DRAFT

COLD LAKE–BEAVER RIVER BASIN

OVERVIEW OF THE STATE OF THE BASIN REPORTS
&
PROPOSED MANAGEMENT RECOMMENDATIONS

Alberta
ENVIRONMENT

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

February 1, 2006

Table of Contents

EXECUTIVE SUMMARY

The Cold Lake–Beaver River Water Management Plan was adopted in 1985 to provide direction on managing water resources in the combined Cold Lake and Beaver River basins. The intent of the plan was to provide for an adequate quantity and quality of water to meet the long-term user requirements of the basin. The Cold Lake–Beaver River Basin is approximately 300 km northeast of Edmonton.

<u>Updating the plan</u>

Over the past 20 years, the region has experienced increased industrial development, considerable population growth, and years of below-normal precipitation, creating record low water levels in the area's lakes, rivers and streams. This has resulted in a need to assess the current situation, including demands on the water resources in the basin, and update the 1985 plan to meet current and future water needs.

Updating the plan will also address new information related to groundwater within the basin. Groundwater is identified as an important component of the regional water resources, and protecting groundwater quantity and quality is one of the main emergent issues in the Cold Lake–Beaver River Basin.

Alberta's *Water for Life* strategy and the Framework for Water Management Planning requires that strategies for the protection of aquatic resources be included in water management plans. The updated plan will be consistent with the goals and objectives of Alberta's *Water for Life* Strategy.

<u>Partnerships in Water Management</u>

Alberta Environment initiated the update of the Cold Lake– Beaver River Water Management Plan in partnership with the Lakeland Industry and Community Association (LICA). A Basin Advisory Committee (BAC) was also established with representatives from local governments, industry, Metis Settlements and First Nations, federal and provincial government departments, and members of the public. The focus of this committee is to provide advice and recommendations on the range of views and community values to be considered in preparing the updated water management plan.

<u>Public Consultation</u>

Public consultation is an integral part of the water management planning process. Issues and concerns within the Cold Lake Beaver River Basin have been identified through a combination of public consultation sessions, meetings with stakeholders and cumulative knowledge gathered since the 1985 plan. Information from the public was gathered through a series of public meetings held in Bonnyville, Cold Lake and Ardmore. Additional opportunities for public consultation are offered through workshops, consultation with identified stakeholders and open house sessions.

<u>Gathering information on the Cold Lake - Beaver River Basin</u>

Four multi-disciplinary technical advisory teams were assembled to review existing information on water resources, identify information gaps, collect new information to address specific objectives, guide the scientific evaluation for the planning process, and provide recommendations: the Groundwater Quality Team, Groundwater Quantity and Brackish Water Team, Surface Water Quality Team, and Surface Water Quantity and Aquatic Resources Team. The results of these studies are summarized in the following four reports:

- *Cold Lake Beaver River Basin — Surface Water Quality State of the Basin Report*
- *Cold Lake Beaver River Basin — Surface Water Quantity and Aquatic Resources State of the Basin Report*
- *Cold Lake Beaver River Basin — Groundwater Quantity and Brackish Water State of the Basin Report*
- *Cold Lake Beaver River Basin — Groundwater Quality State of the Basin Report*

Some of the key findings of these reports include:

- There is sufficient water within the basin to meet current and projected water demands for municipal and industrial sectors (projected to 2020).
- A total of 44 million m^3 of groundwater and surface water licences have been allocated in the basin for multiple uses (e.g. municipal, industrial, agricultural). Together, the licenses for groundwater and surface water allocation represent about 4.5% of the average annual flow of water out of the basin.
- Fresh water use requirements are not projected to increase substantially from 1985 water use volumes.
- The water levels have decreased in most of the lakes and streams since the 1985 water management plan. This is because of less precipitation, low run-off, and increased temperature and evaporation in recent years.
- Despite some low run-off years, Alberta has always exceeded the requirements under the apportionment agreement with Saskatchewan (i.e. 68 per cent of natural flow goes to Saskatchewan).
- Some lakes in the basin are more sensitive than others to regional climate fluctuations (e.g. Muriel Lake, Chickenhill Lake).
- Industrial groundwater pumping does not cause an adverse effect to the water tables and surface water bodies.
- The regional groundwater quality is generally within the Canadian drinking water quality guidelines.
- A number of areas within the basin were determined to be potentially sensitive to contamination.
- Most of the data available on groundwater quality is in the northeast area of the basin and there is a need for more data in other areas.
- Lower lake water levels have resulted in increased salinity and other water quality parameters (e.g. pH, hardness).

Building recommendations

In addition to writing the State of the Basin Reports, the technical teams were asked to develop draft water management options for the basin. The recommendations provided by the technical teams are preliminary and will be finalized after discussions with the Basin Advisory Committee and input from other stakeholders.

Some of the recommended options to improve management of surface and ground water in the Cold Lake – Beaver River Basin include:

- Based on the current and projected industrial water use demands, the 1985 recommendation to access industrial water supply water from the North Saskatchewan River is not required. Water from the Cold Lake – Beaver River Basin will be sufficient for industrial water use requirements.
- The existing cut off level for industrial water withdrawal from Cold Lake should remain at 534.55 meters above sea level.
- No new dams should be constructed within the Cold Lake – Beaver River Basin.
- No water withdrawals will be permitted from May, Muriel, Manatokan, Reita and Tucker Lakes.
- No permanent diversions from lakes or wetlands in the Cold Lake-Beaver River Basin will be permitted.
- No new permanent diversions for steam injection purposes from the Beaver River, Sand River and other streams.
- New licence applications for water use will be considered on a case-by-case basis
- Additional ground and surface water monitoring is required to increase the existing monitoring network already established within the basin
- As part of Alberta's *Water for Life Strategy*, a Watershed Planning and Advisory Council (WPAC) will be established in the basin. The WPAC in partnership with Alberta Environment, will implement the recommendations of the water management plan.
- The regional numerical groundwater model developed for evaluating groundwater – surface water interactions should be continually refined and used as a tool to determine potential effects of groundwater diversion.
- Underground injection of non – saline water in the basin will follow the recommendations outlined in the Minister's *Advisory Committee on Water Use Practice and Policy Report.* The report recommends that a case by case evaluation of projects should be undertaken to minimize the use of non saline water. In water- short areas, non saline water sources should be used only when feasible alternatives do not exist, and environmental risks should be assessed and minimized for each project
- Education and best practices for private well installations and abandonment practices need to be established in order to minimize potential for groundwater contamination.

INTRODUCTION

PURPOSE OF OVERVIEW REPORT

This document provides an overview and summary of the studies undertaken to update the Cold Lake– Beaver River (CLBR) Basin Water Management Plan. It also provides preliminary discussions on alternative water management scenarios, potential strategies for protection of aquatic resources, and protection of surface and ground water quality. As well, the overview report gives suggestions for water conservation and best management practices for land use.

The overview report was prepared as an information resource for the Basin Advisory Committee (BAC) and the stakeholder workshops for developing the draft water management plan update. This document will assist the BAC and stakeholders in gaining knowledge of the issues and sciences involved in updating the CLBR Water Management Plan (CLBRWMP).

The information presented here is a summary of the four State of the Basin reports and the wide range of technical studies that were conducted as part of the plan update. Readers interested in obtaining more detailed information are invited to consult these four State of the Basin Reports:

- Surface Water Quality
- Surface Water Quantity and Aquatic Resources
- Groundwater Quantity and Brackish Water Quantity
- Groundwater Quality.

> The intent of the overview report is to summarize the four state of the basin reports and discuss potential water management scenarios and strategies. Recommended management options and strategies will be identified through consultation with the BAC and stakeholders.

ORGANIZATION OF OVERVIEW REPORT

This overview document is organized in the following manner:

- **Section 1: An overview of the planning process**. This section includes purpose, planning area description and public consultation initiatives.
- **Section 2: Water supply and demand**. This section focuses on the current and future industrial, municipal and agriculture water demand. Also included are water management tools such as the groundwater numerical model and the lake-based water management balance model.
- **Section 3: Strategies for protecting aquatic resources**. This section summarizes the key findings of the aquatic resources component. Also included are potential strategies for

protecting, restoring and enhancing aquatic resources through establishment of water conservation objectives.

- **Section 4: Groundwater/surface water quality**. This section presents the assessment of ground and surface water quality in the basin. Also included are strategies to protect groundwater and surface water quality.
- **Section 5: Potential recommendations and management options**.

SECTION 1. OVERVIEW OF THE PLANNING PROCESS

PURPOSE OF THE PLAN

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 suggest a strategy to meet the current and future water needs of the basin.

The updated CLBR 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;
- protection of aquatic resources.

PLANNING AREA

The Cold Lake–Beaver River planning area is part of the CLBR Basin located in Alberta that drains to the outlet of Cold Lake. It also includes the lower Beaver River Basin which drains to the Alberta/Saskatchewan boundary (Figure 1). While the planning area is the current priority for water management planning in the basin, the headwater area of the Beaver River Basin will be addressed in a later phase as time and resources allow.

The management plan study area focuses on the following major 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

To gain a better understanding of water resources in the CLBR planning area, data collected beyond the planning area boundary will be incorporated into some of the technical analyses. These areas include the Elk Point region and part of the Province of Saskatchewan.

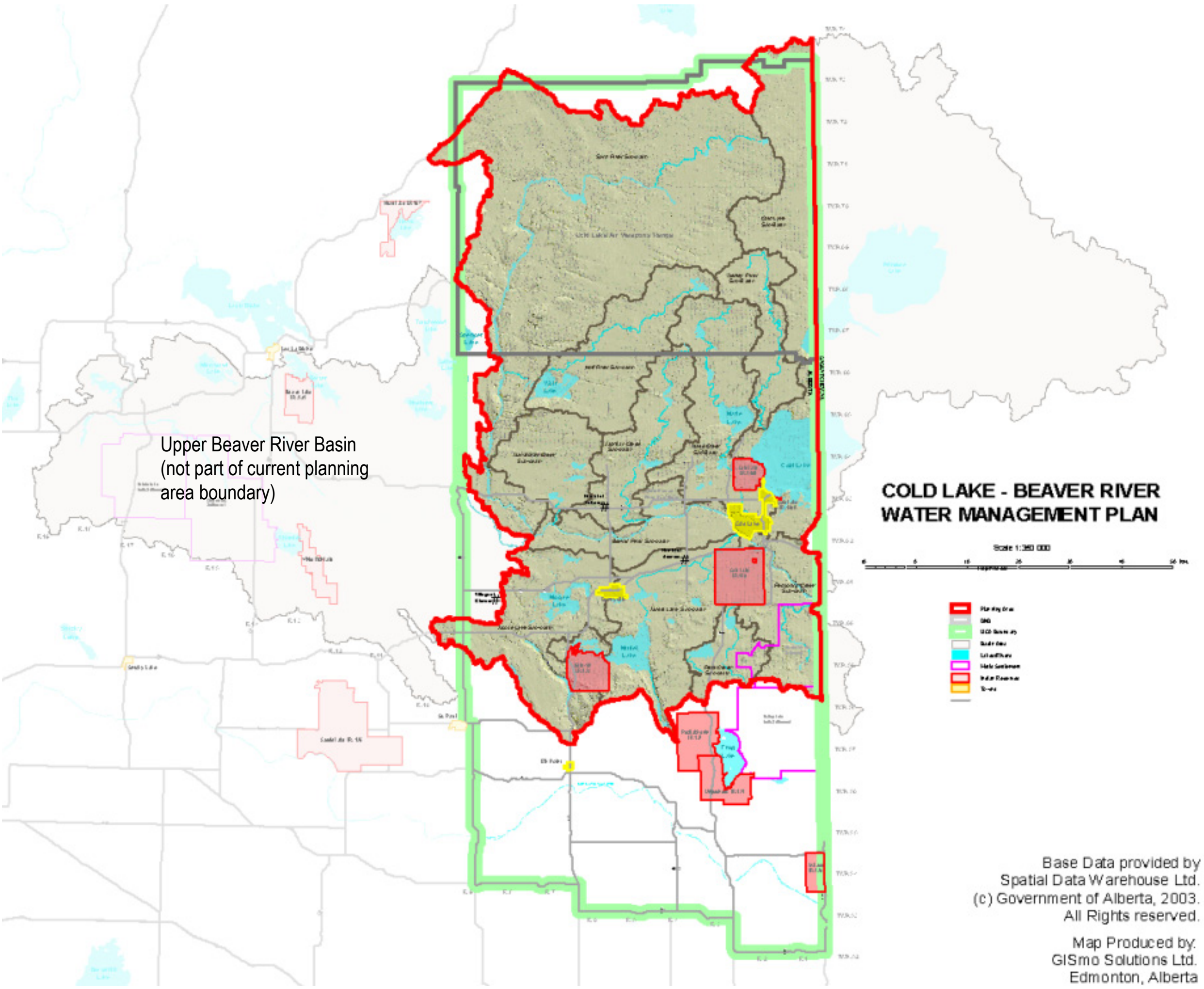


Figure 1. Planning area of the Cold Lake–Beaver River Basin.

How is the Water Management Plan Being Developed?

Alberta Environment initiated the update of the Cold Lake–Lower Beaver River Basin Water Management Plan in partnership with the Lakeland Industry and Community Association (LICA). Four multi-disciplinary technical advisory committees were assembled to guide the scientific evaluation of the planning process. Membership on these committees comprised staff from Alberta Environment, other provincial and federal departments, industry representatives, and non-profit environmental organizations such as Ducks Unlimited.

A Basin Advisory Committee (BAC) was established, comprising a broad mix of people representing local governments, industry, Metis Settlements and First Nations, federal and provincial government departments, and members of the public. This committee provides advice and recommendations on the range of views and community values to be considered when preparing the Water Management Plan Update.

How Have Planning Issues Been Identified?

Planning issues and concerns have been identified through a combination of public consultation and cumulative knowledge gathered since the original management plan was implemented. A Terms of Reference that clearly defined the issues and the process steps involved in updating the plan was developed in consultation with the public during a series of open houses held in Bonnyville, Cold Lake and Ardmore. Additional opportunities for public consultation are offered through workshops/consultation with identified stakeholders prior to drafting the updated plan. As well, the planning team has established an open door policy that invites comments/concerns at anytime to be addressed by any member of the planning team or the BAC. Once drafted, the plan will be available for broad public review through another series of open houses within the planning area.

SECTION 2. WATER SUPPLY AND DEMAND

Issues related to water supply, demand and uses in the basin have been reviewed and assessed by groundwater and surface water quantity technical teams. This section summarizes key findings of these studies. For a more detailed analysis, readers can refer to the *Surface Water Quantity and Aquatic Resources State of the Basin Report* and the *Groundwater Quantity and Brackish Water State of the Basin Report*.

2.1 GROUNDWATER AND SURFACE WATER QUANTITY ISSUES

The Cold Lake–Beaver River Basin Water Management Plan was adopted in 1985 to provide direction on managing the basin's water resources. The main focus of that plan was industrial water supply.

Since 1985 the basin has faced new challenges and emergent issues. The basin has experienced increased industrial and agriculture development and associated population growth. Below normal precipitation and low run-off years in the basin have resulted in record low water levels in local lakes and streams.

Groundwater is identified as an important component of the regional water resources, and protecting groundwater quantity and quality is one of the main emergent issues in the CLBR Basin. Concerns have been expressed about the current knowledge related to groundwater availability, mapping, affects of withdrawals, and the possible interactions with surface water and other aquifers.

Alberta Environment initiated the 1985 water management plan update to accommodate new information as well as to address the recent challenges and emergent issues facing the basin. The key principles in updating the existing plan include:

- Current Industrial use of freshwater is generally less than that predicted in 1985; however, the allocation limits established in the 1985 plan are being approached. (Note: Allocation limits do not reflect actual use at present time.)
- Incorporating advances in technical information related to hydrogeology. Specifically, increased knowledge of regional hydrogeology and groundwater flow systems within the basin will provide the foundation for effective decision-making and planning. The updated plan will incorporate information gains related to groundwater availability, its interaction with surface water resources and potential impacts.
- Alberta's Commitment to Sustainable Resource Management, and implementing the Water for Life Strategy. The province recognizes that protecting the aquatic environment is an essential component of maintaining a healthy ecosystem. *The Framework for Water Management Planning* requires that strategies for protecting aquatic resources be included in water management plans to ensure that critical ecosystem functions are maintained, restored or enhanced.

During the initial public consultation phase of this plan to develop a Terms of Reference, the following concerns were identified by the public regarding groundwater and surface water quantity:

- Securing reliable water for municipal, industrial, agricultural, household and traditional uses.
- Securing sustainable water for aquatic resources and recreational uses.
- Concerns in declining water levels in local lakes, streams and wetlands due to industrial diversions, especially during periods of drought.
- Meeting water flow requirements under the apportionment agreement between Alberta and Saskatchewan.
- Concerns regarding the effects of groundwater pumping on shallow aquifers and surface waterbodies.
- Groundwater and surface water interactions.
- Water conservation initiatives and more efficient water use for industrial, agricultural and municipal water users to ensure sustainable water supplies and healthy ecosystems.

To address the above issues and challenges, in-depth studies of regional hydrology, hydrogeology, water allocations, water uses, future water demands and water conservation practices were undertaken by surface water and groundwater technical teams. The findings of these studies are summarized in the four integrated State of the Basin reports.

2.2 Overview of the Basin's Water Resources

In addition to the vital role of sustaining ecosystems, surface and groundwater, 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 review of the basin's long-term water balance and compares freshwater allocations with allocations for other major river basins in the province.

2.2.1 Basin Water Balance

Figure 2 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 recharges fresh groundwater aquifers. It also discharges to lakes and streams in about the same amount each year. This means the amount of water entering the groundwater system as recharge equals the amount flowing into streams and lakes less the small amount pumped by groundwater users.

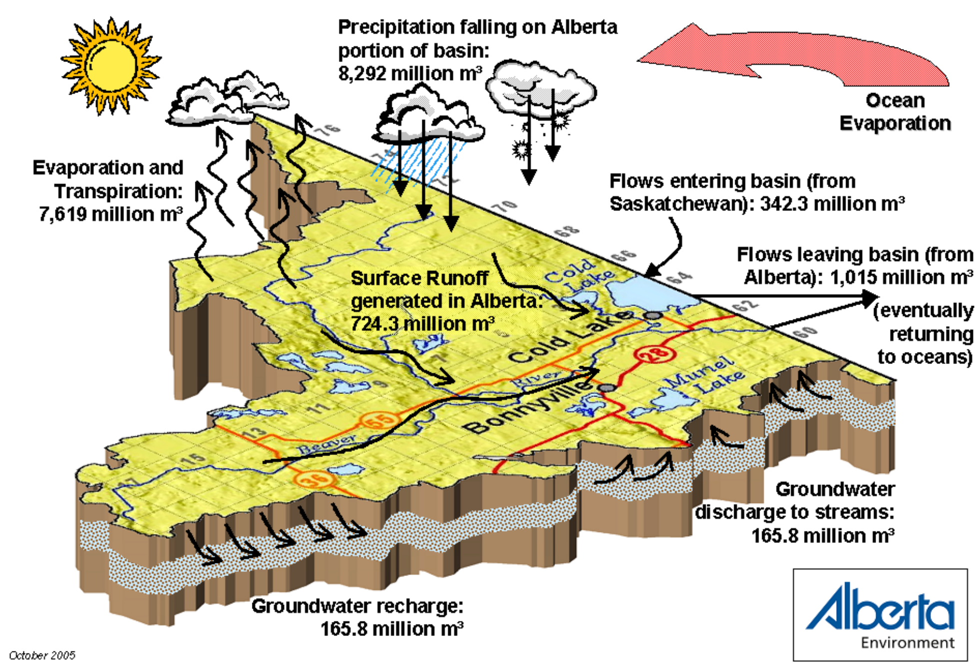


Figure 2. CLBR Basin average annual water balance.

2.2.2 Basin Water Allocation and Comparison With Other River Basins in Alberta

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 leaving the CLBR Basin each year. The actual use is about one third of the allocation or 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 3 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.

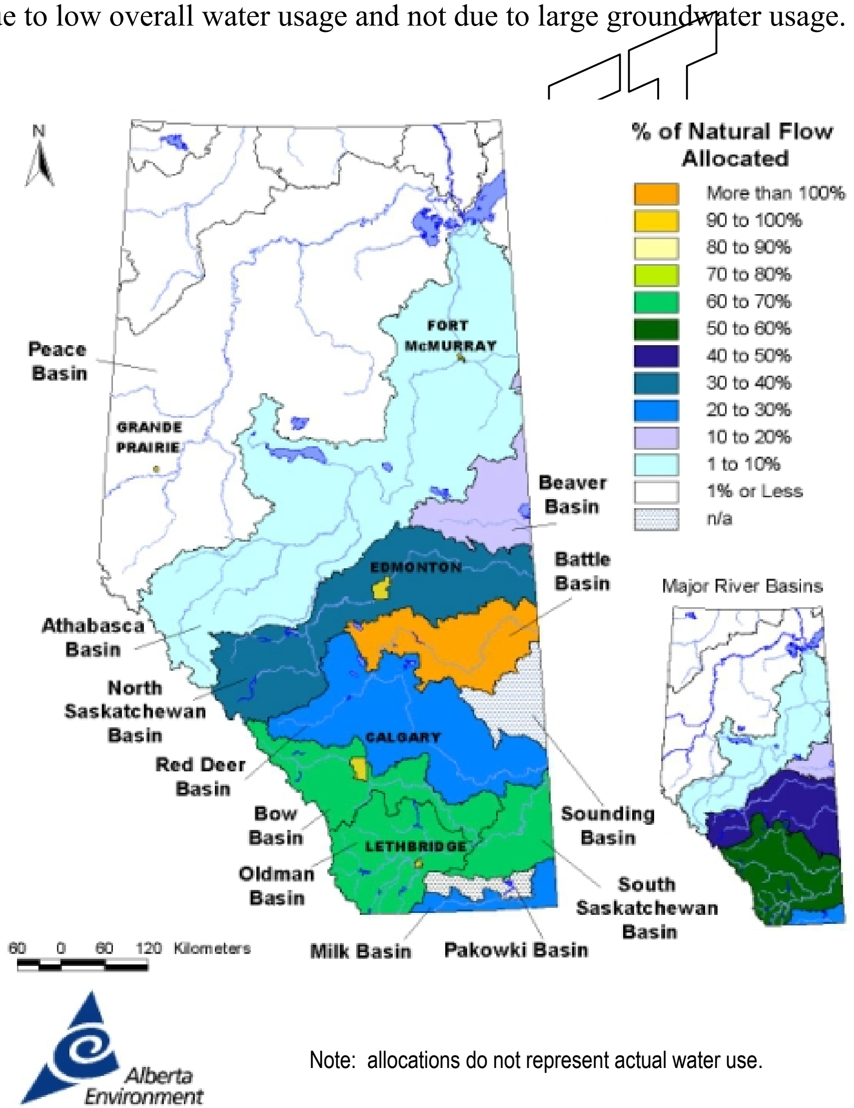


Figure 3. Surface and groundwater allocations in 2004 by river basin compared to average natural flow.

2.3 SURFACE WATER — KEY FINDINGS

2.3.1 Surface Water—Regional Hydrology Trends and Lake-Based Water Balance Models

- Since 1985, the regional hydrology has significantly changed as compared to the long-term averages of 1951-2003. These changes are reflected in all aspects of the hydrological cycle — above average temperature, low runoff and below normal precipitation. Consequently (with the exception of 1996 and 1997), most of the lakes and streams in the basin have recorded low water levels and flows.

- From 1985 to 2003, the annual average flows of Beaver River at Cold Lake were 43% lower than the long-term averages.
- Muriel Lake and Chickenhill Lake are sensitive to regional climate fluctuations. Water levels in both lakes have decreased by more than 3 meters since the early 1980s. Water levels in both lakes did not respond substantially to the high precipitation events that occurred in 1996-97. Both lakes have small drainage areas compared to their lake surface area and would require more consecutive "wet" years to recover.
- Stantec Consultants Ltd. created water balance models for Cold Lake, Moose Lake, Muriel Lake and Marie Lake. The simulated lake levels presented by the model are well correlated with the observed lake levels. The Cold lake and Moose Lake models were used to evaluate the potential impacts of future water diversions.
- Despite the recorded low runoff years of 1985-2003, the basin passes (on average) more than 90% of the apportionment flow to Saskatchewan rather than the 68% required under the Master Agreement.

2.4 GROUNDWATER STUDIES AND MODELING — KEY FINDINGS

As mentioned previously, groundwater is identified as an important component of the regional water resources, and protecting groundwater quantity and quality is one of the main emergent issues in the CLBR basin plan update. The groundwater quantity technical team was established to review the existing information on groundwater resources including regional geological and hydrological conditions; groundwater monitoring; groundwater allocation and use; response to pumping; and surface water and groundwater interactions. A groundwater numerical flow model was also developed to assist in understanding of groundwater flow and interaction with surface water. The technical team also reviewed and assessed industry initiatives to use brackish water.

The following is a summary of the key finding of the study. Groundwater allocation and use key findings are presented in section 2.5.1

2.4.1 Geological and Hydrogeological Conditions

- The surficial geology of the CLBRB generally consists of alternating layers of aquifers separated by till aquitards ("layer cake-stratigraphy") which restrict flow from deep aquifers and the surface.
- Although generally present, the geological framework is more complex than alternating layers. Changes in the thickness of till units, variations in lithology and subcropping units create a three-dimensional labyrinthical structure (layer cake-stratigraphy with holes and thin layers) which allows some vertical hydraulic communication (i.e. flow/pressure transfer) between adjacent formations, aquifer units and the surface.
- Industry generally withdraws water from deep (greater than 100 m depth) aquifers — the Empress and Muriel Lake Formations. The clay till units separating the aquifers from the

surface restrict flow, although some interaction with shallow aquifers and surface water should be expected.

2.4.2 Groundwater Monitoring

The groundwater technical team has reviewed the effectiveness of the current groundwater monitoring program. The key findings of this review are summarized as follows:

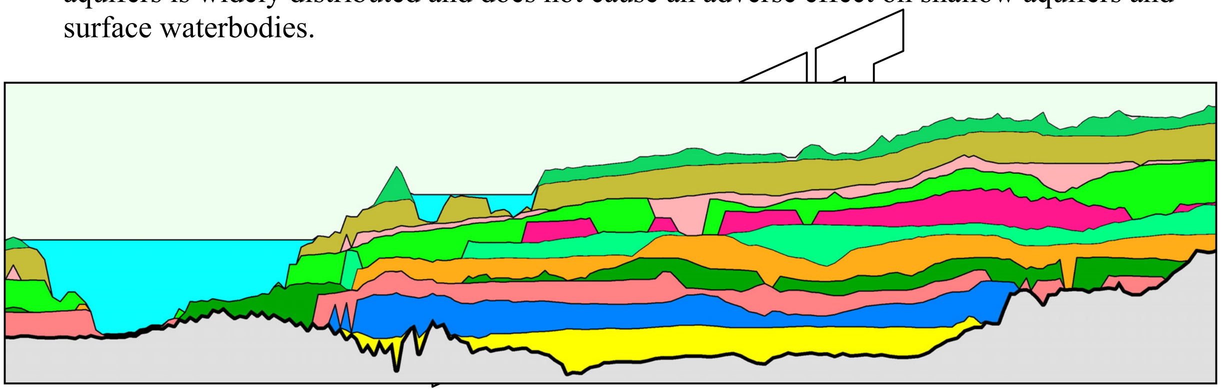
- An extensive network of groundwater monitoring wells exist in the CLBRB. These consist of industry monitoring well networks (hundreds of wells) and Alberta Environment wells which are part of the Provincial Monitoring Network (more than 20 regional wells). Water level data is generally measured daily to weekly.
- The distribution of the current monitoring network of wells is mainly concentrated around the industrial development area, and monitoring wells are relatively sparse across other areas of the basin. Very few monitoring wells are situated in the western half of the basin.
- The current groundwater level observation network appears to do a good job of capturing aquifer responses to large pumping stresses in the northeast part of the basin.
- The technical team has also identified the opportunity to augment the existing monitoring network, and has recommended an additional 30 strategic monitoring wells in the basin. The main purpose of these strategic observation wells is to provide additional information about the natural system and fill existing knowledge gaps. The following locations have been proposed for the new wells:
  - Monitoring wells near major lakes in the basin to gather baseline information about groundwater and lake-water interactions.
  - Monitoring wells in buried valleys to substantiate the knowledge of groundwater flows into and out of the basin along the buried valley aquifers.
  - Monitoring well nests in recharge areas to substantiate the estimates of groundwater recharges.
  - Monitoring wells to improve regional estimates of potentiometer surface to identify areas of hydraulic head change.
  - Regional compliance monitoring wells to ensure the cumulative impact of all groundwater production does not exceed the capacity of the basin to sustain itself.

2.4.3 Response to Pumping and Surface Water/Groundwater Interactions

Groundwater is one of the major sources of water supply for oil injection. Since the 1985 period, intensive groundwater pumping has occurred from 1991 to 1994 and from 1998 to 2001. The groundwater technical team was asked to evaluate the impacts of groundwater pumping on shallow and deeper aquifers. The key findings are provided below:

- The identification of the three dimensional labyrinthical structures suggests that even deep aquifers can interact with shallow aquifers and surface waterbodies. The degree of this interaction is difficult to quantify, but is indicated in the relatively rapid recovery (2 to 4 years) of aquifers following pumping.

- The regional response in deep aquifers indicates the effect of industry pumping from deep aquifers is widely distributed and does not cause an adverse effect on shallow aquifers and surface waterbodies.



- The strong response in surficial (water table) aquifers adjacent to deep wells due to climatic/precipitation effects and not to pumping indicates that industry pumping does not cause an adverse effect to surficial (water table) aquifers and surface waterbodies.
- Pumping from deeper aquifers does increase infiltration at the surface and decreases discharge of groundwater to the base flow of surface waterbodies over a period of years in response to groundwater use during drought periods. However, the impact of this groundwater recharge on surface water availability is small (usually not measurable) in periods of normal precipitation.

2.4.4 Groundwater Numerical Flow Modeling

- Alberta Environment retained the Alberta Geological Survey to compile and analyze groundwater data in the CLBR Basin, and develop a regional groundwater numerical flow model for the CLBR Basin. The model has proven useful in understanding the regional hydrogeological framework, regional groundwater balances, and evaluating the interaction between groundwater and surface water. The model has been used to evaluate the implication of possible groundwater withdrawal scenarios.
- The numerical model was developed as a regional scale model to gain a better understanding of regional water balances and groundwater flows. The model was not intended to provide specific localized assessments. To overcome these limitations, the model requires further refinements, as well as adequate calibrations and adjustment for site-specific assessments.
- Using the numerical groundwater flow model, it was possible to calculate the flux of water moving in and out of the regional groundwater flow system. A steady state scenario was run to compare the basin water balances with and without industrial pumping, (assuming approximately 30,000 m^3/day of groundwater pumping).
- Under the steady state non-pumping scenario, results indicate the majority of water (about 88%) entering into the basin's groundwater system comes from recharge due to infiltrations from wetlands or precipitation. A minor amount (about 12%) is provided by leakage from lakes. Discharge of groundwater occurs as base flow to the major rivers, lakes and/or to the surface. In terms of recharge, under the steady state non-pumping condition, the model

estimates the total recharge in the basin to be about 7 mm/year, which represents approximately 2% of the total annual precipitation in the basin.

- Under the steady state pumping scenario, the most notable changes due to groundwater withdrawals occur in increased surface recharge (8%) and increased recharge from lakes (9%). A decrease in surface discharge is also noted as well as minor changes in discharge to lakes and base flow to rivers.
- The steady-state simulation was used to identify lakes that may contribute to the groundwater flow (recharge lakes) and those that may be fed by groundwater flow (discharge lakes). The results of the steady-state simulations show that Cold Lake, Moose Lake, Muriel Lake and Moore Lake are important regional discharge (gaining) lakes, while Marie Lake and Marguerite Lake are recharge lakes. The losing/gaining status of a lake is dependent on its relative position in the groundwater flow system.
- While groundwater recharge and discharge are sometimes important factors to the overall water balance of a lake, water levels are primarily a reflection of surface water inflows and outflows that are likely much larger in magnitude than groundwater contributions. Cold Lake, for example, receives about 2% from groundwater inflow and 98% from surface water.
- Transition curve analysis has been proposed as a tool to manage groundwater sustainability in the CLBR Basin. Groundwater is viewed as an integral part of the overall environmental resources in the basin. Groundwater pumping or land cover and land use changes alter the dynamic balance between natural recharge and the state of the surface water. The groundwater sustainability objective is to determine the regime of groundwater production (withdrawal) that will still result in acceptable environmental effects.
- Using the groundwater numerical model, a total of 10 transition curves were generated to evaluate the changes predicted during groundwater withdrawal scenarios. A transition curve illustrates how a groundwater source can change from initially being supplied from aquifer storage to having all groundwater production being "captured" from decreased discharge and increased recharge. Figure 5 shows a theoretical transition curve. This graph shows that initially 100% of the groundwater production comes from aquifer storage. As time passes, an increased percentage of groundwater production is captured from induced recharge and decreased discharge from the nearby lakes and streams. A shorter transition time implies a greater interdependence between groundwater and surface water resources. In such cases, a joint groundwater and surface water management tool should be considered. Conversely, if the time-scale of the transition curves is relatively long (century or millennium), the groundwater resources should be managed as a non-renewable resource.

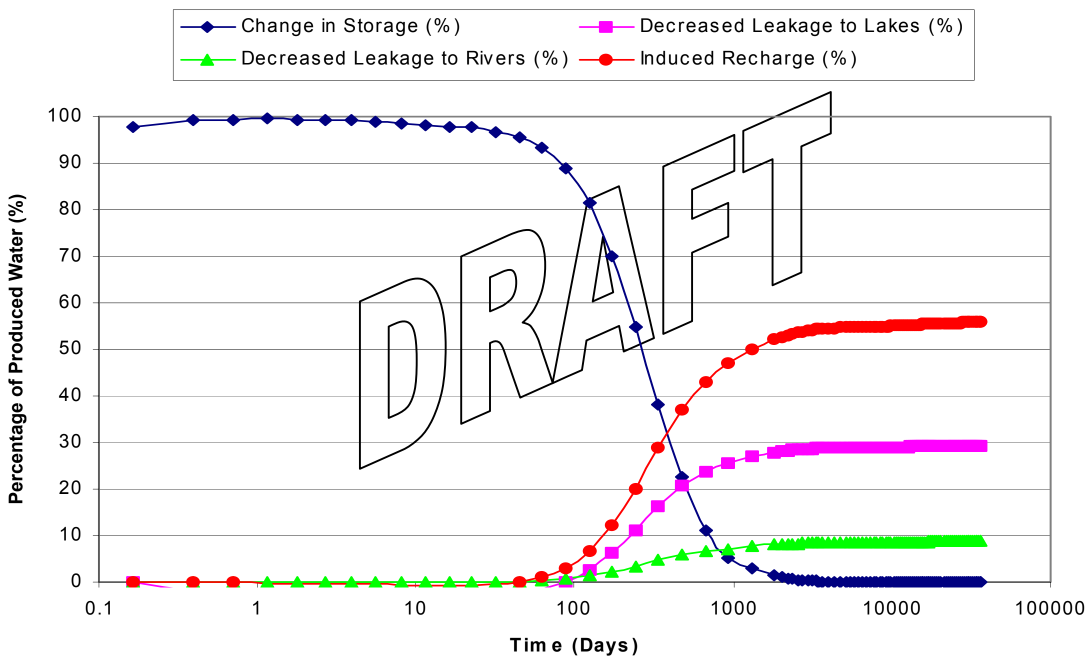


Figure 5. Theoretical transition curve.

2.4.5 Brackish Water Modeling and Studies — Key Findings

- Saline water (brackish water) is defined in Alberta's *Water Act* as water having a total dissolved solid (TDS) concentration of more than 4,000 mg/L. As a result of the high TDS concentrations, brackish water is not potable and not suitable for irrigation and many other purposes. However, brackish water is currently used as a source of water for bitumen recovery operations in the CLBR Basin.
- Although the use of brackish water is not regulated under the *Water Act*, it is an important component of the CLBR Basin water management plan. Brackish water replaces the required equivalent volume of freshwater; an option previously unavailable in the 1985 plan.
- A numerical flow modeling study that assessed brackish water availability was conducted by industry operators in the CLBR Basin. The modeling results indicated there is sufficient brackish water to supply the long-term needs of current and proposed industrial development.
- The results of the modeling study also indicated that during periods of high peak use, inter-well interference may limit pumping capacities. Therefore, it may be necessary to space pumping wells appropriately to maximize pumping capacity.
- Brackish aquifers are located far below potable water aquifers. Withdrawals from brackish aquifers will have no effect on the potable water aquifers located above.

2.5 Review of Water Allocations, Actual Uses and Future Demands — Key Findings

The technical teams reviewed and compared groundwater and surface water allocations in the basin since 1985. A better understanding of water allocation trends and actual uses in the basin is essential for making management decisions that can ensure adequate water levels and flows for aquatic resources and downstream users while considering future water demands and protecting existing water rights.

2.5.1 Water Allocation and Actual Uses — Key Findings

- As of December 2003, a total of 44 million m^3 of groundwater and surface water have been allocated in the basin. This represents an approximate 33% increase over 1985 allocations. The volume of surface and fresh groundwater allocated in the basin is approximately 4.5% of the average annual flow of water leaving Alberta through the Beaver River and Cold River.
- Surface water allocations represent about 62% of the total allocations (27 million m^3). Groundwater allocation is about 38% (about 17 million m^3).
- Water allocated for industrial and municipal purposes represents about 80% of the total allocation. Approximately 17% is for agriculture purposes, and primarily used by the Cold Lake Fish Hatchery licensee. Water allocations for irrigation, registration, commercial and temporary diversions represent the remaining 3% of the total allocation.
- The actual quantity of water used for commercial, irrigation, traditional agriculture and domestic/household purposes is presently unknown.
- The City of Cold Lake and the Town of Bonnyville are the major municipalities in the basin. Their water allocations (10.5 million m^3) have remained unchanged since 1985. Each municipality uses about 30% of its total annual allocation.
- Cold Lake is the only surface water supply for industrial purposes. This allocation (approximately 8 million m^3) has remained unchanged since 1985.
- Since 1985, a total of 9 industrial surface water allocation licenses (4 million m^3) have been cancelled.
- Groundwater allocations have increased approximately 69% from about 9.3 million m^3 in 1992 to about 14.95 million m^3 in 2003 as a result of recent industrial development in the area. The actual industrial groundwater use in 2003 was 4.58 million m^3, or approximately 30% of the total allocation.
- A portion of the industrial groundwater allocation is a contingency license for Imperial Oil Cold Lake operations. This contingency allocation can be used only when the Cold Lake water levels are below the cut-off level of 534.55 m. Therefore, these allocations are counted twice in the total allocation sum, although only one allocation can be used at any one time.
- Figure 6 presents industrial water usage since 1985. The figure shows that industrial groundwater use peaked in the late 1980s, dropped in the mid 1990s, and then began a slow increase from the mid 1990s to present. Unlike municipal water use, industrial water use is more variable and depends on several factors such as the general economic trend, world oil

prices, quantity of bitumen available, and improvements in water recycling and water re-use technologies. The major industrial water users in CLBR Basin are Imperial Oil, Canadian Natural Resources Limited (CNRL) and EnCana.

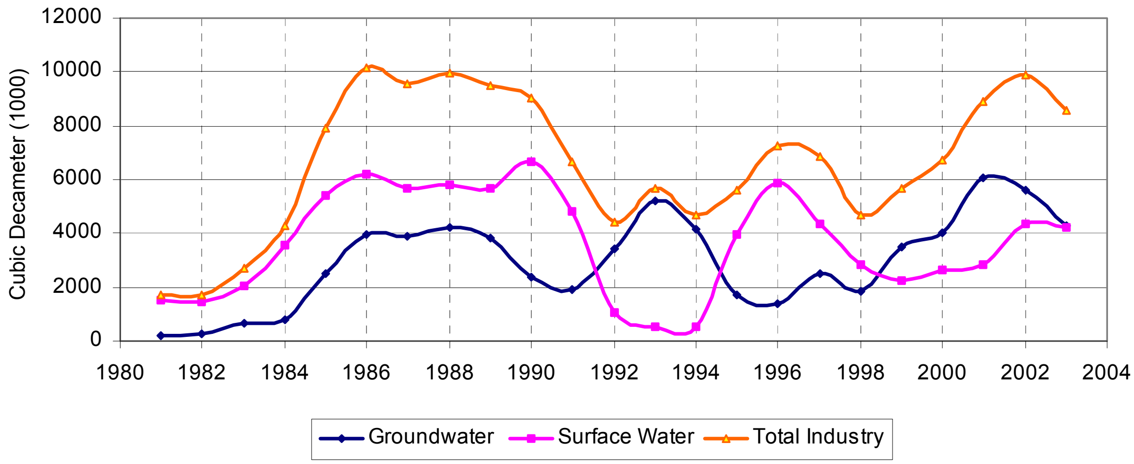


Figure 6. Industrial groundwater and surface water uses (1981-2003).

2.5.2 Projected Water Demand

Local municipalities and industrial operators have been asked to provide their projected water demands for 2004 to 2020. Water use projections for agriculture, irrigation, commercial uses and traditional agriculture and household domestic uses are not included in this plan. The current water usage by these sectors is unknown, and it is anticipated these water demands will not increase substantially over the next 20 years.

Estimating future water demands is useful to planners and regulators who need to make informed decisions on balancing the provision of adequate water supplies with the protection of aquatic resources. However, this estimation is a complex process and based on many variables such as population and economic changes, technological changes and climate change. These factors must all be considered to achieve realistic estimates of future water demands.

The following figures represent the industrial and municipal projected water use from 2004 to 2020. The estimated future water use will be considered as “the most likely water use scenario in the basin” to evaluate potential impacts on regional water resources.

Figure 7 shows population projections and projected water demands for the Cold Lake Regional Utilities Commission and the Town of Bonnyville. The water use projections are calculated based on an historical per capita water use rate multiplied by the projected population estimates. Both municipalities are currently using about 30% of their total allocation; this increase would represent a use of 50% of their current water allocation.

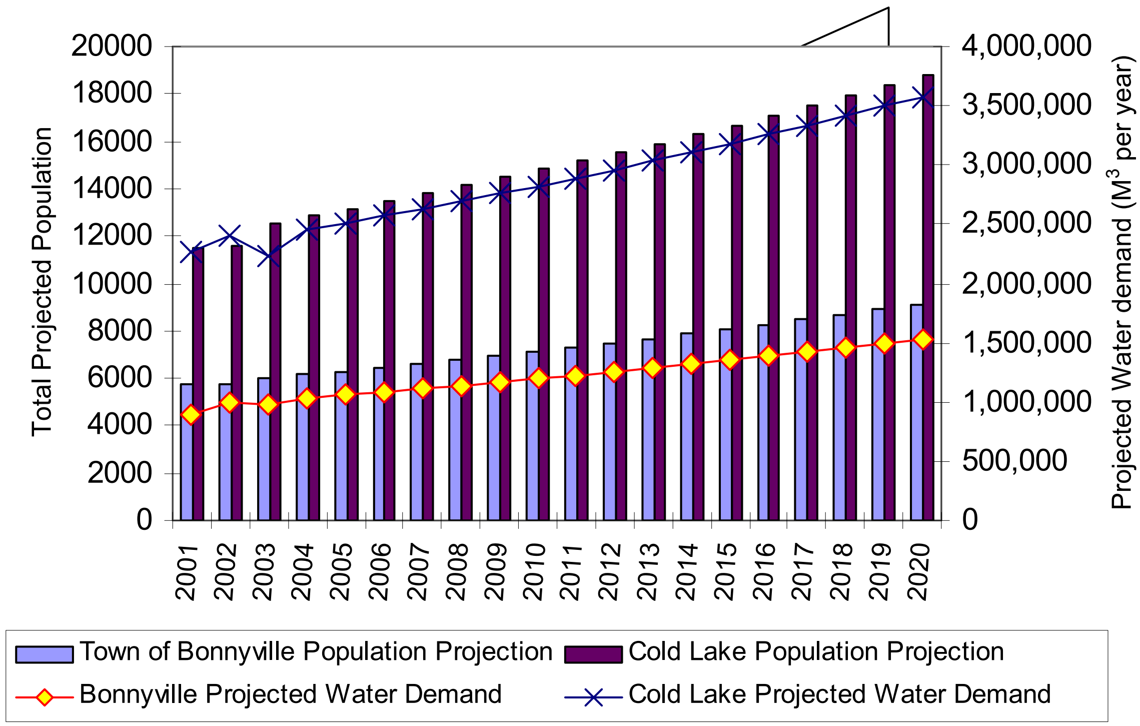


Figure 7. Cold lake and Bonnyville population projections and projected water demands (2004-2020).

Unlike municipal water use projections, future water use estimates for industry appear less predictable and depend on several factors such as the general economic trend, world oil prices, quantity of bitumen available, and improvements in water recycling and the use of alternative water sources such as brackish water. In line with these considerations, the industrial water projections are based on future water demands for the existing operations.

Figure 8 shows the historical and projected industrial freshwater, brackish water and produced water uses. The freshwater use is expected to reach a peak in 2009 due to start up of expansion projects. After 2009, freshwater use will decline as more produced water becomes available. The figure also indicates the projection of brackish water replacing freshwater requirements for start-up and make-up water.

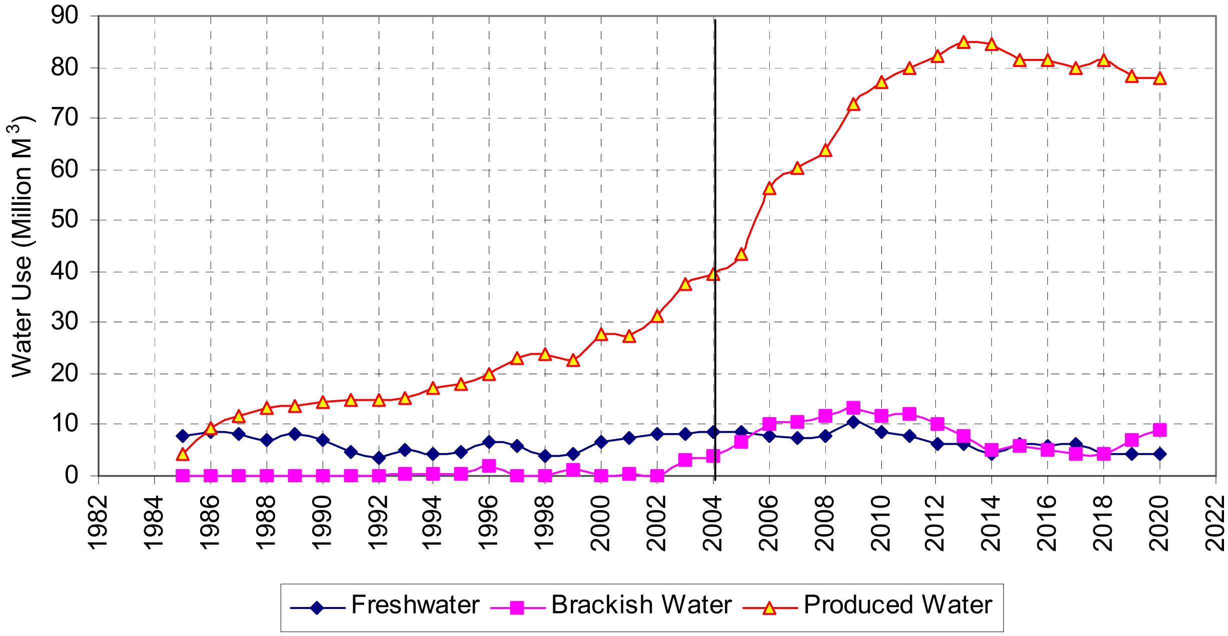


Figure 8. Historical and projected freshwater, brackish and produced water 1985 to 2020.

Figure 9 shows the historical and projected bitumen production and the amount of produced water, freshwater and brackish water required to produce it. As noted earlier, the current industrial operators in the basin provided the projected data.

The figure shows the historical bitumen production has increased from 2 million m^3 per year in 1985 to about 10 million m^3 in 2003. Production is projected to reach more than 25 million m^3 by 2020. During the same period, the amount of freshwater used for steam injection purposes has declined from 70% in 1985 to 15% in 2003, and is projected to be about 5% by 2020. The use of recycled produced water has increased from about 30% in 1985 to an estimate of 85% in 2020.

What is 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 would otherwise be required.

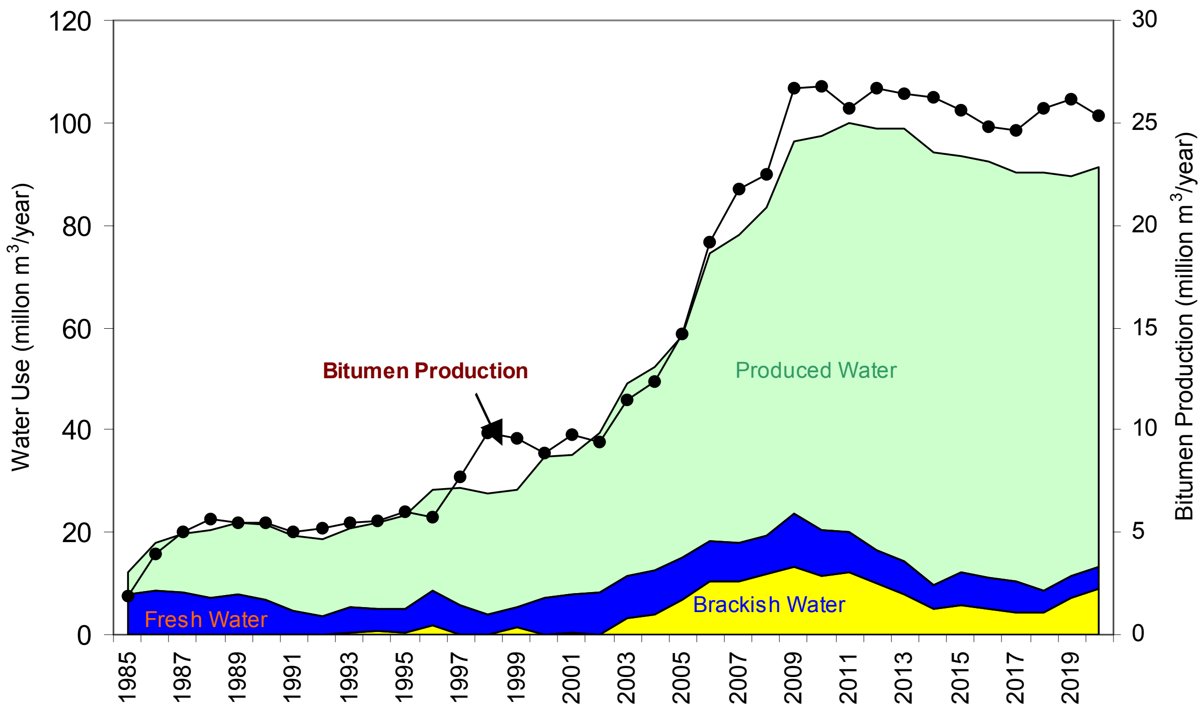


Figure 9. Historical and projected bitumen production vs. water uses.

Brackish water is also an important alternative source of water supply for industrial operations. Development of brackish water resources in the CLBR Basin started in 1993 and this water is used to supplement water needed for steam generation when produced water volumes are not available. Brackish water currently (2003) represents about 8% of the total water used for injection purposes (with the majority being recycled produced water). It is projected to reach about 15% by 2007 due to the start-up phase of Imperial Oil and CNRL expansions.

2.6 Water Conservation

Water conservation is one of the priorities in Alberta's *Water for Life Strategy*. The water strategy identifies a target of 30% improvement in overall efficiency and productivity of water use by 2015. This would involve preparing water conservation and productivity plans for all water use sectors to achieve the provincial target by 2015. Water conservation includes all activities that improve efficiency of use and productivity of water by reducing water demand and usage. Positive outcomes of conserving water include:

- Delaying or eliminating the need to expand water supply facilities.
- Ensuring maximum use of the existing water infrastructure.
- Ensuring a sustainable supply for future use, and sufficient water for healthy aquatic ecosystems.

- Helping to ensure lake water levels and in-stream flows for aquatic resources and recreational uses.
- Preventing water pollution by reducing wastewater flows and chemicals used to purify and treat water.
- Improving drought and emergency preparedness.

2.6.1 Key Findings

- Industry operators in the basin have made significant progress in water conservation since 1985. Industry has developed the technology to recycle produced water, which has increased from 0% recycling in 1978 to 95% in the current operations. Industry has also developed the capacity to treat and use brackish water. This effect has led to a reduction in the amount of freshwater used for steam injection.
- Currently, there are no formal water conservation strategies in place for any of the basin's major municipalities

2.7 Modeling Scenarios Outcomes

This section presents the results of the surface water and groundwater modeling scenarios developed through the lake-based water balance and the groundwater numerical models. The scenarios were developed for Moose Lake, Cold Lake and groundwater sources, as these are the major sources of water diversion in the basin. This section summarizes the key findings of the modeling scenarios.

2.7.1 Moose Lake Modeling Scenarios Results and Key Findings

Moose Lake is a water supply source for the Town of Bonnyville. The following three scenarios were modeled to assess the impacts of the town's historical and projected water diversions:

- Scenario 1. Natural condition — the town's historical water diversion amount was added back to the lake to determine what the natural condition would have been without the diversion.
- Scenario 2. Most likely water use scenario — the scenario was based on the town's projected water use from 2004 to 2020.
- Scenario 3. Worst case scenario — this scenario predicts the possible outcomes if Bonnyville uses 100% of its current allocation of 3.1 million m^3 per year.

Table 1 summarizes the key findings for Moose Lake modeling outcomes. The difference between the natural lake levels and the withdrawal-affected lake levels can be used to indicate the degree of impact that withdrawals have on the lake.

Table 1. Key findings for Moose Lake modeling outcomes.

	Natural conditions	Existing conditions	Most likely scenario	Worst case scenario
Lowest level (m)	532.044	531.928	531.815	531.284
Max decrease from natural conditions (m)	N/A	0.1723 m	0.3295 m	0.9847 m
% of time below sill level	53.2	68.1	70.6	83.8

DRAFT

What is a sill level?

The sill level of the lake is the level at which the lake outflows to a stream or creek.

The table shows that water withdrawal by the Town of Bonnyville causes a reduction in Moose Lake water levels and outflows from their natural condition. If the lake levels are below the sill elevation (i.e., no outflows), the town's water withdrawal become cumulative and causes further reduction in lake levels.

2.7.2 Cold Lake Modeling Scenarios Results and Key Findings

Cold Lake is a source of water supply for municipal, industry and agriculture users. Several scenarios were modeled. This section summarizes the results of the following scenarios.

- Scenario 1. Natural condition — the natural lake levels and outflows are modeled as if there were no diversions from the lake.
- Scenario 2A. Most likely water use scenario — the projected industrial and municipal water uses from 2004 to 2020 with the existing cut-off levels in place are used (i.e., no industrial diversion when the lake levels reach below 534.55 m).
- Scenario 2B. Similar to scenario 2A — the difference is this scenario assumes no cut-off level (assuming industry continues to divert when lake levels drop below 534.55 m).
- Scenario 3. Worst-case scenario — uses total industrial and municipal allocations with existing cut-off levels in place.

Table 2 summarizes the outcomes of the above scenarios. Similar to the Moose Lake scenarios, the difference between the natural lake levels and the withdrawal-affected lake levels is used to indicate the degree of impact that withdrawal has on the lake.

Table 2. Outcomes of scenarios.

	Natural Condition	Existing Condition	Most likely Scenario	Most likely Scenario (no-cut-off limit)	Worst Case Scenario
Lowest water levels (m)	534.31	534.308	534.307	534.299	534.285
Max decrease from the natural condition (m)	N\A	0.016	0.018	0.031	0.047
Lowest percentage of natural flow passed (%)		88	83	74	64

The main conclusions from the table are as follows:

1. Water withdrawals by municipalities, industry and agriculture cause a minor reduction in Cold Lake water levels and outflows from their natural condition.
2. For all the modeled scenarios, with the exception of the worst case scenario, the flow volumes required under the apportionment agreement with Saskatchewan were met.
3. The existing cut-off limit on the industrial water license lessens the industrial withdrawal impacts on the natural lake levels and outflows. If there were no cut-off limits, the natural lake levels and outflows would be reduced by 0.031 m and 26%, respectively. With the current cut-off limits in place, the natural lake levels and outflows are reduced by 0.018 m and 17%, respectively.

2.8 GROUNDWATER MODELING SCENARIOS RESULTS

Four scenarios were modeled to evaluate the potential effects of historical and projected industrial groundwater diversions in the CLBR Basin. The scenarios were simulated using the regional groundwater numerical model developed as part of CLBR Basin water management plan. It should be noted the groundwater numerical model is a regional scale model developed to gain a better understanding of regional water balances and groundwater flow regimes. The model was developed as an analysis tool to support basin scale water management decisions.

The modeling scenarios provide a reasonable assessment of what has happened and what might happen on a general scale, but requires refinement in order to predict localized effects. The most realistic indication of groundwater pumping effects can only be obtained by making actual field observations during the pumping period. Alberta Environment and industry have several strategic observation wells to evaluate the pumping impacts.

The scenarios were simulated only for industrial groundwater uses. Water wells for domestic and stock watering were not included in this simulation. The water withdrawal volumes for these wells are unknown as there are no metering or reporting requirements for the wells under the *Water Act*.

The following four scenarios were simulated for groundwater production (i.e., withdrawal) impacts:

- ► Scenario 1: Steady state scenario using industrial groundwater diversion from 1985 to 2003 — the steady state simulations are used to evaluate the equilibrium condition of the groundwater flows over the long-term average inflow and outflow. In a steady-state simulation, the model is run until hydraulic head values across the basin and aquifer storages do not change over time.

- Scenario 2: Transient scenario using industrial groundwater diversions from 1985 to 2003 — the transient simulation was run to gain further understanding of the dynamic response of the groundwater system to the historical groundwater production from 1985 to 2003. Unlike the steady state simulation, the transient simulations result in hydraulic head changes with time as water is pumped from the aquifers. The simulation also allows groundwater to be released from, or taken into aquifer storage in response to changes in system stresses.
- Scenario 3: Transient scenario for projected industrial groundwater diversion from 2004 to 2020 — This scenario was run to examine the dynamic response of the groundwater flow system to the projected industrial groundwater diversions.
- Scenario 4: Transient curve analysis — this simulation was conducted to gain further understanding of surface water and groundwater interactions and changes in regional water balances in response to groundwater production (withdrawals).

2.8.1 Groundwater Modeling Scenarios — Key Findings

1. Based on the results of the Scenario 1 simulation (steady state – industrial diversions from 1985-2003), it appears the simulated hydraulic head distributions are in general agreement with the head distributions from the steady state calibration run. Relatively small discrepancies were noted near the pumping wells. This was expected, however, as the pumping rates used in the Scenario 1 simulation were actual historical groundwater production rates that differed from the licensed allocations used for the calibration run.
2. Results of the Scenario 2 simulation (Transient - 1985 – 2003 diversion), suggested the major aquifer systems used in the basin for industrial production (Empress 1 Formation, Empress 3 Formation, and Muriel Lake Formation) responded relatively quickly to changes in system stresses.
3. Results of the Scenario 3 simulation (Transient - 2004 – 2020 diversion), generally corroborate the dynamic response of the model observed during the Scenario 2 simulation. Again, the transient simulation results suggested the major aquifer systems used in the basin for industrial production responded relatively quickly to changes in system stresses.
4. The Scenario 2 and 3 simulation results suggested the location and timing of groundwater production in the basin were important factors in understanding the potential effects of groundwater production. The simulated effects of groundwater production were governed in part by groundwater production rates, spatial separation of production wells, and temporal separation of peak production rates. The Scenario 2 and 3 simulation results also indicated the cones of influence surrounding production wells generally did not extend across the basin and were limited to the vicinity of the production wells. This prediction contrasts with findings of the monitoring data assessment, which shows drawdown in the deepest pumping aquifer extends further from the industrial pumping well.
5. Examination of the Scenario 4 transition curves (test of groundwater - surface water interactions) revealed that changes in regional water balances due to groundwater production are highly dependent on the location and completion interval of the production well. It was also noted the transition time (the time taken for the derivation of production volumes to

switch from aquifer storage to other sources) was also dependent on the location of the production well. When the simulated production well was situated adjacent to a major lake, it was observed that as production continued over time, the origin of water changed from primarily aquifer storage to induced recharge from lakes. It was also noted the connection between aquifers and surface waterbodies did not need to be direct for changes in water balances to occur. Indirect connections through overlying aquifers or vertical continuity of recent fluvial deposits appeared to have similar effects, albeit with lower magnitudes or transition times. The simulation results also suggested the proportion of water originating from lakes depends on the degree of connection (direct and indirect) between the lake and the aquifer being produced.

6. Examination of the Scenario 4 transition curves for production wells situated adjacent to major rivers revealed that as production continued over time, the origin of water changed from primarily aquifer storage to induced recharge from rivers.
7. Examination of the Scenario 4 transition curves for production wells that were not well connected to surface waterbodies revealed that as groundwater production continued over time, the origin of water changed from primarily aquifer storage to increased capture of rejected recharge.

SECTION 3. GROUNDWATER AND SURFACE WATER QUALITY

This section highlights the key issues, concerns and findings of surface and groundwater quality in the Cold Lake Beaver River Basin.

3.1 KEY ISSUES

The increasing amount of development and production from oil and gas resources, combined with increased agricultural and domestic activity in the CLBR area, triggered a need to thoroughly evaluate ground and surface water quality and ensure protective measures are implemented where required. The following key issues and priorities have been identified regarding groundwater and surface water quality and the protection of drinking water sources.

- Securing sustainable water quality for drinking water supply, aquatic life and recreational use.
- Securing water quality requirements under the Prairie Province Water Board (PPWB) Agreement between Alberta and Saskatchewan.
- Concerns regarding decreasing surface water quality and recreation potential due to development.
- Potential impacts to groundwater from development.
- Protection of groundwater sources currently being used.
- Protection of useable groundwater resources for the future.

3.2 SURFACE WATER QUALITY FINDINGS

3.2.1 Land Cover and Agricultural Land Use

1. In 1998, agriculture comprised about 85% of the cleared land cover in the CLBR Basin. The total area farmed has increased over the past 20 years by almost 40%. Cattle have replaced hog and chicken operations, resulting in an increase in pasture land. Crop acreage has also increased over the past two decades. The Beaver River Sub-basin was the most affected, with two-to-three times more area disturbed (12% area changed between 1986 and 1998) compared to other sub-basins.
2. From 1970 to 1995, commercial fertilizer application tripled in the Beaver River Basin, mostly due to an increase in fertilized area rather than intensification of fertilizer application.

3.2.2 Lake Water Quality

1. Exceedances of the Alberta Water Quality Guidelines for the Protection of Aquatic Life were few for CLBR Basin lakes:
   - Phosphorus exceeded guidelines in the most fertile lakes: Angling, Long, Kehewin, Moose and Muriel. Phosphorus is naturally high in Alberta soils and water but may have been enhanced by land disturbance or negative land use practices, as evidenced by a strong relationship between phosphorus and land disturbance (Figure 8).
   - The pH exceeded guidelines in most lakes. Lakes in Alberta are naturally well-buffered, but drought may have also played a part in raising the pH.
   - Angling and Muriel lakes had minor arsenic exceedances of guidelines in three samples from 2003. This may be due to naturally occurring arsenic in the local geology, but should be explored further.
2. Lakes in the CLBR Basin range from moderate (mesotrophic) to very high fertility (hypereutrophic). Moose and Kehewin lakes are highly fertile (i.e., hypereutrophic)—more so than the average Alberta lake.
   - In general, the greater the amount of disturbance in a watershed, the more fertile the lake becomes and the clarity is reduced (Figure 8).
   - Fertility indices remained largely unchanged over the past two decades. However, it is unknown at this time if fertility in these lakes increased before the 1980s.
3. Significant increases in ions, salinity and associated parameters (pH, hardness, conductivity, alkalinity) reflect changes in the water balance of the CLBR Basin. As less freshwater enters the waterbodies, flushing of "old" water is reduced and solutes become concentrated. Indeed, lakes with the greatest water level reductions are often most saline (Figure 9).

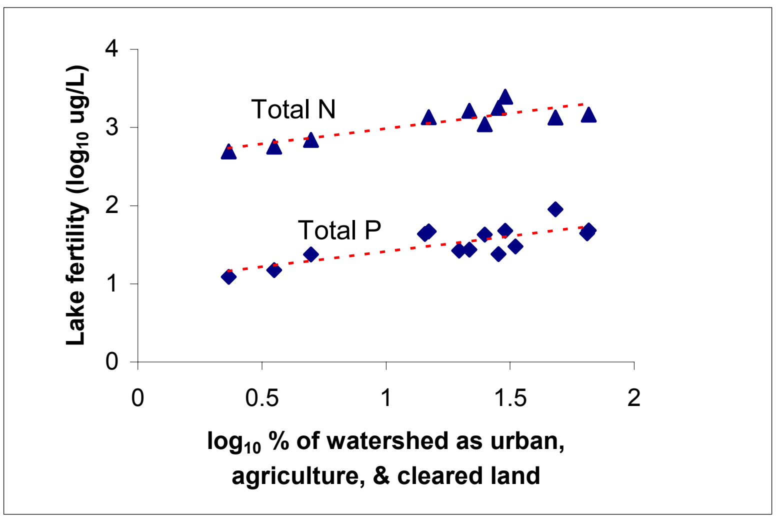


Figure 8. Relationship between percentage of watershed disturbed and summer lake fertility (as total P and N concentrations) among CLBR Basin lakes. (Each point represents one of the following lakes: Angling, Beaver, Chickenhill, Cold, Ethel, Garner, Garnier N+S, Kehewin, Long, Marie, Moose, Muriel, North Buck and Touchwood.)

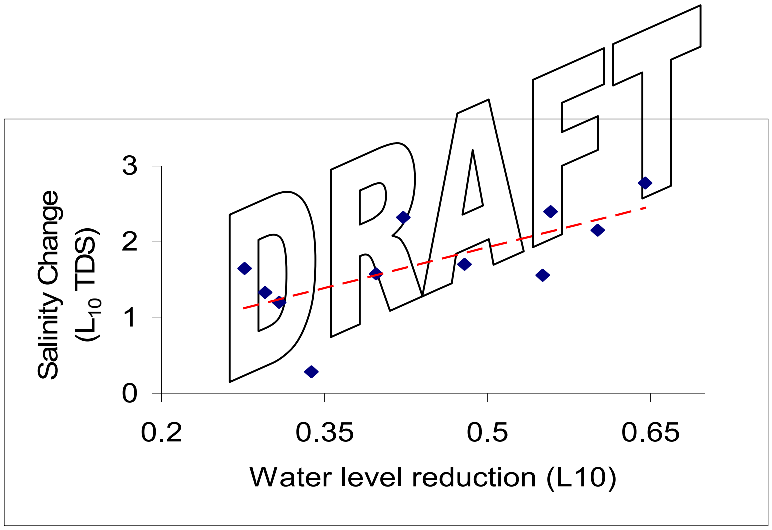


Figure 9. Relationship between water level reduction and salinity change in lakes from CLBR. Note the greater the reduction in lake level, the greater the increase in salinity. (Each point represents one of the following lakes: Beaver, Cold, Ethel, Garnier, Long, Marie, Moose, Muriel, North Buck and Touchwood.)

3.2.3 Beaver River Water Quality

1. The mostly clean Sand River contributes about half the flow of the Beaver River. Because of this, the water quality in the Beaver River near Beaver Crossing is generally good.
2. Exceedances to Prairie Provinces Water Board Water Quality Objectives for the Beaver River were scattered through time and/or attributed to natural conditions. These included total copper (Cu), total iron (Fe), and dissolved manganese (Mn) concentrations, dissolved iron (Fe), total cadmium (Cd), total chromium (Cr), dissolved oxygen, total zinc (Zn) concentrations, and a few exceedances for fecal coliforms.
3. Total dissolved phosphorus and nitrate+nitrite concentrations have decreased since 1985 in the Beaver River. The most likely explanation for this decline is a large reduction in nutrient concentrations emanating from Marie Creek, due to improvements to the City of Cold Lake's wastewater treatment plant.
4. Most ions and salinity have increased, likely due to concentration of ions in the watershed owing to drought and/or a relative increase in groundwater contributions.

3.2.4 Municipal Wastewater Effluent

Effluent discharges have to be strictly controlled to ensure that Prairie Provinces Water Board (PPWB) objectives for the Beaver River are met. The Beaver River is sensitive to discharge from treated municipal wastewater facilities because it is a relatively slow-flowing system. Expected population growth in the CLBR Basin, combined with the known sensitivity of the Beaver River to municipal effluent, requires proactive planning for the anticipated increase in municipal effluent discharge. Treatment of sewage in the CLBR Basin should be based on the capacity of the Beaver River to receive the treated effluent. For this purpose, it is recommended that an effluent quality control policy be developed specifically for the Beaver River. Also, to best control and integrate municipal sewage treatment and discharge, a sewage treatment plant with nutrient control is recommended in the greater Cold Lake area.

3.2.5 Protection of Sources of Drinking Water

In Alberta, source water protection has been practiced informally to some degree through the environmental approval process on wastewater discharge regulation. However, some pollution sources (e.g., non-point source pollution) may not be regulated. Source protection planning is gaining more attention in Alberta, and is currently being developed for major river basins. Alberta Environment regulates municipal drinking water but has no regulatory authority over private drinking water systems as water quality for private wells and cisterns are the responsibility of the owner.

The Town of Bonnyville draws its raw water from Moose Lake and treats it to meet the demands of the town. Treatment challenges have traditionally been related to high organic concentrations and turbidity. Source protection efforts to reduce or control algal blooms and organic inputs in Bonnyville source water can assist the water system in meeting its requirements and reducing treatment costs.

The Cold Lake Regional Utilities Commission (CLRUC) draws raw water from Cold Lake and supplies potable water to Cold Lake North, Cold Lake South, CFB 4 Wing Cold Lake, the Cold Lake First Nations, as well as Ardmore and Fort Kent within the M.D. of Bonnyville. Based on existing information, Cold Lake appears to be a relatively clean source of water. However, potential hazards and risks for contamination that may not be presently detected by current water monitoring programs should be identified in the CLBR Basin as part of a more stringent source protection initiative.

3.3 GROUNDWATER QUALITY ASSESSMENT

The 1985 plan developed for the CLBR Basin did not specifically address groundwater quality in the basin. More recently, the impacts on groundwater quality have become an increasingly high priority issue as industrial development approaches populated areas in the southern and eastern portions of the basin. There is also increased recognition that some industrial, commercial, municipal, agricultural and domestic practices can impact groundwater quality. As a result, in the current planning process the regional groundwater quality was assessed and potential management options were developed.

3.3.1 Groundwater Quality Database

Alberta Environment partnered with the Alberta Geological Survey (AGS) to compile and analyze groundwater data in the CLBR Basin. The goals of this undertaking were to complete a fully digital 3-D geological model of the area, and compile a relational database of groundwater, well and chemistry details and link it to a geographic information system. This information was used to construct a 3-D calibrated regional groundwater flow model of the basin (as discussed in the groundwater quantity section of this report). The purpose behind this project was to build the capacity to manage the groundwater of the CLBR Basin through understanding the natural system and being able to query and display the location of wells and historical static water levels and groundwater quality.

The regional-scale groundwater quality database was developed to provide information on current groundwater quality in the region and allow users to track groundwater quality changes in the future. The database contains information collected from provincial and local governments, and industrial operators in the basin. In total, 1600 wells were included in the database and assessed for over 200 different chemical parameters. The database, combined with the 3-D geological model, allowed the technical team to map concentrations of contaminant indicators in the basin and assess regional groundwater quality.

Included in this project was a compilation of potential contamination sources and a regional-scale map of surficial aquifer sensitivity to contamination.

3.3.2 Arsenic

Although the present study included arsenic as a parameter of concern, it did not focus specifically on arsenic. Previous work by Alberta Environment and Alberta Health and Wellness have examined in detail the arsenic concentrations in the basin. The Alberta Geological Survey also studied arsenic concentrations in groundwater throughout the province. The general conclusion of these studies was that arsenic concentrations are often naturally elevated as a result of the geological setting and composition of the till at the location.

These naturally elevated concentrations of arsenic may be enhanced by geochemical mechanisms associated with the thermal production of bitumen. As a result, in-situ oil sands operators in the CLBR Basin are required to investigate the potential for their operations to release or liberate arsenic into groundwater. Both Imperial Oil and CNRL have investigation programs approved by AENV currently underway, which involve field and laboratory experiments. In addition, both Husky and BlackRock are required, as part of their recently approved projects, to investigate the potential for their operations to release arsenic into groundwater.

3.3.3 Key Findings and Conclusions

The key findings are based on a regional scale assessment. Groundwater quality at a particular location may not meet the Canadian Drinking Water Quality Guidelines due to natural or anthropogenic causes. Individual well owners should test their wells to determine what treatment is needed before using the water.

The key findings of the AGS study were:

1. The regional groundwater chemical quality is generally within Canadian drinking water quality guidelines, and has not changed detectably over time.
2. A number of areas within the basin were determined to be potentially sensitive to contamination.
3. A number of potential point and non-point sources of contamination are located within these sensitive areas.

From the key findings of the study, the groundwater quality technical team developed the following conclusions:

- The finding that groundwater quality is not changing significantly with time is based on only two decades of data for the region. Additional data over time is needed to further evaluate if changes to groundwater quality are occurring as a result of development.
- Areas in the western portion of the basin do not have extensive groundwater monitoring networks associated with industrial operations; therefore, the quality of groundwater in these areas is less certain.
- Potential risks to groundwater from industrial operations in the eastern portion of the basin are well known and studied. The industrial facilities operate with the requirement for groundwater monitoring and submission to regulatory agencies of annual groundwater monitoring reports.
- There is limited regulation of individual water well users for domestic use and small agricultural operations. There are concerns that improper well installation, well maintenance, and well abandonment by individual landowners might be a risk to groundwater quality in the basin.

SECTION 4. STRATEGY FOR PROTECTION OF AQUATIC RESOURCES

This section highlights the important functions of aquatic ecosystems, and the key issues and findings for aquatic resources in the CLRB basin.

4.1 AQUATIC ECOSYSTEMS

Sloughs, ponds, lakes, creeks and rivers do not simply store and carry away surface water. They are complex systems that provide numerous critical functions to aquatic and terrestrial ecosystems and values to humans. Wetlands, lakes and streams are essential, natural systems for physical, biological and chemical filtering of water. They are critical for groundwater recharge, reduction of flooding, and in capturing silt and helping to biodegrade harmful chemicals washed off nearby lands. The success of these functions depends on naturally occurring plant communities that anchor and support healthy, interdependent microbial, invertebrate and aquatic insect populations.

Naturally vegetated riparian and littoral zones also provide essential erosion protection along the margins of waterbodies. Most fish populations and water-based wildlife populations require aquatic vegetation and well-vegetated riparian areas for spawning and nesting sites, nursery areas, feeding areas and shelter.

Resource managers responsible for fisheries and wildlife use the presence and abundance of aquatic vegetation, wildlife and fish as indicators of the healthy functioning of aquatic ecosystems. Studies of fish and fish habitat, and water-based wildlife and its habitat, provide information on the health of a number of in-water and upland components of the aquatic ecosystem and the various stresses that affect it. Studies of water quality provide information on the state of water after the aquatic ecosystem has done its work.

4.2 AQUATIC RESOURCES KEY ISSUES

- The past 25 years have recorded a shortfall in precipitation levels throughout much of the CLBR Basin, resulting in diminished flows and reduced water levels. Fish and water-based wildlife populations are very sensitive to changes in water levels, and their numbers have been reduced where productive habitats have been lost, particularly in shallower waterbodies.
- The health of many fish populations in the CLBR Basin has been below optimum for many years as a result of fishing pressure being well above sustainable levels, as well as decreased habitat quality and quantity in some waterbodies.
- Over the years, some fish populations have become isolated by watershed fragmentation caused by low water levels and man-made structures on connecting streams.

- The 1985 CLBR Long-term Water Management Plan identified Wolf, Burnt, Angling, Caribou and Marie lakes as candidates for dams placed on their outlet channels for water storage and multiple consumptive uses. Currently, Wolf, Angling and Marie lakes, and possibly others, are noted as having high wildlife, fisheries and recreational values that could be threatened by damming and increased water withdrawal.
- The continuing incremental loss and degradation of wetlands and riparian habitat are important factors challenging fish survival, water-based wildlife, water-based recreation, water quality, and the essential functioning of aquatic ecosystems in the basin. The continual expansion of agriculture and cottage developments (new clearing, cultivation, grazing, subdivisions) on uplands and along lakes and streams continue to increase pressure on waterbodies and riparian habitat through erosion, nutrient loading, wetland conversion and shoreline damage.
- The CLBR Basin and surrounding area has the highest concentration of recreational lakes and high-quality beaches in Alberta. Reductions in flow, water level, and water quality can lead to substantial changes in the quality, amount and type of water-based recreational activities possible on the area lakes and rivers.

4.3 KEY FINDINGS

4.3.1 Fisheries

By the mid-1980s, studies on many lakes in the CLBR Basin indicated that most accessible fisheries were experiencing serious population declines. As these declines in regional fisheries became evident, it was necessary for the Alberta Government to implement a more complex lake-by-lake and species-by-species management system for the fisheries. The province undertook legislative, policy and fisheries management initiatives to ensure appropriate action for restoring fish populations to healthier levels (e.g., Walleye Management and Recovery Plan 1995, Northern Pike Management and Recovery Plan 1999).

The health of the sport fish populations in the CLBR Basin remains below optimum; however, there are some signs of improvement. 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. Following 1995, the Fish and Wildlife Division of SRD noted substantial increases in lake trout catch rates. In addition, summer angler effort increased 35% from 0.40 angler-hours/ha in 1992 to 0.62 angler-hours/ha in 2000, and was considered to be much higher in 2004.

Overall, habitat conditions remain good in Cold Lake, provided the water level remains above 534.55 meters above sea level (the current cut-off level for industrial withdrawals). This ensures access to the Cold River outlet for successful lake trout spawning, and enables fish access to the Long Bay complex which is critical to the productive capacity for cool water species such as northern pike, walleye and yellow perch.

- **Walleye —** There are 13 lakes in the lower CLBR Basin containing walleye. Two are classified as *stable*, five are *vulnerable* and six are *collapsed*. Improvements have been noted recently at Moose Lake and Wolf Lake.

- **Northern Pike —** There are 21 lakes in the lower CLBR Basin with northern pike. Two are classified as *stable*, 14 are *vulnerable*, 2 are *collapsed* and 3 are currently unclassified.

Table 3. Population status of walleye and northern pike at 21 lakes in the CLBR Basin planning area.

Waterbody	Walleye Classification	Northern Pike Classification
Angling Lake	N/A	Vulnerable
Beartrap Lake	N/A	Collapsed
Bourque Lake	Vulnerable	Vulnerable
Burnt Lake	Stable	Stable
Cold Lake	Vulnerable	Vulnerable
Crane (Moore) Lake	Collapsed	Vulnerable
Ernestina Lake	N/A	Unclassified
Ethel Lake	Collapsed	Vulnerable
Hilda Lake	Vulnerable	Vulnerable
Kehewin Lake	Collapsed	Collapsed
Leming Lake	N/A	Unclassified
Marie Lake	Vulnerable	Vulnerable
May Lake	Collapsed	Vulnerable
Moose Lake	Vulnerable	Vulnerable
Muriel Lake	Collapsed	Vulnerable
Primrose Lake	Stable	Stable
Sinclair Lake	N/A	Vulnerable
Soars Lake	N/A	Vulnerable
Thompson Lake	N/A	Unclassified
Tucker	N/A	Vulnerable
Wolf Lake	Collapsed	Vulnerable

All existing fisheries in the lower CLBR Basin must be recovered to optimal productive capacity to accommodate the increasing demand for domestic, sport and commercial fishing. In addition to an effective management regime, maintaining the productive capacity of a waterbody is critical to fish recovery. Productive capacity is strongly influenced by water quality, water quantity and habitat conditions. When any one of these interconnected factors is degraded, the productive capacity for fish is impaired.

- Water quality throughout the basin should be maintained at standards that are protective of aquatic life.
- Water levels should be maintained at levels that protect fish habitat, in particular travel and spawning habitat.

On some lakes, land use practices and associated near-shore developments are creating problems through alteration of shoreline habitats and riparian zones (e.g., Moose Lake). Elsewhere in the CLBR Basin, cattle grazing along shorelines of lakes and rivers contributes nutrient input (nitrogen and phosphorus); in turn, this creates conditions for algal blooms and periodic low dissolved oxygen conditions. These factors can contribute to the poor conditions for fish in lakes experiencing very low water levels (e.g., Ernestina and Manatokan lakes). Increasingly poor water quality (i.e., increasing pH and nutrient loading) may be affecting fish productivity in a number of lakes, especially south of the Beaver River (e.g., Muriel, Moose and Kehewin Lakes).

4.3.2 Wildlife

Water-based birds and mammals, and their riparian habitats, are very important and visible indicators of the health of the aquatic ecosystem. In the early 1980s and in 2003, a total of 28 lakes were surveyed for water-based wildlife, and riparian and backshore habitat. The comparison of the survey results shows a number of changes, primarily due to long-term drought. As wetlands dried up, and lake shorelines receded, beaver and muskrat died out or were greatly reduced in many waterbodies. Waterbirds disappeared from small, dried (sometimes cultivated) wetlands and decreased on a number of shrunken, shallow lakes. The 28 surveyed lakes lost almost 50% of their total bird numbers (due mainly to a reduction in number of waterfowl), with small marshy lakes experiencing the greatest loss.

Most of the larger, deeper lakes in the basin experienced some drawdown of their water levels, but had more bird species and more individual birds in 2003. Lakes showing the greatest decline in water levels, and hence a change in waterbird numbers, are located in the southern portion of the lower CLBR Basin. Although some species of waterbirds have declined at affected waterbodies, other species have benefited from the exposed shorelines and beaches. Many waterbodies still provide good quality habitat for water-dependent wildlife.

From 1980 to 2003, industrial, cottage and agricultural activities were responsible for some losses of water-based wildlife owing to the loss or degradation of their habitat and its aquatic ecosystem functions; however, those losses were overshadowed by the losses caused by drought. The dried beds and shores of wetlands, streams and lakes need to be managed carefully so they will again be productive for wildlife, and will carry out their essential ecosystem functions when water levels return.

4.3.3 Water-Based Recreation

Recreation activities noted as being popular in the 1985 CLBR Water Management Plan (swimming, fishing, power-boating, canoeing, sailing, camping, picnicking, nature study, etc.) remain popular today in the CLBR Basin. Extended periods of below-normal precipitation and low water levels have resulted in numerous changes in recreation facility development, however. This includes the decommissioning, closing and/or transferring of provincial recreation areas and municipal campgrounds, consolidation of some facilities, and in some cases the creation of new facilities and enterprises.

Low water levels have seriously impacted certain forms of recreation development and activity for at least four lakes: Muriel Lake, Moose Lake, Manatokan Lake and Tucker Lake. Recreational use of other lakes has remained fairly constant or increased (e.g., Cold Lake and Marie Lake).

There is a growing demand for recreational property and cottage developments at many lakes, particularly at Moose Lake and Moore (Crane) Lake. Moose Lake supports the most intensive cottage/residential development in the study area. Almost all the northeast, east and part of the south shorelines have been developed for cottage use. There are 2 summer villages on the lake (68 developed lots), and an additional 15 registered cottage subdivisions on the lake with a total of 642 available lots. Further back from the shoreline are a number of country residential subdivisions.

Recent data from Alberta Conservation Association assessed the Moose Lake shoreline (riparian) habitat as 73% healthy, 10% somewhat impaired, and 17% highly impaired.

SECTION 5. PLANNING FOR THE FUTURE

The previous sections in this overview report summarized the key issues and findings of the four *State of the Basin Reports*. This section outlines the foundation for the plan and the guidelines that will be used to formulate it. Many of these guidelines are aligned with Alberta's Water for Life Strategy, helping to ensure the final updated plan meets provincial requirements while reflecting the local watershed interests specific to the CLBR Basin.

Ultimately, the updated plan will integrate portions of the existing plan that have effectively addressed specific basin water management issues with the new management tools that reflect updated technical information. Current and future water supply and demand scenarios will be considered in this undertaking.

5.1 Vision and Principles

As indicated in the Framework for Water Management Planning, developing a watershed plan is a complex process that addresses multiple issues, involves different stakeholders and produces recommendations to guide future water management decision in the basin. The Framework recommends that all water management planning initiatives adhere to the vision and the principles adopted by the provincial government. The water management vision and principles were developed through consultation with Albertans.

To ensure consistency with the Framework for Water Management Planning, the updated CLBR Basin plan will adopt the following provincial vision and principles of water management:

Vision	• All Albertans are stewards of Alberta's water; • Albertans act responsibly in managing and conserving water to ensure the environmental, economic and social health of the province; • Albertans recognize the importance of living within the capacity of the natural environment as a means of ensuring the sustainability of water.
Principles	• Water must be managed sustainably. — *Water must be managed and conserved to meet current and evolving needs without compromising the ability of future generations to meet their own needs.* • Water is a vital component of the environment. — *Water is recognized as one of Alberta's most important natural assets;* — *The aquatic environment, including the diversity of aquatic life, must be protected.* • Water plays an essential role in a prosperous economy and balanced economic development. — *Water must be wisely allocated and efficiently used, and regulatory and administrative processes for managing water must be streamlined, user-friendly and fair.* • Water must be managed using an integrated approach with other natural resources.

	— *The interdependence of water quality and water quantity is recognized;* — *The interdependence of natural resources is recognized;* — *Water management is based on a watershed approach.* • Water must be managed in consultation with the public. — *The public must be involved in water management and decision-making;* — *Information sharing and open communication must be provided;* — *Opportunities for public education must be supported.* • Water must be managed and conserved in a fair and efficient manner. — *Water rights which existed under the* Water Resources Act *must be recognized;* — *Enforcement action, when required, must be applied firmly, fairly and consistently;* — *Water management must respond to differing local and regional needs;* — *The Government of Alberta must work cooperatively with governments of other jurisdictions.*

5.2 Goals, Outcomes and Objectives

Goals and outcomes provide specific focus and purpose to the plan update effort. The provincial water strategy has developed and adopted three main goals and outcomes to manage provincial water resources. The goals and outcomes were developed through extensive consultations with Albertans.

To ensure alignment with the provincial strategy, the CLBR Basin plan update will adhere to the following Water Strategy goals and outcomes:

Goals and Outcomes	• Safe secure drinking water supply • Healthy aquatic ecosystems • Reliable, quality water supplies for a sustainable economy

Objectives are specific steps that must be accomplished to achieve the goals and outcomes. The planning team for the CLBRB plan developed the following objectives in conjunction with the Basin Advisory Committee (BAC) and other stakeholders to ensure the shared values of all stakeholders within the community are reflected.

Objectives	• Establish water conservation objectives and develop strategies to protect aquatic resources and health ecosystems. • Ensure safe and secure drinking water. • Promote and encourage water conservation best management practices for all users of water. • Ensure that groundwater and surface water management and allocations are coordinated. • Effectively manage and allocate water resources within the basin. • Establish Watershed Planning and Advisory Council partnerships for management

	recommendations and implementation. • Establish and continue long-term surface and groundwater quality and quantity monitoring. • Incorporate a watershed perspective in land use planning. • Ensure requirements of the Apportionment Agreement between Alberta and Saskatchewan are met. • Promote awareness and educational activities to increase public knowledge and understanding about regional water issues. • Ensure that groundwater and surface water quality in the basin is maintained at a level equal to or better than the present condition. • Use best available scientific information to make water management decisions.

5.4 NEW DIRECTION FOR WATERSHED MANAGEMENT: SHARED GOVERNANCE AND PARTNERSHIP

Water for Life: Alberta's Strategy for Sustainability promotes new directions for water resource management, shifting the focus from a traditional regulatory approach to a more holistic watershed management approach. In particular, the Strategy promotes collaboration and partnership to achieve the goals of the provincial water strategy.

The water strategy promotes three levels of partnership that have different but complementary roles:

1. **Alberta Water Council (AWC)** — Partnership at the provincial scale will be facilitated through the Alberta Water Council. The main tasks for this partnership are to provide advice on provincial water management issues, guide and track implementation of the provincial water strategy and research priorities.
2. **Watershed Planning Advisory Council (WPAC)** — Partnership at the watershed scale such as the Cold Lake–Beaver River Basin, will be facilitated through a Watershed Planning Advisory Council. The key functions of the WPAC include reporting on the state of the watershed, developing and implementing watershed management plans, education initiatives and promoting best management practices. A Watershed Planning Advisory Council is proposed for the Cold Lake–Beaver River Basin.
3. **Watershed Stewardship Group (WSG)** — Partnership at a local scale, such as the Moose Lake Watershed, will be managed through a Watershed Stewardship Group. The WSG partnership is more effective in undertaking stewardship activities and promoting best management practices to improve and protect a local water watershed.

5.5 EVALUATION CRITERIA FOR ASSESSING WATER MANAGEMENT OPTIONS

The Cold Lake Beaver River Basin technical teams have been encouraged to explore the full range of potential water management options in the basin and provide these options to the BAC. The

BAC will consider these options along with any other management options that have been provided from other sources. These alternative options range from the minimum effort of continuing the current practices (i.e., status quo) to developing a new water management regime. The use of any particular alternative management option depends on whether it meets the existing provincial laws and policies, and other planning criteria that have been determined by the BAC.

In order to compare, measure and select among the alternative options, the planning team, in partnership with the BAC, developed the following specific criteria to measure against any potential management options. These criteria will help select the management options for the updated Cold Lake Beaver River Basin Plan.

1. **Effectiveness** — How successful will this option be in resolving a specific problem and achieving a specific objective?
2. **Efficient** — Is this option the most cost-effective means for resolving a problem and achieving a specific objective?
3. **Acceptability** — How acceptable is this management option to the stakeholders?
4. **Compatibility** — Is this option compatible with the existing laws, policies and regulations of the federal, provincial and local governments?
5. **Viability** — Can this option be easily implemented?

SECTION 6. POTENTIAL RECOMMENDATIONS AND MANAGEMENT OPTIONS

Aside from gathering and analyzing information related to the basin, the four technical teams were also asked to recommend management options that would address how water might be managed within the CLBR Basin. It should be noted the recommendations provided by the technical teams, and included in this section, are preliminary and will be finalized only after a thorough discussion with the BAC and input from other stakeholders.

Management Recommendations Outline/Format

The final management plan will be formatted into the three main themes of (1) *Water Supply and Demand,* (2) *Surface and Groundwater Quality* and (3) *Strategies for the Protection of the Aquatic Resources.* Recommendations under each of these three themes will be further subdivided into those that are regulatory (i.e., under the direct mandate of Alberta Environment), and those which are related to best management practices but may not be under the direct mandate of AENV (i.e., non-regulatory).

The recommendations presented in this section follow the same format and outline that will be used in the updated management plan. The outline of this format is as follows:

Part 1: General Recommendations

Part 2: Supply and Demand

- Industrial water uses
- Municipal water uses
- Agriculture, irrigation, commercial and temporary diversion water uses

Part 3: Surface and Groundwater Quality

Part 4: Strategy for the Protection of Aquatic Resources

6.1 PART 1 — GENERAL RECOMMENDATIONS

1. **A review of water demand projections should be undertaken every five years or as necessary to re-assess water supply/demand and evaluate existing management plan recommendations.**

   Estimating future water demands is essential for decision makers in balancing the provision of adequate supply and protecting aquatic resources. However, water use projection is a complex process and contains many uncertainties. It is recommended that water use projections be re-evaluated every five years in order to be consistent with the goals and objectives of this plan.

2. **A Watershed Planning and Advisory Council (WPAC) will be established as an outcome of the management plan. The WPAC will be responsible for implementing the plan's non-regulatory/best management practices in partnership with AENV.**
3. **Data generated from all (non-private) monitoring activities in the CLBR Basin should be available through a public data distribution and storage system. This will require establishing mechanism for managing, distributing and storing data related to groundwater and surface water (quantity and quality) monitoring.**

6.2 PART 2 — WATER SUPPLY AND DEMAND

6.2.1 Industrial Water Use Recommendations

1. Based on the current and projected industrial water use demands, the 1985 recommendation to access industrial water supply water from the North Saskatchewan River is not required. Water from the Cold Lake – Beaver River Basin will be sufficient for industrial water use requirements.

- In 1985 and 1994, withdrawing water from the North Saskatchewan River through a pipeline was the preferred option for industrial water use. At the time these plans were written, the projected demands anticipated a freshwater use of 30 million to 80 million m^3 per year. However, the current and projected water demands indicate that freshwater use (until 2020) is projected to be approximately 10 million m^3 per year.*
- Improved recycling technologies and the use of saline (i.e., brackish) water sources have provided alternatives that offset the demand for freshwater. These alternatives did not exist in previous planning exercises.
- Current legislation from Alberta's *Water Act* prohibits any interbasin transfer of water.
- The potential for a pipeline may be considered in future planning updates if demand for freshwater in the basin reaches the levels projected in 1985 and 1994.

2. To ensure consistency with Alberta's Water for Life Strategy, groundwater and surface water resources in the basin must be managed within the capacity of the Cold Lake –Beaver River Basin.

In addition:

a) Groundwater and surface water allocation limits in the basin should be designed to prevent adverse impacts on the environment and on other users.

b) The foundation for effective water allocation decision making and planning should be based on a sound knowledge of the regional hydrogeology and hydrological cycle.

* *The stated projected water use figure (i.e., not allocation) is based on existing projects and is acquired from industrial applications available within the public domain. These figures are also reported in the Surface Water Quantity State of the Basin Report.*

c) Effects of groundwater production are dependent on pumping rates, spatial separation of wells and temporal separation of pumping periods. Future management of groundwater resources should consider these factors.

3. **Underground injection of non-saline water in the basin will follow the recommendations of the final report of the Minister's *Advisory Committee on Water User Practice and Policy* for oilfield injection. The report recommends that a case-by-case evaluation of projects should be undertaken to minimize the use of non-saline water. In water-short areas, non-saline water sources should be used only when feasible alternatives do not exist, and environmental risks should be assessed and minimized for each project.**

In addition:

(a) Priorities for reduction or elimination of injection of non-saline water within the watershed (based on availability and demand) will be established.

(b) The use of groundwater in localized areas where there are immediate or pending groundwater conflicts will be identified and minimized.

The above recommendation corresponds with the provincial *Water Use Practice and Policy Final Report* for oilfield injection. Water use in the basin requires that alternative sources of water be considered and used prior to the use of any freshwater.

4. **Alberta Environment is also developing a new *Water Conservation and Allocation Policy for Oilfield Injection*, which will be finalized in 2006. The policy applies to the entire province and will guide efforts to minimize the use of non-saline water in enhanced oil recovery projects, including thermal in situ enhanced recovery projects. The policy is accompanied by a *Water Conservation and Allocation Guideline for Oilfield Injection*, which sets out new evaluation and water licence application criteria for non-saline water.**

5. **Existing projects are encouraged to minimize the use of freshwater through increased use of produced and saline water.**

The freshwater use represents about 15% of the total water used for injection purposes. It is recommended that industrial operators continue to reduce and ultimately eliminate the use of freshwater for injection purposes.

6. **The CLBR planning area contains several deemed groundwater licences that will be coming up for renewal on December 31, 2006. Any deemed groundwater licences in the planning area intended for oilfield injection purposes will follow the anticipated province-wide guidelines/policies that will address requirements and conditions for renewal**.

7. **The groundwater numerical model and/or water levels monitoring should be used to evaluate potential impacts of groundwater diversions on shallow aquifers, surface waterbodies and streams.**

The groundwater numerical model and water levels monitoring are essential tools in evaluating and predicting potential impacts of groundwater diversions. Alberta Geological Survey has developed a regional groundwater numerical model for the CLBR Basin. In order for this model to determine site-specific evaluations and predictions, additional refinements are required. As these refinements are made, the model should be available as a decision-making tool for the approval process under the *Water Act*.

The technical team further recommended:

- AENV and industry should work together to refine and update the regional groundwater numerical model.
- AENV, in partnership with other relevant agencies, will maintain and implement future updates of the model.
- Before granting a license, applicants proposing withdrawals greater than 500 m^3/day should use the groundwater numerical model to evaluate the potential impacts on local lakes, streams, wetlands and shallow aquifers. If an applicant wishes to use another model to assess this information, the applicant can also submit the findings from the alternative model.
- Groundwater monitoring of water levels should be recommended for applicants using less than 500 m^3/day in lieu of completing a comprehensive groundwater modeling exercise.

8. **The technical team recommended that further research should be undertaken to better understand the regional hydrogeological system. In particular, the technical team recommends the following:**
   - Better understanding of groundwater and surface water interactions to identify streams and surface waterbodies that are vulnerable to groundwater diversions.
   - Integrating groundwater and surface water balance models to better understand groundwater contributions to surface waterbodies.
   - Better understanding of the potential impacts of land use/land cover changes on the regional hydro-geological system.
   - Continue to evaluate the availability of groundwater in the basin.

9. **Saline water is an important source of water supply for thermal projects in the CLBR Basin. Although the use of saline water is not regulated under the *Water Act*, the technical team recommended that all industry members using or proposing to use saline water should form a mutual cooperative committee responsible for managing saline water resources. The committee's activity should include, but not be limited to the following:**
   - Data collection, long-term monitoring, problem identification and resolutions.
   - Determine if additional monitoring wells are required to ensure the long-term viability of saline water.
   - Modelling results indicate that during high peak brackish water uses periods, inter-well interference may limit pumping capacities. It's recommended to space pumping wells appropriately to maximize pumping capacities.
   - Brackish water chemistry monitoring is recommended as an indicator of quality changes that may affect long-term brackish water use.
   - All industry members using the McMuurray Formation as source of brackish water use should install reliable, elevation-referenced groundwater level monitoring in their source wells and available Mannville Formation monitoring wells as soon as possible.

- Determine if a saline water numerical model should be developed and used as a standard tool to evaluate and predict saline water availability.
- Produce and submit an annual saline water use report to the basin's Watershed Planning and Advisory Council (WPAC).

6.2.2 Municipal Water Use Recommendations

10. Cold Lake Regional Water Utilities should continue using Cold Lake as a source of municipal water, but should consider implementing additional water conservation strategies.

- Metering — Installation of meters at water sources, customer service connections, public buildings, parks and recreation centres. Metering provides opportunities to track water production and deliverables, and identify any leakages in the system.
- Public education and information — The public should be informed of the real costs of water use and the savings that can be achieved through water efficiency.
- 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.
- Provide consumption data to metered customers — The monthly water consumption should be printed on the corresponding water bill as a tool to help residents monitor their water use.
- The City of Cold Lake should develop water conservation targets and implementation schedules to achieve water conservation objectives.
- The City of Cold Lake should consider additional water conservation measures for implementation if water levels in Cold Lake drop below the industrial water use cut-off level.

11. Moose Lake has sufficient quantity of water to meet the Town of Bonnyville's water demands. However, because of other considerations (e.g., lake water quality, upgrading facility to meet new provincial drinking water standards), the town should consider connecting to the Cold Lake regional water system.

6.2.3 Agriculture/Commercial/Irrigation/Temporary and/or Contingency Withdrawal Water Use Recommendations

Water use for agriculture, commercial, irrigation and industrial temporary diversions represent a small portion of the consumptive water use in the basin. Based on the previous 20 years, it is unlikely this type of water use will increase significantly in the next 20 years. In general, rainfall and snow are sufficient to meet these demands. However, during dry years there is growing concern for securing reliable water sources for agriculture, commercial and irrigation purposes. The following recommendations have been suggested by the technical team:

12. Water withdrawal for agriculture, commercial, irrigation and temporary/contingency demands for industrial projects should be met by the local

surface waterbodies, streams and groundwater sources, and the potential impacts should be evaluated on a site-specific basis.

13. **The Cold Lake Fish Hatchery withdraws water under an agriculture licence. As this is a flow-through system, water for this licence should not require modification when the water level in Cold Lake reaches the industrial cut-off level.**

14. **Information should be collected on unknown and unregulated (exempted under the *Water Act*) water withdrawal in the basin.**

15. **Technical assistance should be easily available and readily accessible to farmers and landowners for adopting water conservation practices.**

16. **Education and awareness is necessary.**

6.3 PART 3 — SURFACE WATER AND GROUNDWATER QUALITY RECOMMENDATIONS

17. **An integrated and expanded groundwater-monitoring program should be developed for the basin**.

Currently, groundwater sampling in the basin for quality and quantity is conducted independently by various industrial operators, and to a lesser extent by government agencies (primarily AENV). An integrated monitoring system would allow for a better understanding of overall groundwater quality in the basin.

A study conducted by the Alberta Geological Survey identified several areas where improvement to monitoring could be made to increase understanding of groundwater flow and quality in the basin. An investment in new monitoring wells would be required

18. **As part of any integrated groundwater monitoring program, continued maintenance of the groundwater quality regional database should be undertaken. The database should be made publicly accessible.**

The groundwater quality database created as part of this project provides a base on which further analyses can be conducted as additional groundwater monitoring data are collected. The database will allow decision makers to review and determine if development is having an impact on groundwater quality in the basin. This database should be made accessible to the public.

19. **Continued monthly monitoring of the Beaver River at the Alberta–Saskatchewan border, and close observation of future ion/salinity and nitrogen trends should be carried out.**

Sampling at this site ensures tracking of water quality and verification against objectives before entering Saskatchewan. Alberta Environment should continue to work with the Prairie Province Water Board (PPWB) to continue the long-term monitoring and reporting program for the Beaver River near Beaver Crossing.

20. **A long-term surface water quality monitoring program should be coordinated among all monitoring agencies in the CLBR Basin.**

    This program could be built on current monitoring initiatives in the CLBR Basin. Monitoring in the CLBR Basin is currently conducted by AENV, LICA, local governments, health authorities and as part of industry approvals, but occurs without a formal coordination process. The newly designed monitoring program should take all these monitoring activities into account in order to pool resources and develop a comprehensive approach.

21. **More frequent (approximately every 3 years) monitoring of tributaries should occur (e.g., Sand River, Marie Creek and others as required).**

    A detailed analysis of tributary health requires long-term monitoring to understand year-to-year variation and the statistical ability to track changes or deviations over time.

22. **Prior to any development within the Sand River watershed, an integrated land use plan should be developed for that watershed in order to maintain the integrity of the watershed as well as the water quality of the Sand and Beaver Rivers**

23. **By March 2007, AENV is to develop an effluent quality control policy specific to the Beaver River, using methods outlined in the Water Quality Based Effluent Limits Procedures Manual (1995).**

24. **By year 2015, a tertiary municipal wastewater treatment facility should be built in the Greater Cold Lake area to assure consistency and high quality treatment of municipal wastewater.**

25. **Innovative solutions should be considered to achieve zero municipal effluent discharge to the Beaver River (e.g., industrial use of treated wastewater effluent, etc.).**

26. **No surface water discharge of industrial wastewater.**

    This item is carried over from the previous plan, and will help continue to meet Alberta/Saskatchewan border water quality commitments

27. **An educational program should be delivered for landowners on topics such as best practices for well installation, maintenance and abandonment.**

    The Alberta Government, through the *Environmental Protection and Enhancement Act* and *Water Act*, has the ability to regulate groundwater impacts caused by large industrial operations. However, Alberta Environment does not regulate groundwater withdrawals for individual domestic users. Because individuals are the primary consumers of groundwater in the basin for drinking water purposes, there is a need to educate domestic groundwater users on best practices for well installation, maintenance and abandonment in order to protect groundwater from localized contamination (e.g., *Water Wells that Last for Generations*).

28. A well abandonment program should be developed to help landowners with the cost of properly abandoning wells. (Note: This is a province-wide issue that may require a provincial program.)

Improperly abandoned water wells represent a potential conduit for surface contamination, such as runoff from a confined feeding operation that can affect useable groundwater aquifers. The cost of properly abandoning wells may prevent individuals from taking the required actions to abandon their well when no longer in use. Unfortunately, it is not known how many wells in the basin are in need of abandonment.

29. Encourage municipalities, industry and individuals to include groundwater protection when making development decisions.

The easiest way to protect groundwater quality is to prevent negative impacts from occurring. The CLBR Basin planning update resulted in the development of aquifer sensitivity maps for the basin that can be used by decision makers earlier in a project planning stage to avoid locating potential contamination sources over sensitive aquifers.

30. Establish a formal basin-wide education, awareness and outreach committee that actively promotes, funds, and facilitates water protection activities and projects (e.g., Beneficial Management Practices, Environmental Farm Plans, etc.).

There is evidence that land development activities are affecting water quality in the CLBR Basin. An education and outreach program can increase participation in responsible water and land management programs. Such a program should also actively facilitate and assist landowners and the general public with adopting best management practices.

31. Implement best management practices for groundwater quality protection in the basin, such as wellhead protection areas, developmental restrictions on areas with high sensitivity for aquifer contamination, etc.

The work to date on groundwater quality has indicated there are a number of methods that can be implemented to help protect groundwater and groundwater users. These include establishing wellhead protection areas and zoning restrictions on areas with a high sensitivity to surficial aquifer contamination.

32. Development of a Source Protection Plan for the basin.

A formal source protection planning process will add another barrier of protection for drinking water, and may eventually reduce treatment requirements and costs. As part of this plan, a review of abandoned landfills/dumps and other potential point sources of contamination should be conducted to identify where groundwater impacts may be occurring but not mitigated.

The study determined there are a number of landfills in the basin that have been abandoned over time. Landfill construction and operational requirements have not always been as stringent as they are currently. There is the potential for older landfill sites to have been abandoned without care given to long-term groundwater quality protection.

33. Future research should be directed to areas identified by the groundwater quality technical team. These areas include age dating of formation water to determine

origin, chloride diffusion from bedrock to quaternary aquifers, and effectiveness of oil and gas well abandonment techniques.

The areas mentioned were identified in the technical study and by the team as limitations in knowledge. The lack of information added uncertainty as to whether localized impacts had occurred but were not identified in the study. The research areas identified will help in two broad categories: (1) to distinguish natural groundwater conditions from anthropogenic impacts; and (2) to verify that standard practices are working as intended.

34. Changes in water quality since pre-development times need to be examined in CLBR Basin lakes.

Determining the next "State of the Basin" report will require some measure of a *healthy* or *natural* state. Determining pre-settlement lake conditions and examining changes is vital for goal setting, progress tracking, and lake management in general. Paleolimnology is a valuable tool for establishing baseline conditions and tracking cumulative effects of multiple stressors (e.g., climatic variability, nutrient enrichment) in waterbodies.

6.4 Part 4 — Water Conservation Objectives/Protection of Aquatic Resources

6.4.1 Water Conservation Objectives Recommendations

Water Conservation Objectives (WCOs) can be established under the *Water Act* to protect all or part of the aquatic environment (and for other reasons), pertaining to leaving water in rivers or lakes. WCOs identify the quality and quantity of water to be left in the river or lake for various needs.

35. To maintain access to critical fish spawning habitats in Cold River and Long Bay, the cut-off level for industrial diversions from Cold Lake should remain at 534.55 meters above sea level. When this cut-off level is reached, municipal withdrawals should also be reduced through the implementation of additional conservation measures.

36. In order to protect long-term fish, wildlife and recreational values and aquatic ecosystem functions, there will be no permanant diversions from lakes and wetlands in the CLBR Basin outside of Cold Lake. Low-volume temporary diversions for industrial use and low-volume diversions for non-industrial use may be considered on a case-by-case basis, providing they do not harm these values and functions.

37. In order to protect recreational values, fish populations, other freshwater aquatic life and the aquatic ecosystem functions, no new permanent diversions for steam injection purposes from the Beaver River, Sand River and other streams will be permitted. Low-volume temporary diversions for industrial use and low-volume diversions for non-industrial use will be considered on a case-by-case basis, providing they do not harm these values and functions.

38. **No new dams (as described in the 1985 CLBR Water Management Plan) should be constructed for water storage and multiple uses in the planning area.**

39. **No withdrawals will be permitted from May, Muriel, Manatokan, Reita and Tucker lakes. These lakes will be managed for the purpose of conservation, fisheries, wildlife and recreation.**

6.4.2 Protection of Aquatic Resources Recommendations

40. **Activities should be undertaken to restore, maintain and enhance watershed integrity and safeguard against future watershed fragmentation to ensure fish passage between waterbodies, and to re-establish fish populations in some lakes where numbers are depressed or extirpated.**

41. **A study should be undertaken to identify all impediments to fish passage (weirs, dams, culverts) in the watershed with a view to evaluating and recommending the appropriate prioritized remedial actions for each structure.**

42. **To ensure maximum opportunities for recovery of all aquatic ecosystem functions and services when water levels return to normal, enhanced protection from disturbance to, or destruction of dried wetlands, shores, streambeds and lakebeds should be implemented.**

43. **Measures should be undertaken to enhance, maintain and restore riparian buffers on streams, wetlands and lakes, and encourage improved land use practices in adjacent upland areas to maximize the protection of aquatic ecosystems and water quality.**

44. **An increase in education and awareness programs is needed to highlight the many functions and the importance of undamaged, viable aquatic ecosystems and the legislation that provides protection for those essential ecosystems.**

45. **An increased commitment is needed to enforcement of all legislation and best practice initiatives that provide for the protection of all components of the aquatic ecosystem.**

APPENDIX A. COLD LAKE–BEAVER RIVER BASIN ADVISORY COMMITTEE

The Basin Advisory Committee represents stakeholder interests regarding the management of the water resource within the Cold Lake Beaver River Basin. The Committee is responsible for reviewing technical information, informing their constituents and providing advice on how water should be managed in the basin. The Basin Advisory Committee will assist Alberta Environment in writing the update of the water management plan for this basin.

Town of Bonnyville

- Mayor Ray Prevost
- Kathryn Wiebe (past member)

MD of Bonnyville

- Andy Wakaruk
- Werner Gisler (past member)
- John Foy (past member)

City of Cold Lake

- Mayor Allan Buck
- Marc Brown
- Hansa Thaleshvar (past member)

Cold Lake First Nation

- Chief Dwayne Nest

Kehewin Cree Nation

- Irving Kehewin

Elizabeth Metis Settlement

- Allan Wells

Metis Zone II Regional Council

- Annette Ozirny

Lakeland Industry Community Association (LICA)

- Robert Deresh, LICA Chair
- Carol Engstrom (Husky Energy)
- Brad Braun (CNRL – past member)
- Ron Pernarowski (past member)

Beaver River Naturalist Society

- Iris English

Citizens at Large

- Audrey Campbell
- Ben Lefebvre (past member)

Government BAC Members

- Brad Lloyd, Alberta Energy
- George Walker, SRD
- Dean Anderson, Energy & Utilities Board
- Jamie Wuite, AAFRD
- Abdi Siad-Omar, AENV
- Joe Prusak, AENV
- Drew Craig, 4 Wing, DND
- Candace Vanin, PFRA
- Brian Makowecki, DFO

APPENDIX B. TECHNICAL ADVISORY COMMITTEE MEMBERS

Ground Water Quality Team

- Margaret Klebek, Contaminant Hydrogeologist Alberta Environment
- Jason Pentland, Contaminant Hydrogeologist, Alberta Environment
- Kate Rich, Groundwater Quality Specialist, Alberta Environment
- Tony Lemay, Hydrogeologist, Alberta Geological Survey
- Chrysta Lane, Environmental Team Leader, Imperial Oil Resources

Ground Water Quantity & Brackish Water Team

- Alan Hingston, Hydrogeologist, Alberta Environment
- Rob George, Hydrogeologist, Alberta Environment
- Brad Braun, CNRL
- Stuart Lunn, Imperial Oil Resources, Hydrogeologist
- Dave Edwards, CNRL, Hydrogeologist

Consultant to Groundwater Teams

- Dr. Kevin Parks, Section Lead, Energy, Alberta Geological Survey

Surface Water Quality

- Theo Charette , Limnologist, Alberta Environment
- Rasel Hossain, Municipal Approvals Engineer, Alberta Environment
- Randy Lewis, Source Of Protection Engineer, Alberta Environment
- Jamie Wuite, Water Quality Specialist, Alberta Agriculture, Food & Rural Development
- Candace Vanin, PFRA Ag-Can

Surface Water Quantity Team

- Pat Marriott, Water Team Leader, Alberta Environment
- Abdi Siad-Omar, Planner, Alberta Environment
- Carmen De La Chevrotiere, Hydrologist, Alberta Environment
- Brian Makowecki, Department Fisheries And Oceans Canada
- Wayne Nelson, Area Wildlife Biologist, Alberta Sustainable Resource Development
- George Walker, Fisheries Biologist, Alberta Sustainable Resource Development
- Paul MacMahon, Regional Head, Fisheries Management, Alberta Sustainable Resource Development
- Brian Ilnicki, Ducks Unlimited
- Chrysta Lane, Environmental Team Leader, Imperial Oil Resources, Cold Lake Operations
- Lori Neufeld, Imperial Oil Resources, Environmental Advisor, Cold Lake Operations

APPENDIX C. 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
NTU	Nephelometric turbidity unit (a measure of the particulate matter in the water)
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)
TCU	True colour units
TDL	Temporary Diversion Licenses
TDS	Total Dissolved Solids

THM	Trihalomethane
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 license to use a set allocation of water. This water license outlines the volume, rate and timing of diversion of water.
Approval	Provides authority for constructing works or for undertaking an activity within a water body. 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 water bodies, 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 water bodies.
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.
Water body	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 water body 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).