - The basin's 21 northern pike lakes are classified as 2 stable, 14 vulnerable, 2 collapsed and 3 unclassified.
   - After being collapsed for many years, the recovery of the lake trout population in Cold Lake has been achieved through intensive management and many years of stocking.
   - Yellow perch populations continue to be under considerable stress and should soon be the focus of a provincial species management plan.

2. All existing fisheries must be recovered to optimal productive capacity to accommodate the increasing demand for domestic, sport and commercial fishing.
   - Fisheries managers are optimistic that fish populations will continue to recover under current species management strategies and regulations that maintain harvest below current sustainable production.
   - Maintaining the productive capacity of a waterbody is critical to fish recovery.
     - Productive capacity is strongly influenced by water quality, water quantity and habitat condition. When any of these interconnected factors are degraded, the productive capacity for fish is impaired.
     - Water quality throughout the basin should be maintained at standards that protect aquatic life.
     - Water levels should be maintained at levels that protect fish habitat, in particular travel and spawning habitat.

3. All agencies involved in water allocation, shoreline development processes, habitat protection, fisheries management and environmental enforcement must be fully engaged in the wise use and protection of all aquatic resources. To ensure success, all parties must act in a coordinated fashion in the best interests of those resources.

SECTION 7. WATER-BASED WILDLIFE ASSESSMENT

7.1 INTRODUCTION

7.1.1 Wildlife and Habitat as Environmental Indicators

The CLBR Basin contains wildlife viewing opportunities, populations and habitat that are regionally, provincially and nationally important. Many of these wildlife areas are water-based sites: streams, rivers, muskegs, sloughs, ponds and lakes. Wetlands in the Cold Lake–Bonnyville area are recognized as being especially attractive and productive places in Alberta for bird watching, wildlife viewing and ecotourism.

Many people consider wild animals an important part of their experience or quality of life. Rural residents and urbanites alike derive enjoyment from seeing the spring and summer migrations of Canada Geese, the first American Robin on their lawns, Mallards on ponds and deer in the meadows. Such viewings are taken as a sign the environment is in a state of balance. Plentiful birdlife of a variety of species is an easy-to-observe general indicator of a healthy environment.

Wildlife biologists and managers view wild animals, especially birds, as valuable indicators of environmental change. Birds are especially important, in part because they are very visible, identifiable and countable, and also because many bird species respond in relatively predictable ways to certain changes in the landscape. By measuring the amount of habitat, it is sometimes possible to estimate the number of species and individual birds represented by that habitat.

Since measuring habitat is very difficult, an alternative approach is often used. By counting the number of individual birds of known species in an area, it is possible to assess the health and amount/variety of habitats in the particular area that are of value to birds. This approach was the primary method used to gather information for this report.

Wildlife managers attempt to retain, improve or manage habitat for five main reasons:

1. To help prevent the variety of wildlife species from becoming diminished.
2. To maintain distribution of wildlife across the landscape.
3. To minimize wildlife-related problems for humans.
4. To maximize wildlife benefits for humans.
5. To help prevent new species from becoming at risk of extinction, and return those that are at risk to a more stable population level.

Unless a species is actually threatened or endangered, wildlife legislation alone is rarely sufficient to adequately protect the habitat that wildlife requires. The *Water Act*, through its provisions for planning (such as updating the CLBR Water Management Plan) and its protection for "the aquatic environment", provides a new opportunity for planning and protection of water-based wildlife species in Alberta.

7.1.2 Comparisons of Lake-based Bird Populations, 1980 to 2003

During preparation of the original 1985 CLBR Water Management Plan, assessments of 57 lakes were made in 1980, 1981 and 1982 for their water-based wildlife values (Rippon [sic] 1983). During the summer of 2003, similar assessments were conducted on 28 of these lakes. Those relatively basic lake surveys, conducted about 20 years apart, showed substantial changes in wildlife and their habitat at a number of the lakes. The changes were most often associated with the continuing precipitation deficit (drought) that has plagued much of the CLBR Basin since the early 1980s. The lake surveys provided a wealth of information that was analyzed in a recent report (Rippin 2004).

Rippin's (2004) report focused on 49 bird species that are strongly associated with lakes. He analyzed the changes in bird numbers and habitat recorded at 28 of the lakes that had been surveyed in the early 1980s and in 2003. The report first described the various habitats associated with a lake (open water, non-vegetated beaches, emergent vegetation, shoreline vegetation) and explained how those habitats are important for certain lake-based bird species. The various factors that contribute to lake habitat change (natural precipitation cycles, regional climate shift and a myriad of human activities) were then discussed.

The main part of the report provided lake-by-lake accounts along with a graph of changes in recorded lake levels for about half the lakes. Included for all lakes was a table and graph showing changes in numbers of lake-based birds. The report summarized the changes seen across the 28 lakes, considered the changes and their possible causes within each of the nine subwatersheds, and provided an overall summary and conclusion.

The information in the next section summarizes and elaborates on Rippin's (2004) report regarding the bird populations and wildlife habitat on lakes within the CLBR Basin planning area, and their changes between 1980 and 2003.

7.2 METHODS

7.2.1 Bird Populations and Habitat Changes, 1980 to 2003

The lake-based wildlife surveys of 1980 and 1981 on 57 lakes (Rippon [sic] 1983, referred to here as the 1980s study) and the 2003 surveys (the 2003 study) were conducted in a similar manner. During June–July (nesting season) of 2003, 28 of the lakes from the 1980s study were re-surveyed. The two field crews were supervised by Fish and Wildlife Division (FWD) in St. Paul, and the project was managed by Ducks Unlimited Canada (St. Paul), and funded by LlCA in Bonnyville.

The lakes surveyed for birds and habitat in 1980-1982 and 2003 were the following:

Angling	Garnier (Lower Garnier)
Barbara	Hilda
Barreye	Jessie
Beartrap	Kehewin
Bentley	Maloney
Bluet (Upper Garnier)	Manatokan
Charlotte	Marie
Chickenhill	Moose
Cold	Muriel
Moore (Crane)	Osborne
Edward	Reita
Ernestina	Sinking
Ethel	Tucker
Forsythe	Wolf

During a single day visit, each lake was circumnavigated by canoe or motorboat close to shore (a few almost-dry lakes were studied by telescope). The crew recorded the species and number of lake-based birds on or near the lake, and mapped several features:

- the extent of emergent (rising above the water) vegetation (mostly bulrushes and cattails),
- shoreline and backshore habitat types,
- housing developments,
- bird nesting colonies,
- nests of eagles and osprey,
- beaver lodges, and
- muskrat houses.

Although based on single-day counts during the peak season for birds, and conducted 21-23 years apart by separate teams of moderately to highly skilled observers, the data are remarkably consistent across lakes with similar habitat. The differences between lakes and the trends shown through time are generally consistent with the expectations in hindsight. These changes are described and discussed following the brief description of how lakes and their habitats influence the resident birds.

7.3 Lakes and Birds

7.3.1 Types of Lake Habitat and Resident Birds

From the viewpoint of nesting birds, the lakes differ in the types and amounts of habitat they have. The five very broad categories of above-water habitat are:

1. Open water.
2. Emergent vegetation (cattail, bulrush, reed grass, pond lily).
3. Non-vegetated (or mostly non-vegetated) beaches, islands and peninsulas.

4. Shoreline vegetation.
5. Backshore vegetation.

Most species of lake-based birds spend their spring-summer breeding season at one lake. However, some species (usually larger ones) such as Bald Eagles, Ospreys, gulls, terns, cormorants, herons and pelicans, may nest at one lake and commute to a number of nearby lakes to feed. Also, some subadult birds (usually longer-lived species) such as one- and two-year old pelicans and gulls, spend the spring and summer feeding and loafing at lakes far from the breeding lakes.

The majority of bird species will nest and feed in specific types of habitat to which they are well adapted. If a lake or nearby vicinity does not have both nesting habitat and feeding habitat, the particular species will not breed there.

Lakes in the CLBR Basin vary markedly. Some are deep and cold with little or no emergent vegetation in the shallows and relatively steep, wooded banks. These lakes do not have large numbers of individual birds or bird species. There are, however, certain species that will be found almost exclusively on this type of lake because it provides the habitat required by the particular bird species, such as:

- Common Loon (nesting on the ground within 1 m of the water's edge, and fishing in deep water);
- Common Goldeneye and Bufflehead (nesting in woodpecker holes in sufficiently large trees near the lake);
- Spotted Sandpiper (nesting and foraging along rocky shorelines or vegetated areas close by).

At the other extreme in the basin are shallow, warm lakes with wide zones of cattail or bulrush beds in the shallows and gentle, grassy banks and backshore habitat. These lakes provide nesting and foraging habitat for a larger number of bird species, and often a considerable number of individuals as well, which must have some or all of those habitat features to reside there:

- Mallard and Green-winged Teal (nesting in cattails, under low bushes, in grasslands);
- Red-necked Grebe (building anchored floating nests in bulrush beds or open water);
- Red-winged Blackbird (nesting in colonies in cattail beds, usually over water);
- Franklin's Gull (nesting in colonies with floating nests in thick beds of emergent vegetation);
- American Avocet (nesting among sparse vegetation on sand or mudflats or gravel bars);
- Great Blue Heron (nesting in colonies in large trees; foraging in shallows).

The mixture of habitat types at a lake is important. Some lakes have a broad mix and will have a greater number of species, while other lakes have very limited habitat types and only a small number of bird species. Depending on the type and amount of habitat, there may be few or many individual birds nesting there.

When near a lake with extensive shallows, a large area of ungrazed or lightly grazed pasture can be used by a great number of nesting ducks. Pasture that is moderately or heavily grazed, or a cultivated cereal crop field, provides little protection for duck nests from farm machinery, cattle hooves or predators during spring nesting.

7.3.2 Impacts of Unnatural and Natural Lake Habitat Change

Habitat change can greatly affect nesting bird species and populations, and most habitat losses are permanent and cumulative. Many of the larger bird species (e.g., Osprey, Bald Eagle, cormorants, gulls, Great Blue Herons) cannot tolerate human habitation close by. Thus, when new lakeside residences or recreational beaches are built near their nest sites, the more sensitive bird species move elsewhere. If nesting habitat in other locations is already taken up by members of their species, the displaced birds are forced to forego nesting.

- When tree cover is removed and tame pasture is created near a lake, the forest-nesting birds (e.g., Common Goldeneye, Bufflehead, Osprey, Bald Eagle) that use the lake are displaced permanently.
- When pasture is cultivated and cereal crops are planted, nesting habitat is lost for most pasture-nesting, lake-based species.
- When emergent vegetation is removed, a host of species which nest in that habitat (e.g., blackbirds, Franklin's Gull, Sora, Marsh Wren, Black Tern, Western Grebe, Red-necked Grebe, Horned Grebe, Eared Grebe) are all displaced. As well, their populations at that lake and in the region are permanently reduced.

Nesting birds can be critically affected by human disturbance, which is often an important, although temporary, habitat change. Especially when used aggressively, powerboats and personal watercraft can cause some species such as loons to stop nesting at a lake. The wakes from watercraft smash into floating nests among the emergent vegetation, destroying the nest and/or flipping the eggs onto the lake bottom. People hiking near lakes, particularly when accompanied by off-leash dogs, can disturb ground-nesting birds and cause nest failures. These kinds of disturbances/changes in the use of lakes, and their impacts on nesting birds, can be ephemeral, subtle, and very difficult to detect and measure.

A significant draw-down of lake levels has occurred at a number of lakes in the CLBR Basin, caused by the extensive drought in the region. Throughout much of the area, 1974 was a high-water year with spring lake levels often extending back into the trees. Most of the area's lakes held their levels relatively well through the late 1970s. After that time (through to 2004), a number of the lakes in the basin experienced varying amounts of drawdown, depending in part on the size of the individual lake's catchment basin. This drawdown was due to an annual (except winter 1996-97) deficit of precipitation.

Surface elevations are regularly measured on some of the lakes that were surveyed. For example, the measured water levels at Moose, Jessie, Manatokan and Charlotte lakes (the latter three already being shallow lakes) have dropped by 1 m or more since 1980. Jessie Lake is now considerably smaller, with extensive mudflats and grassy shores, Manatokan Lake has had large areas of dry lakebed evolve into grassland or bush, and Charlotte Lake has shrunk by half with its dry bed being mostly grassland.

During the 1980s when the level of Jessie Lake was higher with two islands rising near its south shore, very large numbers of ducks nested among grass and bushes on those protected islands. Those two islands are now part of the mainland, and in recent years have produced many fewer ducklings each year. Muriel and Chickenhill lake levels have dropped by over 3 m. Owing to their largely sandy and gravel shorelines, much of the exposed area remains unvegetated. These natural shoreline habitat changes have had considerable impact on the nesting birdlife at these lakes.

7.4 RESULTS

7.4.1 Individual Lake Assessments

Table 7-1 summarizes the number of bird individuals and species recorded during the two survey periods, and briefly lists the more noteworthy changes in backshore and lakeshore habitat. Rippin's (2004) report provides greater details about bird species and numbers, and habitat changes at specific lakes.

Table 7-1. Changes in numbers of bird species, individuals and habitat at 28 lakes in the CLBR Basin between 1980-1982 and 2003 surveys.

Lake		1980-82	2003	Change	Habitat Change
Angling	Birds	340	386	+46	More agricultural clearing, roads, oil field development. Relatively stable lake/shore features.
	Species	17	25	+8	
Barbara	Birds	2648	955	–1693	Only minor habitat changes in vicinity. Relatively stable lake/shore features.
	Species	16	20	+4	
Barreye	Birds	1880	23	–1857	Almost completely dry owing to no pumping from Jessie Lake. Emergents mostly gone. Much grass/sedge/forb.
	Species	14	7	–7	
Beartrap	Birds	75	164	+89	Only minor habitat changes in vicinity of lake. Relatively stable lake/shore features.
	Species	6	14	+8	
Bentley	Birds	65	127	+62	Minor habitat changes, significant grazing impacts. Large drop in lake level. Mud, grass, willow shore.
	Species	9	17	+8	
Bluet (Upper Garnier)	Birds	24	55	+31	Moderate habitat changes in vicinity. Somewhat lower lake level, grassed shore.
	Species	8	10	+2	
Charlotte	Birds	2293	498	–1795	Minor habitat changes in vicinity. Good lake/shore features despite 1 m+ drop. Lake now ½ full size.
	Species	13	12	–1	
Chickenhill	Birds	144	283	+139	More agricultural clearing. Cattle fenced out. Dropped 3 m+; much sandy, gravelly shore, some vegetation.
	Species	13	24	+11	
Cold*	Birds		2279		Minor habitat changes nearby. Lake level relatively stable. Mostly poor quality shore; several excellent marsh bays.
	Species		29		
Edward	Birds	2909	2775	–134	More agricultural clearing, intensity. Good lake/shore features despite 1 m+ drop. Lake now ½ full size.
	Species	17	18	+1	
Ernestina	Birds	549	485	–64	Little change in habitat nearby. Dropped 2 m+. New islets. Still poor lake/shore vegetation.
	Species	16	22	+6	
Ethel	Birds	90	97	+7	Minor habitat changes nearby. Marie Creek mostly maintains lake level. Lake/shore relatively poor quality.
	Species	11	15	+4	
Forsythe	Birds	5850	1483	–4367	Woods removed, grazing on dried lakebed. Only 3 small ponds remain, with poor, damaged shore.
	Species	25	19	–6	
Garnier (Lower Garnier)	Birds	24	55	+31	Minor habitat changes nearby. Considerable drop in level. Fewer emergents, more grassed shore.
	Species	8	10	+2	
Hilda	Birds	364	293	–71	No habitat changes nearby. 1- m drop. Lake and shore features relatively stable.
	Species	16	9	–7	
Jessie	Birds	8420	1303	–7117	Minor habitat changes nearby. 1+ m drop. East 1/3 is

Lake		1980-82	2003	Change	Habitat Change
	Species	26	18	–8	all bulrush, central has much mud shore, west part okay.
Kehewin	Birds	776	566	–210	Minor habitat changes nearby. Relatively stable level. Relatively constant lake/shore habitat values.
	Species	19	23	+4	
Maloney	Birds	483	483	0	More agricultural development nearby. Ditching and diversion impacts. Dense bulrush, 3 small ponds remain.
	Species	13	21	8	
Manatokan	Birds	275++	214	–61++	Removal of most tree cover; more grazing and crops. 1+ m drop. East part dry, west part willow, degraded.
	Species	13	12	–1	
Marie	Birds	48	114	+66	2 campsites and 2 subdivisions – relatively minor changes. Marie Creek kept level, relatively stable. Shore unchanged.
	Species	6	11	+5	
Moore (Crane)	Birds	125	48	–77	Minor increase in residences and recreation development. Level relatively stable. Lake/shore values relatively stable.
	Species	13	8	–5	
Moose	Birds	1859	2620	+761	More agriculture, residences nearby, activities on lake. 1+ m drop, lake and shore values relatively stable.
	Species	25	33	+8	
Muriel	Birds	1216	4054	+2838	More agricultural clearing nearby, residences on lake. 3+ m drop. New islands (large gull and cormorant nesting colony), big sand and gravel beaches.
	Species	27	30	+3	
Osborne	Birds	896	105	–791	Minor habitat change nearby. Level dropped. Lake in 2 parts with dense emergents. Relatively low shore values.
	Species	10	7	–3	
Reita	Birds	462	3177	+2715	Minor habitat change nearby. Grazing impacts. 3+ m drop. Lake 2/3 full size. New islets, grass/forb shore.
	Species	17	29	+12	
Sinking	Birds	11306	2039	–9267	Minor habitat change nearby; tree removal. Lake consists of a few isolated ponds, still with significant values.
	Species	22	11	–11	
Tucker	Birds	287	81	–206	No habitat changes. Stable level. Low-quality shore. Many birds thought foraging/molting but not breeding.
	Species	14	12	–2	
Wolf *	Birds		302		Minor habitat changes nearby; increased boating. Stable level. Diverse, productive shoreline.
	Species		20		

* *The 1980-82 raw data for Cold and Wolf lakes could not be located.*

7.4.2 Changes in Number of Bird Species and Individuals

By 2003, the total number of summer birds present had declined by 49% in the 26 lakes that were fully inventoried (Table 7-2).

Table 7-2. Changes in numbers between 1980-82 and 2003.

1980-1982	9 shallow, marsh-like lakes	83% of total birds counted
	17 larger, deeper lakes	17% of total birds counted
2003	9 shallow, marsh-like lakes	43% of total birds (bird numbers decreased by 74% from the 1980-82 survey)
	17 larger, deeper lakes	57% of total birds (bird numbers increased by 78% from the 1980-82 survey)

Of the 49 species of birds surveyed during the two time periods, changes in the presence and abundance of 9 species varied in a manner that reflected changes over a much broader area, rather than those occurring at the more narrow level of the basin. In broad terms, over a period of years across the prairie pothole region and nearby areas, the numbers have increased for the following:

- Gadwall
- Eared Grebe
- Franklin's Gull
- White Pelican
- Double-crested Cormorant
- Canada Goose.

The CLBR Basin surveys strongly reflected the same trends. In addition, steady decreases in numbers have been recorded for several years across the prairie pothole region and nearby areas for:

- Lesser Scaup
- American Coot
- White-winged Scoter.

The CLBR Basin survey results strongly mirrored these trends as well.

For the other 40 species, the changes in presence and abundance at a particular lake corresponded closely with the recorded or observed change in the lake's level and/or habitat. In most cases, when a lake level remained stable or nearly so, the near-shore habitat remained the same from one survey to the next, and the species and abundance of the birds was roughly the same in the two surveys.

At lakes with greatly reduced water levels, there were two quite different results:

1. The original habitat was mostly missing or markedly degraded, and bird species and numbers were much reduced, or
2. The lower lake level provided new shallows, resulting in new or greater amounts of emergent vegetation with its attendant foraging and nesting opportunities, and/or new islands with safe nesting opportunities.

In cases where the amount of precipitation and size and make-up of the watershed protected the lake from change, the numbers of birds remained roughly stable. Where lake levels dropped, the result could either be disastrous or beneficial for birds, seeming to depend on the lake-bottom material, water depth, rapidity of lake level decline, and likely other factors.

Of the 28 lakes surveyed in 2003, the water level was slightly to dramatically (>2.5 m) below the normal high-water mark at 26 of the lakes. The birds' responses showed these drought-caused lower lake levels were the primary reason for changes detected in birds. Although the 2003 survey found local situations where emergent vegetation or shoreline vegetation had been badly damaged or removed by humans or livestock, in no case was the degraded habitat so extensive that 2003 totals for a lake would have been markedly affected.

7.5 Key Points

1. The comparison of bird and lake habitat surveys from 1980-1982 and 2003 on 28 lakes shows a number of changes, primarily due to long-term drought.
   - Between the early 1980s and 2003, the surveyed lakes lost almost 50% of their birds, with small, marshy lakes losing the most.
   - Forty of the 49 lake-based bird species that were surveyed varied in abundance, largely paralleling the changes in lake levels and/or lake habitat. The other nine lake-based bird species varied in abundance in close accordance with the broad regional trends of increase or decline, apparently unrelated to changes occurring in the CLBR Basin.
2. Development on or near lakeshores, such as removing emergent vegetation, manicuring beaches, building subdivisions, removing forested areas and creating pasture or cropland adjacent to lakes, had severe local impacts on certain species on specific lakes. This was not widespread in the CLBR Basin. Changes caused by these developments on local birds could not be detected by this survey method, especially in view of the major changes caused by the drought.
3. Lakes with the most stable levels were generally located in the Boreal Mixedwood Natural Region, and they had mostly forested catchment basins. The lakes with levels showing the greatest decline were in the transitional Parkland Natural Region and were shallow, marshy lakes—some seriously degraded, some almost gone.
   - Even when mostly or totally dry, these lakes or dry lakebeds should be protected from damage to ensure their potential for wildlife habitat is retained for when water levels return.
   - On lakes with moderately or severely reduced levels, beavers and muskrats declined in number or disappeared during the 20-year period between surveys.
   - Muskrats disappeared when the shallows dried up, thereby eliminating their aquatic vegetation food supply and their hiding and transportation medium.
   - Beavers declined as the receding lakeshore and shallows (containing their lodges) became too distant from their food source (willow and aspen trees) on the upland.
4. The amount of decline in lake levels depends in part on the location (boreal areas likely receive more precipitation than parkland), and the ratio of the surface area of the lake to the size of the catchment basin. An additional possible factor is the degree to which the catchment basin has been altered by clearing forests, urbanization, drainage and cultivation of crops, which can result in increased soil temperatures, runoff and evaporation. (This concern merits further investigation, especially if the drought persists and the current land use practices expand or intensify.)
5. Some larger, deeper lakes provided more diverse waterbird habitat as their water levels declined. Overall, there were more species and individuals than at high-water levels.
   - In 2003, they accommodated not only the species that preferred deeper, open water (e.g., loons, diving ducks), but also some species that preferred the new shallow, marshy margins and bays (e.g., dabbling ducks, blackbirds, shorebirds, herons).
   - Also accommodated were species that preferred the newly exposed gravel and mud bars (e.g., plovers, Avocets) and islands (e.g., nesting ducks, gulls and cormorants).
6. Some of the shallow, marshy lakes in the CLBR Basin were extremely productive for birds when water levels were high, and are still moderately productive when water levels are low.

7. The lake-based wildlife, especially the birds, are visible, interesting, and valuable parts of the CLBR Basin's ecosystems and are useful monitors of changes in the environment. Even the drought-reduced populations of water-based birds in the CLBR Basin provide public enjoyment and are attractive elements for education, recreation, and tourism.

SECTION 8. RECREATION ASSESSMENT

8.1 INTRODUCTION

A study was commissioned by Alberta Environment to update the recreation component of the 1985 Cold Lake–Beaver River Water Management Plan. The 1983 recreation study evaluated the demand associated with water-based facilities and activities on lakes and streams within the CLBR area (Marshall Macklin Monaghan Western Limited 1983). The current study focused on possible correlations between changes in water levels from 1983 to 2003, and changes in the recreation facility development and activities on the lakes and streams within the basin.

The boundaries of the current study area were expanded from those of the 1983 study. As a result Angling Lake and Reita Lake, which were included in the 1983 study, but were not within the mandated area, are officially in the current study area. In addition, Moore (Crane) Lake, which was within the study area in 1983 but not included in the study research, has been included in this study, thereby increasing the number of lakes to 14.

The current study found no specific evidence that increased industrial activity in the area had a significant impact on recreational activities and use of the lakes and streams in the study area. Owing to a number of years with low precipitation, most of the lakes have experienced considerable annual fluctuations in water levels with many experiencing an overall decrease in lake levels during the past two decades.

8.2 RECREATION ACTIVITIES IN STUDY AREA

The CLBR Basin and surrounding area has the highest concentration of recreational lakes and high-quality beaches in Alberta. Water-based recreation development in the CLBR area is centered along lake shorelines. Several changes in the number, type, jurisdiction and distribution of public, private, and commercial facility development in the study area have occurred since 1983.

Water-based and land-based activities that were popular in 1983 (swimming, fishing, power-boating, water skiing, canoeing, sailing, camping, picnicking, nature study, general relaxation) remain popular today. These activities have been joined by several other recreational activities over the past 20 years (sea-doos, wake boards, mountain bikes and all-terrain vehicles [ATVs], especially quads.) Winter recreation in the study area continues to be minimal compared to summer activities. Ice fishing, snowmobiling and cross-country skiing remain the region’s predominant winter activities. A comparison of changes in four of the main recreation activities in the basin area is provided in Table 8-1.

Table 8-1. CLBR Basin area recreation activity comparison 1983-1999 (percentage of visitors).

Recreation Activities	1983	1999
Swimming	30	30
Fishing	24	29
Boating/Water Skiing	19	14
Picnicking	8	31

8.2.1 Methods

Lakes included in this study were divided into major, secondary and minor recreation lakes (Table 8-2). The categories were defined as follows:

- Major recreation lakes had at least two of the following four types of recreational developments, and generated in excess of 30,000 user days per year:
  - public facilities (provincial, municipal),
  - private facilities (cottages),
  - institutional development, or
  - commercial development (resorts campground, boat rentals, etc.).
- Secondary recreation lakes may have had one or more of the above four types of recreation development; however, the scale of the facilities and the location, size and appearance generated less than 30,000 user days per year.
- Minor recreation lakes had almost no public, private or commercial developments. Their location made them less accessible and as a result, their user activity was relatively low.
- Inaccessible lakes were located within the Primrose Air Weapons Range. They had no public road access and were not used recreationally at the time of this study.

Table 8-2. Classification of recreational lakes.

Major Recreation Lakes	Cold Lake Ethel Lake Marie Lake Moore (Crane) Lake Moose Lake Muriel Lake
Secondary Recreation Lakes	Angling Lake Manatokan Lake Wolf Lake
Minor Recreation Lakes	May Lake Reita Lake Tucker Lake
Inaccessible Lakes	Burnt Lake Caribou Lake

Provincial Facilities

All provincial sites in the study area are operated by Alberta Community Development (ACD). A number of the Provincial Recreation Areas (PRAs) that existed in 1983 have been closed and/or sold or leased to municipalities, recreation associations or private operators. There are currently 12 camping sites owned by the provincial government on 7 lakes within the study area. Of the 12 sites, 7 are operated ACD, 1 site has been closed (Muriel Lake), and the remainder are either leased to private operators (Crane Lake East and West and Ethel Lake) or have been decommissioned and turned over to the municipalities. These sites provide a total of approximately 530 campsites, an increase of 130 over 1983 figures.

There are two provincial parks within the study area: Moose Lake and Cold Lake Provincial Parks. The number of campsites at these two parks remains unchanged from 1983 (59 for Moose Lake and 117 for Cold Lake).

Municipal Facilities

There are currently six municipal-owned recreation sites in the study area. These are operated by the M.D. of Bonnyville (5 campgrounds) and the City of Cold Lake (1 day use area). The sites owned and operated by the M.D. of Bonnyville provide a total of 209 campsites, an increase of 109 over the number in 1983.

8.3 LAKE RECREATION DESCRIPTIONS

Note: The reader is directed to <u>Section B-1. Fish and Fish Habitat</u> for information on the lakes and their fisheries.

Angling Lake

Angling Lake is located adjacent to Highway #897 about 20 km south of Highway #28. It is an oval-shaped lake, and rather small in relation to most lakes in the study area. Shoreline encroachment by agricultural and oil well development has left a noticeable impact on the lake.

Recreation

The Provincial Recreation Area on the east side of the lake was decommissioned in 1992 and turned over to the Beaverdam Recreation Society. The Hamlet of Beaverdam (east side of the lake) has the only private developments (residential homes) on Angling Lake. There are three registered plans (certificates of title) located on the north, west and southwest shorelines of the lake.

Campsite and Day Use

The recreation site is used mainly by anglers who enter the lake using the boat launch, and receives low-to-moderate use. Lack of facilities, poor access (gravel road) and poor water quality later in the summer limit recreational use of the lake. Most camping, fishing and swimming occurs earlier in the summer.

Water Level Assessment

An ideal water level of 557.1 m was noted in the 1983 study. Depth gradients increase gradually along most shore areas; therefore, decreases in water level quickly expose large areas of lake bottom. The 1983 study concluded that water levels between approximately 556.88 m and 557.38 m were optimal, allowing maximum enjoyment of boating and fishing. Water levels of 1.0 m above mean would result in flooding, thereby deteriorating the recreational value of the lake. A drop in water level of 0.5 m or greater was predicted to cause a noticeable loss of lake surface area and have a negative impact on fish.

Since 1988, the water level at Angling Lake has regularly been below the range prescribed in the 1983 study. Mean water levels are ~556.87, approximately 20 cm below the mean level noted in the 1983 document. Current recreational use of the lake could be further compromised by continued lower water levels, especially along the lake's eastern shore where recreational facilities exist.

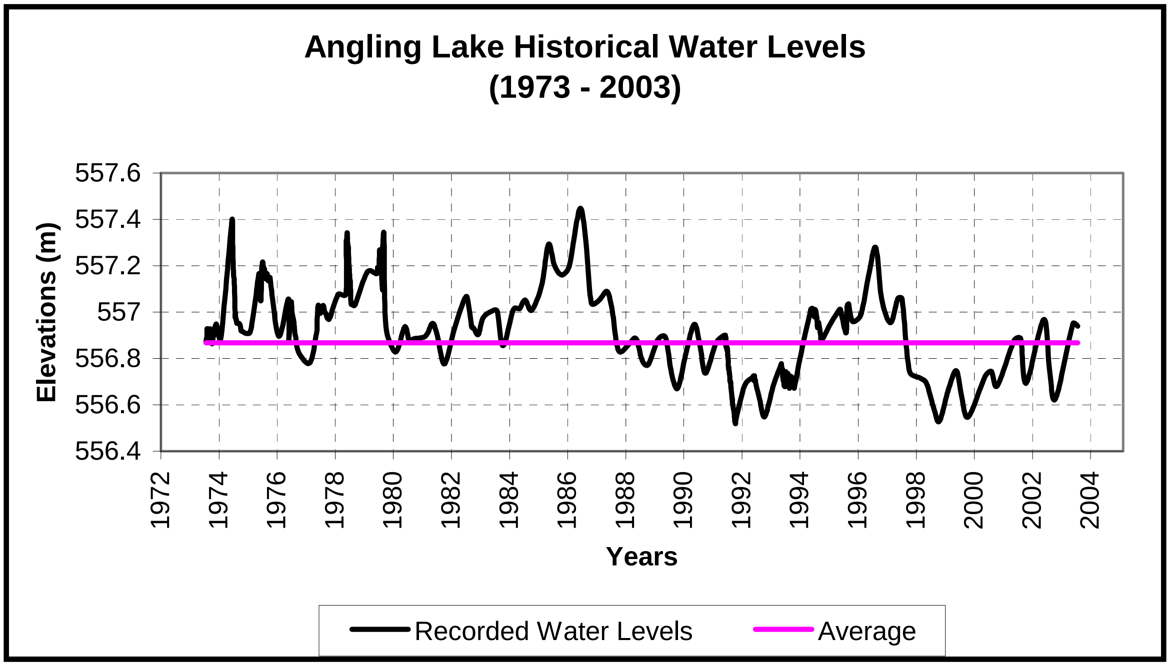


Figure 8-1. Historical water levels, Angling Lake.

Cold Lake

Cold Lake is the seventh largest lake in Alberta. Although the lake has experienced considerable recreation use for several decades, primarily along the shoreline lying within the current limits of the City of Cold Lake, much of the lake's shoreline remains mostly undisturbed. Because of its size and depth, Cold Lake is one of the clearest lakes in the region.

Recreation

There are currently five public recreation facilities on the Alberta side of Cold Lake, three of which are owned and operated by the provincial government: Cold Lake Provincial Park, English Bay Provincial Recreation Area (PRA) and French Bay PRA. The fourth public facility is the Cold Lake M.D. Campground, owned and operated by the M.D. of Bonnyville. Kinosoo Beach, a day use only facility owned by the City of Cold Lake, constitutes the fifth public facility. Recreational activities are similar at each site and include camping, canoeing/kayaking, fishing, power boating, sailing, swimming, water-skiing/wake boarding, sailing, windsurfing and swimming.

The four public camping facilities provide a total of 233 campsites, and group campsites are also available. Cold Lake Provincial Park is the largest public facility within the study area. In addition to the activities common to each site, other popular activities at the provincial park include birding, cross-country skiing, ice fishing, wildlife and scenic viewing, and volleyball.

There are a number of commercial developments that focus on the recreational opportunities provided by the lake. Six bed and breakfast facilities along Lakeshore Drive, directly across from Cold Lake, cater to recreation and tourism traffic. Information provided by the M.D. of Bonnyville indicates there are three registered subdivisions on Cold Lake. The two available subdivision plans showed a total of 70 cottage lots.

English Bay PRA

English Bay PRA showed a gradual, steady growth in camping activity (585 nights) from 1987-1993, and then levelled off for two years. This was followed by two years of decline (581 nights), with an increase of 419 activity nights in 1998 and levelling off again in 1999. No data were submitted for 2000 and 2001.

Day use activity from 1987-1999 fluctuated between a low in 1989 (2855 visits) to a high in 1995 (3775 visits). Otherwise, day use activity was more consistent, ranging from 3175 visits to 3625 visits.

French Bay PRA

Camping at French Bay PRA was relatively stable from 1987-1995, fluctuating between a low in 1990 (313 campsite nights) to a high in 1994 (500 campsite nights). This was followed by an increase of 207 campsite nights in 1996, and then a decline of 428 nights from 1998-2000.

Day use activity increased from 955 party visits in 1988 to 5,475 visits in 1991. This was followed by a period of steady decline from 1991-1995, with visits decreasing by 1,275. There was a slight increase of 225 visits in 1996. No data were available for 1997 and 1998. The total number of visits for 1999 was 4,442.

Cold Lake Provincial Park

The number of campsite nights declined from 1987 (2,508 nights) to 1992 (1,863). Although the pattern fluctuated from year to year, there was a significant increase of 1,344 nights between 1992-2001, with an overall increase of 694 nights from 1987-2001.

Day use activity showed a similar pattern, declining from 20,225 in 1987 to 10,050 in 1992. This was followed by a steady slow growth of 790 visits from 1992-1999. Over the 12-year period, there was an overall decline of 5,385 day use visits. The lowest number of campsite and day use visits (1992) coincided with the opening of Lakeland PRA, which may have influenced visitor numbers.

Commercial Facilities

The Cold Lake Marina is the largest inland marina in western Canada. It contains 250 slips, providing a well-protected and secure permanent home for 25 sailboats as well as 30 cabin cruisers with an average mean length of 20-21 ft. Operations include a café run in conjunction with the marina. According to Marina management, there has been a significant improvement in the quality of fishing over the past two years.

Water Level Assessment

Decreases in water levels at Cold Lake negatively affect recreational activities, particularly boating, fishing and wildlife viewing. The 1983 study indicated that a rise in water levels greater than 0.2 m, or a drop below mean levels, would adversely affect shoreline developments and lake fisheries. A decrease of even 0.2 m was predicted to adversely affect the Provincial Park environmental interpretation areas and have severe impacts on the following:

- boating in Long Bay,
- ability of fish to spawn and develop, and
- shoreline aesthetics.

The water level at Cold Lake has generally been below the ideal mean level. However, recreation on the lake has not been affected to the degree predicted. Instead, the number of recreational opportunities on the lake has increased as population-driven demands have resulted in new projects, such as the Cold Lake Marina, making lake access more convenient.

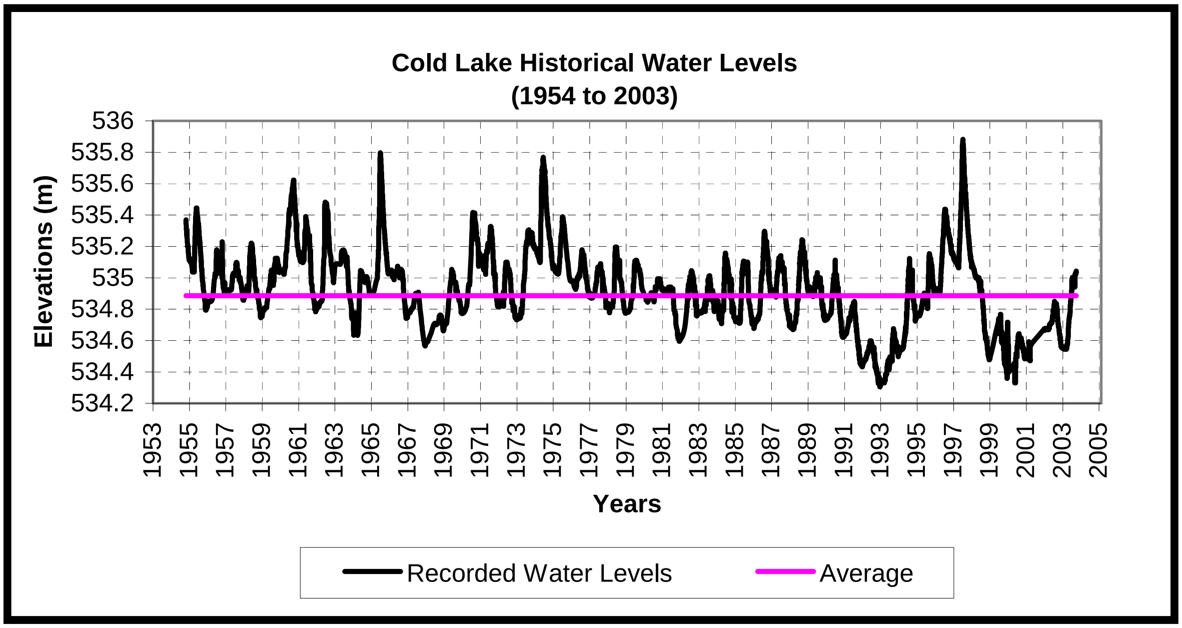


Figure 8-2. Historical water levels, Cold Lake.

Ethel Lake

Ethel Lake is a small, irregularly shaped waterbody with a surface area of 467 ha. The shoreline areas are surrounded by mixedwood forests, and consist of four bays with the southwest bay reaching a maximum depth of 30 m.

Recreation

In 1983, there were three developed campground facilities with boat launches; however, confirmation of ownership and use could not be obtained at the time of this study. The provincial PRA site currently consists of 12 serviced campsites, fire pits, a water pump, a camp kitchen, a swimming area and a boat launch.

Private recreation development consists of three to four cottage lots and six private residences.

The main recreation activities at the PRA are canoeing/kayaking, fishing, power boating, swimming and windsurfing.

Water Level Assessment

In 1983, it was calculated that water levels on the lake would remain acceptable from a recreational standpoint within +/- 0.2 m of the historical mean. The 1983 report also noted that a drop in water levels of 0.5 m would have the following impacts:

- negatively affect boating by substantially increasing shallow areas,
- lead to extensive loss of fish spawning habitat, and
- significantly degrade the aesthetic quality of the lake shoreline.

At the -1.0 m level, access to the southeast bay would become difficult and extensive mudflats would plague the southeast shoreline and the area between the west shore bays. Water levels 0.5 m to 1.0 m above the mean were expected to result in extensive flooding in the southeastern corner of the lake, adversely affecting private recreation areas.

The water level at Ethel Lake has generally been above the acceptable range. Since 1980, the mean water level has been slightly above the 541 m level, an increase of approximately 20 cm from the mean level noted in 1983. During several years, water levels surged above the 541.3 m level, leading to flooding in the southeastern corner of the lake and adversely affecting private recreation areas. Recently the lake has returned to more optimal recreational use levels.

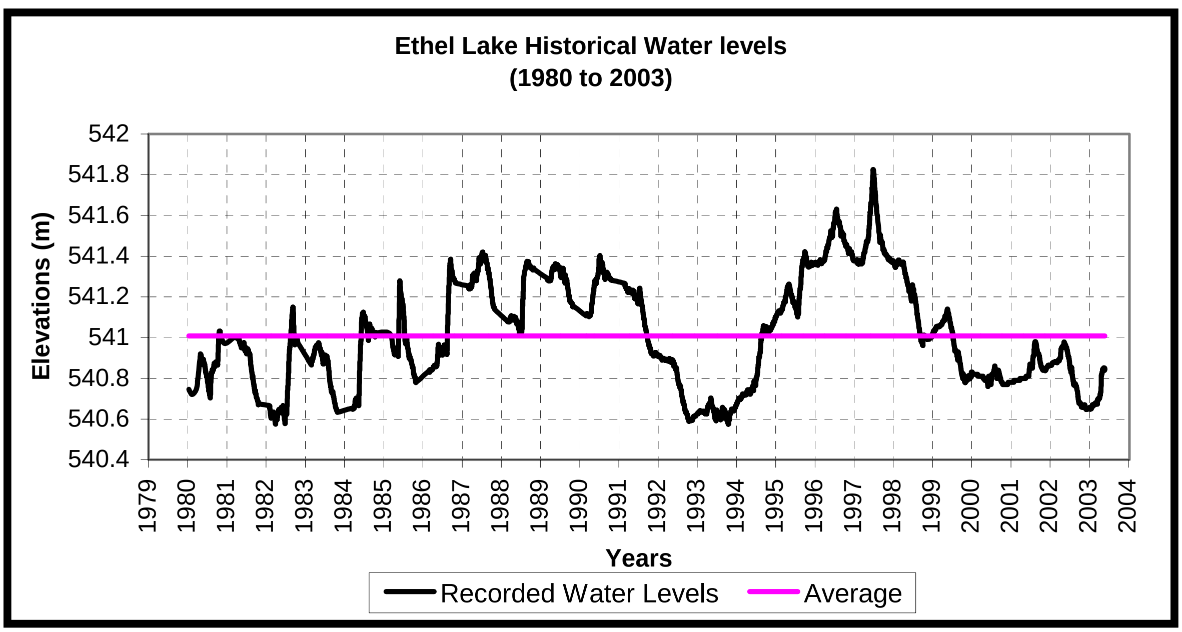


Figure 8-3. Historical water levels, Ethel Lake.

Manatokan Lake

Manatokan Lake is located about 12 km west of La Corey and 4 km north of Highway #55. It is a small, eutrophic lake with two distinct bays and a total surface area of 438 ha. The western bay is the deepest part of the lake with a maximum depth of approximate 6.7 m. The eastern bay is quite shallow and it dried up in 2003. There is considerable agricultural activity in the lake's watershed area.

Recreation

Only one recreational site (campground, boat launch, beach area) remains on Manatokan Lake, and is located on the northeastern shore of the lake's western bay. The site was decommissioned by the province in 1992 and turned over to the M.D. of Bonnyville. Bonanza Beach, a small commercial resort, was closed several years ago. A subdivision (29 lots) was approved after the 1983 report, but did not proceed. No other development has been undertaken on the land.

Water Level Assessment

An ideal water level of 555.5 m was noted in the 1983 study. Because the lake is quite shallow and depth gradients increase gradually, particularly along the south and southwestern shores, small drops in water level would expose large areas of lake bottom and significantly decrease the lake's surface area. A decrease in surface area would affect boating and shoreline recreation at the lake's only remaining campground on the northeast shore of the lake's western bay.

The 1983 study calculated that water levels ranging from the historic mean of 555.29 m to 555.79 m would be ideal from a recreational standpoint, allowing for excellent fishing and swimming. The report also noted that a drop in water levels of 0.2 m would negatively impact the fisheries and lake surface area, and levels 0.5 m or more above the mean would lead to extensive flooding and a deterioration in water clarity and quality.

Water levels at Manatokan Lake have been basically decreasing since 1980. Mean water levels from 1974-2002 are ~555.11, approximately 40 cm below the mean noted in the 1983 study. As of 2002, water levels were approximately 1 m below the acceptable range suggested in the earlier study. Rippin (2004) noted the lake's shallow eastern bay was dry in 2003, and therefore recreation was not possible.

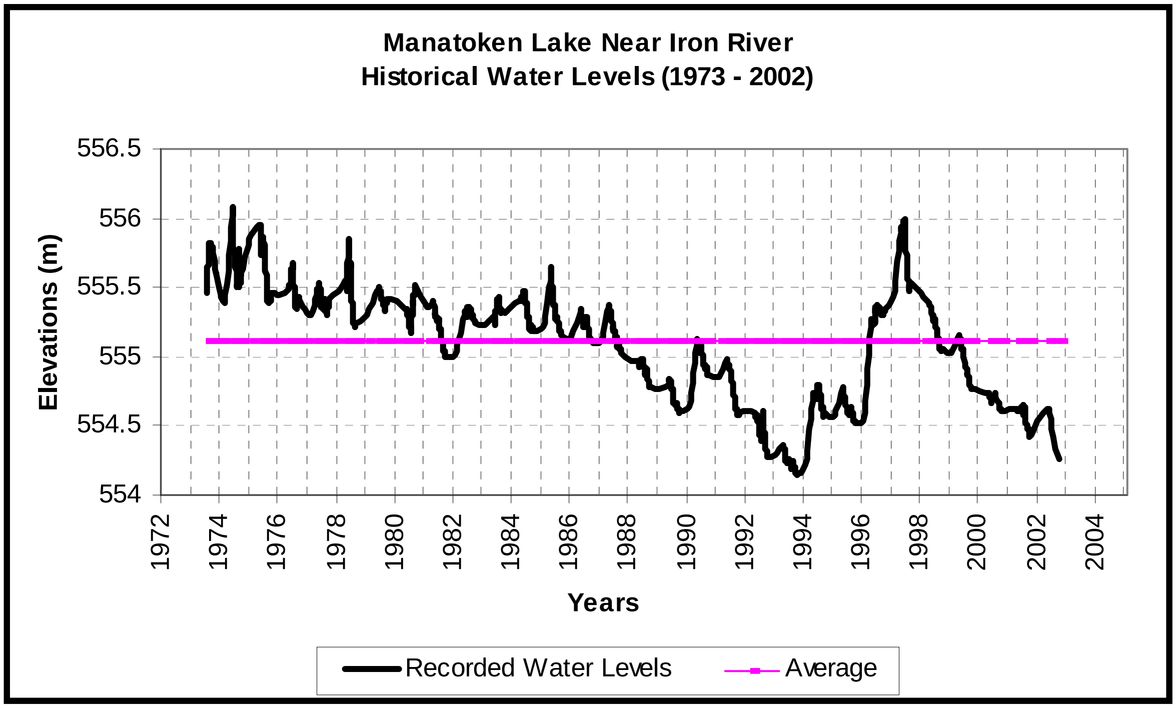


Figure 8-4. Historical water levels, Manatoken Lake.

Marie Lake

Marie Lake is a large, relatively pristine mesotrophic lake with a surface area of 3460 ha. The lake has a shoreline length of 29 km. It is located in a mixedwood forest area 26 km north of the City of Cold Lake along Highway # 897, immediately west of the English Bay PRA. The lake is quite deep with a mean depth of 14 m and a maximum depth of 26 m. It has good beaches and very clear water with little algae growth

Recreation

Marie Lake remains largely undeveloped compared to most major recreation lakes in the study area. There are currently only three recreation developments and one commercial development on the lake:

- a cottage subdivision on the east side of the lake,
- Shelter Bay Resort (established in 1989 on the north shore), and
- a private campground on the former Canadian Forces campground along the southeast shoreline, now leased and operated by the Marie Lake Camping Society since 1999 (private campground reserved almost exclusively for members).

There are no publicly owned recreation sites on Marie Lake. Camping occurs at Shelter Bay Resort and the Marie Lake Camping Society locations, with designated day use sites at the Shelter Bay Resort. The two privately owned campgrounds currently offer 205 campsites, an increase of 65 since 1983.

Commercial Facilities

Shelter Bay resort has 100 campsites, 5 cabins, a day use group area, a beach and a swimming pool as well as access to trails for hiking, biking and ATVs. Recreation activities at the resort include swimming, fishing and boating.

Water Level Assessment

A historic mean water level of 573.52 m for Marie Lake was noted in the 1983 study. With the exception of extended shallow areas on the east and southwest shores of the lake, depth gradients are quite steep along most of the lake's shoreline. Somewhat severe conditions would therefore be needed for the lake to register a noticeable drop in water levels. Decreases in water level would, however, quickly expose the lake bottom along the southwest and eastern shores, diminishing the recreational value of the lake for people with cabins on the eastern shore and users of the Marie Lake Camping Society campground along the southwestern shore.

The 1983 study calculated that water levels on the lake would remain acceptable from a recreational standpoint within +/-0.2 m of the historical mean. However, the report noted that a drop in water levels of 0.5 m to 1.0 m would leave boat ramps and boat docks unusable and substantially increase the distance from cottages to the lakes shoreline, thereby affecting recreational use.

Apart from a dip between 1992 and 1994, water levels at Marie Lake have (since 1980) generally stayed within the acceptable limits suggested in the 1983 study. This would suggest that recreational activities on Marie Lake have not been adversely affected by water levels.

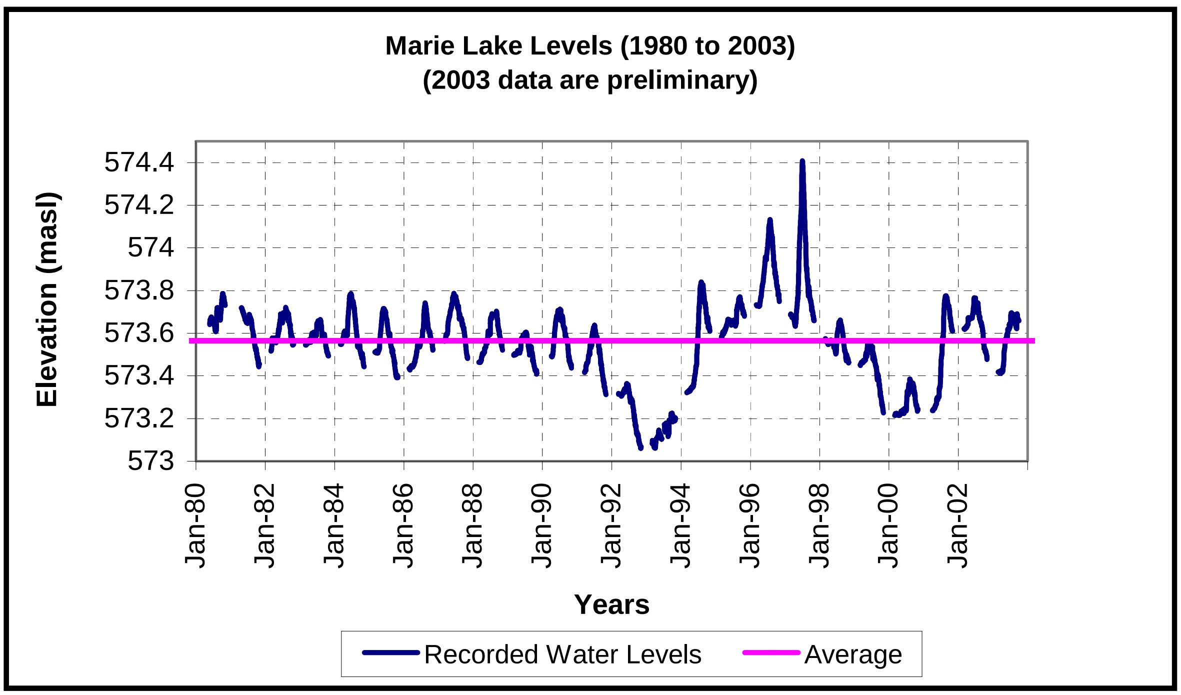


Figure 8-5. Historical water levels, Marie Lake.

May Lake

May Lake is a small, mesotrophic waterbody with a surface area of approximately 301 ha and a maximum depth of 14.5 m. It is located north of Marie Lake on Marie Creek, just south of the

Cold Lake Air Weapons Range. The only access to the lake is by floatplane or a rough trail accessible by 4-wheel drive vehicles.

Recreation

The 1983 study indicated the lake had potential for recreational development. There is no indication that any recreational activity other than informal camping and fishing is occurring at the lake currently. There are also no commercial facilities or cottage developments present.

Water Level Assessment

A historic mean water level of 94.49 m for May Lake was noted in the 1983 study. Depth gradients are fairly steep for all but the south area of the lake, helping to buffer the lake somewhat from a drop in water levels. A decrease in water levels would quickly expose lake bottom areas along the southern shore.

The 1983 study noted that any deviation in water level would negatively affect fishing, the lake's primary draw. As there are no private or commercial developments on May Lake at this time, the quality of fishing is key to the lake's recreational use. (No additional water level data were available for May Lake at this time.)

Moore (Crane) Lake

Moore Lake is a medium-sized lake with a surface area of 994 ha, located 25 km west of Cold Lake along Highway #55 then north on Range Road #444. It was not included in the 1983 study. The lake has a high backshore and is surrounded by mixedwood forest, providing a relatively pristine environment for lake users. The eastern portion is quite deep with a maximum depth of 25.9 m while the western section is shallower, having a maximum depth of 15 m.

Recreation

There are two small PRAs (Crane Lake West and Crane Lake East) owned by Alberta Community Development that are privately managed by the owner of Bodina Resort, which is also on Moore Lake. One other commercial development, Happy Hollow, and a private cottage and permanent residential development are also located on the lake. Combined, the two PRAs have 52 campsites. Bodina Resort has 6 cabins and 100 campsites, while Happy Hollow has 25 campsites and 9 cabins. There are also 4 registered cottage sub-divisions consisting of 184 lots on the lake.

Major recreational activities on the lake include fishing, boating/seadooing, water skiing/wake boarding and swimming.

Campsite and Day Use

Campsite use in Crane Lake West was stable from 1987-1992 (averaging 1,000 nights), followed by a period of steady growth to 1,340 campsite nights in 1996. Levels then declined to 1,252 nights in 1999.

Crane Lake East averaged 900 nights between 1987 and 1990, followed by a gradual increase to 1,085 nights in 1992. Over the next few years, the use levels rose and fell slightly, varying from a low of 1,120 nights (1996) to a high of 1,245 nights (1997).

Day use visits at both sites increased significantly from 1987 to 1992. From 1992-1997, Crane Lake West gradually increased to a high of 8,950 visits before declining to 7,925 in 1999. Crane Lake East also experienced an increase in visits during the same period, reaching a high of 9,325 visits in 1997 before decreasing to 6,788 in 1998 and remaining at that level through 1999.

Commercial Facilities

Bodina Resort experienced a high level of visits in 2002, ranging between 8,000-10,000 people. The 2004 season promised to be successful as well, with 40% of the cabins already reserved by mid February.

Happy Hollow Resort has also experienced a high demand, with the facility operating at full or near capacity (200-300 people) most of the time between May and September. Approximately 90% of the visitors were from Alberta, with the same percentage being repeat visitors. Many cabins were rented for the summer to oilfield workers for their families. The demand for this type of rental has been great enough to make it necessary for management to limit the number of rentals to oilfield workers so as to meet the needs of other regular clients. The owner of Happy Hollow Resort is planning to retire in 2005 and may subdivide the resort property into cottage lots.

Water Level Assessment

Moore Lake gains depth quite steeply along most of its shoreline, with exceptions along the western shoreline and sections of the south and northeastern shores. Lake depth increases gradually from shorelines where Bodina Resort is located and along lakeside cabin developments on the west shore of the lake. Decreases in lake water levels will have a significant effect on access to and recreational use of the lake.

Aside from a major increase in water levels between 1993 and 1998, the levels have decreased somewhat. From a recreation view, this decrease is of concern since it will make access for lake activities more difficult as boat launches, piers and beaches become further from the water.

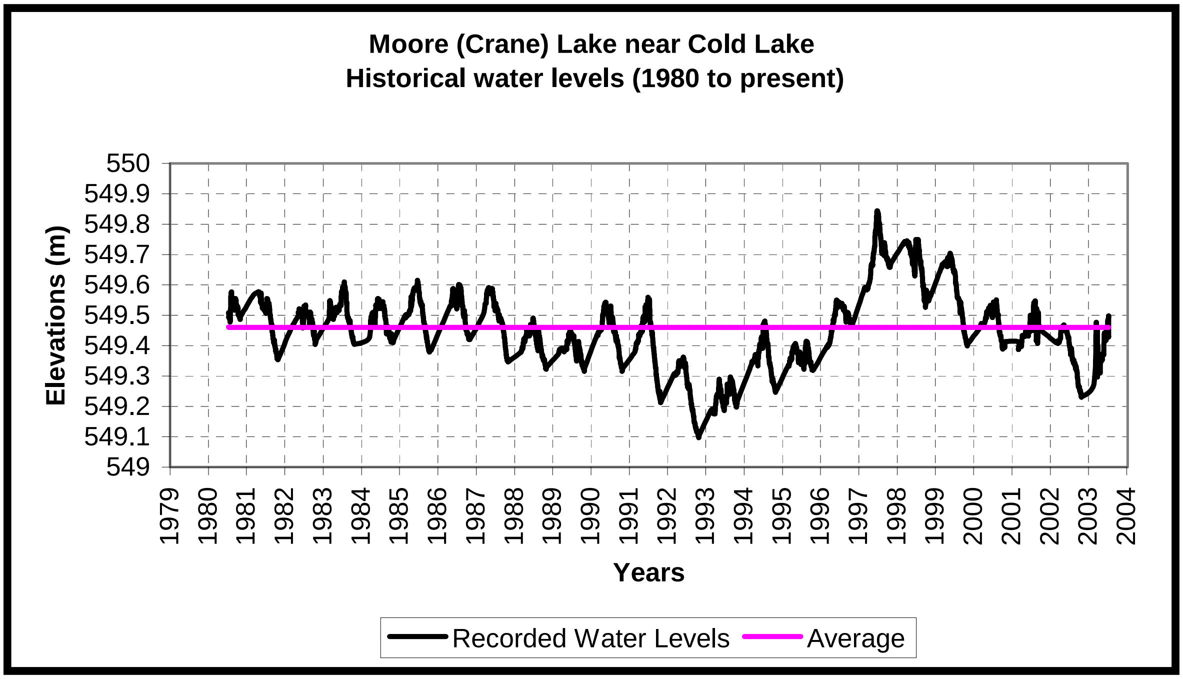


Figure 8-6. Historical water levels, Moore Lake.

Moose Lake

Moose Lake is a rather large lake located just west of the Town of Bonnyville, within the downstream end of the Moose Lake River drainage basin. The lake has a surface area of 4080 ha and a maximum depth of 19.8 m. This is the most developed lake in the study area. The lake has an irregularly shaped and diverse shoreline, providing excellent opportunities for recreation.

Recreation

Moose Lake has experienced continual growth in recreation facility development during the past several decades. At this time, approximately 75% of its shoreline has been developed for public camping and recreation use.

There are two provincial facilities on the lake—Moose Lake Provincial Park and Franchere Bay Provincial Recreation Area. The Provincial Park, owned by Community Development, is operated by Moose Lake Management Services and provides 59 individual campsites and 2 group campsites. The PRA provides 200 campsites. Recreation activities at these two sites include swimming, fishing, camping, group camping, canoeing/kayaking, hiking, power boating, water skiing/wake boarding, sailing and windsurfing.

Eastbourne, Vezeau Beach and Bonnyville Beach PRAs were decommissioned. The Eastbourne site has been reclaimed and is no longer used for recreation. Vezeau Beach PRA has been incorporated into the Bezeau Beach Park, which is operated as an RV park by a local club/association. Bonnyville Beach PRA is currently being used for trailer, boat storage and overflow parking for residents of the Summer Village of Bonnyville Beach.

Pelican Point MD Park is owned/operated by the M.D. of Bonnyville. It provides 40 campsites, a group camp and a day use area. Vezeau Beach Park, which is adjacent to the Bonnyville Golf and Country Club, provides 25 campsites and a day use area.

Moose Lake supports the most intensive cottage development in the study area. Almost all the northeast, east and part of the south shorelines have been developed for cottage use. There are two summer villages on the lake—the Summer Village of Bonnyville (78 lots with 68 developed) and the Summer Village of Pelican Narrows. There are also 15 additional registered cottage subdivisions on the lake with a total of 642 lots. Further back from the shoreline are a number of country residential subdivisions. Many cottages in existing cottage subdivisions (e.g., Sunset Beach) have been replaced by expensive homes.

Campsite and Day Use

Franchere Bay PRA showed a dramatic increase in the occupied campsite nights from 1987-1989, owing to a construction project that closed the campground for much of 1987. This was followed by a steady decline from 1990-1994, then several small decreases and increases from 1995-1998 and levelling off from 1998-1999. The boat launch was unusable during the 1994-1995 season, resulted in a steep decline in campsite usage between 1993-1994 and 1994-1995. Day use increased considerably from 1988-1990, followed by a drop in 1991 and an increase in 1992. A gradual, steady decline occurred from 1992-1997, levelling off in 1999.

Moose Lake Provincial Park campsite activity showed a gradual but steady decline from 2,424 campsite nights in 1987, to about 732 in 1992. This was followed by a period of considerable growth between 1992 and 1997 (732 nights to 1,680). The next year (1998) saw a decline and then numbers levelled off in 1999. Day use activity for the provincial park between 1987 and 1999 was extremely consistent.

Commercial Facilities

Of the five commercial developments on Moose Lake noted in the 1983 study, only one remains—Vezeau Beach RV Park, which is open yearly from May 1 through September 30. Occupancy rates were noted as being near 65% (approximately 7,160-8,350 annual visitors).

Water Level Assessment

Depth gradients along the vast majority of the lake are extremely gradual. The 1983 study concluded that any water level fluctuations would have tremendous impacts on the lake. A drop of 0.2 m from the mean level was predicted to leave silty bottoms exposed and have an adverse effect on dock usage, while a 0.5 m drop would render boat ramps and docks unusable, negatively impact fisheries, and make Island Bay recreationally unusable.

Lake levels have fluctuated significantly since 1980, with a general downtrend being noted. The mean water level for Moose Lake since 1951 is ~532.67 m, which is more than 40 cm below the mean noted in the 1983 report. When last recorded in 2003, water levels averaged 532.1 m, which is 1 m below the historic mean stated in the 1983 study. Moose Lake receives heavy recreational use and plays host to a large number of developments, and this drop in lake water levels has severely impacted the water-based recreational value of the lake. This is evidenced by the decline in number of commercial and public recreational facilities on the lake since 1983.

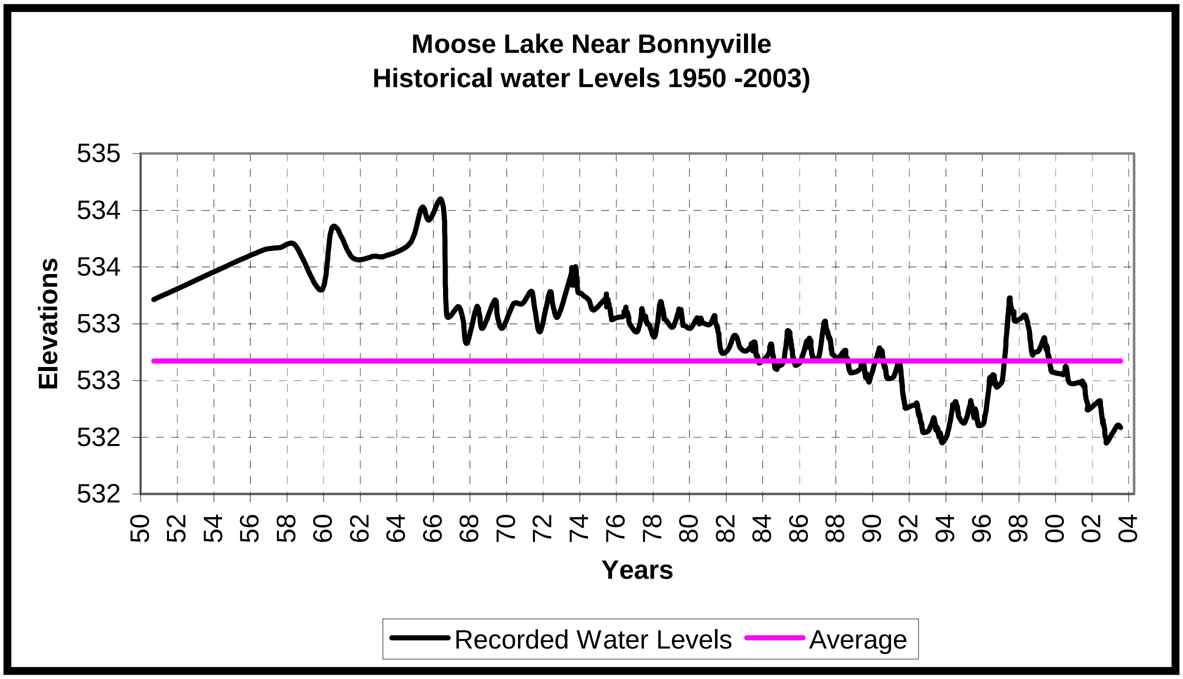


Figure 8-7. Historical water levels, Moose Lake.

Muriel Lake

Muriel Lake is a large, shallow lake located several kilometers south of the Town of Bonnyville. The lake has a surface area of 8,550 ha and a mean depth of 3.7 m. Although the lake was at one time surrounded by mixedwood forest, the area around the lake has experienced more than 40 years of agricultural, industrial (oil field) and recreational development. Recreation development has taken up almost half the shoreline. This development includes public campgrounds, commercial resorts and private developments (cottage subdivisions and permanent homes).

Recreation

Until 2003, two public campground facilities were located on the lake—Muriel Lake PRA and Muriel Lake M.D. Park. The PRA was closed in 2003 by Community Development owing to a gradual, significant drop in lake water levels, a decrease in campers using the facility, and ongoing vandalism. The M.D. Park provides 93 campsites and two group areas.

The 1983 study noted three commercial recreational facilities on Muriel Lake. Of these three, Kopala Beach Resorts no longer exists, Silver Beach Cover has cabin rentals, and Spring Beach Resort has 103 campsites and 3 cabins. Muriel Lake ranks second to Moose Lake in terms of private cottage development. There are 11 registered cottage subdivisions on the lake, providing a total of 399 lots.

Campsite and Day Use

The number of campsite nights at Muriel Lake PRA decreased by 220 between 1987 and 1988, and then remained somewhat stable for the next three years. It increased to the 1987 level of 909 nights, followed by a decline of 383 nights in 1992. This decline continued through 2003, at which time the site was closed. Day use visits increased from 140 visits in 1987 to 6,775 visits in 1991. It then dropped to 5,150 visits in 1992. No data are available after that time.

Water Level Assessment

A mean water level of 559.47 m was noted for Muriel Lake in the 1983 study. Because depth gradients in Muriel Lake are very gradual along most of its shoreline, changes in water level are immediately obvious. The 1983 study noted that while the lake could accommodate a slight increase in water levels, any decrease in water level would have a significant impact on recreation. A decrease of 0.2 m was predicted to leave silty bottom areas exposed, creating stretches of mud between beaches and the water. Mud flats and aquatic vegetation would be exposed on vast sections of the lake if levels decreased below -0.2 m mark.

Water levels have decreased substantially since 1980, dropping 3 m to 557 m in 2003. This was the most dramatic decrease of any lake in the study area, and has had a significant impact on recreational use of the lake.

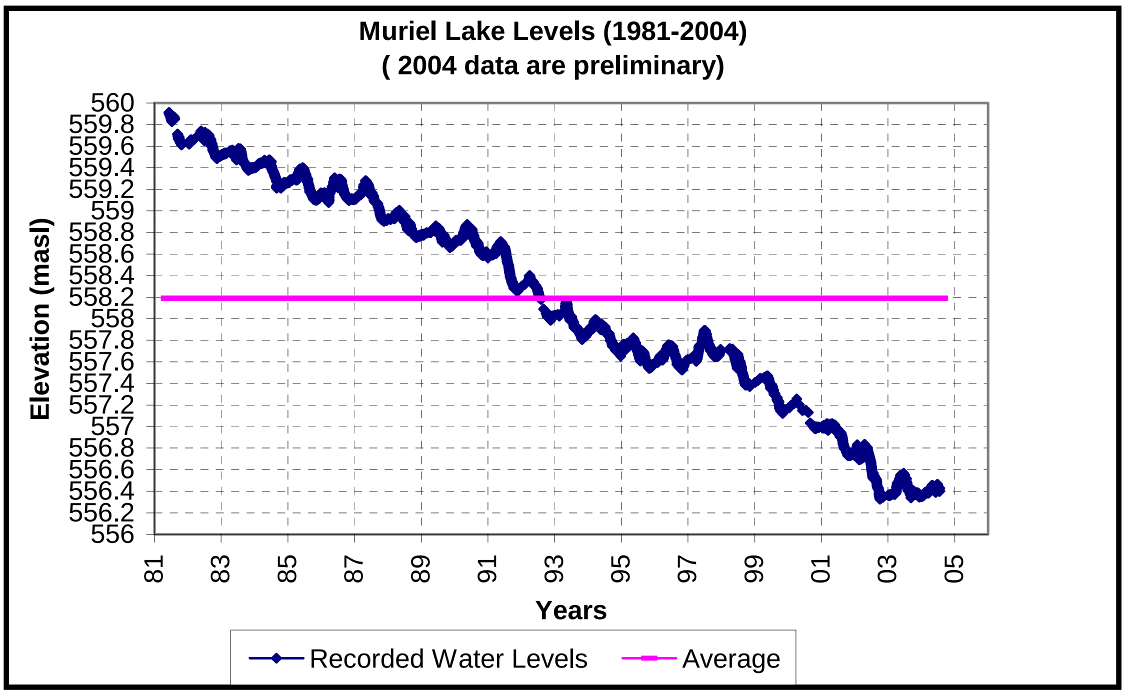


Figure 8-8. Historical water levels, Muriel Lake.

Reita Lake

Reita Lake is located east of Muriel Lake, immediately west of Highway #897 and 40 km southeast of Bonnyville. Agriculture, primarily in the form of cattle grazing, predominates around the lake. The lake itself is very shallow and atrophic, resulting in wide bands of emergent and submergent vegetation.

Recreation

There were no commercial facilities or private recreation developments on the Reita Lake at time of writing.

Water Level Assessment

Reita Lake is a very shallow lake with a maximum depth of approximately 3 m and high levels of emergent and submergent vegetation growth. Because of its shallow nature, any change in water level would significantly affect the lake. A drop in water level would be particularly detrimental, leaving vast areas of organic materials and silt exposed and severely affecting fish habitat.

The 1983 study suggested that a water level increase up to 0.2 m would be acceptable from a fisheries standpoint. The study also noted that in general, the lake is unsuitable for recreational use beyond waterfowl hunting. Water levels on Reita Lake were available only for 2001-2003. Lake levels have declined by more than 0.5 m since 2001.

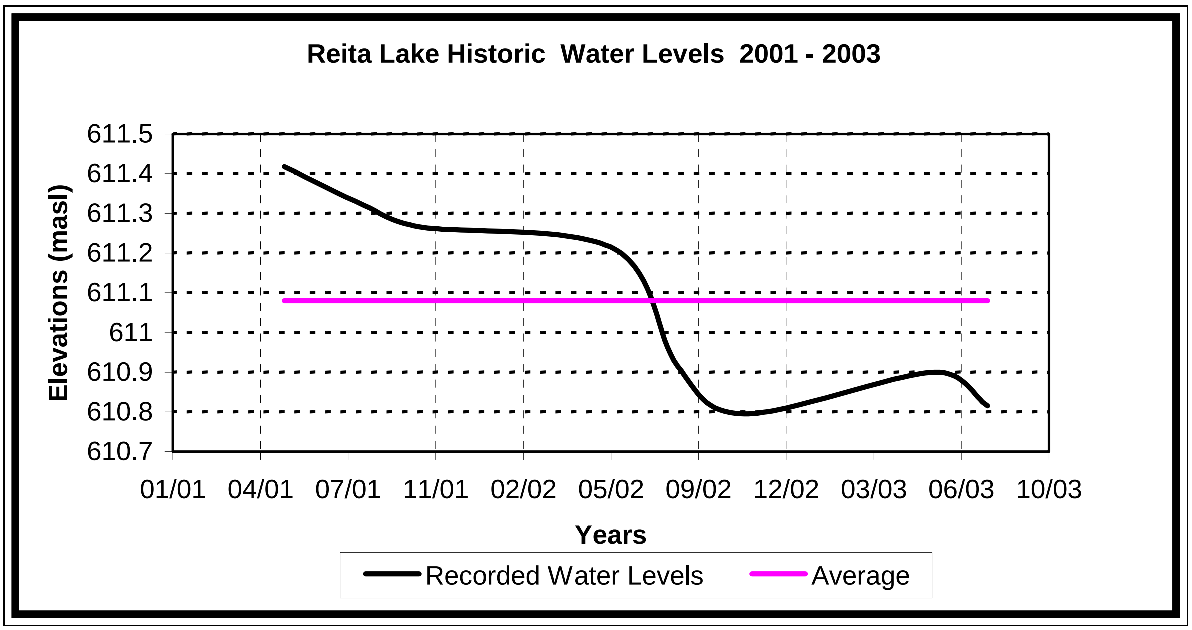


Figure 8-9. Historical water levels, Reita Lake.

Tucker Lake

Tucker Lake is small and shallow, with a surface area of 627 ha and an average depth of 4.3 m. It is located on Jackfish Creek, immediately west of Moore Lake, about 40 km northwest of the City of Cold Lake. The lake is situated in an area of gently rolling hills, covered with mixedwood forests of aspen and jackpine. Access to the lake is very poor, making the lake isolated.

Recreation

Although there are no developed recreation facilities on Tucker Lake, boats can be launched from the end of the access road. There is a small camping area by the lake, and recreational activities include boating, fishing and limited swimming.

Water Level Assessment

A historic mean water level of 553.74 m was noted in the 1983 study. Most of the lake is shallow, but depth gradients are fairly steep for all but the northeast and northwest areas of the lake. A drop in water levels would, therefore, expose lake bottom areas along the northeastern and northwestern shores and could create islands in the eastern section of the lake.

The 1983 study indicated that sportfishing, which is Tucker Lake's primary recreational attraction, would benefit from an ideal water level of 554 m with a range of 0.2 m to 0.5 m above the historic mean being acceptable. Any water level above 554.24 m or below the traditional mean was predicted to have a negative effect on sportfishing. A drop in water levels would expose lake bottom vegetation and negatively impact spawning areas.

According to Rippin (1993), water levels have dropped between 0.5-0.75 m from historic highs (approximate dates of between 1996 and 2003 were given) owing to the lack of precipitation. If this trend continues, fish habitat will be affected and recreational activity on the lake will decrease. Informal recreational activities will also continue to decline.

Wolf Lake

Wolf Lake is a large, relatively pristine waterbody in the west-central portion of the study area, surrounded by boreal mixedwood forests. The Wolf River enters and exits the lake in the northwest corner before flowing west for 8 km to the Sand River. This lake is U-shaped and contains three distinct basins that vary in depth from less than 6 m in the central basin to 15.5 m in the northwest basin. The deepest part of the lake is the long, narrow eastern basin that reaches a maximum depth of about 38.3 m. The lake has a surface area of 3150 ha.

The only road access to the lake is a 40 km access road off Highway #55 at a point 15 km west of Highway #42 and 20 km north of Bonnyville at La Corey.

Recreation

The only recreation facility on Wolf Lake is the Wolf Lake Provincial Recreation Area (43.52 ha) on the south shore of the central basin. It provides 65 campsites (an increase of 5 over 1983), as well as 2 km of hiking trails. Canoeing, kayaking, fishing, power boating and swimming are the most common recreational activities.

Campsite and Day Use

Campsite night statistics for Wolf Lake PRA showed that camping activity at Wolf Lake declined from 2,217 nights in 1995 to 1,448 in 1997, before rebounding to 1,868 in 1998 and 1999. (Additional camping statistics were not available for the PRA, nor were statistics for day use party visits.)

Water Level Assessment

An ideal water level of 597.5 m was noted in the 1983 study. Wolf Lake's shoreline gradients vary, with some areas receding gradually and other areas having steep drop-offs. The 1983 study noted the lake could accommodate a slight increase in water levels, but any decrease in water level would have an impact on recreation.

A water level of 0.2 m below historical means was predicted to have an impact on fisheries and boating. Further decreases would result in numerous shallow areas, leading to constrained boating, extensive loss of fish spawning and developing habitat, and a significant degradation of shoreline aesthetics. At a -1 m level, the passage between the lake's west arm and its main body would be too shallow to allow for motorboat navigation, rendering the area inaccessible by anything but canoes. Because fishing is a major recreation draw to the lake, changes in fish populations would have the largest effect on recreational use.

Water levels at Wolf Lake have fluctuated, but for the most part have remained within an acceptable +/- 0.2 m mean level, which is within limits that maximize recreational potential.

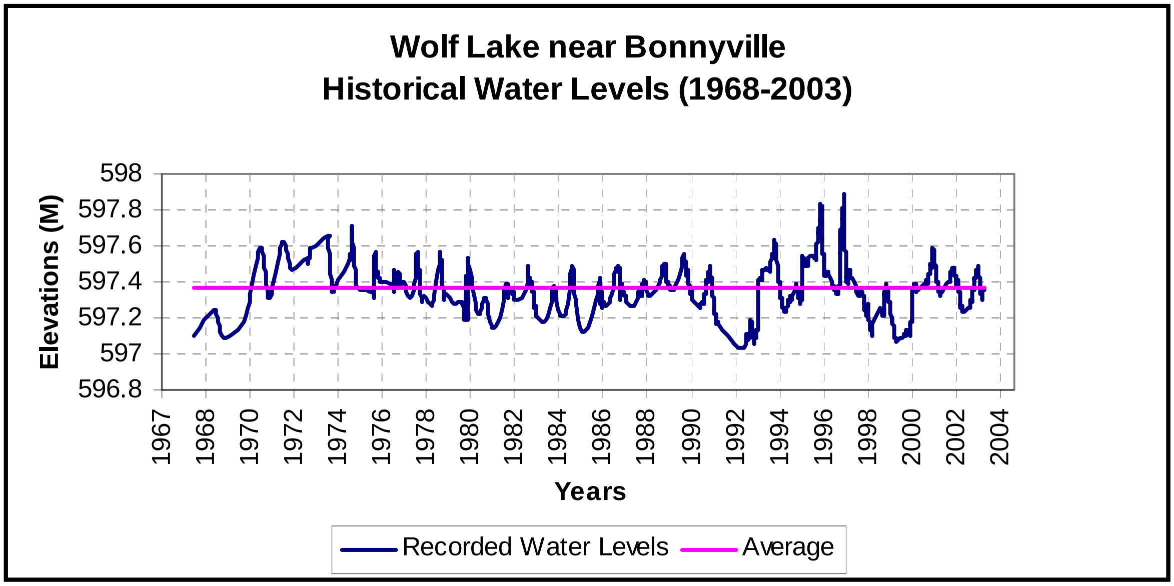


Figure 8-10. Historical water levels, Wolf Lake.

8.4 Other Lakes

8.4.1 Inaccessible Lakes

Burnt Lake

Burnt Lake is located on the Cold Lake Air Weapons Range, which is used by Canadian and NATO forces year-round for pilot training. Canadian Forces has closed access to sportfishing, with this closure applying to the general public as well as military personnel.

Water Level Assessment

A historic mean water level of 662.43 m for Burnt Lake was noted in the 1983 study. The lake is quite shallow, with emergent vegetation growing along most shorelines. Depth gradients are gradual along the southwest and northern shorelines. Any drop in water levels would quickly expose these lake bottom areas. The study noted that a water level of approximately 662.63 m would be ideal, with a range of 662.43 m to 662.93 m being acceptable. Water levels above or below this range were predicted to result in a total loss of the lake's recreational capability. (No additional water level data were available for Burnt Lake at this time.)

Caribou Lake

Caribou Lake is also located on the Cold Lake Air Weapons Range. Canadian Forces has closed access to sportfishing, with this closure applying to the general public as well as military personnel.

Water Level Assessment

An historic mean water level of 633.25 m for Caribou Lake was noted in the 1983 study. The lake is extremely shallow and marshy with emergent vegetation growing along shorelines. The study stated that because the lake has a maximum 2.2 m depth at mean water level, it has almost no potential from a recreational standpoint. Any fluctuation in water levels would result in dramatic changes to the lake. However, an increase in water level to approximately 633.75 m was thought to be ideal for a lake fisheries. Because of its shallowness and location within the Air Weapons Range, Caribou Lake is not considered recreationally viable at this time. (No additional water level data were available for Caribou Lake at this time.)

8.4.2 Other Watershed Lakes

Chickenhill Lake

Chickenhill Lake is a long, narrow lake lying parallel to the southwest border of the study area. Access to the lake is by way of a gravelled road. Maximum depth is around 9.5 m. The shoreline of the lake is generally sandy and water quality has remained fairly conducive to recreation activities such as power boating, water skiing, swimming and fishing.

Recreation

Chickenhill Lake M.D. Park, owned by the M.D. of Bonnyville, is the only known recreational development on the lake. It provides 30 campsites. In recent years, however, cottage development has become more important on the lake.

Water Level Assessment

Water levels on Chickenhill Lake have dropped significantly since 1981, falling approximately 3.5 m, from ~622.25 m to ~618.75 m between 1981 and 2003.

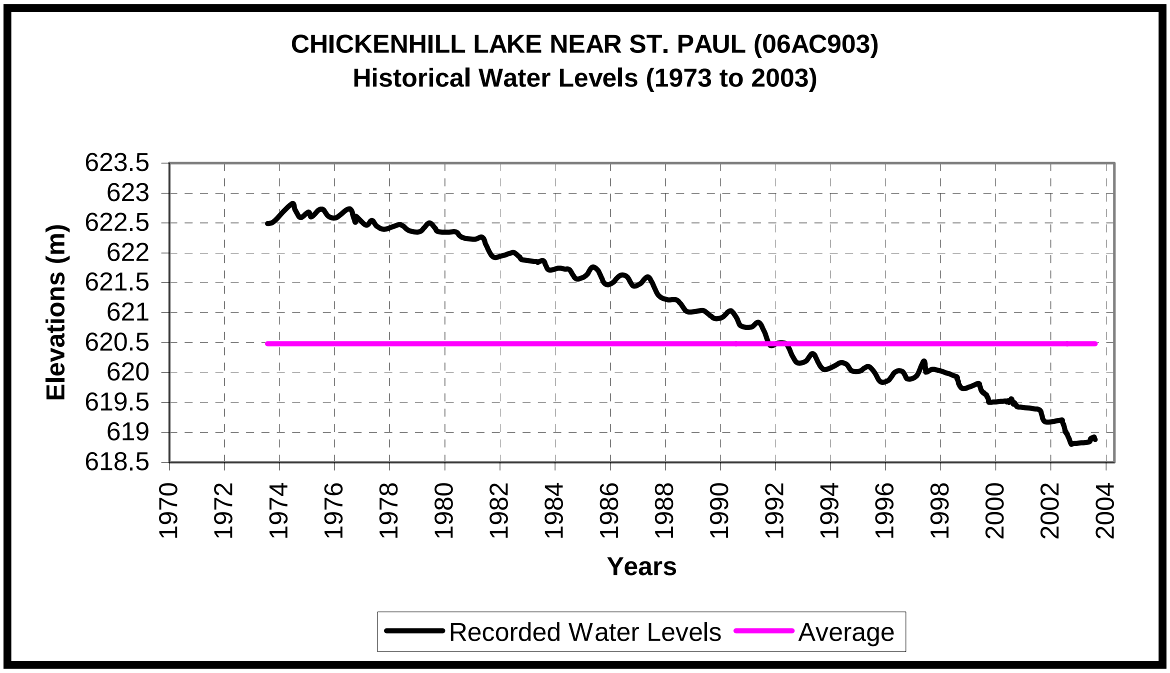


Figure 8-11. Historical water levels, Chickenhill Lake.

Ernestina Lake

Ernestina Lake is a small, eutrophic lake approximately 20 km east of Bonnyville off Secondary Highway #659. The lake has a surface area of 306 ha and a mean depth of 3.5 m. The maximum depth of the lake is 7.9 m. Ernestina Lake is round in shape and has a well-defined shoreline surrounded by deciduous forest. Since 1980, the water level of the lake has dropped 2 m.

Recreation

The 1983 report stated that Ernestina Lake had two public campgrounds—an Alberta Transportation site and an M.D. site providing a total of 35 campsites. Only one small campground (5 campsites) remained at the lake as of 2003.

Hilda Lake

Hilda Lake is a small lake in an area of mixedwood forest to the east of Crane Lake. Access to the lake is gravelled road. At this time, the surface area is approximately 337 ha (440 ha noted in the 1983 study) with a maximum depth of 12.2 m.

Recreation

The 1983 report stated that a private campground on Hilda Lake provided 15 campsites. A campground still exists on the lake and has undergone improvements in recent years.

Water Level Assessment

Hilda Lake has experienced a steady decline in water levels since 1981. Apart from anomalous years in 1997 and 1998 when lake levels surged dramatically, water levels have continued a downward trend, dropping a total of ~0.8 m between 1981 and 2004.

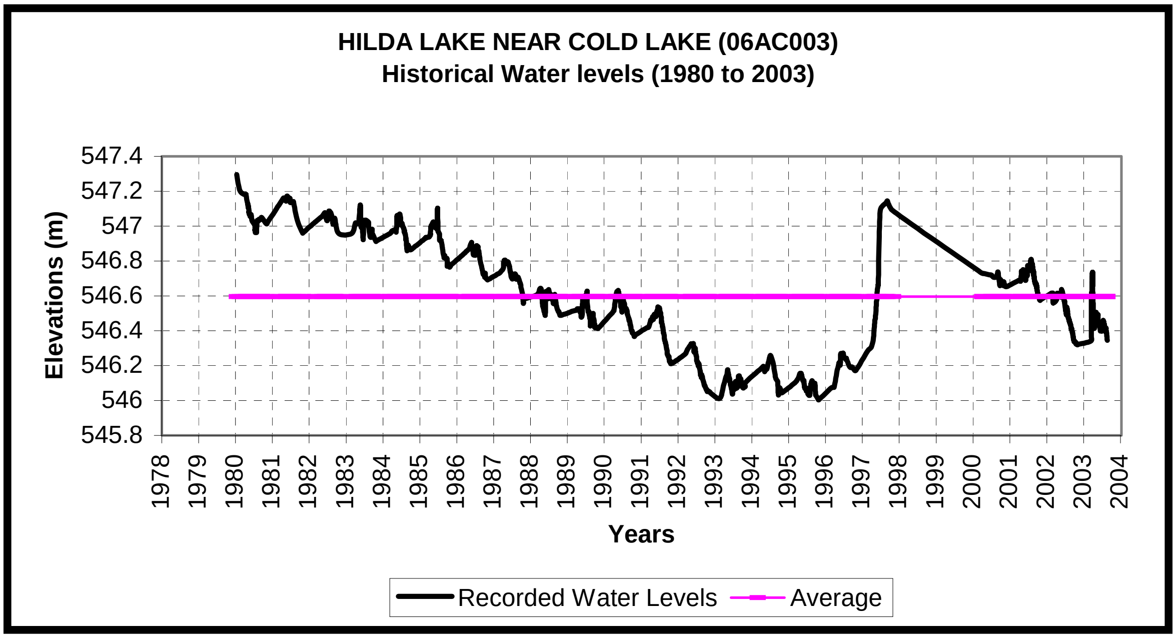


Figure 8-12. Historical water levels, Hilda Lake.

Kehewin Lake

Kehewin Lake is located 45 km northeast of St. Paul and is adjacent to Highway 41 on the southwest corner of the Kehewin First Nations Reserve #123. The lake is long and narrow, and lies in a deep valley at the upper end of the Moose Lake River drainage basin. It has a surface area of 622 ha and a mean depth of 6.7 m. The maximum lake depth is 11.6 m.

Recreation

Two public campsites have been developed on Kehewin Lake—one on the east and one on the west side of the lake. The campsite located along the west shore was constructed after 1980, while the east shore campsite is a Provincial Recreation Area owned and operated by Alberta Community Development. The latter provides 46 campsites. Recreational activities include camping, canoeing, kayaking, fishing, power boating, sailing, swimming, water skiing, wake boarding and windsurfing. There is no commercial, institutional, or private (cottage) development on the lake.

Campsite and Day Use

Occupied campsite nights at Kehewin PRA fluctuated around 2000 between 1987 and 1992. Between 1992-1996, the rate of fluctuation in campsite use was considerably greater with drops outpacing increases. There was a steady increase from 1996 to 1998, then levelling off in 1999. A major decline of ~1250 occupied campsite nights occurred in 2001.

Day use visits peaked in 1988 (almost 12,000), declined to less than 8,000 visits in 1990, and increased to more than 11,000 in 1991 before declining to about 9,500 in 1992. There has been an overall decline of more than 2000 visits from 1988-1992.

Water Level Assessment

Water levels at Kehewin Lake have fluctuated quite noticeably since 1980, ranging from a high of just over 540.3 m in 1997 to a low of just under 539 m in 1993. The mean water level from 1968-2003 was ~439.49 m. Overall, water levels were ~40 cm higher in 2001 than in 1983. When viewed in relation to historic usage figures for Kehewin PRA, there appears to be some correlation between water levels and recreational/camping visits, especially from 1992-1999.

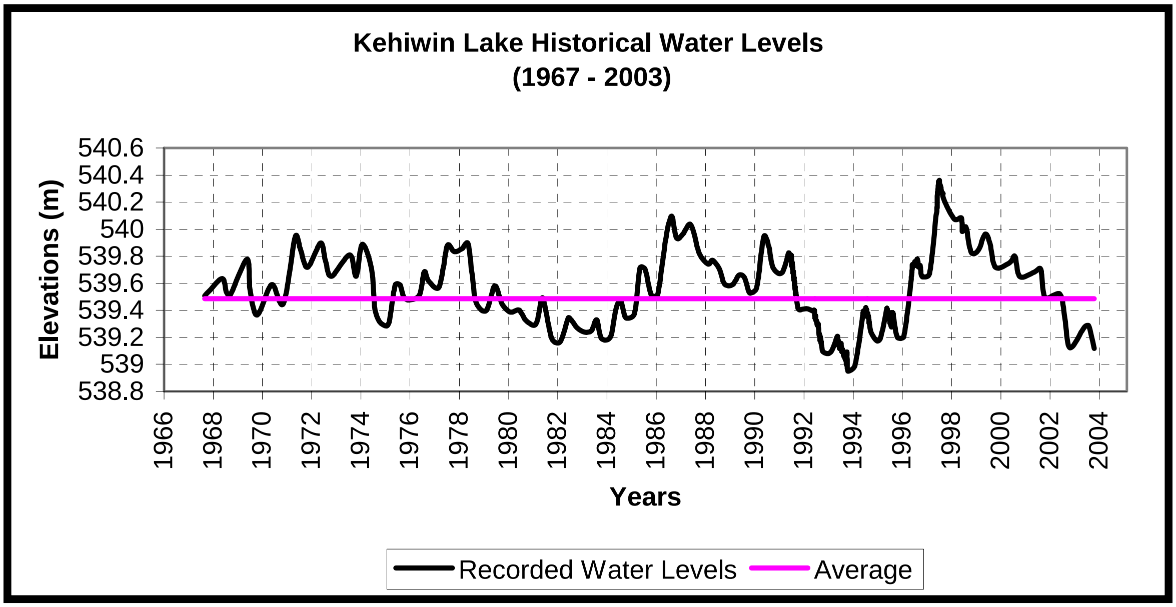


Figure 8-13. Historical water levels, Kehewin Lake.

Minnie Lake

Minnie Lake is a small, relatively deep lake with a surface area of 0.9 km^2 and a maximum depth of 25 m. It is located near the Village of Glendon, 47 km northeast of St. Paul. The lake is used as a water supply source for the village. In a natural condition, Minnie Lake is in a state of hydrologic balance, with precipitation and runoff essentially equalling evaporation.

Recreation

There are two public recreation developments on the lake. The first is the Minnie Lake Provincial Recreation Area on the south end of the lake. This 0.44 ha site is owned by Alberta Community Development and operated by the Moose Lake Management Society. It provides 8 campsites. The second site is Minnie Lake M.D. Park owned by the M.D. of Bonnyville. It provides 12 campsites.

There is at least one cottage subdivision on Minnie Lake. In 1986, it consisted of 15 lots, 13 of which were developed.

Campsite and Day Use

Data for 1992-2001 shows no consistent pattern of campground use. During this 9-year period, camping activity at the lake fluctuated from a high of 284 campsite nights (1993) to a low of 88 nights (1994). This was followed by a steady increase in campsite nights to 222 in 1997 before declining the next year. Campsite use for 2001, the last year for available data, was 117 campsite nights, an overall decrease of 45 from 1992 numbers. (PRA visitation/user data were not available for 1987-1992.)

The pattern for day use activity at Minnie Lake also fluctuated. Between 1994 and 2001, the day use trends varied significantly from campsite use. Day use activity rose from a low of 1,575 day use party visits in 1994 to a high of 3,675, which was an increase of 2,100 or more than one-third, before declining steadily during the next two years. Some of this decline was recovered in 2000, with user rates then stabilizing in 2001.

Recreation activities at Minnie Lake PRA include canoeing, kayaking, power boating, water skiing, wake boarding, fishing, swimming, sailing and windsurfing.

Water Level Assessment

Minnie Lake has experienced a steady and significant decline in water levels since 1981. Lake levels dropped approximately 3 m (from 554.5 m to ~551.5 m) between 1981 and 2003.

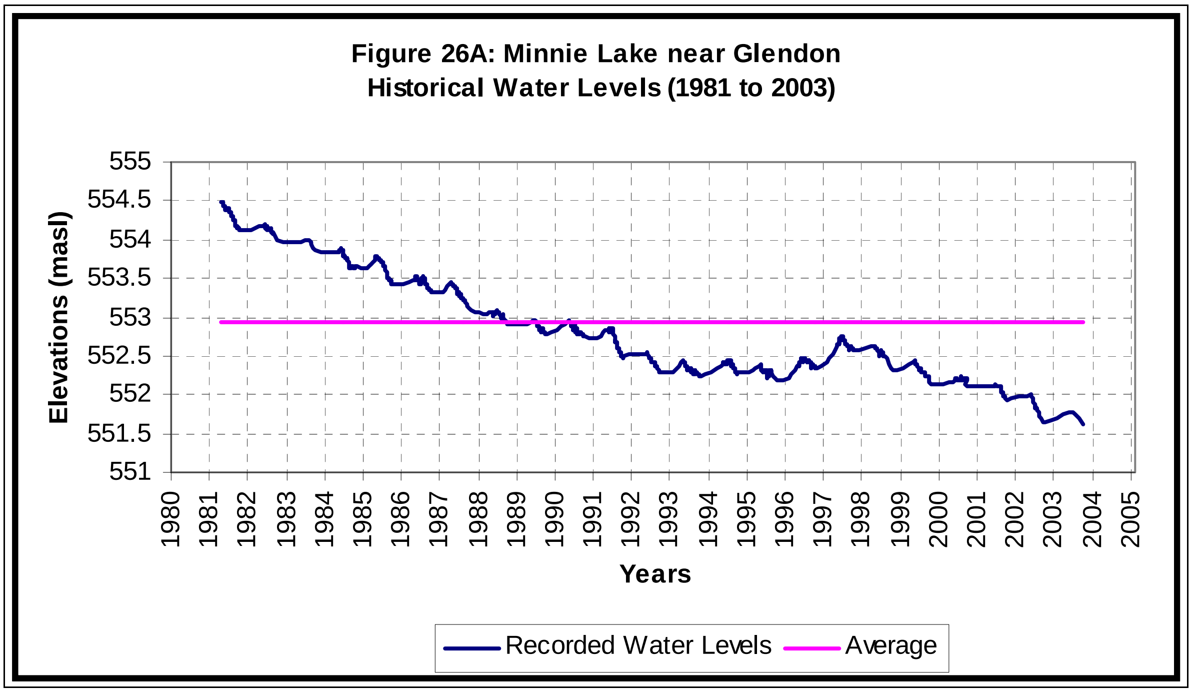


Figure 8-14. Historical water levels, Minnie Lake.

8.5 RIVER SYSTEMS

The recreational use of rivers and streams in the study area has not changed significantly since 1983. The main recreational activity continues to be canoeing, with swimming, fishing and informal camping being somewhat less common. The 1983 report categorized streams within the study area into three broad groupings based on canoeing levels on the waterbody—high to moderate, moderate to low, and low to nil.

High to Moderate Recreation Use

The following three stretches of river have the highest recreation use:

- Wolf River from Wolf Lake to the confluence at the Sand River;
- Sand River between the confluence with the Wolf and Beaver Rivers;
- Beaver River from the confluence with Sand River to the bridge on Highway 41 south of La Corey.

The reach along the Beaver differed somewhat from that described in the 1983 report, which looked at recreation use of the Beaver River from Goodridge on Secondary Highway #881 to the Alberta–Saskatchewan border.

Spring runoff, primarily during the Victoria Day weekend in May, was the most popular time for canoe trips. Runoff from melting snowpacks greatly increased water levels during this season, making hang-ups less likely and canoeing more exciting.

Preferred water levels for canoeing appeared to be as follows:

- Wolf River — flows between 4.2 cms* and 5.0 cms.
- Sand River — flows between 39 cms and 62 cms.
- Beaver River — flows between 40-45 cms and 71.9 cms.

* cms = cubic metres per second

8.6 Winter Recreation

Winter recreation occurs informally throughout the study area. Trails such as the 6.4 km African Lake Bike Trail linking Cold Lake north and south, and the 10 km Wetlands Trail around Jessie Lake in Bonnyville, are used for hiking, nature interpretation and biking in the summer and for cross-country skiing in the winter. The area's longest trail, the multi-use Iron Horse Trail, consists of two routes that are used extensively by hikers, cyclists, ATVs and horseback riders in the summer and snowmobilers and cross-country skiers in the winter.

Winter recreation activities also take place at parks and lakes within the area. Ice fishing occurs at most lakes throughout the winter. Cross-country skiing takes place in Cold Lake Provincial Park, Crane Lake West PRA, Pelican Point M.D. Park and Bodina Resort on Crane Lake, as well as Sir Winston Churchill, Whitney Lakes and Lakeland Provincial parks, and Lakeland PRA. Most of these locations have groomed trails.

Snowmobiling is permitted on designated trails in Lakeland PRA and at Bodina Resort at Moore (Crane) Lake. According to the 1983 study, winter activities that were popular among cottage owners in the study area (particularly on Moose, Muriel, Moore and Marie lakes), included ice boating, ice fishing, cross-country skiing, snow shoeing, snowmobiling and skating. It is likely these same activities are still enjoyed by cottage owners in the area. Owing to low levels of snowfall, however, skidoo sales and usage have declined during the past 10 years.

8.7 Key Points

1. Low water levels have seriously impacted the recreation development and activity use of at least three lakes: Manatokan, Moose and Muriel.
2. Declining lake levels have resulted in numerous changes in recreation facility development in the study area since 1983, including decommissioning, closing and/or transfer of

provincial recreation areas and municipal campgrounds, consolidation of public and commercial facilities and in some cases the creation of new facilities and enterprises.

3. There is growing demand for recreational property, particularly at Moose and Moore lakes.
4. Growth in commercial recreational development at Cold Lake has resulted from the amalgamation of the Towns of Grand Centre, the City of Cold Lake and 4 Wing Cold Lake.
5. There has been a change in the type of recreational activities participated in throughout the region, due to both changes in recreational technology and an aging user population.
6. Overall traffic volumes into the study area via both Primary and Secondary Highways have increased significantly since 1983.

APPENDIX A. LEGISLATION, POLICIES AND GUIDELINES

This appendix highlights and summarizes some of the current legislative statutes, policies and guidelines that influence water management in the CLBR Basin. In addition, information is provided on the inter-provincial agreement between Alberta and Saskatchewan and the Cold Lake Subregional Integrated Resource Plan.

Provincial and Federal Legislation

Managing water resources in the Cold Lake–Beaver River Basin is guided by both provincial and federal laws. The Government of Alberta holds the property rights for water resources, and has the authority to legislate on all aspects of water resources management. The *Water Act* is the main legal tool used to govern water resources management in the province. Specific parts of the *Environmental Protection and Enhancement Act (EPEA)* also regulate aspects of water and water resources activities. Both Acts are administered by Alberta Environment.

The Alberta Energy and Utilities Board (EUB) administers legislation that covers certain aspects of surface water/groundwater through the *Oil and Gas Conservation Act* and *Regulations* (e.g., *Part 2 [Regulations] Licensing of Wells*—Siting facilities with respect to waterbodies and the existing water table).

The Government of Canada has jurisdiction over international water management and inter-provincial water-sharing agreements, as well as migratory birds. Some of the legislation administered by the federal government includes the following:

- *Fisheries Act* (R.S. 1985, c. F-14)
- *Navigable Waters Protection Act* (R.S. 1985, c. N-22)
- *Canada Water Act* (R.S. 1985, c. C-11)
- *Canadian Environmental Protection Act, 1999* (1999 c. 33)
- *Migratory Birds Convention Act, 1994* (1994d, c. 22)
- *Species at Risk Act* (proclaimed 2003).

Several provincial and federal policies also provide direction for water resources management and water-related activities. Provincial water-related policies (www3.gov.ab.ca/env/WATER/Legislation/Index.cfm) include the following:

- Codes of Practice
- Albert Water Strategy
- Framework for Water Management Planning
- Groundwater Evaluation Guidelines.

Other provincial guidelines include:

- A Fish Conservation Strategy for Alberta 2000 –2005.
- Strategic Plan and Industrial Guidelines for Boreal Caribou Ranges in Northern Alberta.

Federal policies include:

- Federal Water Policy (1987)
- Habitat Conservation and Protection Guidelines (1998)
- Policy for the Management of Fish Habitat (1986)
- Federal Policy on Wetland Conservation (1991).

Alberta Water Act

The *Water Act* (W-3 RSA 2000) replaced the *Water Resources Act* (1980 cW-5), and represented a shift from water allocation to a strong focus on water conservation, protection and management guided by the concepts and objectives of sustainable development. The *Water Act* is based on the following principles:

- Water must be managed in a sustainable way.
- Water is a vital component of the environment.
- Water plays an essential role in a prosperous economy and balanced economic development.
- Water must be managed using an integrated approach with other natural resources.
- Water must be managed in consultation with the public.
- Water must be managed and conserved in a fair and efficient manner.

The *Water Act* addresses all actions that may affect water use or the management of water use. In addition, it provides a more streamlined licensing and approval process for water-related activities and diversions. The *Water Act* includes the following actions:

- protects the rights of existing water licences that are in good standing;
- protects existing traditional agriculture uses of water through a streamlined, voluntary registration process;
- protects the statutory rights for household uses of water and grants priority over all other uses;
- prohibits the export of water to United States;
- prohibits any inter-basin transfers of water between Alberta's major river basins;
- allows for flexible water management by allowing transfer of water licences; and
- offers opportunities for Albertans to provide input and advice for water-related activities.

The Act also contains comprehensive tools to protect aquatic resources and riparian areas. These include:

- Strategy for protecting aquatic resources, which is to be developed as part of the provincial water management planning.
- Water conservation objectives (water quality and quantity necessary for a healthy aquatic environment).
- Transfer of water allocations and water conservation holdbacks (up to 10% of the water being transferred may be withheld to protect the aquatic environment).
- Framework for water management planning, which provides guidelines for water management planning.

The *Water Act* encourages cooperation and proactive measures to resolve management issues, and provides a wide range of enforcement tools where necessary. The Act also contains also tools for supervising water licences and approvals, which are issued by Alberta Environment.

Environmental Protection and Enhancement Act (EPEA)

The *Environmental Protection and Enhancement Act* (E-12 RSA 2000) provides a strong regulatory framework for environmental protection in Alberta. As part of its objective, the Act addresses specific aspects of water resources and water-related activities, as follows:

- **Environmental Impact Assessment** — *EPEA* establishes a legislative process for reviewing the potential environment impact of proposed development. The review process evaluates impacts of proposed development on water quality, protecting surface and groundwater, deposition of harmful substance into waterbodies, and land and water-based activities.
- **Potable water** — *EPEA* regulates the treatment and supply of water for human consumption.
- **Groundwater and related drilling** — *EPEA* regulates the drilling of water wells and provides protection for groundwater quality.
- **Wastewater and Storm Drainage** — *EPEA* regulates the operation of wastewater collection and treatment systems, as well as disposal of wastewater sludge and storm drainage.

As shown in the *Water Act*, *EPEA* also contains strong enforcement measures to ensure the compliance of environmental regulations. Penalties under *EPEA* range from fines to imprisonment, or both depending on the infraction.

Fisheries Act (Government of Canada)

The federal *Fisheries Act* was established to manage and protect Canada's fisheries and their supporting habitats. It applies to all Canadian waters and the exclusive economic zone and continental shelf of Canada. The Act also applies in all provinces and territories, and affects provincial, territorial and federal governments.

The *Fisheries Act* is a powerful regulatory tool and provides strong penalties for contraventions. The penalties for harmful destruction, alteration or disruption or deposition of deleterious substance in fish-bearing water ranges up to $300,000 depending on the severity of the offence, with penalties up $1M for more severe offences.

The Department of Fisheries and Oceans Canada (DFO) is responsible to Parliament for administering the provisions of the *Fisheries Act*, which are designed to protect fish habitat. The provisions described below are particularly relevant for protecting and conserving fish and fish habitat.

Fish Habitat Protection

Section 35(1) of the *Fisheries Act* frequently applies to projects undertaken in or near water. This section prohibits the unauthorized "harmful alteration, disruption or destruction of fish habitat" (HADD). DFO defines HADD as "... any change in fish habitat that reduces its capacity to support one or more life processes of fish."

Any HADD that occurs as a result of a work or undertaking is a violation of s. 35(1) of the *Fisheries Act*, unless authorized by the Minister of Fisheries and Oceans (under s. 35[2]) or by regulation. The planning, design, construction and operation phases of a project should include measures to avoid adverse effects on fish habitat. Such measures may include relocating or redesigning the project.

In keeping with the no net loss guiding principle outlined in DFO's Policy for the Management of Fish Habitat (1986), an authorization may be issued if HADD cannot be avoided. An authorization is generally issued when the HADD can be compensated. Where adequate compensation is not possible, the habitat losses are unacceptable, or for other reasons (e.g., habitats that are essential or critical for the survival of a fish species), an authorization may be denied.

Other Sections of the *Fisheries Act*

Within the *Fisheries Act* are other sections that also protect fish and fish habitat from the effects of human activities. These include the following:

- *s.20(1)* Requirement for safe passage of fish around an obstruction using fish-ways or canals.
- *s.21(4)* Provision of fish stops or diverters at obstructions.
- *s.22(1)* Provision of sufficient flow over obstructions.
- *s.22(2)* Provision for free upstream and downstream movement of fish during construction of an obstruction.
- *s.22(3)* Provision of sufficient water downstream of an obstruction for the safety of fish and flooding of spawning grounds.
- *s.26* Main channel not to be obstructed.
- *s.29* Nets, weirs, etc., not to obstruct passage.
- *s.30(1)* Requirement for fish guards and screens at water intakes, ditches, channels or canals.
- *s.32* Prohibition of the unauthorized destruction of fish by means other than fishing.
- *s.36(1)* Prohibition of throwing overboard certain substances.
- *s.36(3)* Prohibition of the discharge of deleterious substances in waters frequented by fish, unless otherwise authorized by regulation.
- *s. 36(5)* Governor in Council may make regulations for authorizing certain deposits.
- *s.37(1)* Requirement to provide plans specifications or undertake studies at the request of the Minister of Fisheries and Oceans.
- *s.37(2)* Requirement to implement modification or mitigation measures if ordered by the Minister of Fisheries and Oceans.

Navigable Waters Protection Act (Government of Canada)

The *Navigable Waters Protection Act* (R.S. 1985, c. N-22) (*NWPA*)) applies to many different types of projects undertaken on any of the navigable waterways and coastal zones of Canada. It is implemented to protect the public right to marine navigation, ensure the safety of mariners, and protect the marine environment by enforcing the *Navigable Waters Protection Act* and the *Environmental Assessment Act* with respect to major projects.

The principle objective of the Act is to protect the public right of navigation by prohibiting the building or placement of any "work" in, upon, over, under, through, or across a navigable water without authorization from the Minister of Transport. All structures that are between low and high water marks require federal approval under *NWPA*. Works subject to approval under *NWPA* are listed in Part 1 of the Act.

The authority to determine the navigability of a waterway and consequently the requirement for an application under the *NWPA* rests with the Minister of Transport or designate (see Appendix B for definition of navigable waterway).

Note: An approval granted by the Minister of Transport is not a general approval of construction or an authorization under any law, aside from the *Navigable Waters Protection Act*. An authorization may also be required from the Minister of Fisheries and Oceans under the *Fisheries Act*. DFO should be contacted to obtain information on requirements under the *Fisheries Act.* In addition, local, municipal, provincial and other government offices should be contacted to determine if other approvals are required for the proposed project.

Provincial Initiatives

Water for Life: Alberta's Strategy for Sustainability

Water for Life: Alberta's Strategy for Sustainability is the Government of Alberta's new approach to water management. Released in November 2003, the strategy identifies short-, medium- and long-term goals to ensure safe, secure drinking water, healthy aquatic systems, and reliable quality water supplies for a sustainable economy. It provides a road map to improved water management for years to come.

This strategy was developed following extensive consultation with Albertans. During the public consultations concern was expressed regarding the use of freshwater for oilfield injection purpose, specifically the "permanent loss" of water for oilfield injection. Albertans were also concerned that fresh-water uses for injection purpose could reduce the amount of water available to other water users. (Summaries of all the consultations as well as background and process information on the strategy are available from the following website: www.waterforlife.gov.ab.ca/.)

In response to these concerns, the Minister of Albert Environment established the Advisory Committee on Water Use Practice and Policy in September 2003, to provide advice and recommendations on fresh-water uses for oilfield injection purposes.

The water strategy focuses on three core areas, including water conservation and attaining the knowledge needed to make wise water management decisions. One of the most significant initiatives reflected in the strategy is the partnership approach, which provides opportunities for Albertans to work collaboratively on watershed management. In support of this, a long-term goal of the strategy is to develop Water Management Plans for all major watersheds in Alberta.

Water Management Planning

Water management planning is a process that addresses multiple issues, involves stakeholders, and produces recommendations for water management. These recommendations are then used in forming the basis for a water management plan. The plan is used to provide guidance for water management decision makers when their decisions may affect water quantity, quality, habitat or species within a particular watershed. All activities within a watershed can impact the water sources within it.

The Framework for Water Management Planning outlines the process for water management planning and the components for water management plans in the province (http://www3.gov.ab.ca/env/water/Legislation/Framework.pdf). The Framework applies to all types of waterbodies including streams, rivers, lakes, aquifers and wetlands. Staff within Alberta Environment will work with stakeholders and watershed organizations to develop water management plans for Alberta's major watersheds. Using the Framework, individuals or organizations may initiate a water management plan by following the direction and process provided, to ensure appropriate input is obtained from stakeholders and the necessary steps are followed to obtain support from Alberta Environment.

Groundwater Allocation Policy for Oilfield Injection Purposes

In 1990, Alberta Environment implemented the Groundwater Allocation Policy for Oilfield Injection Purposes. The purpose of this policy is to manage groundwater resources in the White Area (settled area of the province) in a manner that provides continued protection of the existing and future domestic, municipal, agricultural and industrial water users while maintaining the principle of multi-purpose use of water. Under this policy, oil and gas industries are required to investigate alternative recovery methods and alternative sources of water before applying to use potable groundwater. The policy also outlines quantity limitations and time limit restrictions on water diversions. The main principles of the policy are described below.

Principles of Policy

- **Quantity Limitation —** Applicants proposing to use potable groundwater for oilfield injection will be restricted to a maximum of one half of the long-term yield of a given aquifer in the immediate vicinity of the water source well.
- **Time Limit Restriction —** All initial approvals will be limited to a one year time period. The first five-year extension will be issued only if the aquifer is performing in accordance with the terms and conditions of the approval, and without unreasonable negative impact on other wells in the community. Future annual extensions will automatically be granted for five-year time periods if the required conditions are met, and no applications that exceed the remaining available aquifer capacity have been received from the surrounding community.
- **Surface Water, Non-Potable Groundwater and Non-Water Alternatives —** It is understood that an appropriate level of investigation into the use of surface water, non-potable water and non-alternatives water will be carried out by the applicant prior to the submission of an application to develop a potable groundwater source for oilfield injection purposes.
- **Monitoring Stations —** Groundwater monitoring stations must be established and available for inspection by designated officials and affected parties.

Cold Lake Subregional Integrated Resource Plan

Cold Lake Subregional Integrated Resource Plan (IRP) was prepared by government agencies and public consultants in recognition of the need for improved management of Alberta's lands and resources. It was approved by Cabinet in 1996, and applies only to public lands within the Cold Lake planning area, not to Métis Settlements or private or federal lands. The plan is intended to be a guide for resource managers, industry and the public in the Cold Lake area, rather than a regulatory mechanism.

The Cold Lake IRP focuses on land allocation and management. It also addresses water management as a necessary means to reduce impacts on water resources, and to maintain habitat as well as opportunities for recreational use. However, the IRP is based on the 1985 Cold Lake–Beaver River Long-Term Water Management Plan, which is being updated by the Cold Lake–Beaver River Water Management Plan (2004) to more accurately reflect changing use of the area.

Prairie Provinces Master Agreement on Apportionment

Alberta shares borders with British Columbia, Northwest Territories, Saskatchewan and Montana. Currently, apportionment agreements only exist with Saskatchewan and Montana. In the North and South Saskatchewan and Cold Lake-Beaver River watersheds, the water originates in Alberta and flows into Saskatchewan. The Prairie Provinces Master Agreement on Apportionment (1969) between Alberta and Saskatchewan governs how this water is shared.

The agreement is managed by the Prairie Provinces Water Board (PPWB). It provides for "reasonable and equitable" apportionment of river waters by allotting provinces 50% of the natural flow arising in or flowing through an upstream province, thereby balancing the concepts of territorial sovereignty and territorial integrity. All water diversions and consumptive uses come under the agreement. Natural flow is an important part of the Master Agreement's formula. Broadly defined, it is the volume of flow that would occur in a particular river if that river had never been affected by human activity.

However, it was also recognized that there are downstream surface water quality impacts on some jurisdictions. The Agreement on Water Quality was signed, and became Schedule E to the Master Agreement on Apportionment in 1992. The Agreement defines the water quality mandate of the Board in interprovincial watercourses. It states the PPWB shall "foster and facilitate interprovincial water quality management among the parties that encourages the protection and restoration of the aquatic environment".

APPENDIX B. RELATED TERMINOLOGY AND ACRONYMS

AC	Asbestos cement (pipe)
ALMS	Alberta Lake Management Society
AMWWP	Alberta Municipal Water/Wastewater Partnership
APF	Agriculture Policy Framework
ATV	All-terrain vehicle
BMP	Best management practices
CAFWP	Canada-Alberta Farm Water Program
CAWSEP	Canadian–Alberta Water Supply Expansion Program
CCME	Canadian Council of Ministers of the Environment
CFB	Canadian Forces Base
CLAWR	Cold Lake Air Weapons Range
CLBR	Cold Lake–Beaver River
CLRUC	Cold Lake Regional Utilities Commission
CNRL	Canadian Natural Resources Limited
CSS	Cyclic Steam Stimulation
DFO	Department of Fisheries and Oceans (Canada)
DND	Department of National Defence
EPEA	*Environmental Protection and Enhancement Act* (Alberta)
GIS	Geographic Information System
HADD	Harmful alteration, disruption or destruction (of fish habitat) (Federal *Fisheries Act*)
IMAC	Interim maximum acceptable concentration
LICA	Lakeland Industry and Community Association
MASL	metres above sea level
MD	Municipal District
NWPA	*Navigable Waters Protection Act*
NWSEP	National Water Supply Expansion Program
PFRA	Prairie Farm Rehabilitation Association
PPWB	Prairie Provinces Water Board
PRA	Provincial Recreation Area
SAGD	Steam Assisted Gravity Drainage
SSARR	Streamflow Synthesis and Reservoir Regulation (model)
TDL	Temporary Diversion Licences
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency

Alberta Water Council	A multi-stakeholder group formed in 2004 to provide direction and advice to the Alberta government, stakeholders and the public on improving water management, provide guidance on the implementation of the water strategy, and investigate and report on existing and emerging water issues in Alberta (www.waterforlife.gov.ab.ca).
Allocation	Water redirected for a use other than for domestic purposes. Agricultural, industrial and municipal water users apply to Alberta Environment for a licence to use a set allocation of water. This water licence outlines the volume, rate and timing of diversion of water.
Approval	Provides authority for constructing works or for undertaking an activity within a waterbody. The approval includes conditions under which the activity can take place.
Aquatic ecosystem	An aquatic area where living and non-living elements of the environment interact. These include rivers, lakes and wetlands, and the variety of plants and animals associated with them.
Aquiclude	An impermeable body of rock that may absorb water slowly but does not transmit it.
Aquifer	An underground water-bearing formation that is capable of yielding water. Aquifers have specific rates of discharge and recharge. As a result, if groundwater is withdrawn faster than it can be recharged, the aquifer cannot sustain itself.
Aquitard	A layer of rock having low permeability that stores groundwater but delays its flow.
Brackish water	Salty or briny water.
Consumptive use	The balance of water taken from a source that is not entirely or directly returned to that source. For example, if water is taken from a lake for cattle to drink, it is considered a consumptive use of water.
cubic dam (dam^3)	1,000 cubic metres of water
Discharge	Water exiting groundwater systems in an upward-oriented, exiting flow into surface waterbodies, marshes, wetlands, springs, etc.
Diversion of water	The impoundment, storage, consumption, taking or removal of water for any purpose. This does not include the taking or removal for the sole purpose of removing an ice jam, drainage, flood control, erosion control or channel realignment.
Domestic water use	Water used for drinking, cooking, washing and yard use. A very small percentage of the water used in this province is used for domestic purposes.
Drinking water	Water that has been treated to provincial standards and is fit for human consumption.

Evapotranspiration	Process where moisture is returned to the air by evaporation from the soil and transpiration by plants.
Groundwater	All water under the surface of the ground whether in liquid or solid state. It originates from rainfall or snowmelt that penetrates the layer of soil just below the surface. For groundwater to be a recoverable resource, it must exist in an aquifer. Groundwater can be found in practically every area of the province, but aquifer depths, yields and water quality vary.
Habitat	The term used to describe the natural home of a living organism. The three components of wildlife habitat are food, shelter and water.
HADD	Any change in fish habitat that reduces its capacity to support one or more life processes of fish. (DFO)
Household purposes	Water used for human consumption, sanitation, fire prevention and watering animals, gardens, lawns and trees.
Hydrologic cycle	The process by which water evaporates from oceans and other bodies of water, accumulates as water vapor in clouds, and returns to oceans and other bodies of water as rain and snow, or as runoff from this precipitation or as groundwater. (Also called water cycle.)
Instream needs	The scientifically determined amount of water, flow rate or water level that is required in a river or other body of water to sustain a healthy aquatic environment or to meet human needs such as recreation, navigation, waste assimilation, or aesthetics. An instream need is not necessarily the same as the natural flow.
Irrigation district	A water delivery system for a given region.
Littoral zone	The shallow shoreline area of a lake.
Micro-organisms	Tiny living organisms that can be seen only with the aid of a microscope. Some micro-organisms can cause acute health problems when consumed in drinking water.
Natural flow	The volume of flow that would occur in a particular river if that river had never been affected by human activity Natural flow is the flow in rivers that would have occurred in the absence of any man-made effects.
Navigable water	Designates any body of water capable, in its natural state, of being navigated by any type of floating vessel for the purpose of transportation, recreation or commerce and includes a canal and any other body of water created or altered for the benefit of the public, as a result of the waterway assigned for public use. (NWPA)
Non-consumptive use	A use of water in which all of the water used is directly returned to the source from which it came. For example, water used in the production of hydroelectricity is a non-consumptive water use.

Non-point source pollution	Contamination that cannot be identified as originating from one site. This type of pollution comes from a larger area of land and is carried by runoff and groundwater.
Organic contaminants	Carbon-based chemicals, such as solvents and pesticides, which can enter water through runoff from cropland or discharge from industrial operations.
Point source pollution	Pollution that originates from an identifiable cause or location, such as a sewage treatment plant or feedlot.
Potable water	Water that is fit for human consumption, but has not been treated.
Produced water	Water that comes from an oil or gas well during production is called produced water. Some of this water exists naturally within the formation. In the case of steam injection processes, however, the term generally refers to water recovered from an oil reservoir following steam injection. This recovered water can be recycled and used over again, and is an important factor in minimizing the volumes of freshwater that could otherwise be required.
Raw water	Water in its natural state, prior to any treatment for drinking.
Recharge	Water entering groundwater flow systems through the downward-directed percolation of infiltrating precipitation or directly from surface waterbodies.
Reservoir	Man-made lake that collects and stores water for future uses. During periods of low river flow, reservoirs can release additional flow if water is available.
Riparian area	The area along streams, lakes and wetlands where water and land interact. These areas support plants and animals, and protect aquatic ecosystems by filtering out sediments and nutrients originating from upland areas.
River basin	An area of land drained by a river and its associated streams or tributaries. Alberta's *Water Act* identifies seven major river basins within the province: Peace/Slave River Basin, Athabasca River Basin, North Saskatchewan River Basin, South Saskatchewan River Basin, Milk River Basin, Beaver River Basin, Hay River Basin.
River reach	A group of river segments with similar biophysical characteristics. Most river reaches represent simple streams and rivers, while some river reaches represent the shorelines of wide rivers, lakes and coastlines.
Runoff	Refers to water that moves over the surface of the ground. Runoff collects sediments and contaminants as it moves from higher elevations to lower elevations.
Surface water	Water sources such as lakes and rivers, from which most Albertans get their water. The runoff from rain and snow renews

	surface water sources each year. If the demand for surface water is higher than the supply, there will not be enough available to balance the needs of Albertans, the economy and the environment.
Water allocation transfer	A water allocation transfer occurs after the holder of an existing water withdrawal license agrees to provide all or part of the amount they are allocated to another person or organization, Alberta Environment next approve any transfer of this kind. When this occurs, the allocation is separated from the original land, and a new license, with the seniority of the transferred allocation, is issued and attached to the new location. Under the *Water Act*, Alberta Environment can place conditions on the new license. Water allocation transfers can occur only if authorized under an approved water management plan, or by the Lieutenant Governor in Council.
Waterbody	Any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent or occurs only during a flood. This includes, but is not limited to, wetlands and aquifers.
Water conservation	The planned protection, improvement and wise use of natural resources. It includes controlling, protecting and managing water.
Water conservation objective	As outlined in Alberta's *Water Act*, a water conservation objective is the amount and quality of water necessary for the protection of a natural waterbody or its aquatic environment. It may also include water necessary to maintain a rate of flow or water level requirements.
Watercourse	A creek, ditch or other permanent or intermittent stream that has a well-defined channel with a streambed or banks.
Water license	Provides the authority for diverting and using surface water or groundwater. The license identifies the water source; the location of the diversion site; an amount of water to be diverted and used from that source; the priority of the "water right" established by the license; and the condition under which the diversion and use must take place.
Watershed	The area of land that catches precipitation and drains it into a larger body of water such as a marsh, stream, river or lake.
Watershed approach	Focuses efforts within watersheds, taking into consideration both ground and surface water flow. This approach recognizes and plans for the interaction of land, waters, plants, animals and people. Focusing efforts at the watershed level gives the local watershed community a comprehensive understanding of local management needs, and encourages locally led management decisions.

Water well	An opening in the ground, whether drilled or altered from its natural state, that is used for the production of groundwater, obtaining data on groundwater, or recharging an underground formation from which groundwater can be recovered. By definition in the provincial *Water Act*, a water well also includes any related equipment, buildings, and structures.
Wetland	Wetlands are formed in depressions or low areas where the ground is saturated with water or is flooded. Alberta has five types of wetlands: bogs, fens, swamps, marshes and ponds.
Xeriscape	The conservation of water and energy through creative landscaping (from the Greek word "Xeros" meaning dry).

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APPENDIX D. TECHNICAL ADVISORY COMMITTEE MEMBERS

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