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COLD LAKE–BEAVER RIVER BASIN WATER MANAGEMENT PLAN

Alberta
ENVIRONMENT

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

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 located approximately 300 km northeast of Edmonton. 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.

Updating the Plan

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

In addition to taking more of a watershed perspective for managing water resources in the basin, the updated plan also incorporates new information related to groundwater within the basin. Groundwater was identified as being an important component of the regional water resources, and protecting groundwater quantity and quality as well as gaining better information related to groundwater and surface water interactions are emergent issues in the Cold Lake–Beaver River Basin.

In comparison to the 1985 plan, the 2006 updated plan manages the demand for water based on the capacity of the basin. It also uses a broader watershed management perspective that recognizes other agencies which affect and influence the management of the water resource. Other changes from the 1985 plan include the use of best (beneficial) management practices to promote efficiencies rather than relying on control structures, an emphasis on shared responsibility and partnerships, and the integration of groundwater and surface water that will be managed as a single resource.

Alignment With Provincial Policy and Legislation

The 2006 Cold Lake–Beaver River Basin Water Management Plan is aligned with the *Water Act* and, where appropriate, with the *Environmental Protection and Enhancement Act* (EPEA). In addition, the plan adheres to the goals and objectives specific to *Water for Life: Alberta's Strategy for Sustainability* (i.e., the *Water for Life Strategy*), and follows the guidelines required for planning as stated in the *Framework for Water Management Planning.* As such, the management plan incorporates water conservation objectives (WCOs) and includes strategies for the protection of aquatic resources. The recently approved *Water Conservation and Allocation Policy for Oilfield Injection* is also incorporated into this management plan. Finally, the 2006 plan also recognizes and adheres to the Apportionment Agreement as determined by the inter-provincial master agreement between Alberta and Saskatchewan.

Partnerships in Water Management

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), co-chaired by Alberta Environment and LICA, was established with representatives from local governments, industry, Métis Settlements, First Nations, federal and provincial government departments, and members of the public. The Basin Advisory Committee provided advice and recommendations on the range of views and community values to be considered in the updated water management plan.

As part of Alberta's *Water for Life Strategy*, a Watershed Planning and Advisory Council (WPAC) will be established in order to continue local input into the management of this basin. The WPAC will help implement portions of the management plan, promote and participate in education and stewardship activities, and provide direction on how water will be managed within the basin.

Public Consultation

Issues, concerns and recommendations for water management within the Cold Lake–Beaver River Basin have been identified through a combination of public consultation sessions, meetings with stakeholders, and knowledge/data accumulated 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 were offered through workshops, consultation with identified stakeholders and open house sessions.

Gathering Technical Information on the Cold Lake–Beaver River Basin

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*

Key Findings and Recommendations

Key findings from the basin reports were identified. Based on these, supporting data, and stakeholder input, Alberta Environment and the Basin Advisory Committee determined management guidelines and recommendations that should be used by decision makers when managing water resources within the Cold Lake–Beaver River Basin.

Recommendations for the 2006 water management plan were divided into the three main themes: (1) Water Supply and Demand, (2) Surface and Groundwater Quality, and (3) Strategies for Protection of the Aquatic Resources. Some of these recommendations are regulatory (i.e., under the direct mandate of Alberta Environment), while others are related to best management practices and are not under the direct mandate of AENV (i.e., non-regulatory).

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1.0 BACKGROUND

1.1 INTRODUCTION

The Cold Lake–Beaver River Basin is located in the Cold Lake region of northeastern Alberta. The Beaver River Basin, one of seven major river basins in Alberta, is a source of water supply for industrial, municipal, domestic, agricultural and recreational users. The basin is also an important source of water for aquatic resources.

The Cold Lake–Beaver River Water Management Plan was adopted in 1985 to provide direction on the management of water resources in the Cold Lake and lower Beaver River Basin. The intent of the plan was to provide an adequate quantity and quality of water to meet the long-term user requirements of the basin. Since that time, the basin has experienced increased industrial development, increased population growth, and years of below-normal precipitation and low run-off, resulting in record low water levels in area lakes and stream flows.

Protecting groundwater quantity and quality has become an emergent issue and a public concern in the last 20 years. Alberta's commitment to a sustainable environment and protecting healthy ecosystems were also identified as important components to incorporate into the updated plan. These factors have created a need to assess the current situation and review direction for water management in order to meet current and future water needs within the basin, and to ensure groundwater quantity and quality are protected and critical health ecosystem functions are maintained, restored and enhanced.

Alberta Environment is committed to the protection and management of water resources in Alberta. As part of this commitment, the Department initiated the update of the 1985 Cold Lake–Beaver River Water Management Plan. Work on the updated plan was undertaken in partnership with the Lakeland Industry and Community Association (LICA), with other agencies that have an interest or mandate affected by the plan, and in consultation with stakeholders and the general public.

The updated Cold Lake–Beaver River Water Management Plan was prepared in accordance with the *Water Act*, provincial *Water for Life Strategy*, Alberta's *Framework for Water Management Planning*, and other pertinent legislation and policies relevant to water resources management.

In addition to being consistent with the guidelines and directions of the provincial *Water for Life Strategy*, the updated plan balances community, economic, and environmental issues and values with government legislation and policies for the protection and management of water resources in this area.

1.2 COMPARISON OF UPDATED PLAN WITH THE 1985 PLAN

Over the past 20 years, provincial water management legislation and policies have been enhanced to ensure that Alberta's water is managed and conserved for present and future generations. The

Water Act, which was proclaimed in 1999 and replaced the *Water Resource Act,* focuses on managing and protecting Alberta's water rather than being primarily a tool for allocating water resources. Alberta's *Water for Life Strategy*, adopted in 2003, outlines water management policy directions and specific actions and strategies to balance social, economic and environmental needs.

The 1985 plan was an essential tool for making water management decisions in the basin. Specific components (e.g., cut-off levels and withdrawal moratoriums for certain lakes) remain relevant and have been brought forward as part of the updated plan. However, to ensure consistency with the guidelines and directions of the *Water Act*, the *Water for Life Strategy*, and other water-related policies that have been implemented recently (i.e., Water Conservation and Allocation Policy for Oilfield Injection), the following are some the key shifts from the 1985 plan.

1985 Plan	Plan Update
Water management: focused mainly on water allocations.	Watershed approach: integrate water quantity, quality, land use practices and protection of aquatic resources.
Target management approach: established maximum target limits for surface water and groundwater withdrawals in the basin.	System management approach: focuses on the interdependence and interactions of surface water and groundwater, land use practices, aquatic resources needs, climate change, and cumulative impacts on the system.
Interbasin water transfer: recommended transfer of water from the North Saskatchewan River to augment future industrial water demand in the basin.	Manage within the capacity of the watershed: consistent with the *Water for Life Strategy*, focuses on meeting water demands within the capacity of the basin.
Structural solution: recommended the construction of control structures (e.g., weirs) for water storage purposes.	Non-structural solutions: focuses on water conservation and best management practices to protect aquatic resources and the recreational values of local lakes and wetlands.
Government and regulatory management approach: a tool for Alberta Environment to make water allocation decisions in the basin.	Shared responsibility and partnership approach: focuses on building partnerships and establishing a Watershed Planning Advisory Council (WPAC) to implement the non-regulatory components of the plan.
Separate management model: groundwater and surface water were managed separately.	Integrated approach: groundwater and surface water are interconnected and recognized as a single resource.

1.3 Purpose of the Plan

The purpose of this planning initiative was to update the 1985 water management plan and provide a framework for decision-making by the Alberta government. Alberta Environment, in particular, uses the water management plan to make water management decisions under the *Water Act* and, where appropriate, under the *Environmental Protection and Enhancement Act*.

The updated plan provides a current look at the state of the Cold Lake–Beaver River (CLBR) Basin, and suggests a strategy to meet the current and future water needs of the basin. The plan also includes strategies to protect groundwater and surface water quality and meet water conservation objectives to ensure that healthy ecosystem functions are protected.

1.4 Outcome of the Plan

The updated Cold Lake–Beaver River Water Management Plan is an authorized water management plan under the *Water Act* as approved by the Director responsible for water management planning.

As required by the *Water Act* and the *Framework for Water Management Planning*, the CLBR Water Management Plan is considered by Alberta Environment when making day-to-day decisions within the Cold Lake-Lower Beaver River Basin. Other resource decision-makers may also use this plan when making decisions that could impact the basin's water resources.

1.5 Planning Area

The Cold Lake–Lower Beaver River planning area is part of the CLBR Basin 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 update study area focuses on lakes and rivers that seem to be most affected by industrial and municipal water withdrawals. The waterbodies are as follows:

– 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 was incorporated into some of the technical analyses. These areas include the Elk Point region and part of the Province of Saskatchewan.

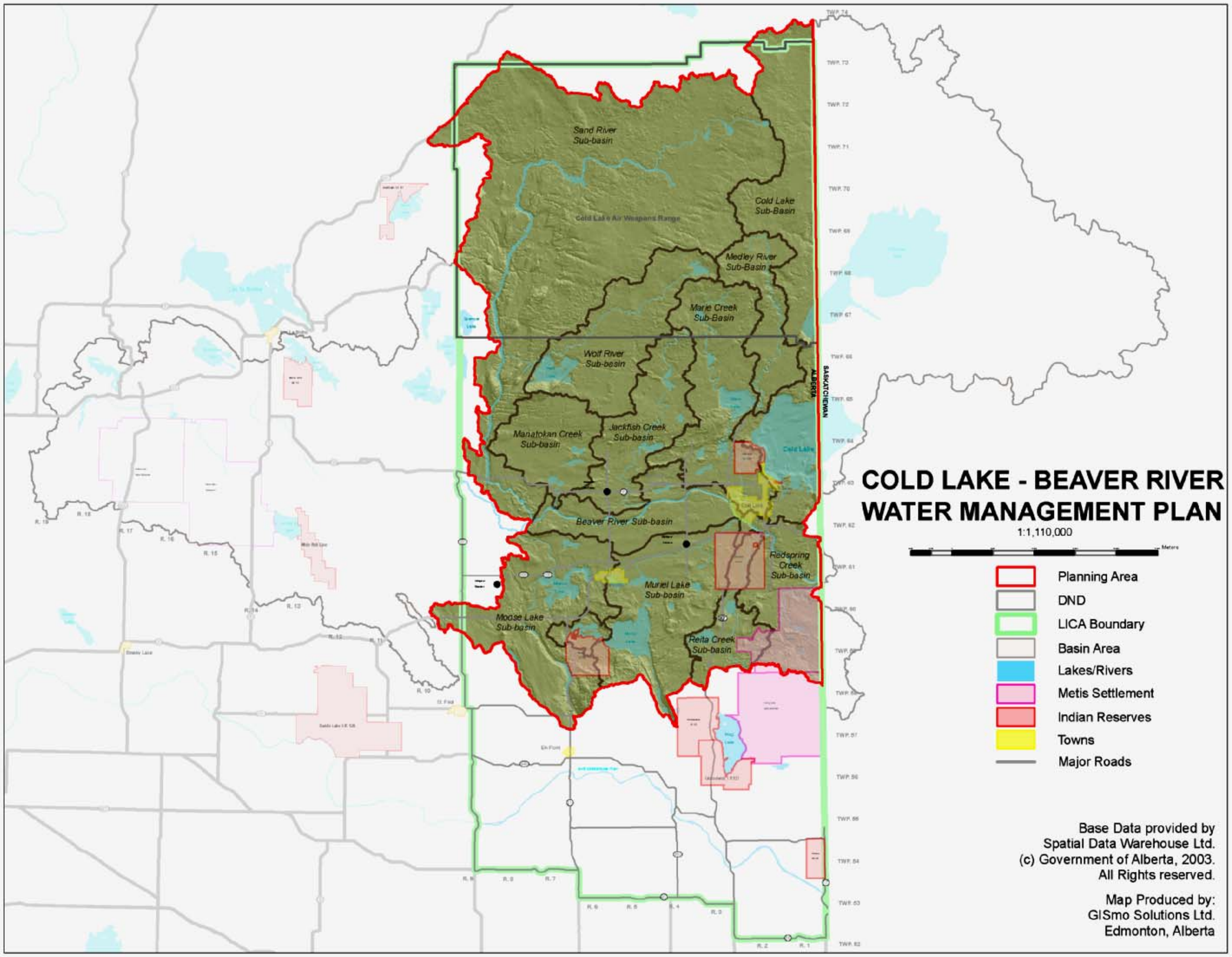

Figure 1. Planning area of the Cold Lake–Beaver River Basin.

1.6 Public Consultation

As noted previously, Alberta Environment initiated the update of the Cold Lake–Beaver River Water Management Plan in partnership with 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 public consultation strategy was developed and included in the planning process. The goal of public consultation was to create and maintain communication with regional stakeholders and the public to ensure long-term viability of the updated water management plan. The following public consultation strategy has been adopted:

- **A Basin Advisory Committee (BAC)** was established, comprising a broad mix of people representing local governments, industry, Métis Settlements and First Nations, federal and provincial government departments, and members of the public. The role of this committee was to provide advice and recommendations on the range of views and community values to consider when preparing the updated water management plan.
- **Open house meetings** were held in the City of Cold Lake and Ardmore and the public was provided opportunity to participate and become informed about the goals, objectives and the scope of the plan update. The public was also provided opportunity to review and comment on the draft terms of reference and identify and prioritize all relevant issues that need to be addressed.
- **Two open houses** were held in Bonnyville to review and comment on the findings of the data collection initiatives and scientific reports.
- **A stakeholder workshop** was held in Bonnyville that included a discussion forum between the stakeholders, the project technical and planning teams and the Basin Advisory Committee. The stakeholders have been provided an opportunity to provide advice and input into the draft water management plan.
- **Open house meetings** were held to review and comment on the draft management plan.

LICA's newsletter was also used to disseminate project information. The project's terms of reference, technical reports, and communications materials were made available on the LICA and AENV websites. Throughout the public consultation, valuable advice and input were provided by BAC, the stakeholders and the public to be considered by the technical teams and incorporated into the water management plan.

2.0 ALIGNMENT WITH PROVINCIAL AND REGIONAL STRATEGIES AND OTHER PLANNING INITIATIVES

2.1 PROVINCIAL WATER STRATEGY

In 2003, Alberta Environment adopted a province-wide comprehensive strategy, *Water For Life: Alberta's Strategy For Sustainability*, "…that will identify short-, medium- and long-term plans to effectively manage the quantity and quality of the province's water systems and supply." The strategy outlines three main objectives: (1) a safe, secure drinking water supply, (2) a healthy aquatic environment, and (3) reliable, quality water supplies for a sustainable economy. Guidelines and directions from the water strategy were incorporated into all phases of this plan update.

2.2 WATER USE PRACTICE AND POLICY

In 2006, Alberta Environment adopted the *Water Conservation and Allocation Policy for Oilfield Injection*. The policy outlines strategies and recommendations to reduce or eliminate underground injection of non-saline water. The guidelines and directions of this policy were incorporated in the updated this updated plan.

2.3 REGIONAL STRATEGIES AND OTHER PLANNING INITIATIVES

Several Environmental Impact Assessment (EIA) studies and water management initiatives were completed or underway during development of the updated CLBR Water Management Plan. Information and data from these studies were incorporated in the updated water management plan.

3.0 SUMMARY OF ISSUES AND ASSEMBLED INFORMATION

3.1 SUMMARY OF THE ISSUES

Planning issues and concerns were identified using a combination of public consultation and accumulated knowledge/information gathered since the 1985 water management plan was implemented. The key points in updating the existing plan are provided below.

- Current industrial use of freshwater was generally less than 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*.)
- Advances in technical information related to hydrogeology were incorporated. Specifically, increased knowledge of regional hydrogeology and groundwater flow systems within the basin provided the foundation for effective decision-making and planning. The updated plan incorporates information gains related to groundwater availability, and its interaction with surface water resources and potential impacts.
- The province recognized, through its commitment to sustainable resource management and implementation of the *Water For Life Strategy*, that protecting the aquatic environment was an essential component of maintaining a healthy ecosystem. Further, the *Framework for Water Management Planning* required that strategies for protecting aquatic resources be included in water management plans to ensure critical ecosystem functions are maintained, restored or enhanced.

3.1.1 Key Issues and Priorities

During the initial public consultation phase to develop the Terms of Reference, the public identified several key issues and priorities. These are noted below.

Issues Related to 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.
- Decreases in water levels in local lakes, streams and wetlands potentially due to industrial diversions, especially during periods of drought.
- Securing water flow requirements under the Apportionment Agreement between Alberta and Saskatchewan.
- Potential impacts 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.

Issues Related to Groundwater and Surface Water Quality

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

Issues Related to Protection of Aquatic Resources

- In the past 25 years, a shortfall in precipitation levels was recorded throughout much of the CLBR Basin, which had resulted 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 that is well above sustainable levels, and from 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 to be placed on their outlet channels for water storage and multiple consumptive uses. Currently, Wolf, Angling and Marie lakes, and possibly others, have 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 continues 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.

3.2 Summary of the Information Assembled

The information listed below has been assembled to address the issues and the priorities identified during the public consultation phase.

- Overview of regional hydrology.
- Water balance model for Cold Lake, Moose Lake, Muriel and Marie lakes.
- Review of current and historical groundwater and surface water allocations and actual uses.
- Regional groundwater appraisal.
- Regional groundwater numerical flow model.
- Regional groundwater quality appraisal.
- Industrial brackish water usage.
- Overview of regional water conservation practices.
- Review of regional surface water quality and protection of sources of drinking water.
- Assessment of changes in habitat and associated wildlife on 28 lakes in the Cold Lake–Beaver River Basin.
- Water-based recreation: a comparative study covering 1983-2003.
- Update of the fisheries and fish habitat studies of 1983.

4.0 OVERVIEW OF WATER RESOURCES IN THE CLBR BASIN

In addition to the vital role of sustaining ecosystems, surface water 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 to ensure that 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.

4.1 BASIN WATER BALANCE

The average Cold Lake–Beaver River Basin annual water balance is depicted in Figure 2. The basin cycle is part of the global hydrologic cycle mediated by weather systems and predominantly driven by the sun. Solar energy evaporates water from the oceans, and a portion of this water precipitates as freshwater in the CLBR Basin. On average, 8,292 million m^3 (8.3 billion m^3) of water fall 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 flow 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 1,015 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 enter 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 roughly equals the amount flowing into streams and lakes, minus the small amount pumped by groundwater users.

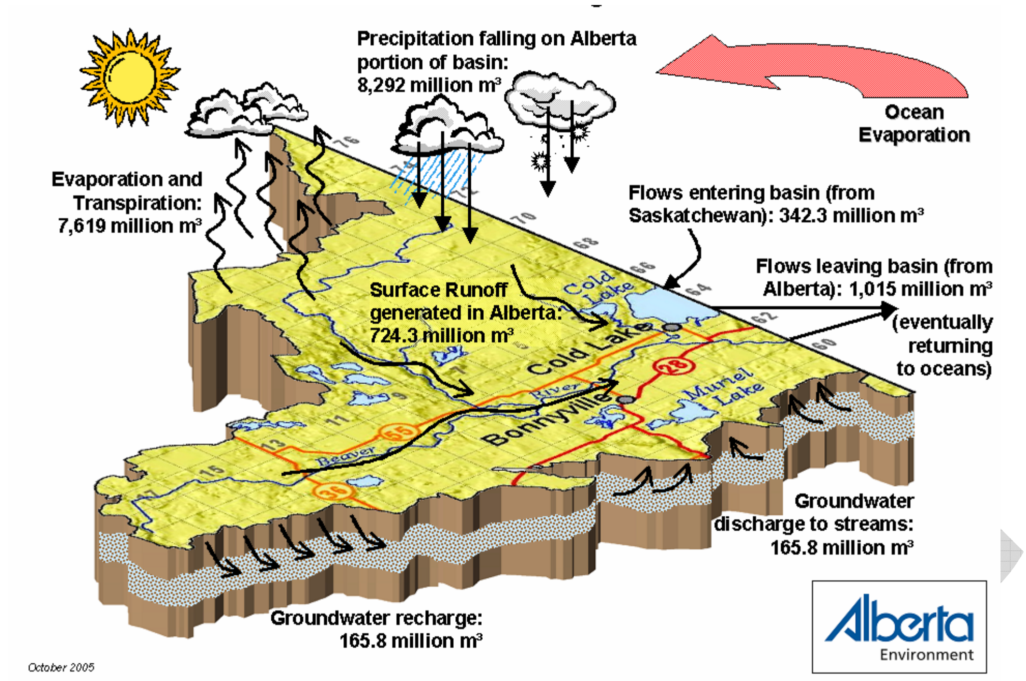

Figure 2. CLBR Basin average annual water balance.

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

As of December 2003, a maximum amount of 44 million m^3 of groundwater and surface water was allocated in the basin. This represented about 4% of the average 1 billion m^3 of surface water leaving the 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 comprise about 1.5% of the average annual flow leaving the CLBR Basin each year. The actual amount used is about one third of the allocation, or 0.5% of 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, allocations in the CLBR Basin represent less than half of one percent of water allocated for use in Alberta. Figure 3 shows surface and groundwater allocations as compared to the average natural flow for Alberta river basins. 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 other basins in the province.

In updating the CLBR Basin plan, it was determined the actual allocation amount in the Beaver River Basin is less than that shown in Figure 3, since the allocation (as a percentage of the flow leaving the CLBR Basin) is about 4%. One difference in water use in the CLBR Basin, compared to other basins, was the percentage of groundwater used in the basin as compared to the percentage of surface water used. In the CLBR Basin, groundwater is about 33% of the total water allocation compared to less than 3% at the provincial level. This is largely due to low overall water usage rather than the result of significant groundwater usage.

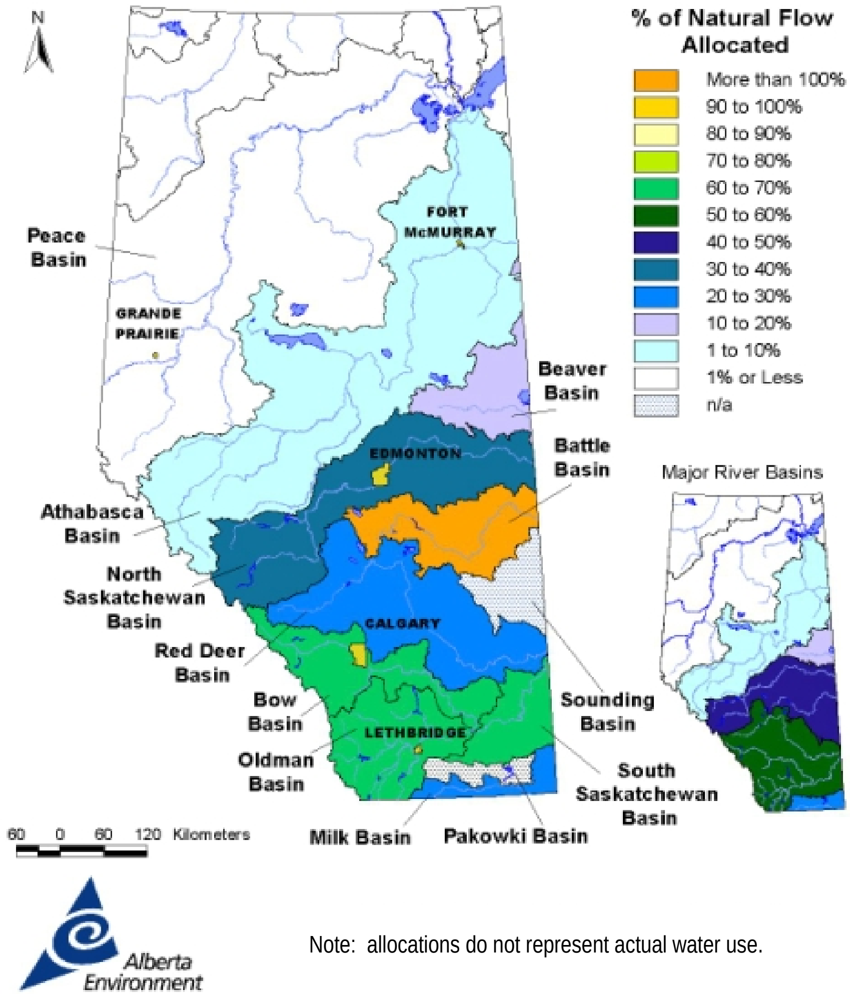

Figure 3. Surface and groundwater allocations in 2004 by river basin compared to average natural flow.

5.0 SUMMARY OF THE KEY FINDINGS

5.1 Surface Water–Regional Hydrology Trends and Lake-Based Water Balance Models

- Since 1985, the regional hydrology has changed significantly 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 1996-1997. 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.

5.2 Groundwater Monitoring

The groundwater technical team 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 exists in the CLBR Basin. These consist of industry's monitoring well networks (hundreds of wells) and Alberta Environment's wells which are part of the Provincial Monitoring Network (more than 20 regional wells). Water level data is generally measured daily to weekly.
- The current distribution of monitoring wells is primarily around the industrial development area, with monitoring wells being relatively sparse across other areas of the basin. Very few monitoring wells are situated in the western half of the basin.

- The 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 opportunity to augment the existing monitoring network was identified, and the technical team recommended an additional 30 strategic monitoring wells in the basin. The main purpose of these wells is to provide additional information about the natural system to fill existing knowledge gaps. The following have been proposed for 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.

5.3 Response to Pumping and Surface Water/Groundwater Interactions

Groundwater is one of the major sources of water supply for oil injection. Since the 1985 plan, 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 structure in Quaternary sediments (layer cake stratigraphy with holes and thin layers resulting in the interconnection of sand aquifers) suggests that even deep Quaternary aquifers can interact with shallower aquifers and surface waterbodies. As a result of this structure, there is likely flow between aquifers that would not be noted in the case of alternating layers of sand and clay. The degree of this interconnectivity is difficult to quantify, but its existence is suggested in the relatively rapid recovery (2 to 4 years) of deep aquifers following pumping, which is partly due to the in-flow of water from vertically interconnected aquifers
- 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.

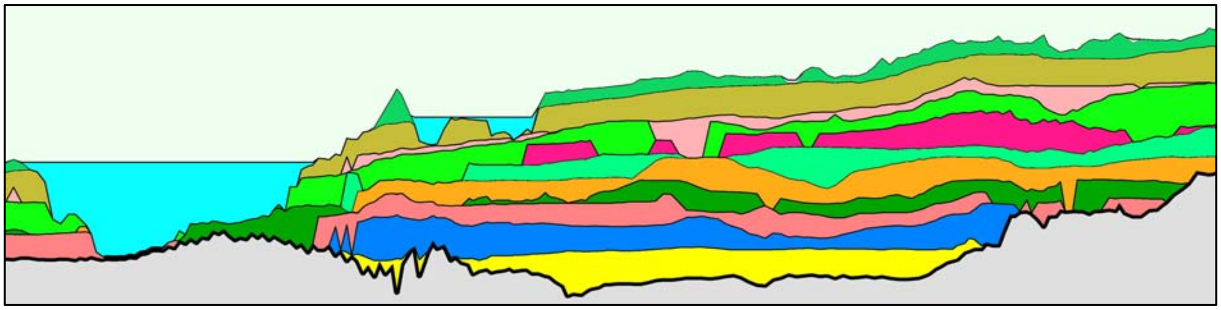

Figure 4. Three-dimensional labyrinthical structure (Cold Lake/Marie Lake area).

5.4 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 numerical model was developed as a regional scale model to gain a better understanding of regional water balances and groundwater flows, and 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.

The model has proven useful in providing an understanding of the regional hydrogeological framework and regional groundwater balances, and in evaluating the interaction between groundwater and surface water. The model has also been used to evaluate the implication of possible groundwater withdrawal scenarios.

- Modeling suggested that pumping from deeper aquifers did increase infiltration at the surface and decreased the 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 in periods of normal precipitation.
- 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 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 from groundwater withdrawals occurred in increased surface recharge (8%) and increased recharge from lakes (9%). A decrease in surface discharge was also noted, as well as minor changes in the 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 showed that Cold Lake, Moose Lake, Muriel Lake and Moore Lake were important regional discharge (gaining) lakes, while Marie Lake and Marguerite Lake were recharge (losing) lakes. The losing/gaining status of a lake depends 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 was to determine the regime of groundwater production (withdrawal) that would 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 being supplied initially from aquifer storage, to having all groundwater production "captured" from decreased discharge and increased recharge. A theoretical transition curve is provided in Figure 5, and 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 may imply a greater interdependence between groundwater and surface water resources. In such cases, a joint groundwater and surface water management tool should be considered.

Induced recharge occurs when lakes, streams and wetlands lose water to the adjacent groundwater aquifer as a result of groundwater pumping from a nearby well.

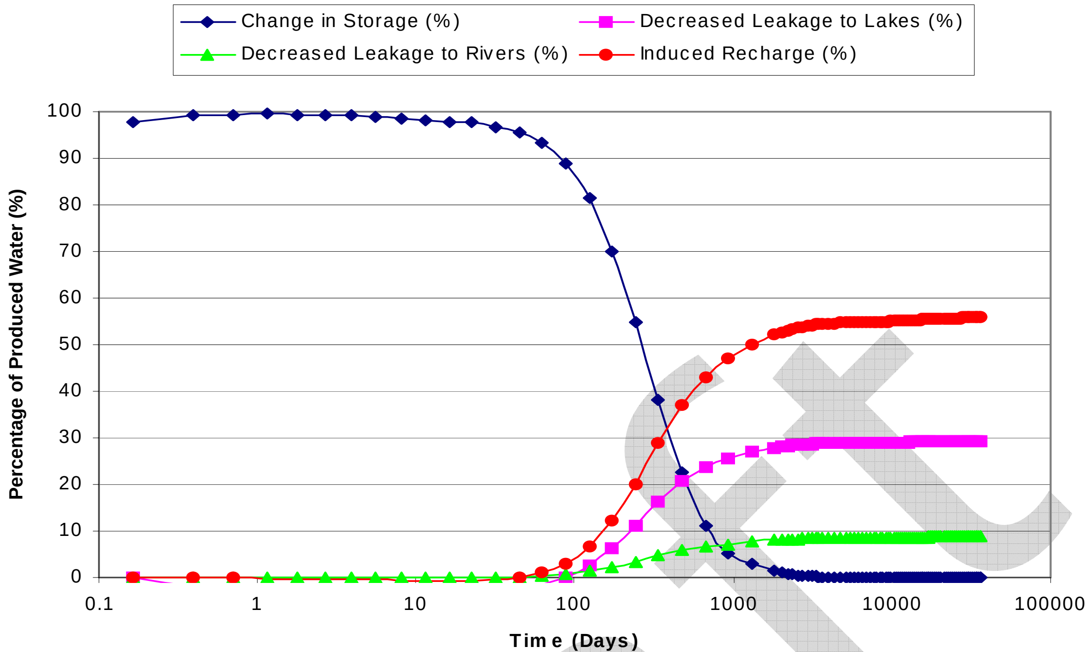

Figure 5. Theoretical transition curve.

5.5 Brackish Water Modeling and Studies

Saline water (brackish water) is defined in the *Water Act* as being water with a total dissolved solid (TDS) concentration of more than 4,000 mg/L. As a result of the high TDS concentration, brackish water is not potable and not suitable for irrigation and many other purposes.

Although brackish water is not regulated under the *Water Act*, it is currently used as a source of water for bitumen recovery operations in the CLBR Basin and is an important component of the updated CLBR Basin plan. Brackish water replaces the required equivalent volume of freshwater, an option previously unavailable in the 1985 plan. Withdrawals from brackish water aquifers will have no effect on potable water aquifers located far above them because they are separated by impermeable layers.

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 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.

5.6 Water Allocation and Actual Uses

- As of December 2003, a total of 44 million m^3 of groundwater and surface water has been allocated in the basin. This represents an approximate 33% increase over 1985 allocations. The volume of surface water 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 used for agriculture purposes, primarily by the Cold Lake Fish Hatchery licencee. Water allocations for irrigation, *Water Act* registrations, and 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 33% of its total annual allocation.
- Cold Lake is the only supply source of surface water for industrial purposes. This allocation (approximately 8 million m^3) has remained unchanged since 1985. Industry uses about 33% of its total annual allocation.
- Since 1985, a total of 9 industrial licences for surface water allocation (4 million m^3) have been cancelled.
- As a result of recent industrial development in the area, groundwater allocations have increased approximately 69% from about 9.3 million m^3 in 1992 to about 14.95 million m^3 in 2003. 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 licence for Imperial Oil's 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 metres above sea level. Therefore, these allocations are counted twice in the total allocation sum, although only one allocation can be used at any given time.
- 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 (Figure 6). 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, and EnCana.

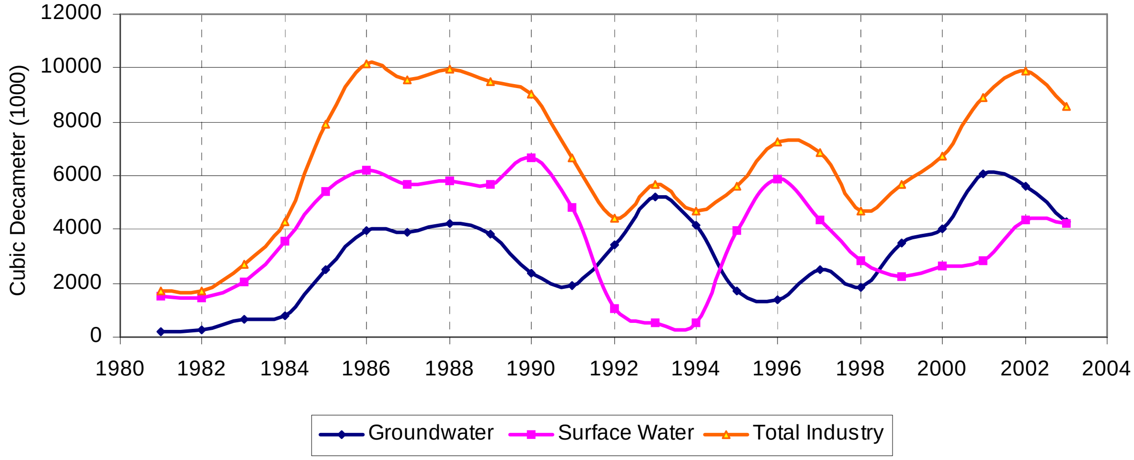

Figure 6. Industrial groundwater and surface water uses (1981-2006).

5.7 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; however, 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. 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.

Figures 7-9 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 currently use about 30% of their total allocation; this increase represents a use of 50% of their current water allocation.

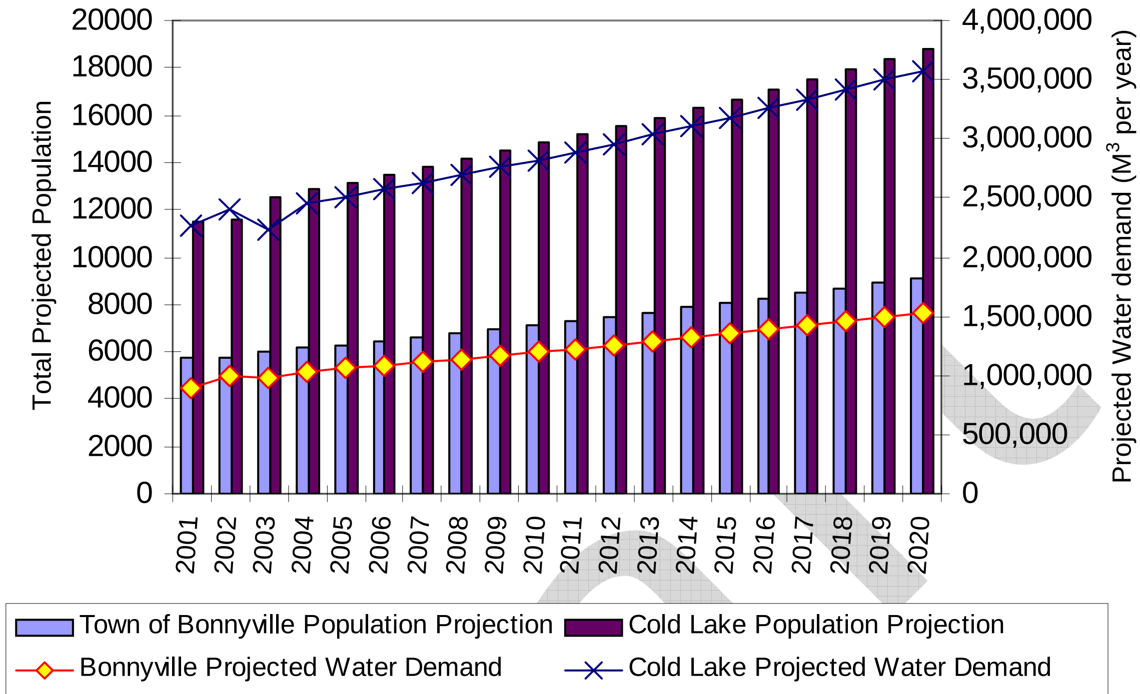

Figure 7. Cold Lake and Bonnyville population projections and projected water demands (2004-2020).

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 keeping 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.

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. It is an important factor in minimizing the volumes of freshwater that would otherwise be required.

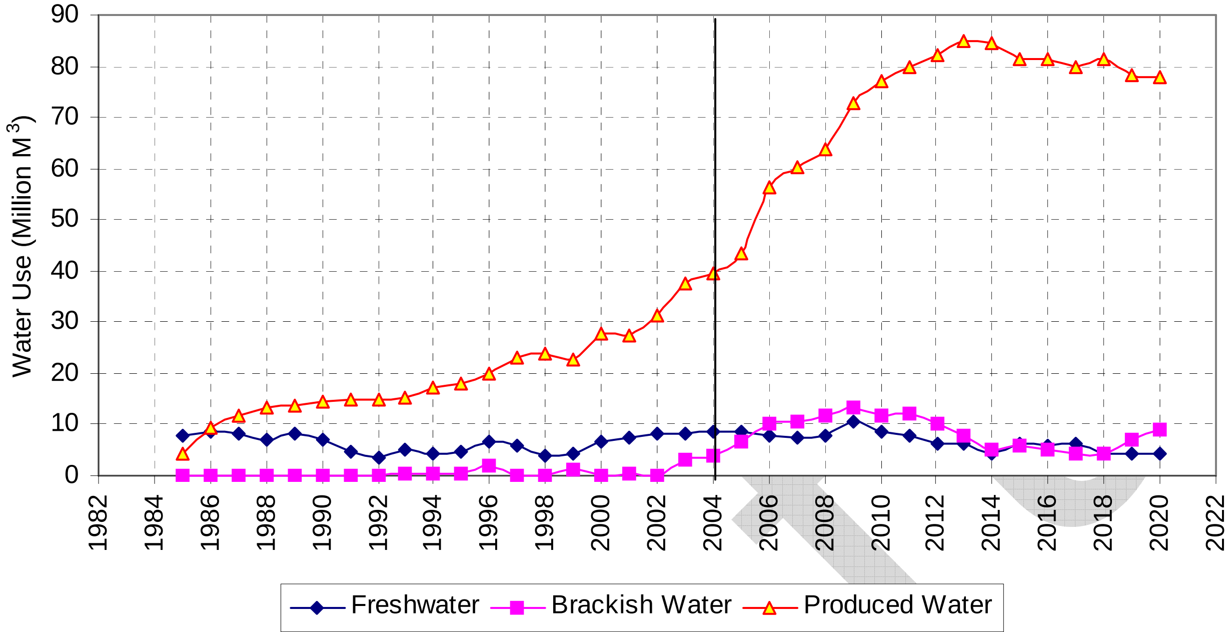

Figure 8. Historical and projected freshwater, brackish and produced water, 1985-2020.

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. This 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 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 estimated 85% by 2020.

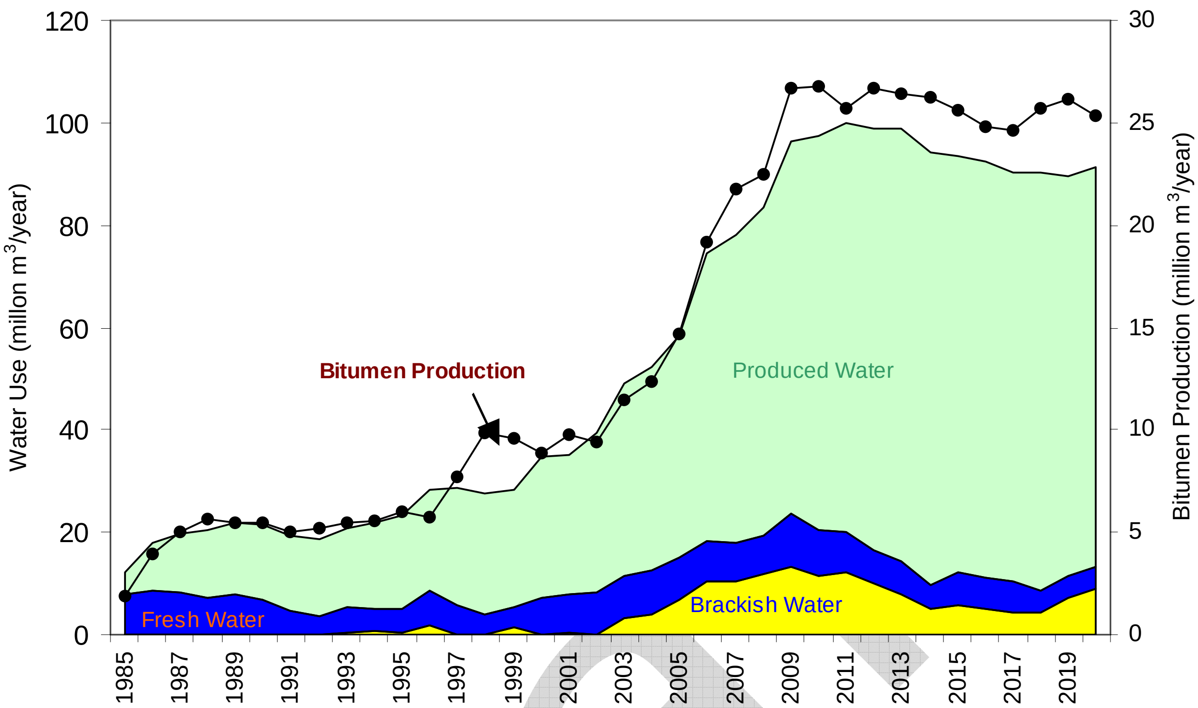

Figure 9. Historical and projected bitumen production vs. water uses.

Brackish water is also an important alternative source of water supply for industrial operations, and development of brackish water resources in the CLBR Basin started in 1993. This type of water is used to supplement water needed for steam generation when produced water volumes are not available. In 2003, brackish water represented about 8% of the total water used for injection purposes, with the majority being recycled produced water. Brackish water use is projected to reach about 15% by 2007 due to the start-up phase of Imperial Oil and Canadian Natural Resources Limited expansions.

5.8 Modeling Scenarios Results—Key Findings

The following section summarizes the key findings 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 to evaluate the potential impact of historical and projected municipal and industrial water uses.

- The model shows that current and projected water withdrawal (2004-2020) by the Town of Bonnyville will cause 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 would become cumulative and cause further reduction in lake levels.

- Current and projected water withdrawals (2004-2020) by municipalities, industry and agriculture would be expected to cause a minor reduction in Cold Lake water levels and outflows from their natural condition. The modeling scenarios also indicated the flow volumes required under the interprovincial apportionment agreement would be met.
- The existing cut-off limit on the industrial water licence would lessen 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 would be reduced by 0.018 m and 17%, respectively.
- Results of the industrial projected groundwater diversion simulation (transient scenario 2004 to 2020) indicate the major aquifer systems used in the basin for industrial production (Empress 1 Formation, Empress 3 Formation and Muriel Lake Formation) would respond relatively quickly to changes in system stresses.
- Simulation results suggest the location and timing of groundwater production in the basin are important factors in understanding the potential effects of groundwater production. The simulated effects of groundwater production would be governed in part by groundwater production rates, spatial separation of production wells, and temporal separation of peak production rates.
- Simulation results indicate the cones of influence surrounding production wells generally would not extend across the basin and would be 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.
- Examination of transition-curves simulation (test of groundwater–surface water interactions) revealed that changes in regional water balances due to groundwater production would be highly dependent on the location and completion interval of the production well.
- The transition time (the time taken for the derivation of production volumes to switch from aquifer storage to other sources) would depend 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.
- The connection between aquifers and surface waterbodies would 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 would depend on the degree of connection (direct and indirect) between the lake and the aquifer being produced.

5.9 SURFACE WATER AND GROUNDWATER QUALITY—KEY FINDINGS

Exceedances of the Alberta Water Quality Guidelines for the Protection of Aquatic Life were few for CLBR Basin lakes, as noted below.

- 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.
- The pH levels exceeded provincial guidelines in most lakes. Drought may have played a part in raising the pH, as lakes in Alberta are naturally well-buffered.
- Angling and Muriel lakes had minor guideline exceedances of Canadian Drinking Water Guidelines for arsenic in three samples from 2003. This may be due to naturally occurring arsenic in the local geology.
- Lakes in the CLBR Basin range from moderate (mesotrophic) to very high fertility (hypereutrophic). Moose and Kehewin lakes are highly fertile, more so than the average Alberta lake.
- 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, the flushing of “old” water is reduced and solutes become concentrated. Indeed, lakes with the greatest water level reductions are often most saline.
- Exceedances of the 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), dissolved manganese (Mn), dissolved iron (Fe), total cadmium (Cd), total chromium (Cr), dissolved oxygen and total zinc (Zn) concentrations, and a few exceedances for fecal coliforms.
- 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.
- The regional groundwater chemical quality is generally within Canadian Drinking Water Quality Guidelines, and has not changed detectably over time.
- A number of areas within the basin were determined to be potentially sensitive to contamination.
- A number of potential point and non-point sources of contamination are located within these sensitive areas.
- The finding that groundwater quality is not changing significantly with time is based on only two decades of data for the region.
- 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. As part of their operating requirements, industrial facilities must conduct groundwater monitoring and submit annual groundwater monitoring reports to the regulatory agencies.
- There is limited regulation of individual water well users for domestic use and small agricultural operations. Concerns exist that improper well installation, well maintenance, and well abandonment by individual landowners might be a risk to groundwater quality in the basin.

5.10 AQUATIC RESOURCES—KEY FINDINGS

- Over the past 25 years, a shortfall in precipitation levels has been recorded 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 the 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, the quality and quantity of habitat have decreased in some waterbodies.
- Over the years, some fish populations have become isolated by watershed fragmentation caused by low water levels and man-made structures placed on connecting streams.
- The 1985 CLBR Water Management Plan identified Wolf, Burnt, Angling, Caribou and Marie lakes as candidates for dams constructed 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 ongoing expansion of agriculture and cottage developments (new clearing, cultivation, grazing, subdivisions) on uplands and along lakes and streams continues to place increased pressure on waterbodies and riparian habitats 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's lakes and rivers.

6.0 PLANNING FOR THE FUTURE

Previous sections in this overview report summarized the key issues and findings of the four *State of the Basin Reports*. Section 6.0 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*, which helps to ensure the final updated plan meets provincial requirements while still reflecting the local watershed interests specific to the CLBR Basin.

Ultimately, the updated plan will integrate the portions of the existing 1985 plan that 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 as part of this undertaking.

6.1 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 principles adopted by the provincial government. The water management vision and principles were developed through consultation with Albertans.

As a way 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.*

6.2 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 goals and outcomes in the *Water for Life Strategy*.

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 CLBR Basin 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 into 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 the best available scientific information to make water management decisions.

6.3 New Direction for Watershed Management—Shared Governance and Partnership

The *Water for Life Strategy* 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 as a way to achieve the goals of the provincial water strategy.

The *Water for Life Strategy* promotes three levels of partnership that have different but complementary roles:

(a) **Alberta Water Council (AWC)** — Partnership at the provincial scale is 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 identify research priorities.

(b) **Watershed Planning Advisory Council (WPAC)** — Partnership at the watershed scale, such as for the Cold Lake–Beaver River Basin, is 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 and education initiatives, and promoting best management practices.

(c) **Watershed Stewardship Group (WSG)** — Partnership at the local scale, such as for the Moose Lake Watershed, is 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.

6.4 Evaluation Criteria for Assessing Water Management Options

The Cold Lake–Beaver River Basin technical teams were encouraged to explore the full range of potential water management options in the basin and provide these options to the BAC. These alternative options ranged from the minimum effort of continuing the current practices (i.e., status quo) to developing a new water management regime. The BAC considered these options along with other management options from other sources. The use of a particular alternative management option depended on whether it met existing provincial laws and policies, and other planning criteria determined by the BAC.

The planning team and BAC developed the following specific criteria to compare, measure and select management options for the updated Cold Lake–Beaver River Basin plan.

1. **Effective —** 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. **Acceptable —** How acceptable is this management option to the stakeholders?
4. **Compatible —** Is this option compatible with the existing laws, policies, and regulations of the federal, provincial and local governments?
5. **Viable —** Can this option be easily implemented?

7.0 POTENTIAL RECOMMENDATIONS AND MANAGEMENT OPTIONS

In addition to gathering and analyzing information related to the basin, the four technical teams were asked to recommend management options that would address how water might be managed within the CLBR Basin. These recommendations, which are included in this section, are preliminary and will be finalized only after thorough discussions with the BAC and input from other stakeholders.

Management Recommendations Outline/Format

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

The recommendations presented here follow the same format and outline used in the updated management plan:

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

7.1 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 a mechanism for managing, distributing and storing data related to groundwater and surface-water (quantity and quality) monitoring.**

7.2 PART 2 — WATER SUPPLY AND DEMAND

7.2.1 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.*
   - Current legislation from Alberta's *Water Act* prohibits any interbasin transfer of water.
   - 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.
   - 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:
   - Groundwater and surface water allocation limits in the basin should be designed to prevent adverse impacts on the environment and on other users.
   - The foundation for effective water allocation decision-making and planning should be based on a sound knowledge of the regional hydrogeology and hydrological cycle.
   - 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 *Water Conservation and Allocation Policy for Oilfield Injection*. This policy 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**

* *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.*

alternatives do not exist, and environmental risks should be assessed and minimized for each project.

4. **In addition to the *Water Conservation and Allocation Policy for Oilfield Injection,* Alberta Environment has also developed an accompanying guideline document (*Water Conservation and Allocation Guideline for Oilfield Injection*) which will guide efforts to minimize the use of non-saline water in enhanced oil recovery projects, including thermal in situ enhanced recovery projects. All applicants in the CLBR watershed must follow the specific requirement that have been set out in the guideline document.**

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 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.**

> *Deemed licences were temporary diversion permissions issued under the Water Resource Act. Under the new Water Act, these temporary permissions became deemed licences with expiration dates.*

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. The 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 a licence is granted, 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:**
   - A better understanding of groundwater and surface water interactions is needed to identify streams and surface waterbodies that are vulnerable to groundwater diversions.
   - Groundwater and surface water balance models should be integrated to provide a better understanding of groundwater contributions to surface waterbodies.
   - A better understanding is needed regarding the potential impacts of land use/land cover changes on the regional hydro-geological system.
   - Continued evaluation of the availability of groundwater in the basin should occur.
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.
   - Space pumping wells appropriately to maximize pumping capacities based on modeling results which indicate that during high peak saline water use periods, inter-well interference may limit pumping capacities.
   - Review if saline water chemistry monitoring is useful as an indicator of quality changes that may affect long-term brackish water use.
   - All industry members using the McMurray Formation as a source of saline water should install reliable, elevation-referenced groundwater-level monitoring in their source wells and in 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.
   - Provide annual saline water use data to the basin's Watershed Planning and Advisory Council (WPAC) as required.

7.2.2 Municipal Water Use Recommendations

1. **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 — Install 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.
- Water conservation targets — The City of Cold Lake should develop water conservation targets and implementation schedules to achieve water conservation objectives.
- Additional water conservation measures — 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.

2. **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.**

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

Water use for agriculture, commercial, irrigation and industrial temporary diversions represents 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 over 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:

1. **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.**
2. **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.**
3. **Information should be collected on unknown and unregulated (exempted under the *Water Act*) water withdrawal in the basin.**
4. **Technical assistance should be easily available and readily accessible to farmers and landowners for adopting water conservation practices.**
5. **Education and awareness are necessary.**

7.3 PART 3 — SURFACE WATER AND GROUNDWATER QUALITY RECOMMENDATIONS

1. **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 and ongoing monitoring would be required

2. **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.

3. **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 the water 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.

4. **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.

5. **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.

6. **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.**

7. **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).**

8. **By 2015, a tertiary municipal wastewater treatment facility should be built in the greater Cold Lake area to assure consistent and high-quality treatment of municipal wastewater.**

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

10. **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

11. **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*[1]).

12. **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 proper abandonment.

13. **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 plan 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.

14. **Establish a formal basin-wide education, awareness and outreach committee that actively promotes, funds and facilitates water protection activities and projects (e.g., Best 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.

15. **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.**

[1] *Produced by Alberta Agriculture, Food and Rural Development.*

- 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.

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

- A formal source protection planning process will add another level 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.

17. 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.

18. 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.

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

7.4.1 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.

1. **As stated in the original 1985 Water Management Plan, there will be no withdrawals permitted from May, Muriel, Manatokan, Reita and Tucker lakes. These lakes will be managed for the purpose of conservation, fisheries, wildlife and recreation.**
2. **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.**
3. **In order to protect fish, wildlife and recreational values and aquatic ecosystem functions, there will be no long-term diversions (i.e., more than one year) for steam injection purposes from lakes and wetlands in the CLBR Basin outside of Cold Lake. Other diversions from surface waters will be considered on a case-by-case basis, providing they do not harm these values and functions.**
4. **In order to protect recreational values, fish populations, other freshwater aquatic life and the aquatic ecosystem functions, there will be no diversions for steam injection purposes from the Beaver River, Sand River and other streams. Other diversions will be considered on a case-by-case basis, providing they do not harm these values and functions.**
5. **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.**

7.4.2 Protection of Aquatic Resources Recommendations

1. **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 species extirpated.**
2. **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.**
3. **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.**
4. **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.**
5. **An increase in education and awareness programs is needed to highlight the many functions and importance of undamaged, viable aquatic ecosystems and the legislation that provides protection for those essential ecosystems.**
6. **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

- To be determined

Kehewin Cree Nation

- Irving Kehewin

Elizabeth Métis Settlement

- Allan Wells

Métis 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
- Wes English, 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 and 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. ACRONYMS AND DEFINITIONS

AC	asbestos cement (pipe)
ALMS	Alberta Lake Management Society
AMWWP	Alberta Municipal Water/Wastewater Partnership
APF	Agriculture Policy Framework
ATV	all-terrain vehicle
AWC	Alberta Water Council
BMP	best (beneficial) 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 Licences
TDS	total dissolved solids
THM	trihalomethane
USEPA	United States Environmental Protection Agency
WPAC	Watershed Planning Advisory Council
WSG	Watershed Stewardship Group

Alberta Water Council — a multi-stakeholder group formed in 2004 to provide direction and advice to the Alberta government, stakeholders and the public on improving water management, provide guidance on the implementation of the water strategy, and investigate and report on existing and emerging water issues in Alberta (www.waterforlife.gov.ab.ca).

allocation — water redirected for a use other than for domestic purposes. (Agricultural, industrial and municipal water users apply to Alberta Environment for a licence to use a set allocation of water. This water licence outlines the volume, rate and timing of diversion of water.)

approval — provides authority for constructing works or for undertaking an activity within a waterbody. (The approval includes conditions under which the activity can take place.)

aquatic ecosystem — 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.

deemed licences — temporary diversion permissions issued under the *Water Resource Act*. (Under the new *Water Act*, these temporary permissions became deemed licences with expiration dates.)

discharge — water exiting groundwater systems in an upward-oriented, exiting flow into surface waterbodies, marshes, wetlands, springs, etc.

diversion of water — the impoundment, storage, consumption, taking or removal of water for any purpose. (This does not include the taking or removal for the sole purpose of removing an ice jam, drainage, flood control, erosion control or channel realignment.)

domestic water use — water used for drinking, cooking, washing and yard use. (A very small percentage of the water used in this province is used for domestic purposes.)

drinking water — water that has been treated to provincial standards and is fit for human consumption.

evapotranspiration — process where moisture is returned to the air by evaporation from the soil and transpiration by plants.

groundwater — all water under the surface of the ground whether in liquid or solid state. (It originates from rainfall or snowmelt that penetrates the layer of soil just below the surface. For groundwater to be a recoverable resource, it must exist in an aquifer. Groundwater can be found in practically every area of the province, but aquifer depths, yields and water quality vary.)

habitat — the 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 — 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.)

induced recharge — occurs when lakes, streams and wetlands lose water to the adjacent groundwater aquifer as a result of groundwater pumping from a nearby well.

instream needs — 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 seen only with the aid of a microscope. (Some micro-organisms can cause acute health problems when consumed in drinking water.)
natural flow	— 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	— 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	— use of water in which all of 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 fit for human consumption but not treated.
produced water	— water obtained from an oil or gas well during production. (Some of this water exists naturally within the formation. In the case of steam injection processes, however, the term generally refers to water recovered from an oil reservoir following steam injection. This recovered water can be recycled and used over again, and is an important factor in minimizing the volumes of freshwater that could otherwise be required.)
raw water	— water in its natural state, prior to any treatment for drinking.
recharge	— water entering groundwater flow systems through the downward-directed percolation of infiltrating precipitation or directly from surface waterbodies.
registration	— Land owners who traditionally used water for agricultural purposes (i.e. stock watering, herbicide / pesticide applications etc.) but were not licenced under the old *Water Resources Act* could apply to register this use under the new Water Act. Applicants had a three year window (1999-2001) to register.

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	—	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	—	water that moves over the surface of the ground. (Runoff collects sediments and contaminants as it moves from higher elevations to lower elevations.)
saline water	—	water with a total dissolved solids (TDS) content exceeding 4000 milligrams per litre (mg/l).
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	—	process that occurs after the holder of an existing water withdrawal licence agrees to provide all or part of the amount they are allocated to another person or organization. (Alberta Environment must approve any transfer of this kind. When this occurs, the allocation is separated from the original land; a new licence, 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 licence. Water allocation transfers can occur only if authorized under an approved water management plan, or by the Lieutenant Governor in Council.)
waterbody	—	any location where water flows or is present, whether or not the flow or the presence of water is continuous, intermittent, or occurs only during a flood. (This includes, but is not limited to, wetlands and aquifers.)

water conservation — the planned protection, improvement and wise use of natural resources. (It includes controlling, protecting, and managing water.)

water conservation objective — the amount and quality of water necessary for the protection of a natural waterbody or its aquatic environment (*Water Act*). (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 licence — provides the authority for diverting and using surface water or groundwater. (The licence 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 licence, 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 — 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 — conservation of water and energy through creative landscaping (from the Greek word "Xeros" meaning dry).