THE PEACE WATERSHED

CURRENT AND FUTURE WATER USE AND ISSUES, 2011

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Mighty Peace Watershed Alliance

Watrecon Consulting

This report was prepared for the Mighty Peace Watershed Alliance

It was prepared by Watrecon Consulting, in association with Ellehoj Redmond Consulting, Aquality Environmental Consulting Ltd., and Duane McNaughton, P. Geol.

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EXECUTIVE SUMMARY

This study was undertaken to assist the Mighty Peace Watershed Alliance (MPWA) in developing its state of the watershed report. The objective of this report is to summarize what is currently known about water quantity, water quality, water use and potential water supply and quality issues throughout the Peace watershed.

The Watershed

The scope of this study is the entire Peace Watershed within Alberta; including the main stem and all major tributaries. The Peace River is about 1,923 kilometres (km) in length and stretches from the head of the Finlay River, located in British Columbia, to Lake Athabasca. Water from the Peace watershed and the Athabasca river system then join to form the Slave River which travels 434 km before draining into Great Slave Lake in the Northwest Territories. The Peace watershed drains an area of approximately 302,500 square kilometres (km^2), of which 60% (182,500 km^2) is in Alberta. The Peace watershed covers about 28% of the landmass of Alberta. There are six sub-basins in the watershed, including three along the mainstem of the Peace River (upper, central and lower), one for the Slave River, and two for the major tributaries (Smoky/Wapiti and Wabasca). This report provides an overview of water quantity, quality, use and issues for each of the six sub-basins as well as for the entire watershed.

The People

In 2006, approximately 136,800 people lived in the Alberta portion of the Peace River Watershed. This represents about two-thirds of the population of the entire Peace River basin and 4% of the Alberta population. People living in the Smoky/Wapiti sub-basin, which includes the City of Grande Prairie, account for two out of three people living in the Alberta portion of the watershed. The remaining third of the population is relatively equally distributed throughout the upper, central and lower Peace sub-basins and the Wabasca sub-basin. Only 85 people are estimated to live in the Slave sub-basin. Compared to the Alberta average, the population of the Peace watershed tends to be younger, with a higher percentage of Aboriginal people. People living in the Peace watershed are more likely to participate in the labour force and be employed in natural resource-based industries. Median incomes in the watershed are similar to the Alberta median income.

Land and Resource Use

Agriculture, oil and gas, forestry and other human activity has disturbed about 57% of the watershed. The upper reaches of the watershed are more disturbed than the lower reaches, parts of which are located in Wood Buffalo National Park. Agriculture occurs on about 25% of the land in the watershed, with 50% of farms occurring in the Smoky/Wapiti sub basin and 25% in the Upper Peace sub-basin. Nearly two-thirds of farms (62%) raise livestock. In 2006 there were five times as many cows as people in the watershed and slightly more than one pig per person. Livestock generated 7.2 million tonnes of manure.

About 6.4 million cubic metres of timber were harvested in the Peace watershed in 2009/10. This represents one third of all wood harvested in Alberta. Much of the land in the watershed is being harvested under the terms of a Forest Management Agreement (FMA).

There are 61,851 oil and gas wells, 305,400 km of cutlines, and 34,216 km of pipelines in the Peace watershed. The highest land disturbance from oil and gas occurs in the Upper Peace sub-basin where there are 6.6 kilometres of seismic lines and pipelines for each square kilometre of non-agricultural land. The average for the watershed is 2.1 km/km^2. High levels of disturbance are also found in the Smoky/Wapiti sub basin (4.1 km/km^2). However, the Wabasca sub-region accounts for 35% of all seismic lines in the watershed.

Surface Water

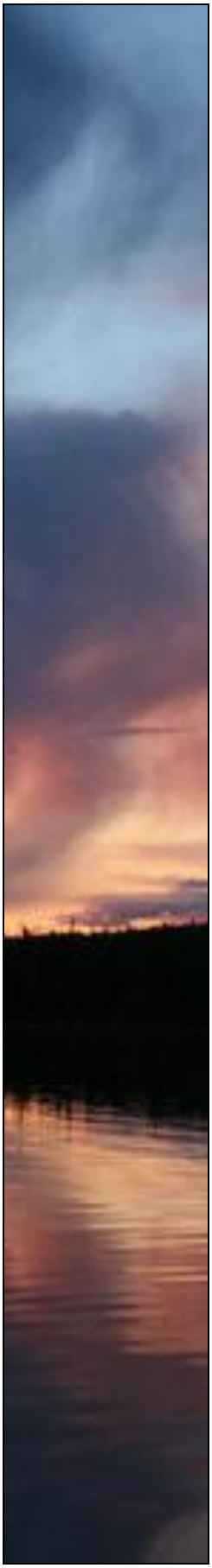
The Peace River is a regulated river, which means that flows in Alberta are strongly influenced by releases from the Williston Dam in British Columbia that produce hydroelectric power. The effect of these releases has been to increase flows during winter flows (when power is required) and to reduce flows during the spring and summer (when water is being stored for power production in the following winter). The effects of flow regulation occur along the entire length of the Peace River, although the effects are partially buffered as a result of inflows from major tributaries, such as the Smoky River and the Wabasca River. The Peace River contributes about 65% of the average flow of the Slave River.

Water Use

As of 2011 water licences and registrations issued to people and companies allow withdrawals of up to 148,728 cubic decametres (dam^3) of surface water for use. This represents 89% of water allocations in the watershed. Allocations of surface water account for about 0.3% of the average annual flow of the Peace River at Peace Point.

Nearly two thirds of these allocations are for commercial purposes, including pulp mills, coal mines and thermal power projects. Another 19% of surface water allocations are for municipal purposes, with 7% for industrial purposes (oil and gas). Allocations for agricultural use (including agriculture, irrigation and registrations) account for 5% of total allocations. Allocations of surface water in the Smoky Wapiti sub-basin account for 57% of total allocations, while the Central Peace sub-basin accounts for another 36%. The Upper Peace sub-basin accounts for only 5% of total allocations while the Lower Peace and Wabasca sub-basins account for only 1% of the total. There were no surface water allocations in the Slave sub-basin.

Under the terms of water licences, 38% of licensed withdrawals can actually be used; the remainder is expected to be returned after use. Commercial users are expected to return 53% of withdrawals after use while municipal users are expected to return 72%. Available information suggests that 29,397 dam^3 of surface water was actually used in 2011. This represents 20% of total surface water allocations and 52% of licensed surface water use. Municipal and commercial water use each accounted for 22% of total surface water use in the Peace watershed, with agricultural water uses accounting for 27%.



Water Quality

The quality of surface water in the upper parts of the Peace watershed, including the Smoky River, is generally considered to be 'good' based on the CCME guidelines for the protection of aquatic life. However, water quality declines slightly in the lower reaches of the Peace River and in the Slave River, due to increased amounts of suspended solids, nutrients and metals, as well as increased biological oxygen demand and turbidity. The water quality in some of the smaller tributaries in upper parts of the watershed has been rated 'marginal' due to high levels of nutrients resulting from agricultural activities.

In the past, there were concerns about the effects of pulp mills in terms of their discharges of nutrients (which increase biological oxygen demand) and chlorinated compounds (such as adsorbable organic halides). However, recent changes in pulp mill technology have significantly reduced the amounts of these materials being discharged. Each of the pulp mills in the watershed (one in Grande Prairie and one near Peace River) monitors its effects on aquatic health and periodically reports this information to Environment Canada and Alberta Environment and Water.

Groundwater

Groundwater can be drawn from deeper bedrock aquifers, or shallower surficial or over-burden aquifers, such as the Grimshaw Aquifer. Within the Peace watershed, the highest groundwater yields are found in shallow overburden sands making up the Grimshaw Aquifer and from buried valley aquifers in the Wabasca sub-basin where yields in excess of 100 imperial gallons per minute (IGPM) are noted. The lowest yields are found in the Upper Peace sub-basin (less than 5 IGPM).

Water Use

Water licences and registrations issued for groundwater allow withdrawals of up to 18,684 dam^3 of water for use. This represents 11% of water allocations in the watershed. Just over half of these allocations (51%) were for industrial purposes (oil and gas), 26% was for municipal purposes, and 13% was for agricultural purposes. Allocations of groundwater in the Smoky/Wapiti and Wabasca sub-basins accounted for 84% of total groundwater allocations within the Peace watershed.

Under the terms of water licences, 85% of licensed withdrawals can actually be used. Municipal users are expected to return 55% of water after use. Available information suggests that 8,402 dam^3 of groundwater was actually used in 2011 in the Peace watershed. This represents 45% of total groundwater allocations and 53% of licensed water use. Industries accounted for 39% of actual groundwater use, while agricultural uses accounted for 21% and municipal use accounted for 21%.

Water Quality

The quality of water from both surficial and bedrock aquifers in the Peace River watershed is generally chemically hard and high in dissolved iron, and high in Total Dissolved Solids (TDS). The best quality groundwater is found in the west-central portion of the watershed. Many of the surficial aquifers underlying the agricultural areas in the Wapiti/Smoky and Upper and Central Peace sub-basins are vulnerable to contamination from underlying saline water.

The quality of groundwater is being monitored by Alberta Environment and Water at observation wells within the Peace River watershed in the general vicinity of Grande Prairie, Peace River, and Fort Vermilion.

Future Water Use

Over the period from 2011 and 2025, water use in the Peace watershed is predicted to increase by 40%. Industrial water use, especially related to oilsands and the use of in-situ thermal (steam) technology, is expected to account for 61% of the increase. Population growth in some parts of the watershed will continue to increase the demand for water and there are expected to be relatively small increases in water use by the agricultural sector. Most of the predicted increases in water use will occur in those parts of the basin that have oil sands and heavy oil deposits, specifically in the Central Peace and Wabasca sub-basins. Groundwater use will increase from 22% of total water use in 2011 to 31% by 2020.

Current and Future Water Issues

Despite the perception that the watershed has an abundance of surface water, water shortages are an important issue because most users are not located on one of the major rivers in the watershed. Many municipalities and other users have licences that allow them to take water from more than one source. During a prolonged drought, senior water users (those with the oldest licences) have priority so junior licensees will have to cease water withdrawals, resulting in lost production and economic hardship. Management of available water during drought periods will necessitate a better understanding of allocations and actual water use, and this is currently problematic because not all licensees, especially those with licences issued for irrigation, agricultural or other water uses, have been reporting actual water use, and very few water users report return flows.

Increased demands for surface water will place increasing demands on rivers and lakes and, at present, there is limited information on the health of aquatic ecosystems in the Peace watershed and on whether ecosystem health is remaining the same or deteriorating. A key challenge will be to undertake instream flow needs assessments for most of the main tributaries of the Peace River in order to determine how much water can be withdrawn without compromising the health of aquatic ecosystems. This not an issue for the mainstem of the Peace River; releases for hydroelectric power generation have resulted in higher flows during the summer periods than would occur under normal conditions.

An existing and increasingly important issue in the Peace watershed and elsewhere in Alberta relates to the protection of groundwater quantity and quality, especially in regard to the effects of coal bed methane (CBM) extraction, mining, drilling, seismic activities, and the practice known as “fracking”. However, the Alberta Government has established a regulatory framework to protecting aquifers from over-use and physical damage or impairment.

The most important future issue for the Peace watershed is the development of additional hydroelectric capacity and the resulting effects on river flows. Changes in flows as a result of the Williston Dam are believed to have changed the frequency of ice jams on the lower Peace River and these effects, combined with drought conditions, have already resulted in a serious reduction in perched lakes and wetlands in the Peace Athabasca Delta (PAD).

Planned hydroelectric projects include a small run-of-river project on the Peace River near Dunvegan (approved but not yet built) and the proposed Site C hydroelectric project in British Columbia. There is also potential for hydroelectric development on the Slave River.

Concerns associated with additional hydroelectric development are related to changes in downstream flows (especially during reservoir filling), changes in the ice regime (especially in terms of the PAD), effects on navigation, and effects on fish habitat, mortality and migration. It is expected that issues will be addressed during regulatory reviews for the proposed projects.

Climate change may also be an issue in the watershed. There are already reduced snowpacks (due to less snow and more rain) that result in lower flows and a reduced probability of ice jams. Climate change is also expected to affect the thickness and location of river ice.

LIST OF ABBREVIATIONS

AARD	Alberta Agriculture and Rural Development
AESA	Alberta Environmentally Sustainable Agriculture
AEW	Alberta Environment and Water
AGD	Alberta Geological Survey
ALMS	Alberta Lake Management Society
AOX	Adsorbable organic halides
BOD	Biological oxygen demand
CBM	Coal bed methane
CCME	Canadian Council of Ministers of the Environment
dam^3	Cubic decametre
EC	Environment Canada
EEM	Environmental effects monitoring
ERCB	Energy Resources Conservation Board
FITFIR	First in time, first in right
FMA	Forest Management Agreement
ha	hectare
IGPM	Imperial gallon per minute
km	Kilometre
km^2	square kilometre
MPWA	Mighty Peace Watershed Alliance
MRBB	Mackenzie River Basin Board
N	Nitrogen
NADC	Northern Alberta Development Council
NRBS	Northern River Basins Study
PAD	Peace Athabasca Delta
PCB	Polychlorinated biphenyls
PFRA	Prairie Farm Rehabilitation Administration
RGA	Regional groundwater assessment
TDS	Total dissolved solids
WPAC	Water Planning and Advisory Council
WQI	Water quality index

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1.0 INTRODUCTION

The Mighty Peace Watershed Alliance (MPWA) is one of several Watershed Planning and Advisory Councils (WPACs) that were created under Alberta's Water for Life strategy. This strategy has three goals:

- Safe, secure drinking water supplies
- Healthy aquatic ecosystems
- Reliable, quality water supplies for a sustainable economy

As part of the strategy, it is expected that a "state of the watershed report" will be completed for each major river basin, including the Peace watershed.

To assist in developing a state of the watershed report for the Peace, the MPWA commissioned this study to summarize what is currently known about:

- water quantity
- water quality
- water use
- potential water supply and quality issues

throughout the Peace watershed. This information is needed to assist the MPWA in identifying the ongoing and future management issues that it will attempt to address. It is hoped that this information will also give basin residents and others a better understanding of how water, and the way it is being managed, affects them and their communities.

What is a Watershed?
A watershed is the area of land that catches precipitation and drains into a larger body of water such as a marsh, stream, river, or lake. A watershed is often made up of a number of sub-watersheds that contribute to its overall drainage.

What is a River Basin?
A river basin is the same as a watershed and the Alberta *Water Act* identifies seven Major River Basins in Alberta, one of which is the Peace/Slave River Basin.

The terms watershed and basin are used interchangeably throughout this report

1.1 Study Objectives

The objective of this study is to provide an overview of water availability, demand and use in each of the six Peace sub-basins in Alberta, and to describe water quality conditions. It will consider use of both surface and groundwater. It will summarize current water management issues for the watershed and for the six sub-basins. Land and resource uses that affect water demand and quality will also be described. The report will also identify data gaps and the emerging issues and challenges facing the Peace watershed.

1.2 Scope of the Study

The scope of this study is the entire Peace Watershed within Alberta, including the main stem and all major tributaries. Unlike most other rivers in Alberta, the headwaters of the Peace River are located in British Columbia. The river stretches from the head of the Finlay River to Lake Athabasca, a distance of about 1,923 kilometres (km). Water from the Peace watershed and the Athabasca river system then join to form the Slave River which travels 434 km before draining into Great Slave Lake in the Northwest Territories. In total, the Peace watershed drains an area of approximately 302,500 square kilometres (km^2), of which 60% (182,500 km^2) is in Alberta. The Peace watershed covers about 28% of the landmass of Alberta.

1.2 Methodology and Data Sources

The contents of the report provide a summary of recent published information. Much of this information comes from technical studies prepared as part of developing an Alberta-BC trans-boundary agreement as well as water management studies prepared by and for Alberta Environment and Water (AEW) and the results of the Northern River Basins Study.

Information related to historical flows in the Peace and other major rivers in the watershed was taken from the Water Survey of Canada as well as studies by AEW.

The Alberta Geological Survey, which is administered by the Alberta Energy Resources Conservation Board (ERCB), is the primary repository for information, maps, and digital data on the stratigraphy, bedrock topography and hydrogeology of the province. The ERCB issued ERCB/AGS Open File Report 2009-02, titled: "Compilation of Alberta Groundwater Information from Existing Maps and Data Sources" (Lemay and Guha, 2009). That report presents a series of maps generated using GIS software that summarize existing groundwater information in Alberta.

Information related to water demand is based on water licence information provided by AEW and is current to September 2011. AEW also provided information on reported water use, although this information is known to be incomplete because not all licensees are required to report water use and some of those who are required to report have not submitted annual reports. Consequently, some of the water use estimates, especially for the agricultural and other sectors, were developed using the methodology employed by AMEC Earth and Environmental in its 2007 report that described current and future water use in Alberta. Water use forecasts were based on the list of major projects developed by the Alberta Government as well as the 2007 forecast of water use (AMEC).

The 2006 census provided information on socio-economic characteristics and agricultural activities in the watershed. At this time only the population counts from the 2011 census have been provided and detailed information will not be available until 2012.

Information on surface water quality in the Peace watershed is based on studies completed by Alberta Agriculture and Rural Development (AARD), AEW, Environment Canada (EC), Alberta Lake Management Society (ALMS), and the Mackenzie River Basin Board (MRBB). Surface water quality monitoring within the Peace watershed is currently undertaken by AEW, AARD, EC, Alberta Tourism, Parks and Recreation, and various municipalities and stewardship groups.

Groundwater quality studies for areas within the Peace River watershed have been completed by: the Prairie Farm Rehabilitation Administration (PFRA), Hydrogeological Consultants Ltd. (HCL), Canada-Alberta Environmentally Sustainable Agriculture Agreement (CAESA), Alberta Geological Survey (AGS), and AARD. Groundwater quality monitoring is currently undertaken by AEW. Currently, there are few observation wells within the Peace River Watershed Region and they are clustered around Grande Prairie, Peace River, and High Level. Most groundwater quality monitoring in the region is in the form of samples submitted to Alberta Health and Wellness by municipalities and rural well owners for potable water testing.

2.0 OVERVIEW OF THE PEACE WATERSHED

Alexander Mackenzie was the first white man to explore the Peace River watershed. In 1792 he over-wintered at the junction of what are now called the Smoky and Peace rivers, as he explored the river in an effort to find a route to the Pacific coast. At that time, the area was populated by nomadic hunters – the Beaver – who were gradually being pushed westward by the influx of Cree people as the fur trade pushed across the country. Fur trading along the Peace commenced shortly after Mackenzie's visit, with construction of trading posts at Dunvegan, Fort Vermilion, Fort St John, and McLeod. The Catholic and Anglican missionaries soon followed.

The area along the Peace River remained sparsely settled until the early 1900s, when scores of settlers arrived to farm the land. They first settled the Alberta portion of the area, but expanded into British Columbia after 1912 when 3.5 million acres were made available for settlement.

The third wave of development in the area occurred after 1945. This development consisted of exploration and production of oil and gas resources in the region as well as the construction of road and rail access that linked the region to the rest of British Columbia. Development of the heavy oil deposits north of the Town of Peace River commenced in 1979.

The 1960s saw the development of the river's hydroelectric potential. Construction of the Bennett Dam on the Peace River at Hudson Hope was completed in 1968 and created Williston Lake. This was followed by construction of the Peace Canyon Dam in 1980, which created a small reservoir called Dinosaur Lake.

The next phase of regional development involved the extraction of coal resources. The first major coal development in the watershed occurred in the upper part of the Smoky River watershed near Grande Cache in the 1970s. This was followed by construction of the Bullmoose and Quintette mines in the upper Murray River watershed in British Columbia in the 1980s that resulted in construction of a new community at Tumbler Ridge.

A subsequent phase of economic development focussed on the forest industry. Although the first development of the region's spruce and aspen forests occurred with construction of a pulp mill at Grande Prairie in 1972, rapid expansion of this sector occurred in the 1990s with construction of the Peace River pulp mill. A major lumber mill opened in 1990 in High Level. Oriented strand board mills that use timber resources from the Peace watershed were opened in High Prairie in 1995 and in High Level in 2000.

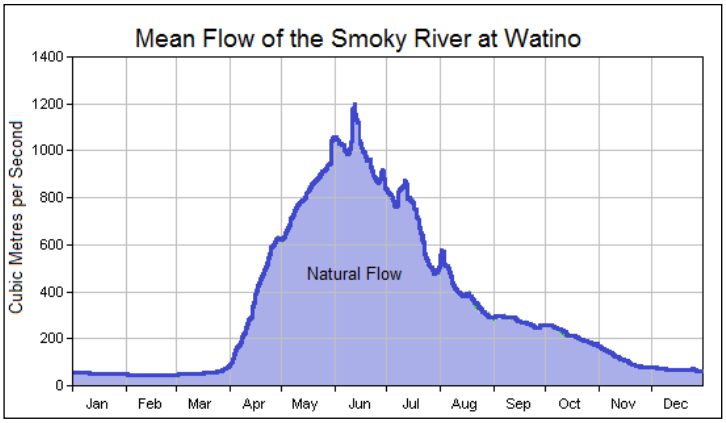
The most recent phase of development has involved developing the heavy oil deposits in the watershed. Although some heavy oil development has been occurring in the area northeast of Peace River since 1979, the recent development of steam assisted gravity drainage (SAGD) recovery technology has resulted in considerable recent oil development in the region, especially in the Wabasca sub-basin. Companies also have plans for major new heavy oil recovery projects in the upper end of the Central Peace sub-basin.

2.1 Hydrology

2.1.1 Surface Water

The headwaters of the Peace watershed are located in British Columbia and consist of the Finlay and Parsnip sub-basins. The hydrology of the watershed changed profoundly with the creation of the Bennett Dam. According to BC Hydro, the resulting reservoir (Williston Lake) is 1,761 km^2 in area and flooded the lower reaches of both sub-basins. The reservoir is 251 km in length, holds 74 million cubic decametres (dam^3) of water, and is the seventh largest reservoir in the world. The reservoir has the ability to store the equivalent of 1.5 times the mean annual flow of the Peace River at the British Columbia-Alberta boundary.

Prior to the Bennett Dam, the natural flows of the Peace River were very much like other unregulated rivers on the east slopes of the Rocky Mountains. As shown for the Smoky River near Watino, natural rivers flows are low during the winter months. River flows start to increase in April due to run-off and high elevation snowmelt, peak in June or July, and then decline in the fall months.

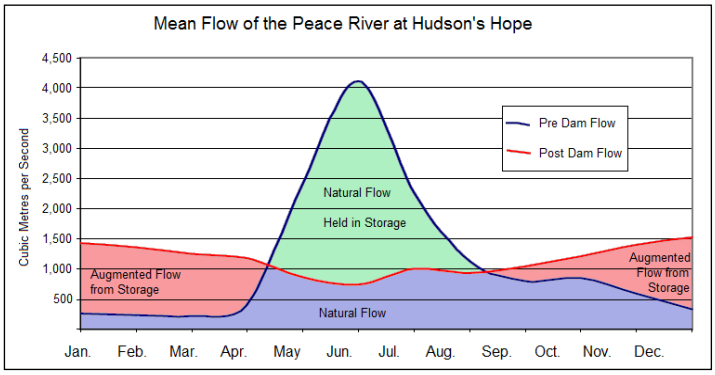


Water from the Williston Reservoir is now released to produce electricity, and this has significantly changed the pattern of flows in the river below the dam. The difference in the flow of the Peace River downstream of the dam (at Hudson's Hope) with and without the dam is shown below.

Natural Flow

This refers to what the flow of the river would have been without any human activity. Natural flows are calculated by combining information on actual or measured flows with estimates of water use.

Prior to the Bennett dam, the Peace River had an average flow of about 250 m^3/sec during the winter months of January, February and March. However, to meet demands for electricity, about 1500 m^3/sec is now being released during this period; this is six times higher than natural flows. The high spring and summer flows of the upstream sub-basins are now stored for release in the following winter, so that summer flows below the dam are about 16% of the pre-dam natural flows.



Downstream from Hudson's Hope, the river then flows into Dinosaur Lake, which is a small reservoir created by the Peace Canyon Dam, which also generates hydroelectric power. Two major tributaries enter the Peace River below the Peace Canyon Dam: the Beatton and Murray rivers. The Peace River enters Alberta about 25 km downstream from its junction with the Murray River. The average annual flow of the Peace River just upstream of the Alberta Border is 1,540 m³/sec.

The Peace River flows for about 128 km before reaching the Dunvegan Bridge on Highway 2. The river drops about 44 metres over this distance. The recently-approved Dunvegan Hydroelectric Project would be located on the river just upstream from the bridge.

The Dunvegan Hydroelectric Project

This project consists of a run-of-river 100 MW project on the Peace River, two kilometres upstream of the Dunvegan Bridge. Although the project was approved in 2008, TransAlta is currently collecting additional information needed for project design. There is no information on when construction of the project will commence.

Flooding in the Town of Peace River

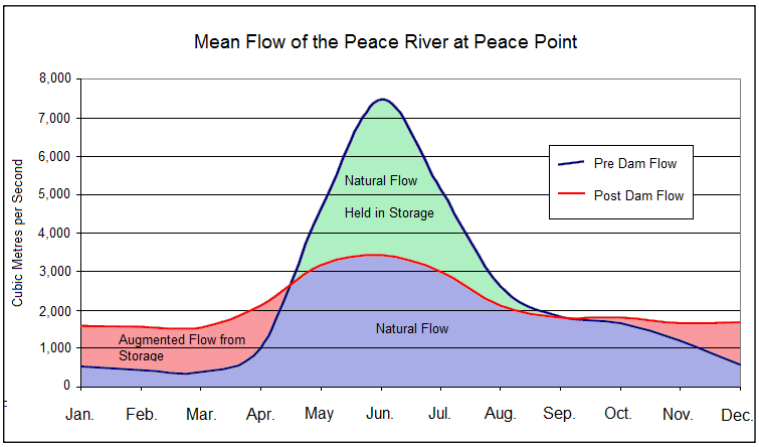
Parts of the Town of Peace River were flooded in 1982, 1992, 1997, and 2005. Flooding can occur during freeze-up, due to ice jams caused by a sudden melt during periods of high flow, or during the spring thaw, if spring break-up on the Smoky River occurs when there is still an intact ice surface on the Peace River. To address these issues, the Town has constructed a continuous dyke system that prevent flood damage from high flows (1 in 100 year flood events) and ice-jam floods. BC Hydro can also reduce the amount of water being released from the Williston Dam in order to stabilize or reduce water levels.

From Dunvegan, the river travels another 102 km before it is joined by the Smoky River at the Town of Peace River. Over this distance the river drops 28 metres. The headwaters of the Smoky River are in British Columbia and it drains an area of about 50,300 km^2. The average annual flow of the Smoky River is 339 m³/sec. Just downstream from the junction with the Smoky River, the average annual flow of the Peace River increases to 1,830 m³/sec.

The next major community downstream the Town of Peace River is Fort Vermilion, located about 430 km downstream. The river drops a total of 64 metres over this distance. Inflows from rivers like the Whitemud, Cadotte, Notikewin, Wolverine and Buffalo, increase the average annual flow of the Peace River to about 1,950 m³/sec.

The Wabasca River enters the Peace River about 55 km downstream from Fort Vermilion. The Wabasca River drains an area of about 36,300 km^2 and has an average annual flow of 83 m³/sec.

Peace Point is located 311 km downstream from Fort Vermilion. At this point, the river is draining an area of 293,000 km^2 and the average annual flow increases to 2,080 m³/sec. The pattern of water releases from the Bennett Dam still has an important effect on Peace River flows at this point on the river.

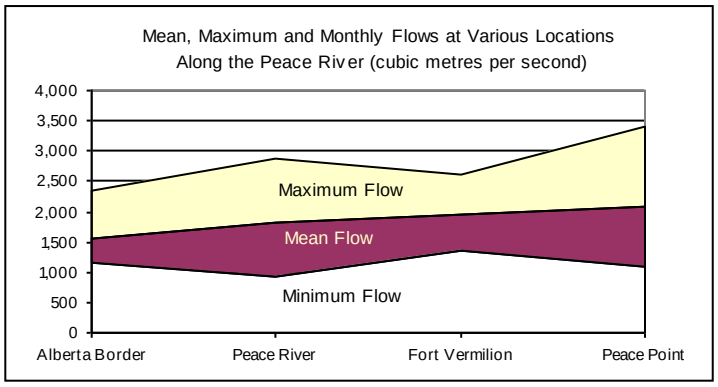


Peak spring and summer flows at Peace Point are about 50% of natural flows, while flows in the winter months can be three times greater than under pre-dam conditions.

Downstream from Peace Point, the river passes Carlsons Landing before reaching the junction with the Rivière des Rochers, which is one of the main channels by which water from the Athabasca watershed travels through the Peace-Athabasca Delta to join the Peace River. This last section of the Peace River is very flat, with the river dropping a total of only 5 m over a distance of 99 km. At this point it has an annual flow of 2,161 m^3/s.

The Slave River commences at the junction of the Peace River and the Rivière des Rochers and travels 494 km before entering Great Slave Lake. At Fitzgerald, just south of the NWT border, the Slave River drains an area of about 606,000 km^2 and has an average annual flow of 3,370 m^3/sec. Thus, the Peace River contributes about 65% of the average flow of the Slave River.

Flows in the Peace River are highly variable. Flow information from the Water Survey of Canada shows that peak monthly flows on the Peace River can be 50% higher than the mean (average) monthly flows, while low flows can be 40% less than the mean.



2.1.2 Groundwater

The groundwater resource in the Peace watershed is important both from the standpoint of water supply, and also as a water storage and release component of the hydrological cycle. Concerns about groundwater generally centre around the continued availability of groundwater supply for agricultural, domestic and industrial consumption.

Significant groundwater supply is available from bedrock aquifers principally in the southern portion of the Peace River watershed. In the mountains, bedrock aquifers consist principally of fractured rock (mostly limestone and shale formations). On the Alberta High Plains, the Quaternary Paskapoo (Sandstone) Formation forms an important aquifer within the Peace watershed extending from the foothills northward to about Township 64. The Upper Cretaceous Wapiti Formation, which underlies the basin from roughly township 66 to 76, and from the fifth Meridian westward to the British Columbia boundary (as well as an outlier beneath the Clear Hills north of Grande Prairie), is also an aquifer, generally suitable for supplying widespread domestic requirements. Farther north, the lower Cretaceous Dunvegan (Sandstone) Formation, where it has not been removed by erosion, is an aquifer in the Peace River Area.

Groundwater is also available from surficial, or overburden aquifers within the Peace watershed. Over a large portion of the watershed these can generally be described as:

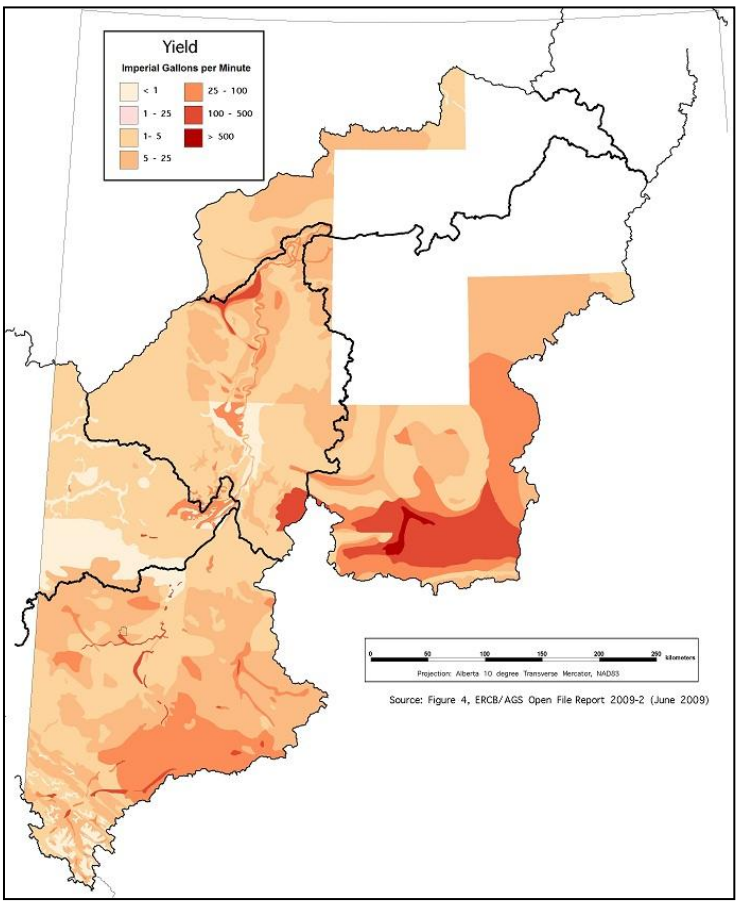
- present day, coarse river sediment (alluvium) made up of sand and gravel occupying river valleys and river beds. These types of surficial deposits are common, and are often categorized as aquifers under the effect of surface water

- buried valley aquifers, consisting of sand and gravel deposited in river valleys that existed before the age of the glaciers, and were subsequently buried by thick clay-rich glacial sediments ("drift") deposited by glacial ice;
- sand and gravel aquifers (termed "drift aquifers") deposited during glacial times, when brief periods of warming caused the glacial ice to melt. These sand and gravel deposits were later buried by additional glacial sediment when the climate cooled and the glaciers again began to advance;
- recent (deposited since glacial time) sand and gravel, deposited as sand dunes by the wind (Aeolian deposits) or by running water, often where deltas formed as water ran off the glaciers as they melted for the last time; and,
- present day muskeg deposits, although these are not officially classed as "aquifers" by AEW.

An example of a high-yielding recent sand and gravel aquifer is found in the Grimshaw Area, and is known as the Grimshaw Aquifer.

Many groundwater wells on farmsteads beyond the extent of the Paskapoo and Wapiti Formations extract water from overburden aquifers, and these are therefore important sources of domestic water supply over a very large portion of the Peace River Basin where bedrock aquifers do not exist. Natural flowing groundwater conditions (flowing wells) may exist where water wells penetrate into pre-glacial buried valley aquifers.

Groundwater is also available from deep bedrock aquifers in the Peace River Basin, which due to the brackish to saline quality of groundwater they yield, are below the base of groundwater exploration. These aquifers, where present, are valuable in their own right, generally for the purposes of water supply for oilfield injection and potentially for other industrial processes.

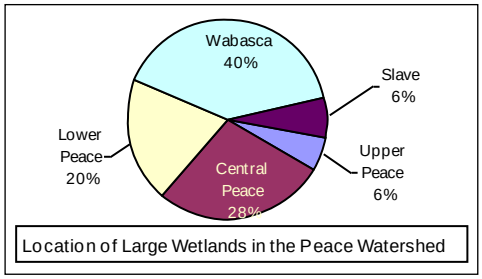


Available information on groundwater yields in the Peace watershed indicate that the highest yields are found in the Wabasca sub-basin, with some areas having yields in excess of 100 imperial gallons per minute (IGPM). In comparison, most of the Upper Peace sub-basin has groundwater yields of less than 5 IGPM.

Groundwater yields in the Central Peace sub-basin are also relatively low, with higher yields in areas close to the Peace River. Yields are higher in the Smoky/Wapiti sub-basin and are higher in the southwest corner of the sub-basin. There is little or no information on groundwater yields for much of the Lower Peace, Wabasca and Slave sub-basins.

2.1.3 Wetlands

According to available satellite land cover information, large wetlands (larger than 5,000 hectares) cover 7.6% of the Peace watershed; this represents an area of 27,145 km^2. These large wetland areas are found primarily in the downstream sub-basins.



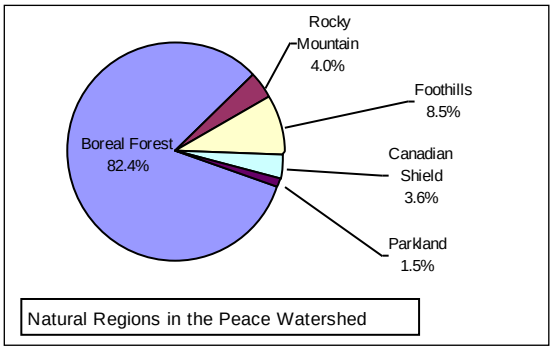
Location of Large Wetlands in the Peace Watershed

The Peace–Athabasca Delta

The Peace- Athabasca delta is about 3,820 km^2 in size and consists of a flat area between the Athabasca and Peace rivers that includes Lake Claire, Mamawi Lake and various smaller lakes and wetlands. In 1972 it was identified as: one of the most extensive boreal deltas in the western hemisphere; one of the continent's last relatively undisturbed deltas; the largest area of undisturbed sedge and grass meadows in North America; a key link in the four major flyways for migratory birds; an important breeding area for ducks, an important grazing area for wood bison; and a nesting area for peregrine falcon. The existence of the delta is related to periodic flooding associated with flows in one or both rivers. However, following completion of the Bennett Dam in BC, changes in the flow of the Peace River has resulted in less frequent flooding, resulting in major changes to the Delta. These changes and the factors behind them are addressed in the discussion of the Wabasca Sub-basin (Chapter 7).

No large wetland areas are found in the Smoky/Wapiti sub-basin. Most large wetlands areas in the watershed are located in the Wabasca sub-basin (40% of wetlands in the watershed), with 28% in the Central Peace sub-basin, and 20% in the Lower Peace sub-basin. Smaller amounts of large wetland areas within the watershed are found in the Slave sub-basin (6% of the watershed) and the Upper Peace sub-basin (6%). Some of the most important wetlands in the watershed are found in the Peace-Athabasca Delta.

2.2 Physiography



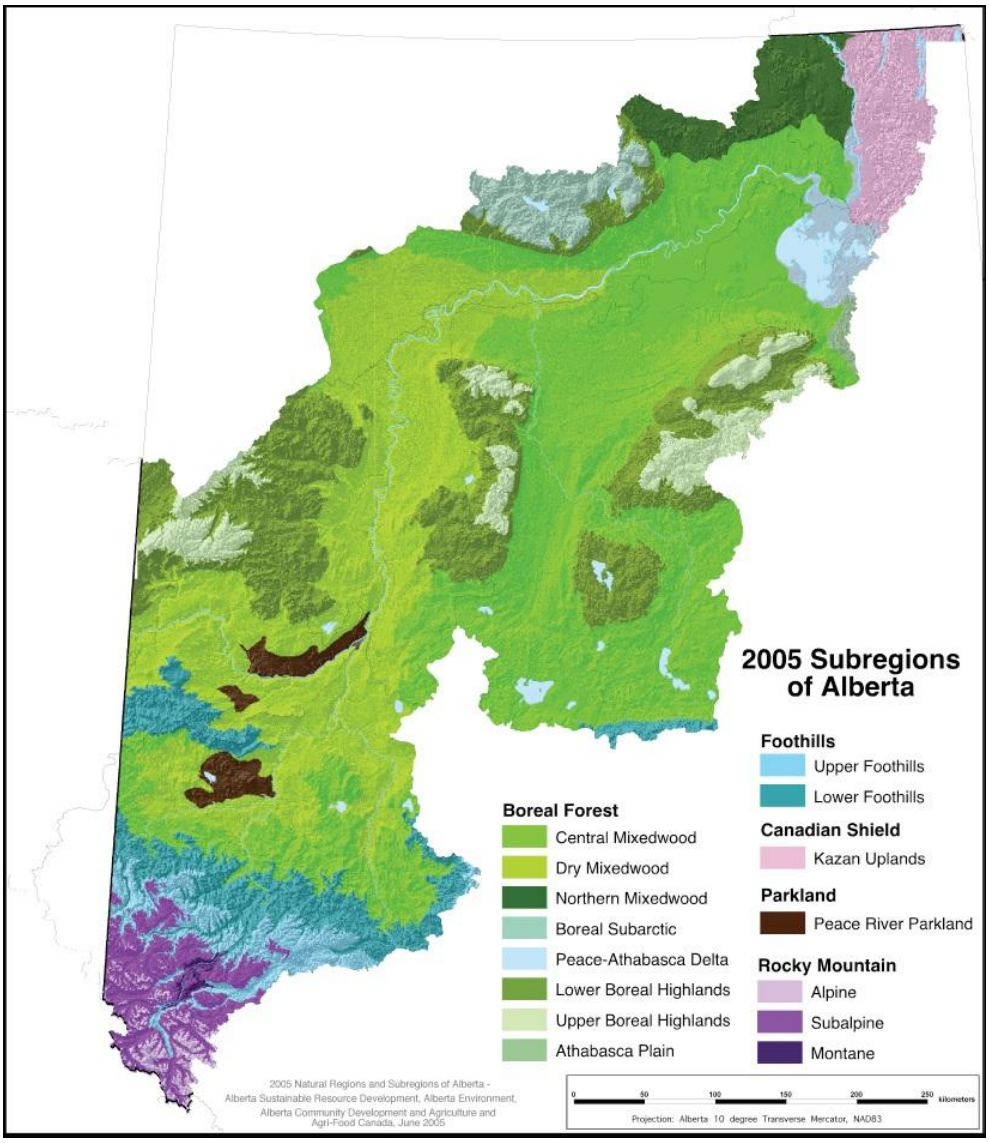
Natural Regions in the Peace Watershed

Throughout its journey, the Peace River flows through five of Alberta's six natural regions. Natural regions are areas that contain a mix of similar vegetation, soil and landform features. The majority of the watershed (82%) is located in the Boreal Forest Natural Region. This natural area includes large amounts of forested area, with tree species such as white spruce, balsam fir, aspen, balsam poplar or jack pine, and extensive wetland areas. The Peace watershed includes parts of six sub-regions within the Boreal Forest, including: Dry Mixedwood, Central Mixedwood, Wetland Mixedwood, Sub-Arctic, Peace River Lowlands and Boreal Highlands.

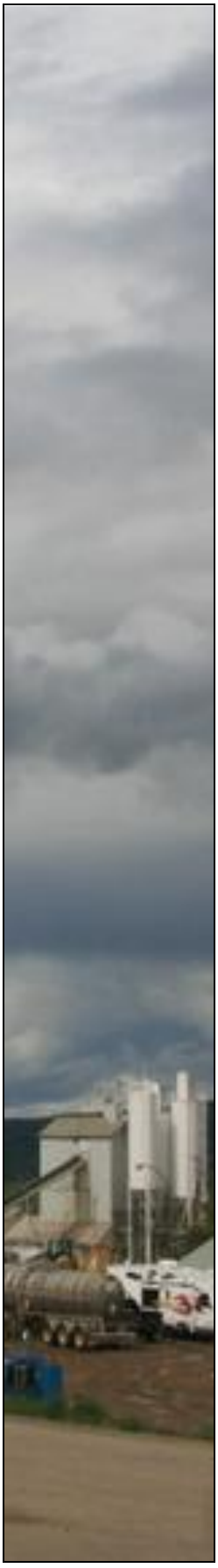
The upper part of the Smoky/Wapiti sub-basin is located in the Rocky Mountain natural region and Foothills Natural Region. The Rocky Mountain Natural Region (4.0% of the watershed) is found at higher elevations and is characterized by closed forests and vegetated areas, bare rock, and glaciers above treeline.

The Foothills Natural Region (8.5% of the watershed) is characterized by extensive forests, most commonly lodgepole pine on the uplands, especially following fire.

The Peace watershed also includes small amounts of the Aspen Parkland Natural Region (1.5% of the watershed), including the Peace River Parkland. This region represents a mosaic of grasslands and aspen forests.

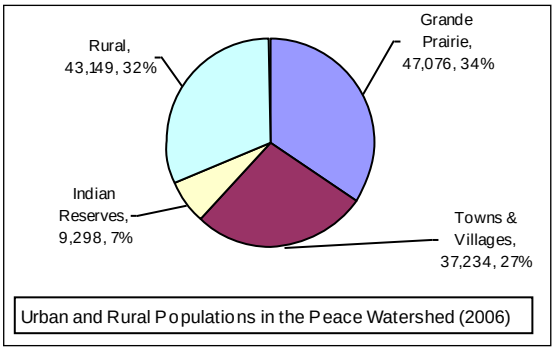


The lower portion of the watershed is located in the Canadian Shield Natural Region (3.6% of the watershed). This area is characterized by outcroppings of Precambrian granitic bedrock with open forests of jack pine with black spruce in wet areas.



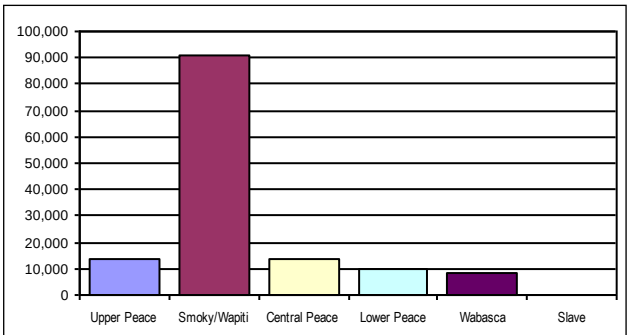
2.3 Socio-Economic Characteristics

In 2006, approximately 136,800 people lived in the Alberta portion of the Peace River watershed; this represents about two-thirds of the population of the entire Peace River basin and 4% of the Alberta population.



Urban and Rural Populations in the Peace Watershed (2006)

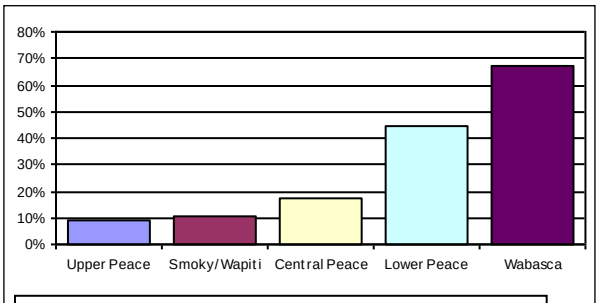
In 2006, just over one third of the population in the Peace watershed (34%) lived in the City of Grande Prairie. Another 27% of the population lived in a town or village. About 7% of the population lived on an Indian reserve. The remainder (32%) lived in rural parts of the watershed



Population Distribution in the Peace Watershed 2006

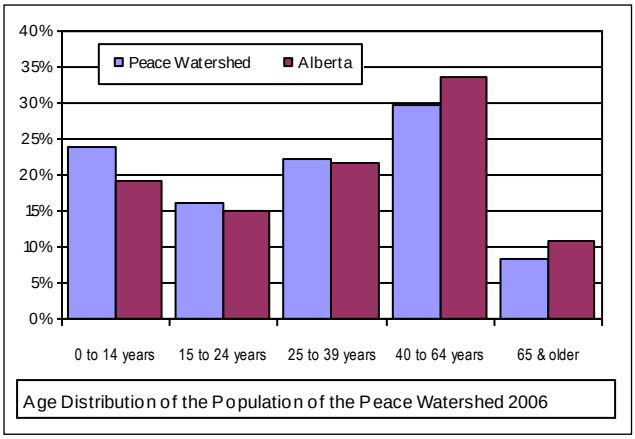
Two-thirds of the Alberta portion of the population (66.5%) lived in the Smoky/Wapiti sub-basin. About 10% of the population lived in each of the Upper and Central Peace sub-basins, 7% lived in the Lower Peace sub-basin, and 6% lived in the Wabasca sub-basin. Only about 85 people lived in the Slave sub-basin; this represents 0.1% of the population in the Peace watershed.

Aboriginal people accounted for 16.7% of the population of the Peace watershed. However, this ranged from a low of about 10% in the Upper Peace and Smoky/Wapiti sub-basins to 67% in the Wabasca sub-basin. The Aboriginal proportion of the population increases in the downstream sub-basins.

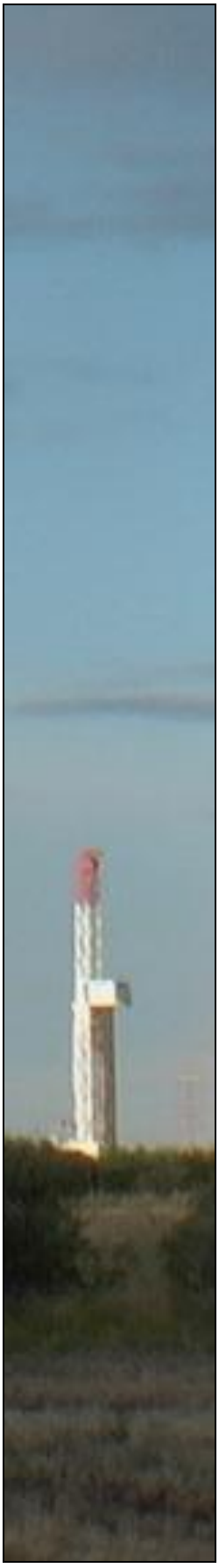


Aboriginal Portion of Population of the Peace Watershed 2006

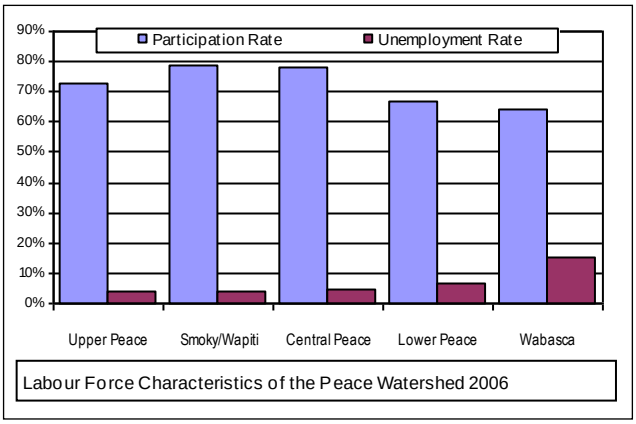
The population of the Peace watershed tends to be younger than the provincial average, with higher percentages of people under the age of 40 and lower percentages of people aged 40 and greater. The greatest difference is the percentage of children under 15 years of age; this group accounted for 19.2% of the Alberta population in 2006 but 23.8% of the population of the Peace watershed.



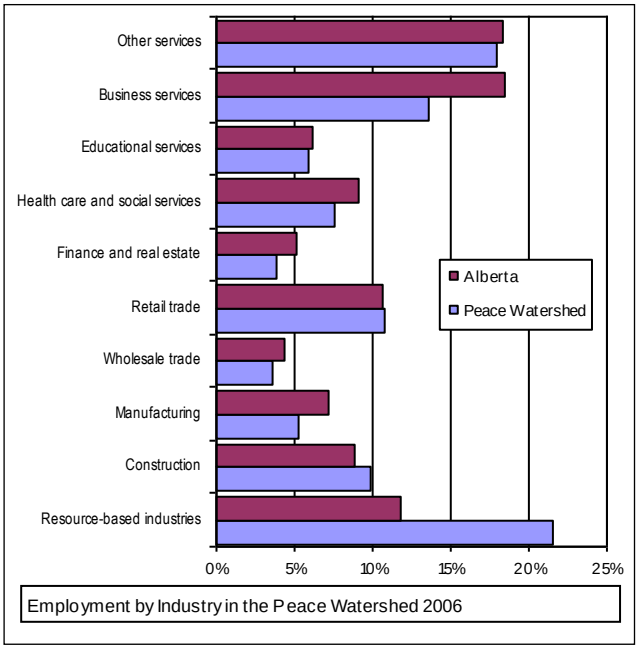
Age Distribution of the Population of the Peace Watershed 2006



In 2006, 76.5% of the adult labour force in the Peace watershed were either working or seeking work (the labour force participation rate) and 4.8% were unemployed. Both the labour force participation rate and the unemployment rate for the watershed were higher than for Alberta. There was lower participation in the labour force in the downstream sub-basins, and the rates of unemployment were higher.



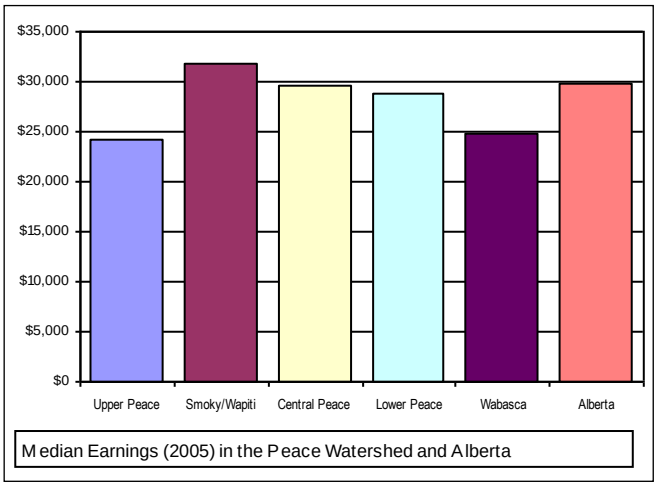
Labour Force Characteristics of the Peace Watershed 2006



Employment by Industry in the Peace Watershed 2006

The employment profile for the Peace watershed, based on industry of employment, was different from the Alberta profile. About 22% of workers in the Peace watershed were employed in resource-based industries (including agriculture) compared to only 12% of Albertans. However, lower percentages of basin residents were employed in service industries, especially business services and health care and social services, and in manufacturing. The percentage of Peace watershed residents employed in retail trade, education and other services was about the same as for Alberta.

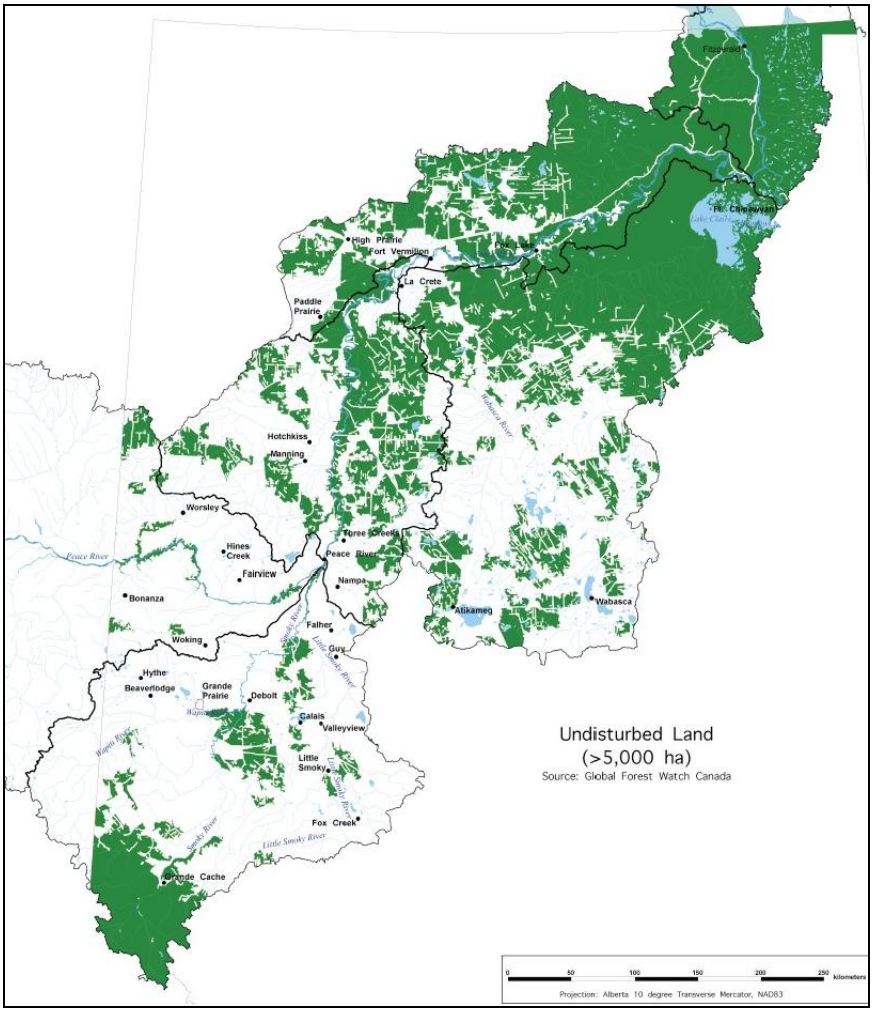
Workers in the Peace watershed generally had earnings that were the same as for Alberta. The median earnings in the watershed for 2005 were $30,296 which was slightly higher than for Alberta ($29,738). Workers in the Smoky/Wapiti sub-basin reported the highest median earnings ($31,864) while workers in the Wabasca sub-basin had the lowest median earnings ($21,851)



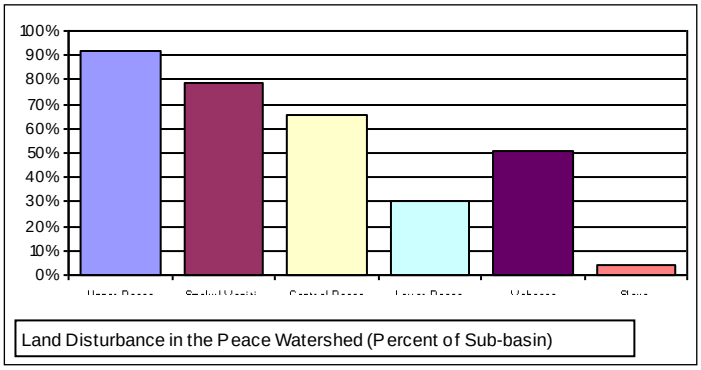
Median Earnings (2005) in the Peace Watershed and Alberta

2.4 Land and Resource Use

According to Global Forest Watch Canada (2009), about 57% of the land in the Alberta portion of the Peace watershed has been disturbed as a result of some form of human activity, including agriculture, forestry, oil and gas development, mining, urbanization, or linear developments (roads, transmission lines). The undisturbed portions of the watershed are located in the mountainous areas in the upper portion of the Smoky/Wapiti sub-basin and in the lower portions of the watershed, particularly in the Lower Peace, Wabasca and Slave sub-basins. About 30% of the undisturbed land in the watershed is located in Wood Buffalo National Park, which accounts for 13% of watershed.



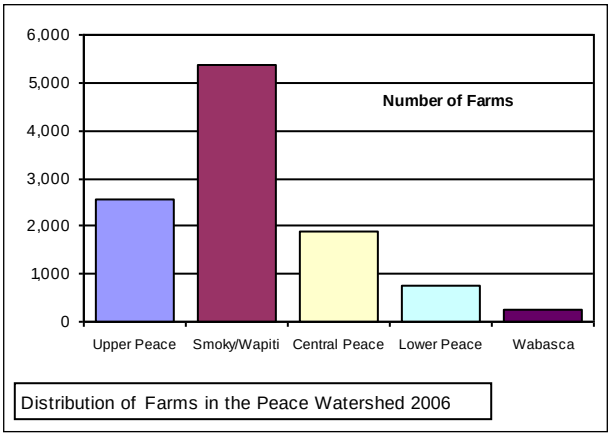
The percentage of each sub-basin that has been disturbed is highest in the upper most parts of the watershed and decreases in the downstream areas. In the Upper Peace sub-basin, 91.9% of the land base has been disturbed.



This drops to 78.6% in the Smoky/Wapiti sub-basin. In comparison, only 30.3% of the Lower Peace sub-basin and 4.1% of the Slave sub-basin have been disturbed.

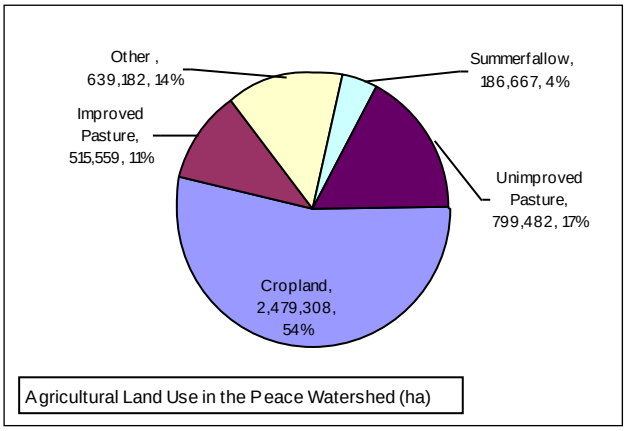
2.4.1 Agriculture

According to the 2006 Census of Agriculture, there were 10,820 farms in the Alberta portion of the Peace watershed in 2006. These farms covered an area of 4.62 million hectares (ha) or the equivalent of 11.4 million acres. This represents 25% of the watershed.



Distribution of Farms in the Peace Watershed 2006

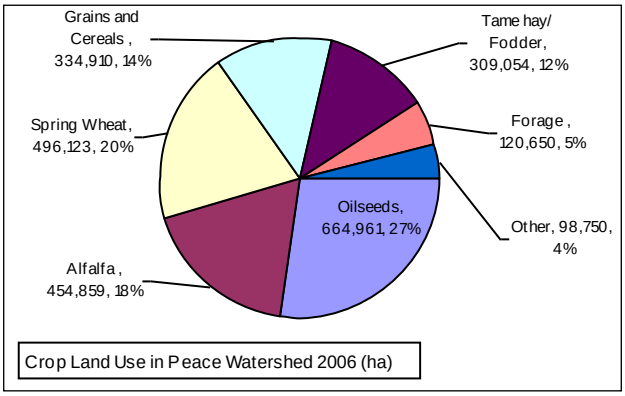
Half the farms in the entire watershed (50%) are located in the Smoky/Wapiti sub-basin, with another 24% located in the Upper Peace sub-basin. The number of farms gradually decreases in the downstream portions of the watershed. There are no farms in the Slave sub-basin.



Agricultural Land Use in the Peace Watershed (ha)

There were 2.48 million ha of cropland in the Alberta portion of Peace watershed in 2006; cropland accounted for 54% of total agricultural land. Another 17% of agricultural land consisted of unimproved pasture (0.80 million ha) while there were 0.52 million ha of improved pasture. The remaining agricultural land consisted of summerfallow (4%) or land used for other agricultural purposes (14%).

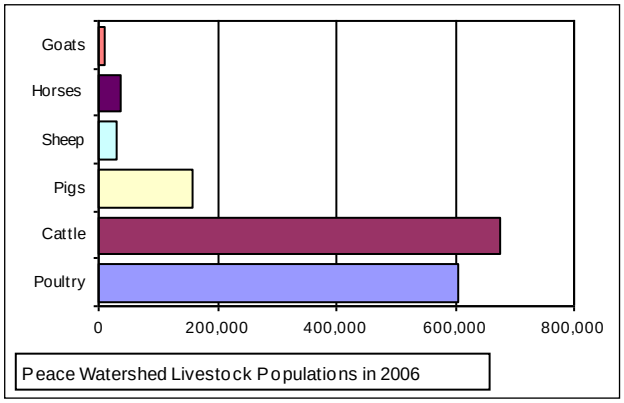
About 0.66 million ha of cropland were used to grow oilseeds; this accounted for 27% of all cropland in the Alberta portion of the Peace watershed. Cereal crops were also important, with 0.50 million ha of spring wheat and another 0.33 million ha of other grains and cereals. However, 36% of cropland (0.88 million ha) was used to grow alfalfa (18% of total cropland), tame hay/fodder (12%) and forage crops (5%) in support of regional livestock production. The other 4% of cropland was used to raise specialty crops, including potatoes and fruit.



Crop Land Use in Peace Watershed 2006 (ha)

Ninety farms in the Peace watershed reported using irrigation on 2,354 ha of land. Nearly half of these farms (41 or 46%) were located in the Smoky/Wapiti sub-basin. The majority of irrigation was used for hay and pasture (48% of irrigated land) while field crops accounted for 43% of irrigated land. Irrigation was also used to grow fruits and vegetables.

The majority of the farms in the Alberta portion of the Peace watershed (62%) raised livestock. About 44% of farms raised cattle (averaging 144 animals per farm) and 33% raised horses (9 per farm). Small number of farms raised other types of livestock including poultry (9%), hogs (4%), sheep (4%) and goats (3%). In total, there were about 674,000 cattle in the Peace watershed in 2006; there were five cows for every person. There were also 156,600 hogs (this is the slightly higher than the human population), 35,500 sheep, 30,700 horses and 9,100 goats. These animals generated 7.17 million tonnes of manure.



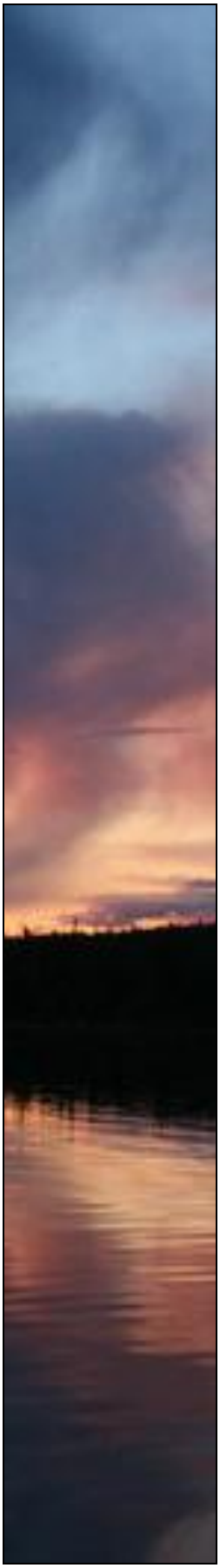
In addition, 44% of farms reported using chemical fertilizers on 1.69 million ha which represents 68% of cropland.

2.4.2 Forestry

According to the Alberta Forest Products Association (2012), there were 12 sawmills, two pulp mills, and two panel board operations in the Peace watershed. The facilities were located throughout the watershed. The pulp mills are located in Grande Prairie and Peace River, while panel board plants were located in Grande Prairie and High Level. The sawmills were scattered among various communities, including three near La Crete, one near Hines Creek, two near Grande Prairie, and one each in Grande Cache, High Level, Nampa, Peace River, Manning and near Tallcree. However, not all of these facilities are still operating. The pulp mills are the only component of the forest sector that uses large amounts of water. Water use by these facilities is described in Section 2.5.

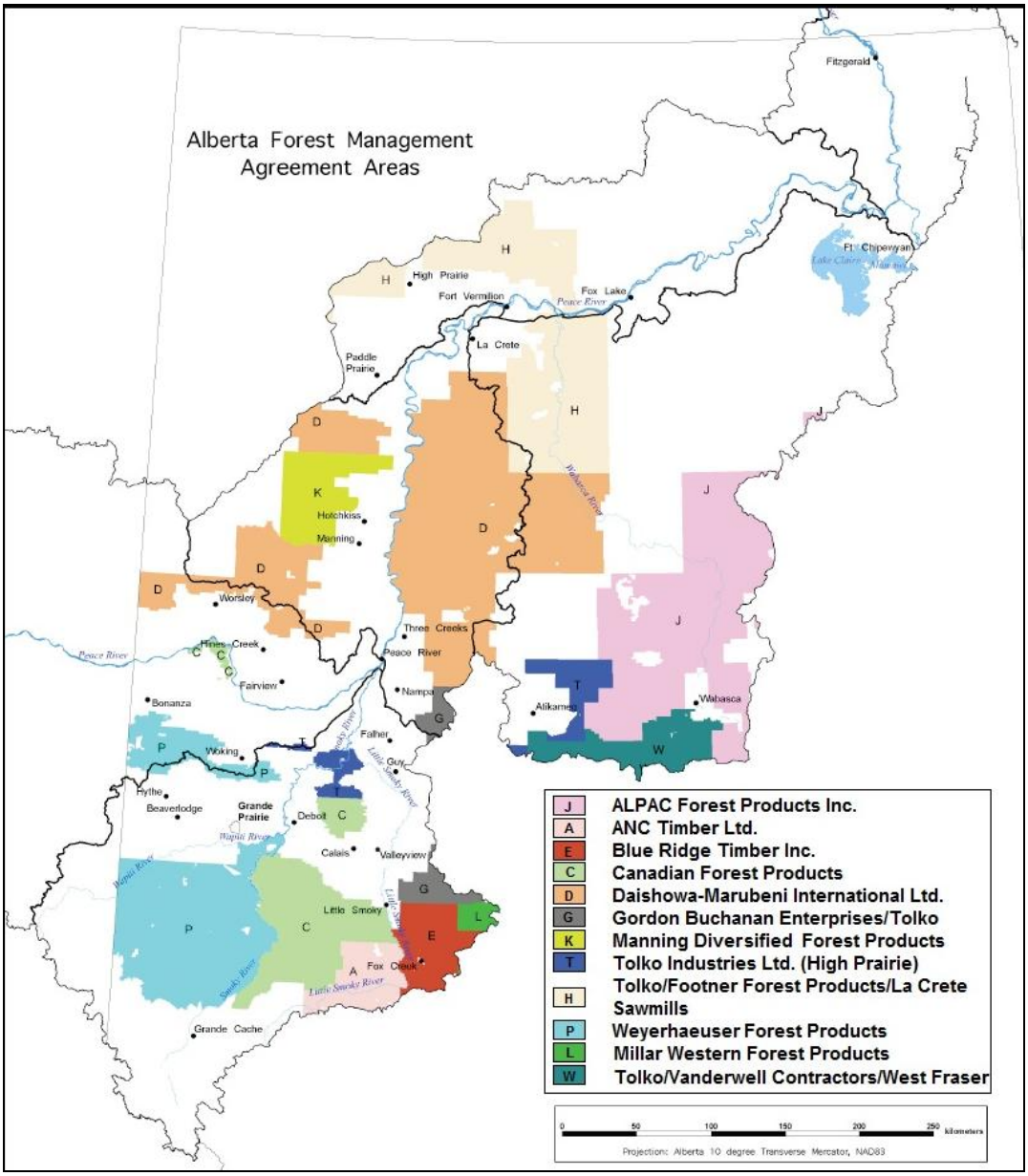
The Peace watershed is situated in two of the regions identified in Alberta's Land Use Planning Framework. The Upper Peace Region generally includes the Upper Peace and Smoky/Wapiti sub-basins, while the Lower Peace Region includes the Central Peace, Lower Peace and Wabasca sub-basins. In 2009/10, a total of 6.35 million cubic metres of timber was harvested in these two regions (Alberta Sustainable Resource Development, 2010).

Land Use Framework Region	Coniferous Timber	Deciduous Timber	Total Harvest	Percent of Alberta
	Cubic metres harvested			
Upper Peace	2,403,972	1,000,065	3,404,037	17.3%
Lower Peace	2,095,068	851,125	2,946,193	15.0%
TOTAL	4,499,040	1,851,190	6,350,230	32.3%



Together, the two regions in the Peace watershed accounted for nearly one-third (32.3%) of all wood harvested in Alberta, including 34.6% of coniferous timber and 27.9% of deciduous timber. Harvesting in the Upper Peace region accounted for slightly more than half (53.6%) of all harvesting in the Peace watershed.

The majority of wood supplies are managed under the terms of Forest Management Agreements (FMAs). The map below shows the FMA holders in the Peace watershed (Alberta Sustainable Resource Development, 2010). It should be noted that some of the timber being harvested from within the Peace watershed, especially in the Smoky/Wapiti and Wabasca sub-basins, is processed in mills located outside the watershed.

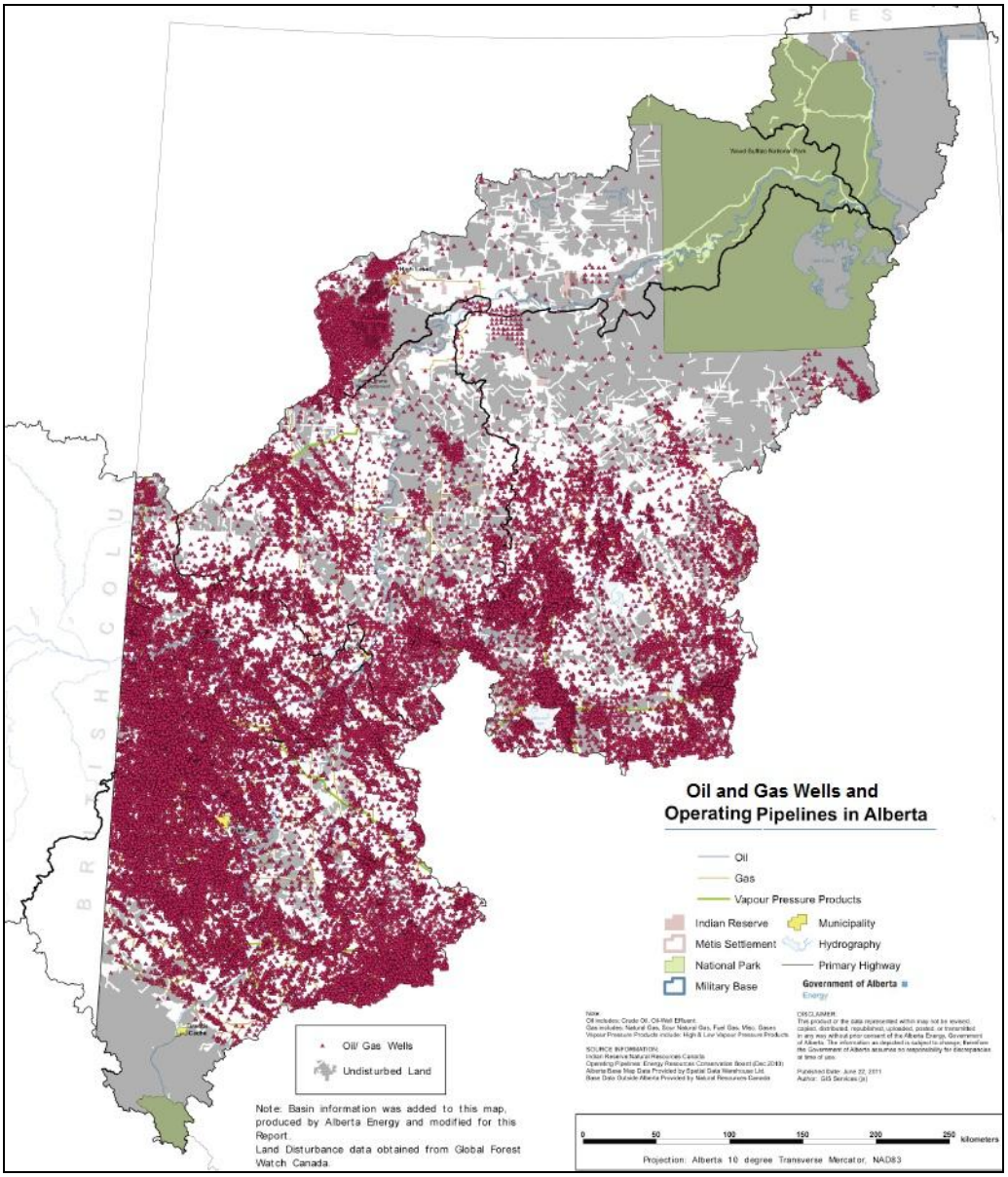


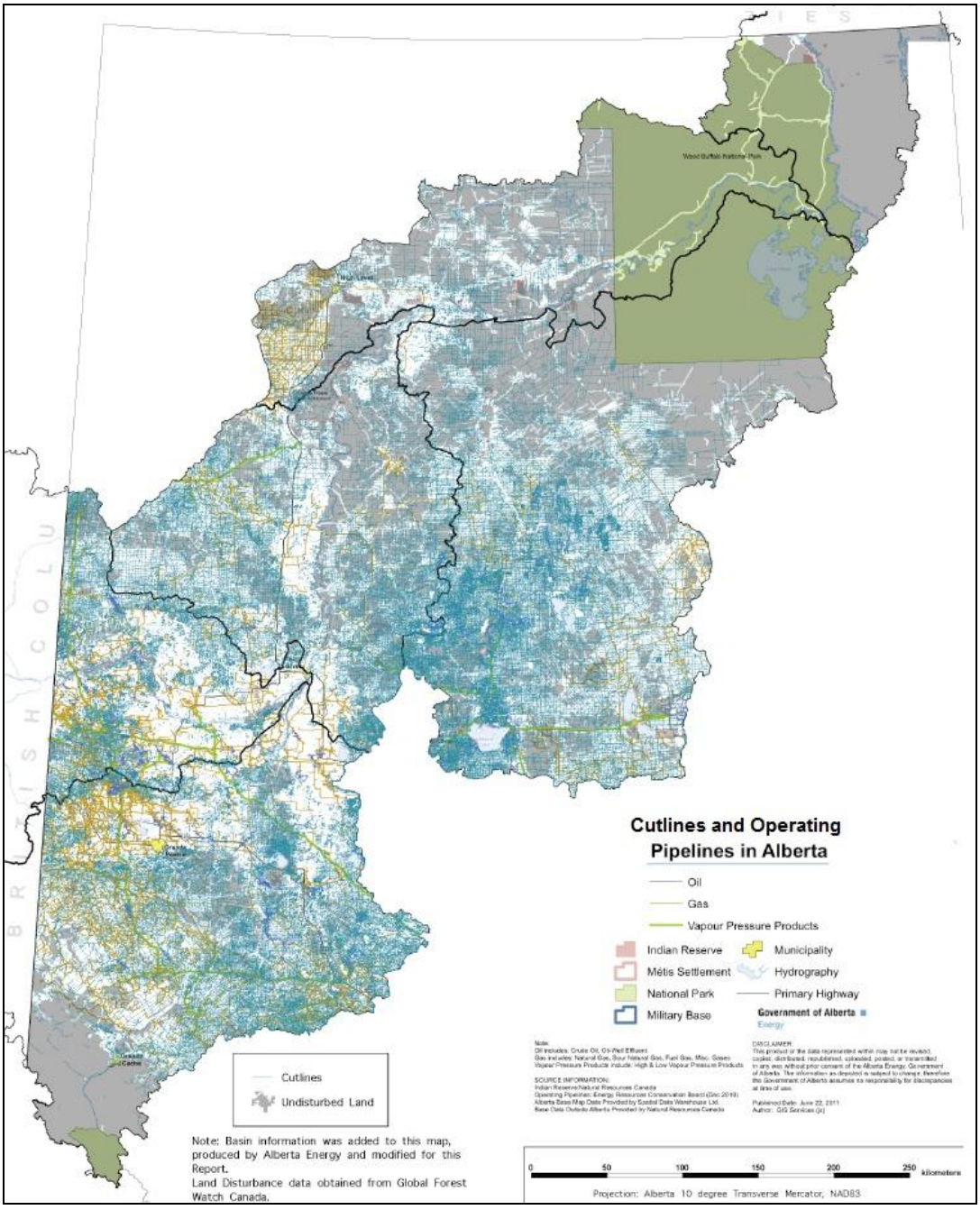
2.4.3 Oil and Gas

According to Alberta Energy, there are 61,851 oil and gas wells, 305,400 km of cutlines, and 34,216 km of pipelines in the Peace watershed. The distribution of wells, pipelines and seismic lines throughout the watershed is summarized below:

Sub-basin	Wells	Pipelines (kilometres)	Seismic Lines (kilometres)	Disturbance Index (km/km^2)
Upper Peace	13,067	7,085	32,388	6.9
Smoky/Wapiti	26,331	14,954	85,051	4.1
Central Peace	7,134	3,668	65,902	2.6
Lower Peace	1,769	1,871	16,199	0.7
Wabasca	13,550	6,637	105,667	1.7
Slave			201	0.0
TOTAL	61,851	34,216	305,409	2.1

The disturbance index is calculated as the kilometres of linear disturbance (pipelines and seismic lines) per square kilometre in each sub-basin, excluding agricultural land.



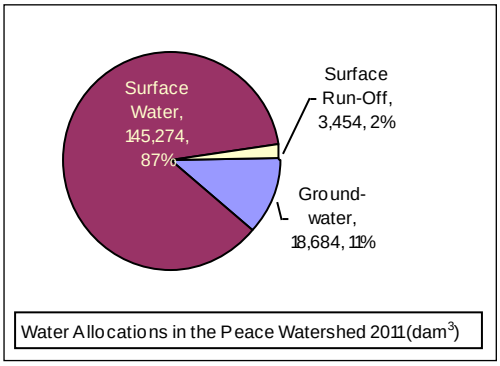


The data indicate that the highest density of land disturbance due to oil and gas development is in the Upper Peace sub-basin, followed by the Smoky/Wapiti sub-basin and the Wabasca sub-basin. While the Smoky/Wapiti sub-basin accounts for 43% of oil and gas wells and 44% of pipelines, the Wabasca sub-basin has been the most intensively explored, with 35% of all seismic lines in the watershed. The Upper Peace has the highest levels of disturbance from oil and gas development on non-agricultural land.

2.5 Water Use

2.5.1 Water Allocations

As of 2011, 14,489 water licences and registrations had been issued to allow people and companies to withdraw and use water (see Appendix A for a description of how water is allocated in Alberta). These licences and registrations allow the withdrawal of up to 167,413 cubic decametres (dam^3) of water for use. The vast majority of licensed withdrawals (145,274 dam^3 or 87%) allow water users to take surface water directly from rivers or lakes while another 2% (3,454 dam^3) allows users to capture and use surface run-off. The other 11% of allocations allow waters users to withdraw 18,683 dam^3 of groundwater.



Water Allocations in the Peace Watershed 2011 (dam^3)

Units for Measuring Water	
1 litre	0.22 gallons
1 cubic metre (m^3)	1,000 litres
	220.14 gallons
1 cubic decametre (dam^3)	1,000 cubic metres
	1,000,000 litres or 1 megalitre (ML)
	0.811 acre feet

Allocations of surface water account for about 0.3% of the average annual flow of the Peace River at Peace Point.

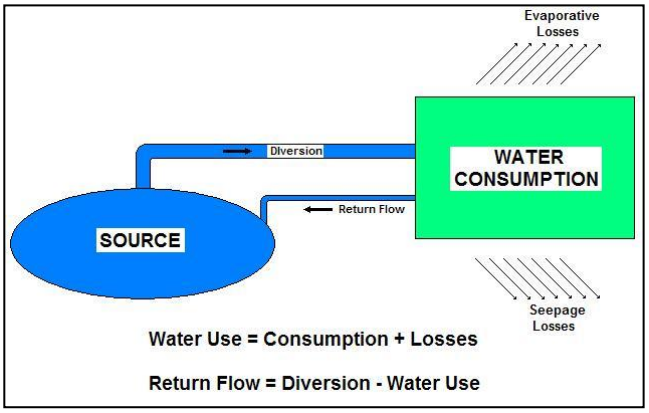
Under the Alberta *Water Act*, water licences are allocated for specific purposes. This assessment describes water allocation and use in terms of seven purposes:

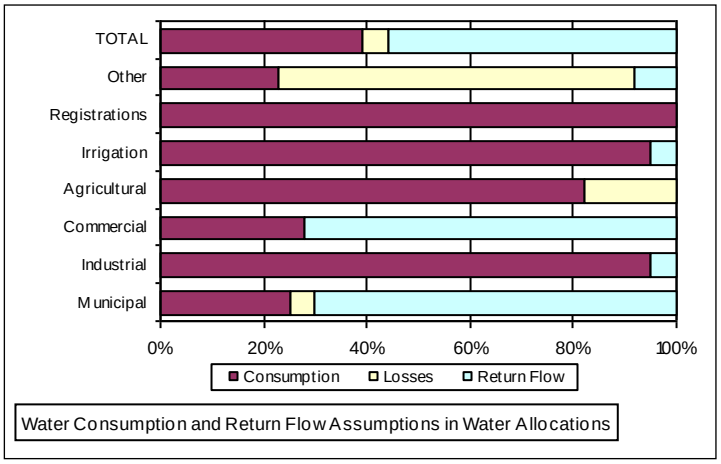
Purpose	Specific Water Uses
Municipal	Urban use, camps, water use cooperatives, schools and institutions
Agricultural	Feedlots and stock watering
Irrigation	Irrigation
Registrations	Traditional agricultural users (maximum 6.25 dam^3 per year)
Commercial	Pulp mills, coal mines, aggregate washing, bottling, golf courses, cooling, dust control
Industrial	Gas and petrochemical plants, oilfield injection
Other	Water management, dewatering, lake level stabilization, recreation, fish farms, wildlife, wetlands, other purposes specified by a Director

It should be noted that communities on First Nation reserves are not required to obtain a water licence if the water is being taken from water bodies inside the reserve. In addition, people living adjacent to surface water or above groundwater are allowed to take and use without requiring a licence; this is described as a domestic water right. There is no information on water use by domestic water users.

Licences issued for other purposes are somewhat different than licences issued for municipal, commercial or industrial purposes. In many cases, water is not actively withdrawn for "other" purposes but licences are issued to reflect the evaporative losses that would result from lake stabilization or for maintaining wetlands. According to AEW, some of the older licences issued for "other" purposes are based on the amount of evaporation from the entire water body, and consequently seriously overstate the increased amount of evaporation associated with water management projects.

Not all of the water that can be withdrawn is expected to be used. The total amount of water allocated for withdrawal includes allowances for the amount of water that will actually be used as well as possible losses due to seepage and evaporation, and an expectation that some water may be put back after use (return flow).





Thus, there is a difference between licensed withdrawals and licensed water use. For example, the water licences issued for some purposes, such as municipal and commercial use, assume that high percentages of water withdrawals will be returned after use. For these types of uses, water use represents about 30% of withdrawals. For other purposes, such as agriculture, irrigation, registrations and industrial purposes, there is expected to be very little return flow.

2.5.2 Water Use

There is also a difference between licensed water use and actual water use. Many water users do not use the full amount of their allocations each year. For some uses, like irrigation, there is no need to pump water in a rainy year. As oil production decreases, there may be less need for water. And, not all industrial and commercial facilities operate at 100% capacity.

There is limited information on actual water use, however, as not all licensees are required to report their use. A summary of the percentage of licences for which water use reports are available in 2010 is provided below.

Purpose of Allocation	Percent Reporting	Proportion of Total Allocation	Percent of Licensed Use Actually Used
Municipal	14%	65%	83%
Commercial	21%	98%	26%
Industrial	72%	89%	33%
Other	3%	5%	46%

This shows that, while only 21% of commercial water users with water licences reported their use, these users accounted for 98% of allocations so the estimates of reported use (26% of allocations) are considered very reliable.

Similarly, water use information was provided by the 72% of industrial licensees that accounted for 89% of allocations, so the estimate of reported use is also very reliable. There is some variability in actual water use by commercial and industrial licensees in each of the sub-basins, and total water use estimates for the watershed and the sub-basins have been estimated using these factors.

The water use report information for municipal use is more complicated. Although water withdrawal data was available for 14% of licences, many municipal users have more than one licence and may have licences for more than one source, but only submitted one report for all their licences. However, reported water withdrawals accounted for 65% of licensed withdrawals, so the estimates of municipal water use are considered fairly reliable.

A problem arises, however, when attempting to estimate actual municipal water use. While licensees may report their withdrawals (usually based on the amount of water being treated for distribution), very few licensees report return flow. As a result, there is some confusion as to whether the municipal water use data simply refer to withdrawals or actual use. In the absence of return flow data, it appears that actual water use for those licensees who did report was four times higher than what their licences actually assumed they would use. Thus, the water use estimates for the watershed and sub-basins can only be reliably estimated in terms of their withdrawals and not their net use. However, net municipal water use has been estimated assuming that licensees are operating in a manner that is consistent with the return flow component of their water licences. The extent to which this assumption could under- or over-estimate actual use is not known.

While there is also no actual water use information for the agricultural sector (agriculture, irrigation or registrations), water use by livestock can be estimated based on livestock populations and their annual water requirements (as used by AEW to estimate agricultural water requirements for licences). Based on livestock populations in 2006, their total water consumption from rivers, streams, lakes run-off and groundwater is estimated to be 8,958 dam^3. However, total allocations by way of registrations and licences issued for agriculture amounted to 9,380 dam^3. Thus, actual water use by livestock is determined to be equal to 95% of total allocations of water from run-off, and surface and groundwater sources.

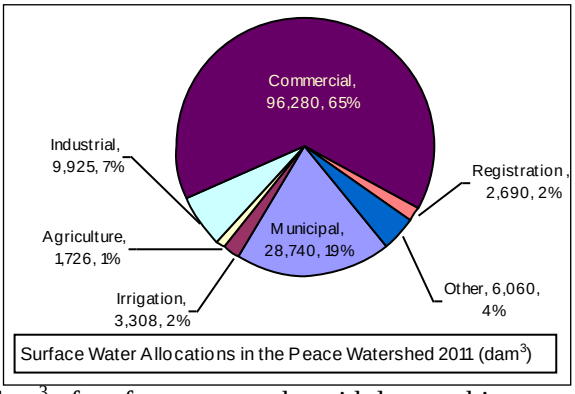
Sub-basin	Allocation (dam^3)	Estimated Livestock Use	
		(dam^3)	% of Allocation
Upper Peace	1,889	2,488	132%
Smoky/Wapiti	6,281	4,805	76%
Central Peace	1,082	1,265	117%
Lower Peace	70	103	425%
Wabasca	58	296	178%
TOTAL	9,380	8,958	95%

At a sub-basin level, the use estimates suggest that, with exception of the Smoky/Wapiti, actual water consumption by livestock exceeds the amount of water allocated by way of registrations and agricultural licences. This suggests that agricultural users are either exercising their rights as an exempted agricultural use (see Appendix A) or they have not applied for licences that would provide them with clearly established rights in case of a water shortage.

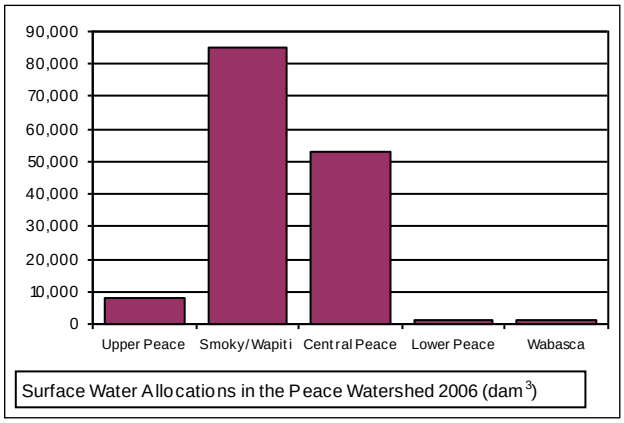
Almost no water use information is reported for licences issued for other purposes and no water use information has been provided by people who have licences for irrigation. Water use for these uses has been estimated assuming that licensees are using the full amounts of their entitlement.

2.5.3 Surface Water Allocations and Use

Licensed Withdrawals – Commercial water use accounts for nearly two-thirds (65%) of surface water allocations in the Peace watershed. Commercial use includes allocations for the pulp mills, coal mines and thermal power projects as well as other commercial purposes, and licences allow 96,280 dam^3 of surface water (including run-off) to be withdrawn for use. Licences issued for municipal purposes allow another 28,740 dam^3 of surface water to be withdrawn; this represents 19% of total allocations. Industrial allocations amount to 9,925 dam^3 which represents 7% of total allocations. Allocation for agricultural use (including agriculture, irrigation and registrations) amounts to 7,724 dam^3; this represents 5% of total allocations.



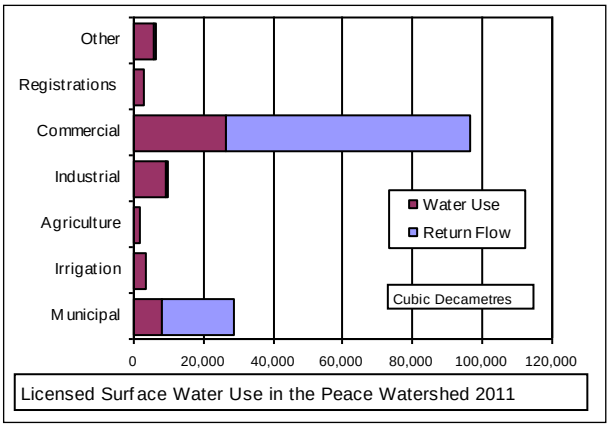
Surface Water Allocations in the Peace Watershed 2011 (dam^3)



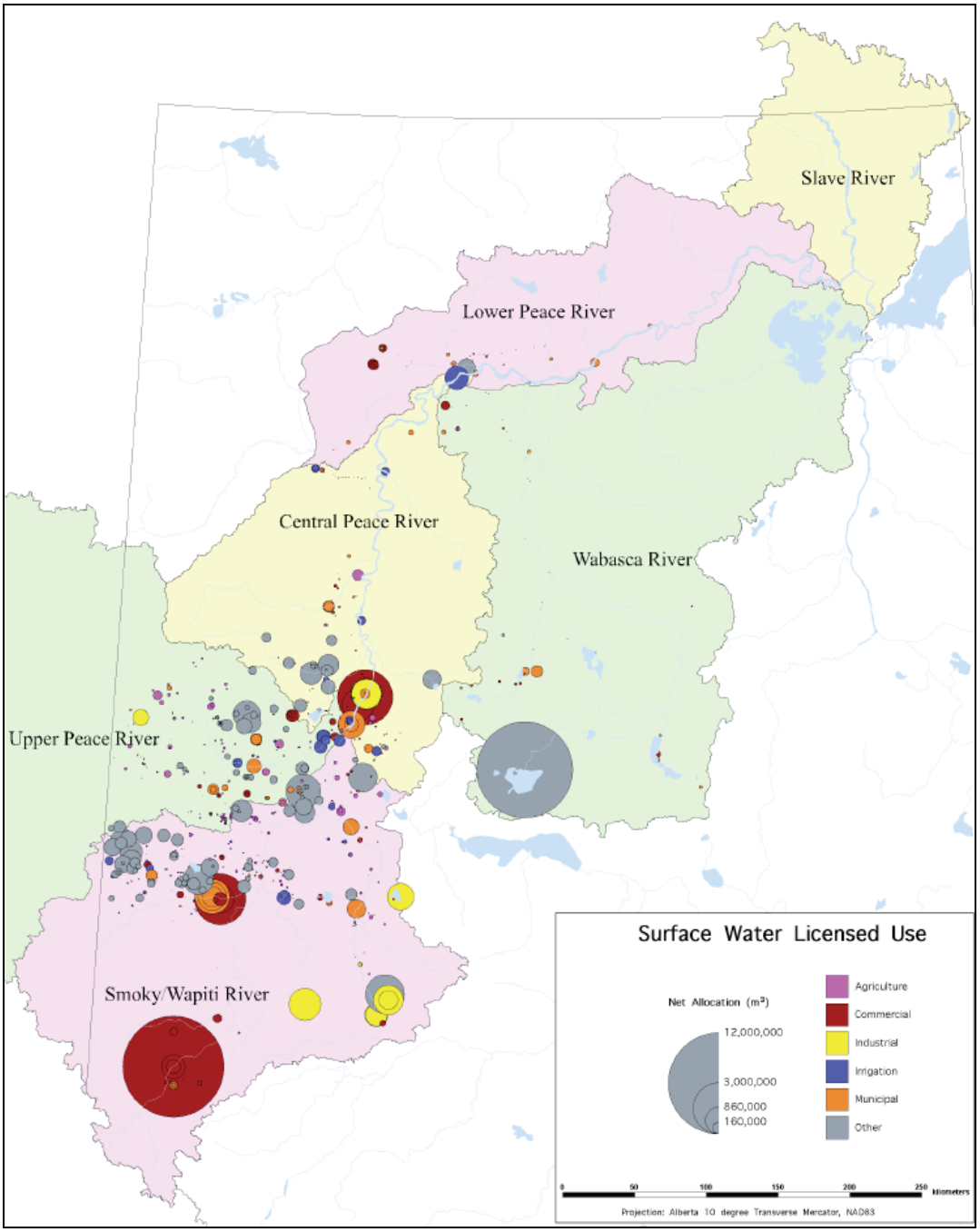
Surface Water Allocations in the Peace Watershed 2006 (dam^3)

The majority of surface water allocations in the Peace watershed are for uses in the upper sub-basins. Water allocations in the Smoky Wapiti sub-basin account for 57% of total allocations, while the Central Peace sub-basin accounts for another 36%. The Upper Peace sub-basin accounts for only 5% of total allocations while the Lower Peace and Wabasca sub-basins account for only 1% of the total. There were no surface water allocations in the Slave sub-basin.

Overall, 30% of surface water allocations allow users to take water directly from the Peace River, including 46% of industrial withdrawals, 40% of commercial withdrawals, 40% of irrigation withdrawals and 27% of municipal withdrawals. These allocations are equivalent to 0.08% of the average annual flow of the Peace River at Peace Point.

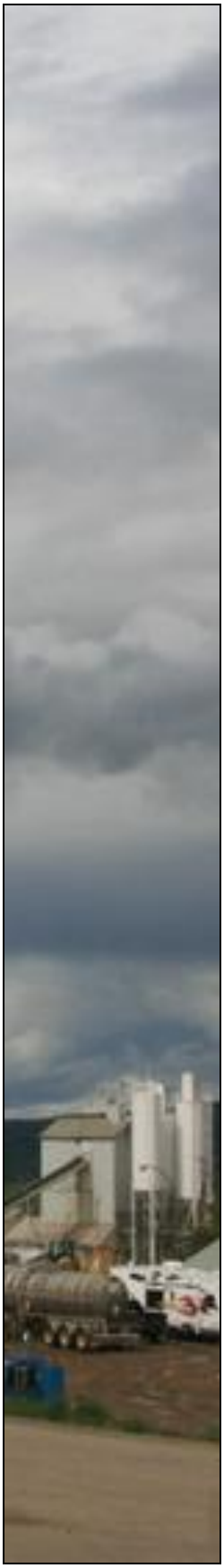


Licensed Surface Water Use in the Peace Watershed 2011



Another 38% of surface water allocations allow users to take water from the Smoky and Wapiti rivers. These allocations include 45% of municipal allocations and 56% of commercial allocations. These licensed withdrawals are equivalent to 0.6% of the average annual flow of the Smoky River at Watino.

Licensed Water Use – Under the terms of water licences, a total of 56,511 dam^3 of surface water can be used each year; this represents 38% of licensed withdrawals. While commercial users are allowed to consume 26,484 dam^3 (47% of the total), this represents only 28% of licensed withdrawals. Similarly, 7,911 dam^3 of water can be used for municipal purposes (14% of the total) and 72% of withdrawals are to be returned after use.



All other uses are almost entirely consumptive (little or no return flow) such that industrial water users are actually expected to use more water than municipal water users.

In terms of number and size, the largest allocations tend to be in the Smoky Wapiti sub-basin, with the largest of these being:

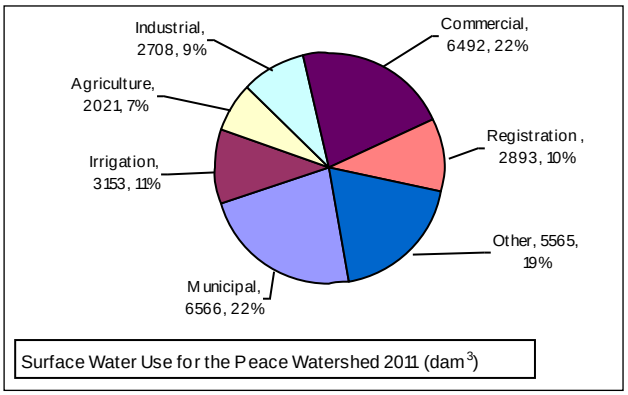
- Milner thermal power plant at Grande Cache
- Weyerhauser mill near Grande Prairie
- Fox Creek stabilization project at Iosegun Lake
- Egg Lake water management project
- Aquatera Utilities which treats and distributes water to the City of Grande Prairie, the County of Grande Prairie, the Hamlet of Clairmont and the Town of Sexsmith

Other projects that have large allocations of surface water include:

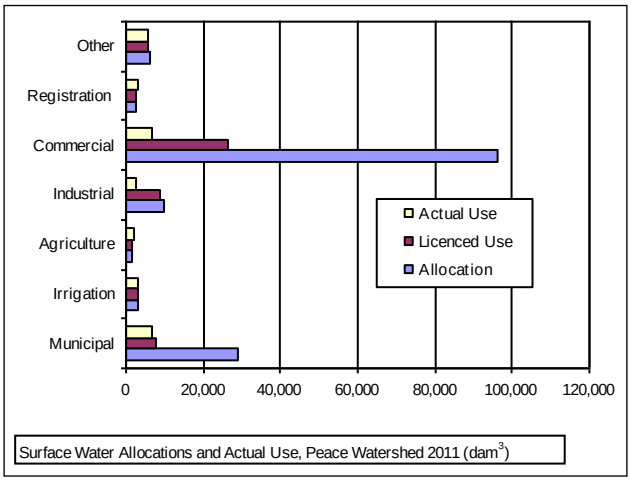
- Ducks Unlimited lake stabilization project at Gift Lake (Wabasca sub-basin)
- Daishowa-Marubeni International Ltd. pulp mill (Central Peace sub-basin)
- Silica sand mining and processing operation (Central Peace sub-basin)

Registrations are small amounts of water (6.25 dam^3 or less) that are used for traditional agricultural purposes. The map on the following page shows that there are numerous registrations (11,295 in total) in the Peace watershed. The registrations are also concentrated in the Smoky/Wapiti sub-basin and are correlated with areas of agricultural activity. About one-third of surface registrations (34%) are for surface run-off while the remainder are for water from surface water bodies.

Actual Water Use – The exact amount of surface water being used in the Peace watershed is not exactly known because, as noted earlier, relatively few licensed water users report their actual withdrawals and even fewer report return flow. However, based on the assumptions listed above, it is estimated that a total of 29,397 dam^3 was actually used in 2011.



Surface Water Use for the Peace Watershed 2011 (dam^3)

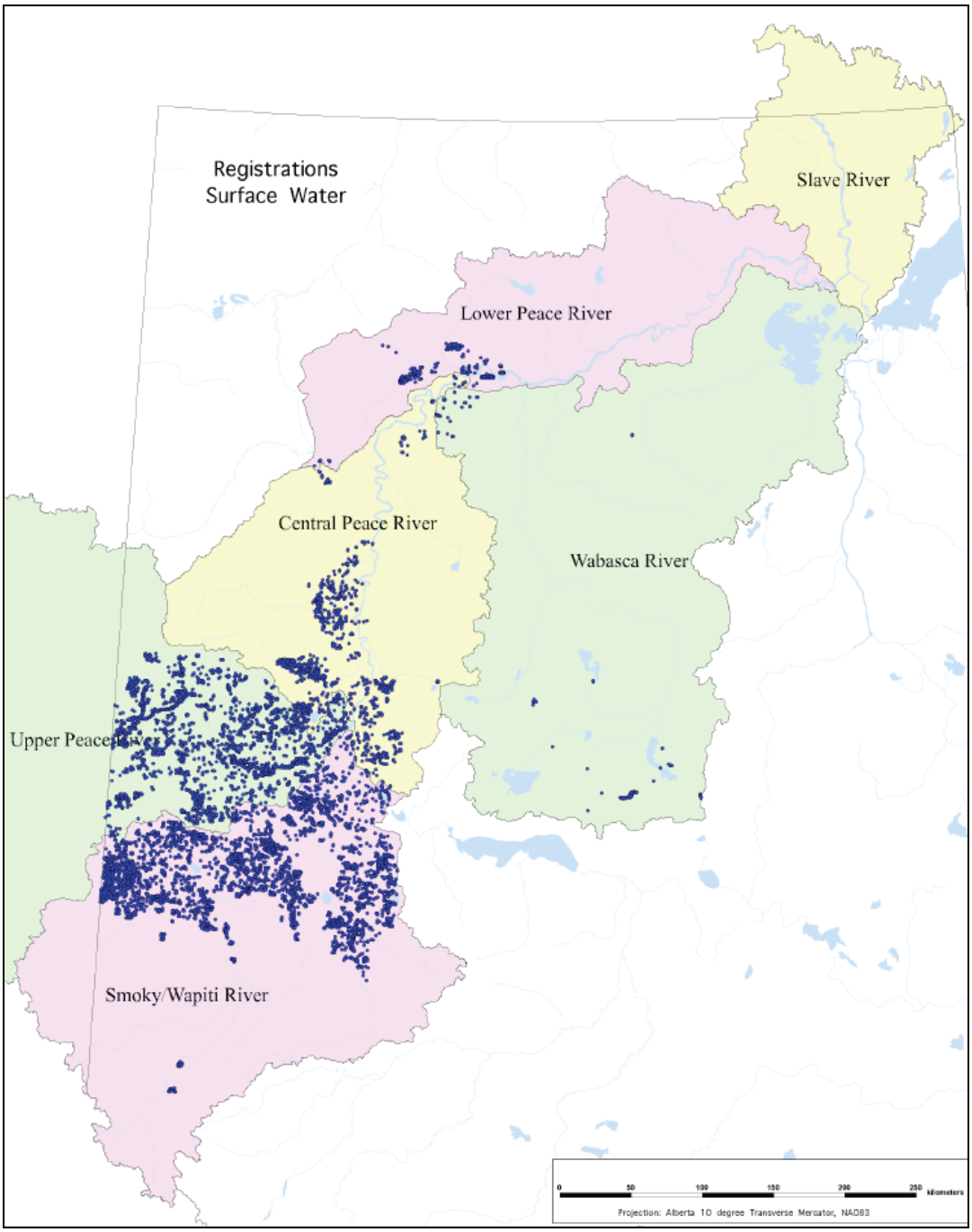


Surface Water Allocations and Actual Use, Peace Watershed 2011 (dam^3)

Actual use represents 20% of total water allocations and 52% of licensed water use. Based on actual water use, municipal and commercial water use each accounted for 22% of total surface water use in the Peace watershed, with water use for other purposes accounting for 19%.

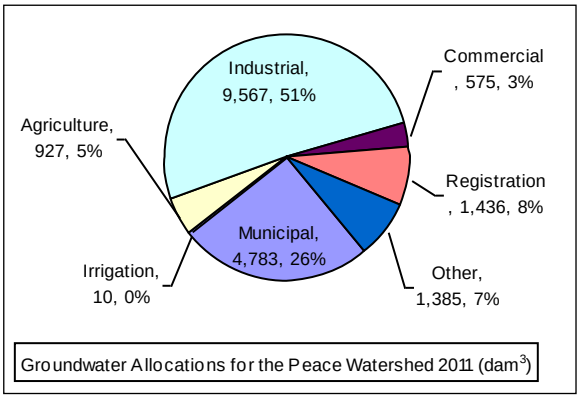
Agricultural water use accounted for 27% of total surface water use; this includes 11% for irrigation, 10% for registrations and 7% of agricultural licences. Industrial water use accounted for another 9% of water use.

There are major differences in terms of the amount of surface water allocated to each of the six sectors, compared to the amount of water that each sector is estimated to have used. While 65% of surface water allocations are for commercial purposes, commercial water use only accounted for 22% of actual use.

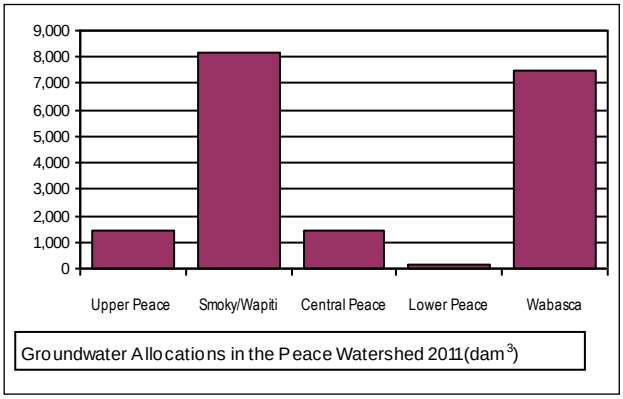


2.5.4 Groundwater Allocations and Use

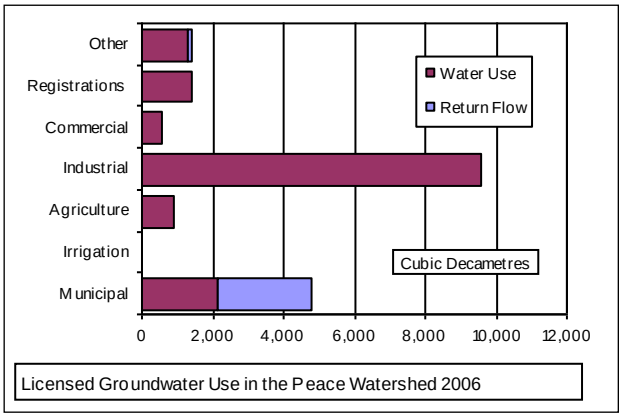
Licensed Withdrawals – Industrial water withdrawals accounts for more than half (51%) of groundwater allocations in the Peace watershed. Licences allow 9,567 dam^3 of groundwater to be withdrawn for industrial use. Licences issued for municipal purposes allow another 4,783 dam^3 of groundwater to be withdrawn; this represents 26% of total allocations. Allocations for agricultural uses (including agriculture, irrigation and registrations) amount to 2,373 dam^3; this represents 13% of total groundwater allocations. Very little groundwater (575 dam^3) is allocated for commercial purposes.



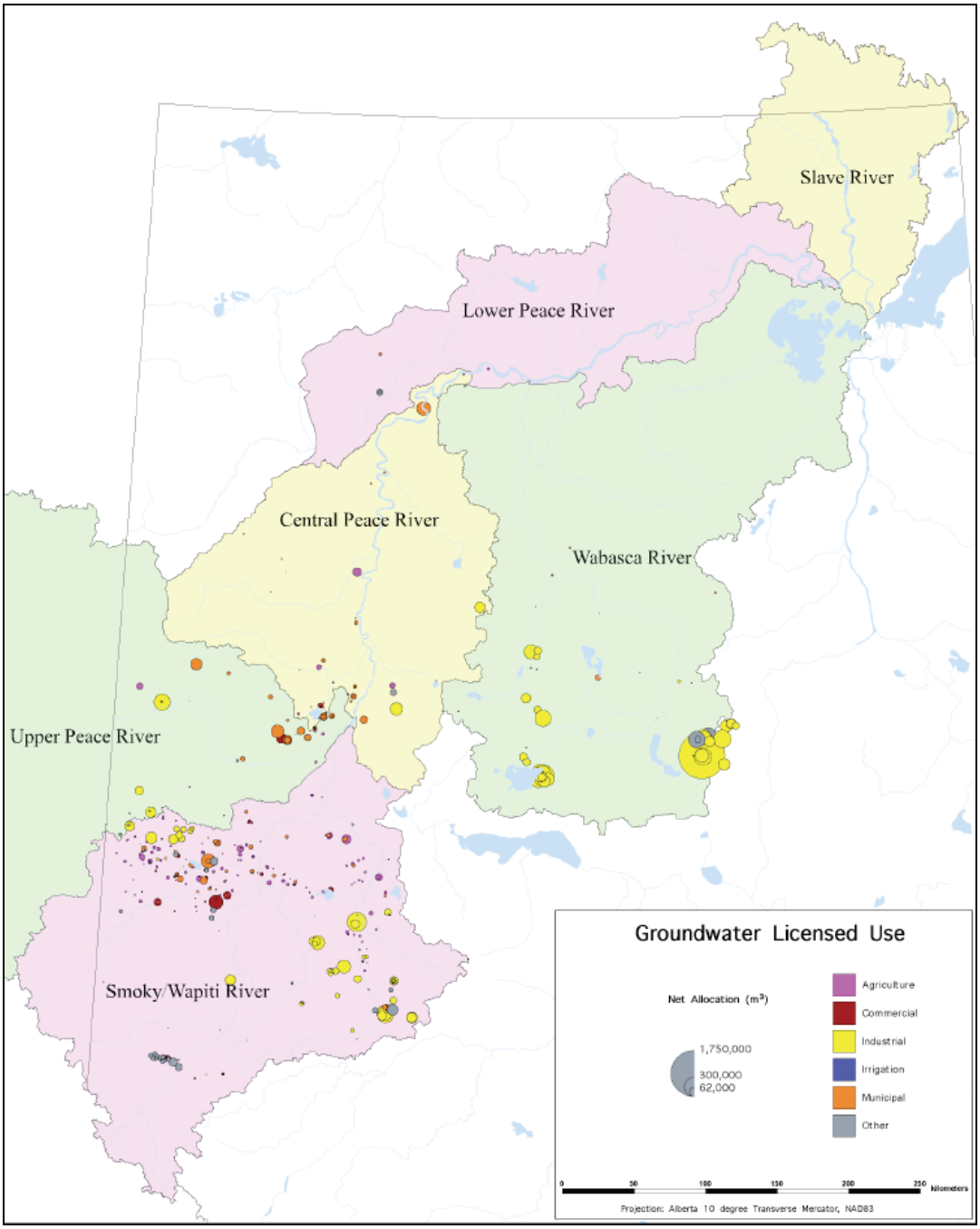
Groundwater allocations are of particular importance in the Smoky/Wapiti and Wabasca sub-basins. Together, they accounted for 84% of groundwater allocations in the Peace watershed. The Upper Peace and Central Peace sub-basin each accounted for 8% of total allocations while the Lower Peace sub-basin accounted for only 1% of the total. There were no groundwater allocations in the Slave sub-basin.



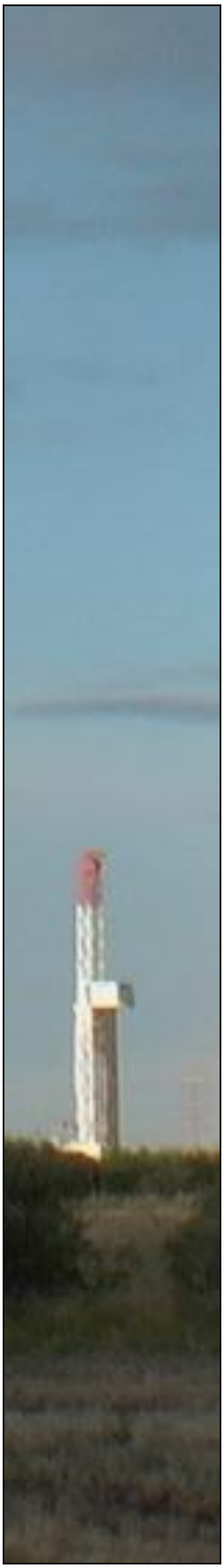
Licensed Water Use – Under the terms of water licences, a total of 15,925 dam^3 of groundwater can be used each year; this represents 85% of licensed withdrawals. Return flow is only expected from municipal water withdrawals of groundwater, with licensed consumption accounting for 45% of withdrawals. Nearly all other uses are almost entirely consumptive (little or no return flow).

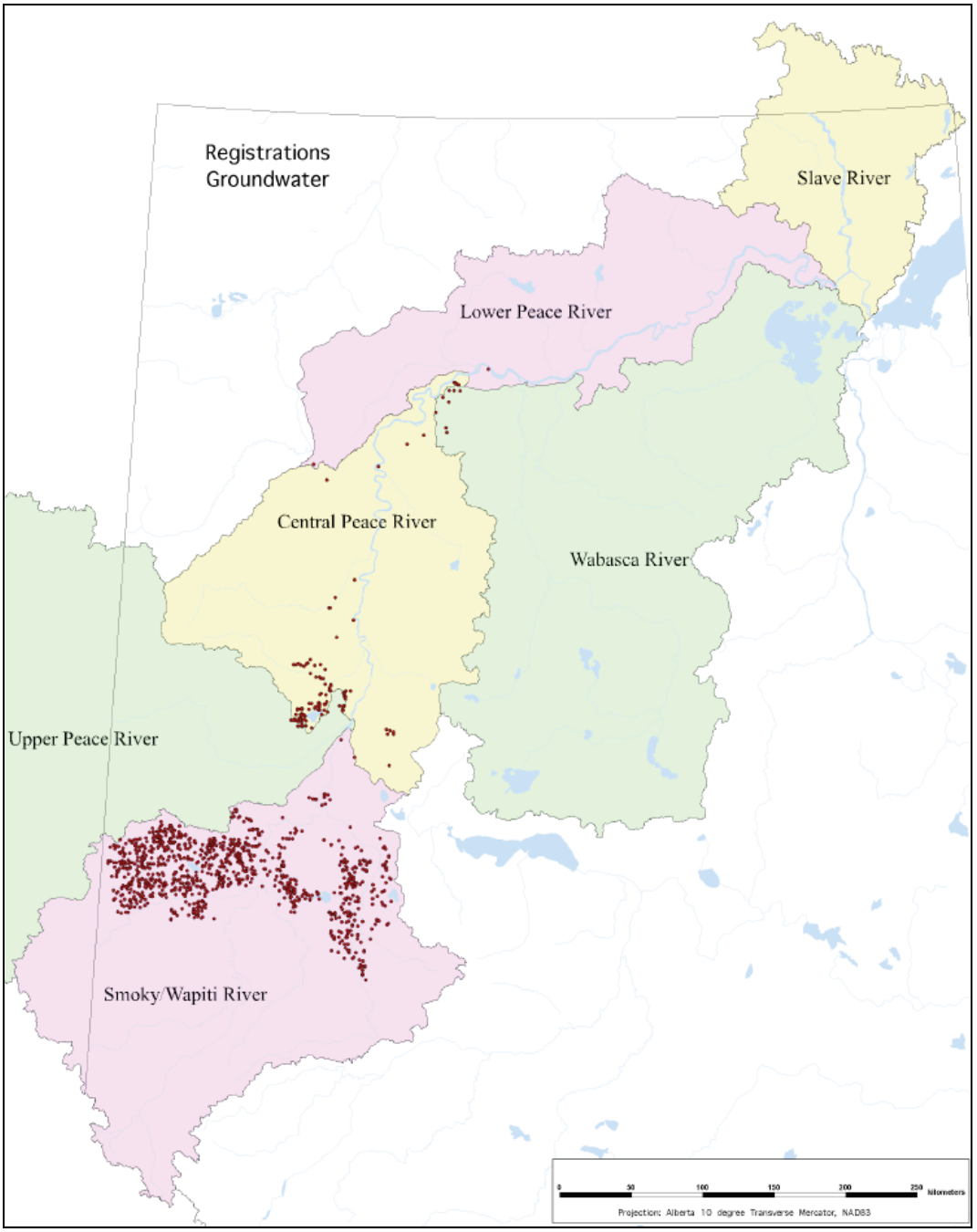


The maps on the following pages show the location and types of groundwater allocations, in terms of the amount of licensed water use, as well as the location of registrations for groundwater. The largest groundwater licences have been issued for industrial purposes, specifically injection projects at Wabasca, Gift Lake and Atimakeg, in the Wabasca sub-basin.

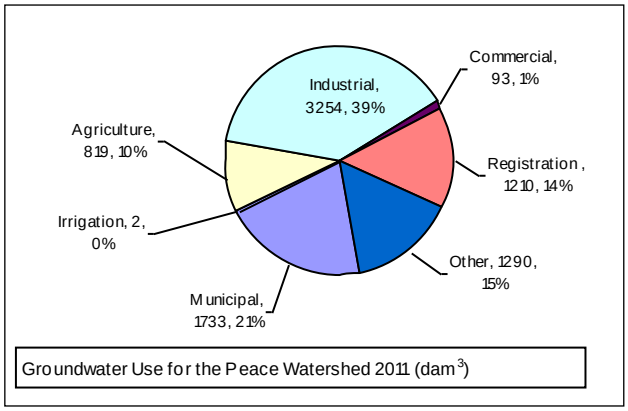


In the Smoky/Wapiti sub-basin, large groundwater licences have also been issued to Ainsworth Lumber (commercial purposes) and Grande Prairie County (municipal purposes). Only 1,370 registrations have been issued for groundwater. Almost all of these are located in the Smoky/Wapiti sub-basin.



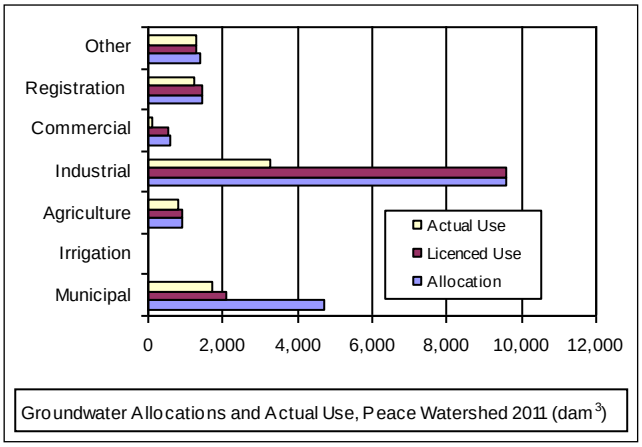


Actual Water Use – The amount of groundwater actually being used in the Peace watershed can be estimated based on the assumptions listed above. Total groundwater consumption (actual use) was estimated to be 8,402 dam^3 in 2011. Actual use represented 45% of total groundwater allocations and 53% of licensed water use.



Based on actual water use, industrial water use accounted for 39% of total groundwater use in the Peace watershed. Agriculture (agricultural and irrigation licences and registrations) accounted for 24% while municipal use accounted for 21%.

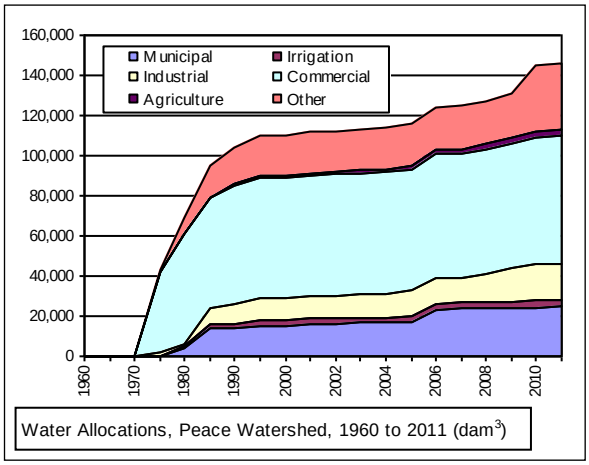
There are major differences in terms of the amount of groundwater allocated to each of the seven sectors, compared to the amount of water that each sector is estimated to have used. Only 34% of industrial water allocations and 37% of municipal allocations are actually being used.



Groundwater Allocations and Actual Use, Peace Watershed 2011 (dam^3)

2.5.5 Future Demand

Since 2000 there has been a 32% increase in total water allocations in the Peace watershed. This represents an average increase in allocations of about 3,260 dam^3 per year. Most of the increase (63%) has occurred since 2006.



Water Allocations, Peace Watershed, 1960 to 2011 (dam^3)

Over the period from 2000 to 2011, the increase in allocations was mainly due to increased allocations for other purposes (38% of the increase), municipal purposes (26%), industrial purposes (20%) and commercial purposes (10%). Allocations for agriculture have changed very little since 2000, accounting for only 6% of the increase in allocations.

Since 2000, new water allocations in the Wabasca sub-basin have accounted for 50% of total new allocations in the Peace watershed. Another 33% of the increase in allocations occurred in the Smoky/Wapiti sub-basin. There was a relatively small increase in water demand in the other three sub-basins, with new allocations in the Central Peace sub-basin accounting for 11% of the increase, the Upper Peace accounted for 4% and the Lower Peace accounted for 1%.

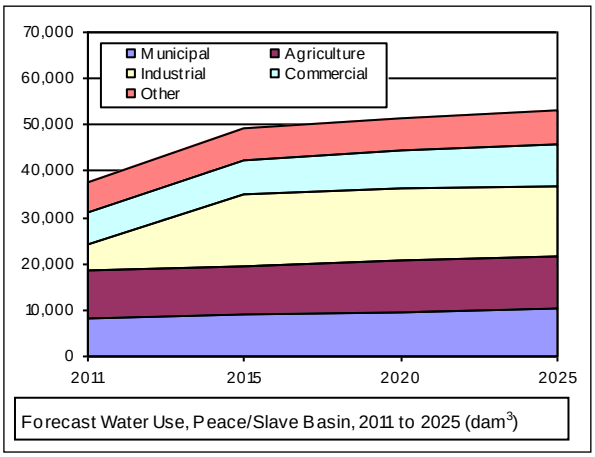
According to the Alberta Treasury Board and Enterprise (2011), 25 major projects (those costing $5 million or more) have been announced or proposed for communities or regions in the Peace watershed. These 25 projects are valued at $5.66 billion. While many of these are relatively small transportation projects or commercial or residential buildings, two of them are major projects that could significantly increase water demand in the watershed. These include:

Project	Location	Cost (millions)
Carmon Creek Bitumen Project	Northern Sunrise County (NE of Peace River)	$3,450
Milner Expansion Coal - Fired Generating Plant (500MW)	MD of Greenview (near Grande Cache)	$1,400

The extent to which these projects will increase demands for water is unknown, although the amount of water consumed by power projects is relatively small compared to total allocations. However, the data suggest that water use by the oil and gas industry, especially related to oilsands and the use of steam assisted gravity drainage (SAGD) technology, is likely to drive future increases in water use in the Peace watershed. Population growth in some parts of the watershed will continue to increase demands for water. As in recent years, there is expected to be relatively little change in water demand by the agricultural sector.

These predictions are generally consistent with the results of a water use and demand study undertaken for the Peace/Slave basin in 2007 (AMEC). This study predicted that water use in the basin would increase by 54% between 2010 and 2025. The forecast predicted that increased industrial demand for water (specifically water used for petroleum purposes) would account for 78% of the increase, compared to 12% for commercial use, 8% for agricultural uses, and 1% for each of municipal and other purposes.

When the water demand projections for the individual water use sectors are applied to current water use, the results suggest that water use in the Peace watershed could increase by 40% between 2011 and 2025, with industrial use accounting for 61% of the increase. There would be minor increases in water use for the other sectors.



Forecast Water Use, Peace/Slave Basin, 2011 to 2025 (dam^3)

Another implication of the AMEC study is that use of groundwater will become increasingly important. Although groundwater accounts for 22% of total water use in the Peace watershed in 2011, this proportion is predicted to increase to 31% by 2020 as a result of groundwater use for industrial purposes (oil and gas extraction). Most of the predicted increases in water use will occur in those parts of the basin that have oil sands and heavy oil deposits, specifically in the Central Peace and Wabasca sub-basins.

2.6 Water Quality

Water quality in the watershed is determined by a number of factors, including discharges from point sources (like sewage treatment plants), non-point sources (like agricultural run-off), and natural factors (the quality of groundwater influx to surface water bodies, and sediment releases due to storm events).

2.6.1 Surface Water

According to Hatfield (2009), there are 11 major point sources of effluent that are discharged into surface water. These include:

Source	Effluent	Frequency	Treatment	Receiving stream
Weyerhaeuser Grande Prairie pulp mill	Mill effluent	Continuous	Secondary	Wapiti River
Grande Prairie wastewater system (Aquatera Utilities)	Municipal	Continuous	Tertiary	Wapiti River
Grande Cache wastewater system	Municipal	Continuous	Secondary	Smoky River
Smoky River Coal Mine	Surface run-off	Intermittent	Settling pond	Smoky River
Milner Generating Station	Surface run-off	Intermittent	Settling ponds	Smoky River
Daishowa-Marubeni Int. Ltd. pulp mill	Mill effluent	Continuous	Secondary	Peace River
Peace River Oil Production	Process water	Not operating at present		Peace River
Peace River wastewater system	Municipal	Continuous	Secondary	Peace River
Peace River Correctional Centre	Municipal	Continuous	Secondary	Peace River
Manning wastewater system	Municipal	Continuous	Secondary	Notikewin River
Wabasca wastewater system	Municipal	Continuous	Secondary	North Wabasca Lk.

Numerous smaller wastewater systems also discharge into water bodies within the Peace watershed one to three times per year.

Sewage Treatment

Primary treatment consists of placing effluent in a tank and removing materials that settle to the bottom or float on top

Secondary treatment removes dissolved and suspended biological matter using water-borne micro-organisms

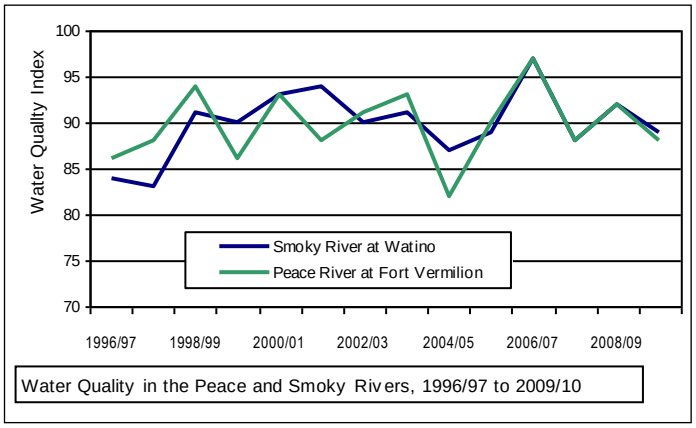
Tertiary treatment is sometimes defined as anything more than secondary treatment, and can include disinfection and removal of some nutrients

The quality of surface water in the Peace River watershed is assessed in terms of AEW's River Water Quality Index. This index is calculated as the average of four sub-indices which include:

- metals (up to 22 variables measured quarterly) nutrients (5 variables measured monthly),
- bacteria (2 variable measured monthly) pesticides (17 variables measured four times during the open water season)

There are four long-term water quality monitoring sites in the Peace watershed. Three of these are federal and provincial monitoring sites on the Peace River at Dunvegan, Fort Vermilion and Peace Point. The fourth is a federal long-term monitoring site at Fitzgerald on the Slave River within Alberta.

For 2009/2010, the quality of the Smoky River at Watino and Peace River at Fort Vermilion were both considered 'good', which reflects a score of 81 to 95. This means that the CCME Guidelines for the protection of aquatic life were occasionally exceeded, but usually by small amounts, and the overall threat to quality is minimal.



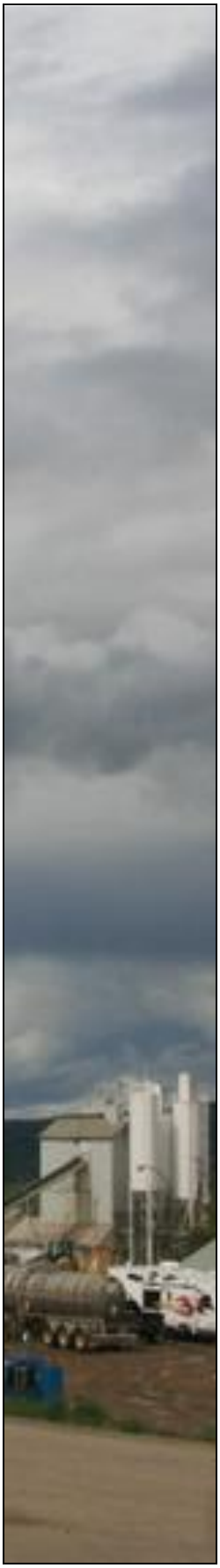
Water Quality in the Peace and Smoky Rivers, 1996/97 to 2009/10

The water quality index scores for the Smoky and Peace rivers have been relatively consistent since 1996/97, never falling below a score of 82 and reaching a high of 97 (excellent) in 2006/07. The factors most affecting water quality relate to a number of instances where water samples exceeded the guidelines for nutrients and metals.

According to AEW's 2007 Summary Report on the Initial Assessment of Ecological Health of Aquatic Ecosystems in Alberta, water quality in the upper reach of the Peace River (BC Border to Smoky River Confluence) was considered to be 'good'. For this reach of the river, the main factors influencing water quality are the altered river discharge patterns (due to hydroelectric development in BC) and the variation in suspended sediment transport. Most sediment transported downstream originates from highly erodible soils associated with agriculture and forest land use in BC. Levels of suspended sediment, particulate nutrients, and some metals tend to rise during floods and other high discharge events.

Water quality in the middle reach (Smoky River Confluence to Fort Vermilion) and in the lower reach (Fort Vermilion to the Delta was considered to be 'good' and 'fair', respectively. As the river flows towards Fort Vermilion, concentrations of most water quality indicators increase progressively. Nutrient levels, and especially particulate phosphorus associated with suspended sediments, are relatively high in the middle reach. Water quality is considered 'good' until the lower reach, where it shifts to 'fair' because of consistently higher levels of suspended sediment, and related increases in associated water quality parameters (nutrients, metals, biological oxygen demand, and turbidity). Water quality conditions in the lower Peace River and the Slave River are similar and have been given the same health ratings.

AARD has monitored water quality at Hines Creek above Gerry Lake, Kleskun Hills Main Drain near Grande Prairie, and Grande Prairie Creek near Sexsmith for the Alberta Environmentally Sustainable Agriculture (AESA) program. Environment Canada has a long term monitoring station at Peace Point on the Peace River (within Wood Buffalo National Park). There are various stewardship groups and municipalities that monitor water quality within their jurisdictions. Generally, the monitoring stations are designed to provide data for water upstream and downstream of major influences, such as effluent discharge, and river confluences. Industries discharging effluent are required to comply with AEW water quality monitoring specifications.



Historically, there were a number of water quality issues in the Peace River and tributaries associated with industrial effluents and wastewater discharge. Pulp mill effluents, which contain significant amounts of organic matter, were lowering oxygen levels in the Peace and Smoky rivers; these effects are measured in terms of Biological Oxygen Demand (BOD). These effects were studied as part of the Northern River Basins Study (NRBS). After completion of the NRBS, technological upgrades at the mills were implemented to reduce BOD loadings. As a result, the total BOD loadings decreased from about 9,700 kg/day in 1990 to 3,800 kg/day in 2001. The upgrades also led to a reduction in the loading of total suspended solids.

A second water quality problem involved chlorinated organic compounds such as Adsorbable Organic Halides (AOX), which are a group of mainly chlorinated organic chemicals that are found in bleached kraft pulp mill effluents, and to a lesser extent in treated sewage. A study performed by Alberta Environment in 1990 found elevated levels of AOXs in the Smoky and Wapiti rivers. Subsequently, the bleached kraft pulp mills upgraded their technology to substantially reduce the use of chlorine and improve effluent treatment. As a result, the AOX loadings from pulp mill effluents in the Peace River watershed has decreased by 70% since the early 1990s.

The effects of pulp mill effluent on water quality and aquatic life continue to be monitored by Environment Canada. In 1992, the federal government established an updated regulatory framework for pulp and paper mill effluent that sets stringent discharge limits for mills across Canada and included an Environmental Effects Monitoring (EEM) program. EEM provides information on the potential effects of effluent on fish populations, fish tissue, and benthic invertebrate communities. To date, pulp and paper mills have submitted five sets of monitoring reports, based on three or four year cycles. The most recent report (Stantec, 2004) for the Daishowa-Marubeni International Ltd. pulp mill near Peace River indicated that there was no evident nutrient enrichment effect from effluent discharges and that the discharge did not appear to be having an effect on the benthic invertebrates of the Peace River. Because of the high dilution rate of the treated effluent, no adult fish survey was required. The most recent report (Hatfield, 2010) for the Weyerhaeuser pulp mill on the Wapiti River near Grande Prairie indicated that effluent quality has remained the same or improved and no effluent toxicity was observed. The implementation of new nutrient-reduction technologies resulted in a 16% reduction in total phosphorus in effluent released during the summer-fall.

In the late 1990s, concerns were raised regarding the fate and effects of selenium in aquatic ecosystems near mountain coal mines in west-central Alberta. Open-pit mines facilitate the mobilization of selenium from geologic sources into surface water. AEW data for the upper Smoky River from 1998 to 2003 showed selenium concentrations that were at least ten times higher than water quality guidelines. The Smoky River upstream and downstream of the mine site continues to be monitored by AEW, and by personnel from the coal mine.

2.6.2 Groundwater

Concerns about groundwater quality generally focus on the potability and usefulness of ground-water for agricultural operations and domestic consumption. Potability is defined in terms of Health Canada's Canadian Drinking Water Guidelines.

Canadian Drinking Water Guidelines

Representative of the governments of Canada and all the provinces have established guidelines for drinking water based on current research on health effects, aesthetic effects and water treatment technology. Guidelines have been developed for contaminants that are known to cause health problems, are commonly found in drinking water supplies, and can be detected. Standards have been established for four microbiological parameters including coliforms and turbidity, 17 chemical and physical parameters (including arsenic), and six radiological parameters. More details on the guidelines can be found at: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/water-eau/2010-sum_guide-res_recom/sum_guide-res_recom-eng.pdf

The Regional Groundwater Assessment (RGA) completed by HCL for PFRA indicates that groundwater from surficial aquifers within the Peace River watershed can generally be described as:

- chemically hard and high in dissolved iron;
- high in Total Dissolved Solids (TDS), except for the west-central portion of the watershed;
- having elevated levels of sulfate where there are elevated levels of TDS; and
- having a few instances where nitrate + nitrite (as N) concentrations exceed standards.

Groundwater from deeper bedrock aquifers in Alberta is typically high in TDS, with concentrations ranging from less than 500 to more than 28,000 mg/L. AEW defines water with a TDS of less than 4,000 mg/L as being 'non saline' or 'fresh' water while water with a TDS of greater than 4,000 mg/L as being 'saline' or 'brackish' water. Groundwater with TDS values greater than 2,000 mg/L are mainly found in the central and far northern parts of the Peace watershed. Water from deeper bedrock aquifers also tends to have elevated levels of sulfate when there are elevated levels of TDS but low levels of nitrate + nitrite. Fluoride concentrations from 40% of the groundwater samples from bedrock aquifers were considered too low (less than 0.5 mg/L) to meet the recommended daily needs of people.

Monitoring of groundwater quality is currently undertaken by AEW. There are observation wells within the Peace River watershed in the general vicinity of Grande Prairie, Peace River, and Fort Vermilion. Groundwater quality was monitored by Alberta Environment from 1980 to 1997, and began again in 2008. Water quality data from these observation wells is currently being validated and is projected to be available to the public by the end of 2013. Additional information on groundwater quality comes from analysis of potable water samples submitted to Alberta Health and Wellness by municipalities and rural well owners.

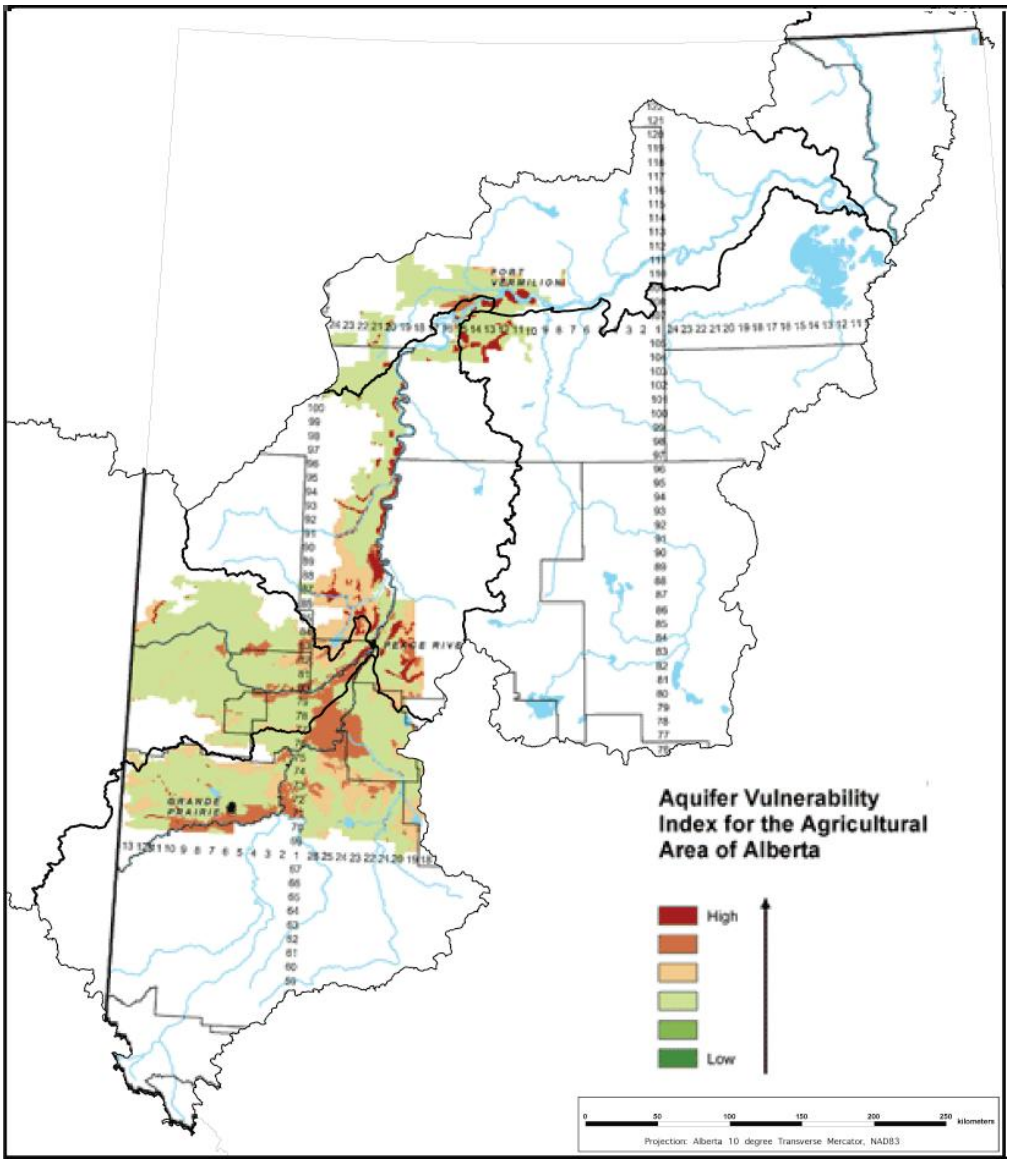
As many groundwater wells on farmsteads extract water from shallow aquifers (surficial deposits), there is always a danger of drilling too deep and allowing saline water from deeper formations to contaminate shallow aquifers.

To prevent this from happening, AEW and AGS created a map of the Base of Groundwater Protection to identify the depth at which saline water might be found. This information was then used to identify areas within the agricultural area of Alberta, including the Peace watershed, where aquifers are vulnerable to contamination from saline water.

Base of Groundwater Protection

The Base of Groundwater Protection is defined as the elevation below which the groundwater will have more than 4,000 mg/L of total dissolved solids. This establishes the maximum drilling depth for a water well that is to be used for agricultural purposes or potable water supply, without major risks of contamination from saline water

In the Peace watershed, aquifers are highly vulnerable (dark red) in about 3% of the area, notably along the central and lower portions of the Peace River valley. Another 9% of the watershed is considered to be vulnerable (dark orange). The Alberta Tier 1 Soil and Groundwater Remediation Guidelines have been developed as set of best management practices that will protect aquifers from contamination from various land use practices.



2.7 Ecosystem Health

The health of the aquatic ecosystems is generally measured in terms of water quality, sediment quality, and the health of fish and other biota. Although the MPWA has commissioned a separate study to assess ecosystem health in the Peace watershed, available information suggests that overall ecosystem health is considered "good" where data are available.

Some sediment quality data was collected for the Peace River in the 1990s as part of the Northern River Basins Study and the Northern River Ecosystem Initiative. These studies determined that sediment quality in the upper and middle reaches of the Peace River was rated "good" but there were insufficient data to rate sediment quality in the lower Peace River. Additional sediment studies were conducted by Alberta Environment in 1997 in the Smoky, Wapiti and Peace rivers to determine levels of polychlorinated biphenyls (PCBs). PCB concentrations were found to be below CCME guidelines but, on the Wapiti River, the levels of PCB concentrations were higher downstream of Grande Prairie than in upstream reaches of the river. Sediment quality in the Wapiti River is considered to be "fair".

In terms of the health of fish populations, the Peace River basin has a diversity of fish species. Fish species of concern include Arctic grayling, bull trout, largescale sucker, northern redbelly dace, northern pike minnow (all listed as "sensitive" in Alberta), and spoonhead sculpin (listed as "may be at risk" in Alberta). Although research has been conducted on the health of some localized fish populations or species of importance for sport fishing, background studies undertaken for the development of a transboundary water agreement between British Columbia and Alberta (2009) concluded that not much is known about the health of fish populations throughout the Peace River.

Historically, there have been concerns about the "health" of fish populations, with consumption advisories having been issued. These include advisories related to elevated levels of mercury in fish in the Williston Reservoir, and the presence of dioxins and furans in mountain whitefish in the Wapiti River, and PCBs in the livers of Burbot taken from the Peace River. Changes in pulp mill technology and waste treatment has led to easing of restrictions on consumption of fish from the Wapiti River. At present, there are fish consumption advisories for Burbot and Mountain Whitefish taken from various rivers in the Smoky/Wapiti sub-basin.

Fish Consumption Advisories

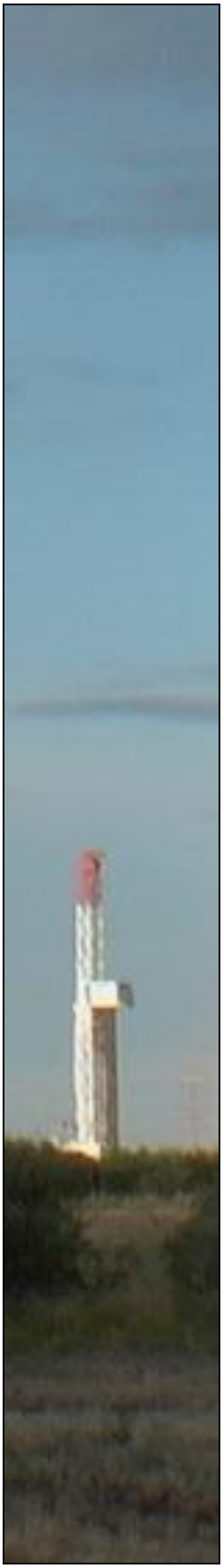
Burbot: Avoid eating the liver, only fillet portions can be eaten without limits, from

- Cutbank River and tributaries
- Kakwa River and tributaries
- Little Smoky River and tributaries
- Smoky River and tributaries
- Wapiti River and tributaries

Mountain whitefish: pregnant women and young children should avoid, others should limit consumption to no more than 1.5 servings/week from

- Cutbank River and tributaries
- Little Smoky River and tributaries
- Simonette River and tributaries
- Smoky River and tributaries
- Wapiti River and tributaries

More details on the advisories can be found at: http://www.mywildalberta.com/Fishing/SafetyProcedures/FishConsumptionAdvisory.aspx



Most available information on non-fish biota in the Peace watershed has been taken from environmental monitoring studies associated with the two pulp mills and the sewage treatment plants. There is very little information on the health of non-fish biota in other parts of the watershed.

An overview of the aquatic health of the Peace and Slave river basins was undertaken by North/South Consultants in 2007. This study evaluated the status of aquatic health as well as the state of knowledge about aquatic health. The study concluded that there was relatively poor information on sediment quality and non-fish biota for most of the watershed. While the quality and quantity of data for the Wapiti River is considered "good" and "marginal" for the Smoky River, the data quality/quantity for most of the rest of the watershed is considered "poor". There is "poor" information for the mainstem of the Peace River downstream of Fort Vermilion and for the Slave River, as well as for the PAD.

Reach	Water Quality	Sediment Quality	Non-fish biota
Peace River: Border to U/S of the Smoky River Confluence [1]	G	M	P
Peace River: D/S of the Smoky River Confluence to Fort Vermilion	G	F	BI F / PP P
Peace River: Fort Vermilion to the Delta	F	P	P
Slave River [2]	M	P	P
Smoky River	G	M	M
Wapiti River	G	G	G
Agricultural Stream: Hines Creek	G	P	P
Agricultural Streams: Kleskun Drain and Grand Prairie Creek	G	P	P
Coal Mining Streams: Beaverdam and Sheep creeks	F	M	P
Lakes previously monitored by AENV [1] Monitored primarily to assess trophic status.	Variable	P	P
Select Recreational Lakes [1]	Variable	P	P
Boreal Lakes	P	P	P
Boreal Wetlands	P	P	P
Peace-Athabasca Delta	P	P	P

Good | Fair | Marginal | Poor

BI = Benthic Invertebrates. PP = Primary Producers.

Thus, there is really limited information on the health of aquatic ecosystems in the Peace watershed. This conclusion was reiterated in the background studies undertaken in 2009 for the development of a transboundary water agreement between British Columbia and Alberta. The background study concluded that there was lack of knowledge about the effects of climate change, pollution and flow regulation associated with hydroelectric development on aquatic habitat, fish population, riparian habitats and channel morphology and maintenance due to changes in sediment discharges.

2.8 Water Issues

Assessments of water issues in the Peace watershed were undertaken in 1987 by the Northern Alberta Development Council (NADC) and again in 1996 as part of the Northern River Basins Study (NRBS). The NADC assessment identified 10 issues, including protection of groundwater, safe drinking water, erosion control and drainage to protect farmland, surface water quality, water supplies for farms, water quality to support recreation and tourism, water demands for industrial growth, water concerns of native people, diversions of water to southern users, and the need for watershed and wetland management.

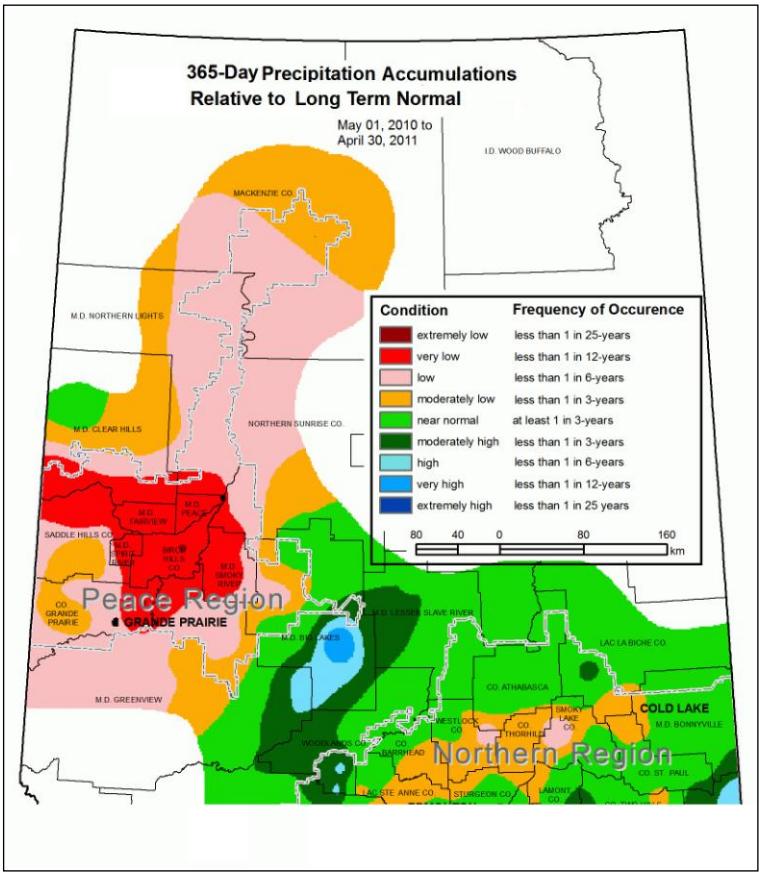
In 1996, the list of issues identified during the NRBS was similar, although the reasons behind some of the issues had changed. Pulp mills were seen as the key factor affecting water quantity and quality in the watershed, followed by municipal use, other industries, logging and agriculture.

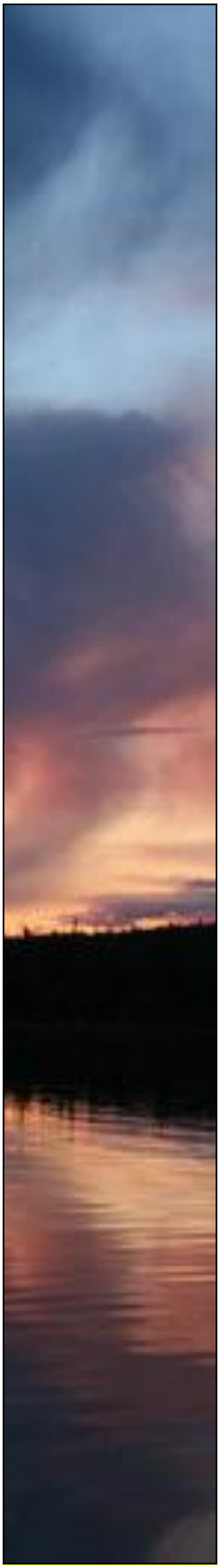
Less than 5% of stakeholders identified oil and gas as being a key factor affecting water. Stakeholders called for reducing effluent loads to rivers, more monitoring of industrial effluent, and better enforcement of pollution laws.

2.8.1 Current

Since 1996, issues around water quality and water quantity still remain. However, while issues related to pulp mills have largely disappeared due to changes in process technology and effluent treatment, the current focus is on the effects of the oil and gas industry.

An overarching concern is still the adequacy of supply. While the overview of water supply and demand suggests that residents of the watershed are water rich (less than 0.1% of the flow of the Peace River is currently being used), such is not the case. Most users are not located on one of the major rivers in the watershed and are instead reliant on groundwater or surface run-off rather than lakes or streams. In addition, many municipalities and other users have licences that allow them to take water from more than one source, just in case a surface or ground water supply no longer can be used. Water from surface sources accounts for 78% of total water use in the watershed, so when a drought occurs, such as in 2010/11, most water users not located on a river mainstem are forced to reduce their water use or find an alternative source. During 2010/11 very few parts of the watershed had near average levels of precipitation, with the most populated part of the watershed receiving very low levels of precipitation.





One of the implications of drought is that available water will have to be rationed among existing users. In Alberta, water is rationed on the principle of first in time, first in right (FITFIR), which means that domestic water users and senior licensees, those with the oldest water licences and registrations, are allowed to take and use all of their entitlements before junior water users, those with the newest licences and registrations. Although the effects of droughts can be reduced through sharing agreements and through active management of withdrawals (known as water mastering), there may be an increasing number of occasions when junior licensees are required to cease water withdrawals, resulting in lost production and economic hardship.

However, to ensure that water is being used and rationed appropriately, more current and accurate information on actual water withdrawals and return flows is required. As noted in Section 2.5.2, not all licensees are reporting actual water use and very few report return flows. Although water use information is being provided by most of the large users that account for the majority of use in the commercial and industrial sectors, and most municipal use, there is almost no water use information being reported by people or organizations that have been issued licences for irrigation, agricultural or other water uses. And, based on available licence information, some of these allocations, especially licences issued for other purposes, are very large. Thus, a key challenge will be to develop a better understanding of actual water use.

Another arising issue relates to the question of how much surface water needs to remain in rivers to maintain health of the water body? At the present time, there is limited information on the health of aquatic ecosystems in the Peace watershed and on whether ecosystem health is remaining the same or deteriorating. However, with possible increased frequency of droughts and lower natural flows, there are concerns that water withdrawals for human activities will result in flow conditions in rivers and streams that will seriously compromise aquatic health. Under the Alberta *Water Act*, the Government can reserve unallocated water to maintain the natural integrity of riparian and aquatic habitat. Determination of how much water is required to maintain aquatic health involves conducting studies of instream flow needs. Thus, a key challenge will be to undertake instream flow needs assessments for most of the main tributaries of the Peace River. This is less of an issue for the mainstem of the Peace River because releases for hydroelectric power generation have resulted in higher flows during the summer periods than would occur under normal conditions. It is also expected that development of a transboundary water agreement between British Columbia and Alberta will result in a flow regime that will ensure that the health of the mainstem of the Peace River will be maintained or enhanced.

An existing and increasingly important issue in the Peace watershed and elsewhere in Alberta relates to the protection of groundwater quantity and quality, especially in regard to the effects of coal bed methane (CBM) extraction, mining, drilling, seismic activities, and the practice known as "fracking".

What is "Fracking"?

Fracking, or hydraulic fracturing, is a procedure used by the energy industry to increase the extraction rates and ultimate recovery of oil and natural gas. It involves injecting fluids at high pressure into wellbores in order to create fractures that allow oil and natural gas to flow more freely. The fluids being injected can include large amounts of water but may also include grains of sand, ceramic, or other particulates that prevent the fractures from closing when the injection is stopped. There are concerns that fracking can affect groundwater in bedrock aquifers.

Groundwater resources from the Paskapoo Formation may be at risk where wells are drilled through groundwater formations. In addition, aquifers in overburden aquifers have been jeopardized in the past by seismic drilling, and the term "flowing shot hole" generally refers to the resulting groundwater flow from seismic shot holes where they have penetrated an aquifer with flowing artesian conditions. Negative effects of this include the wastage of the groundwater resource, as well as the creation of man-made springs and boggy areas resulting from groundwater discharge.

The Alberta Government has established a regulatory framework to protect aquifers from over-use and physical damage or impairment. It has created a series of guidelines for development of groundwater resources and has implemented standards for testing water wells prior to the exploration for and exploitation of coalbed methane (CBM) resources (Alberta Environment, 2006). These standards provide well owners with the opportunity to seek a legal remedy for damages to water wells that may occur as a result of CBM activities.

The use of deep bedrock aquifers is not regulated under the Alberta *Water Act*; rather the use of saline water is governed by the Department of Energy through the Energy Resources Conservation Board (ERCB).

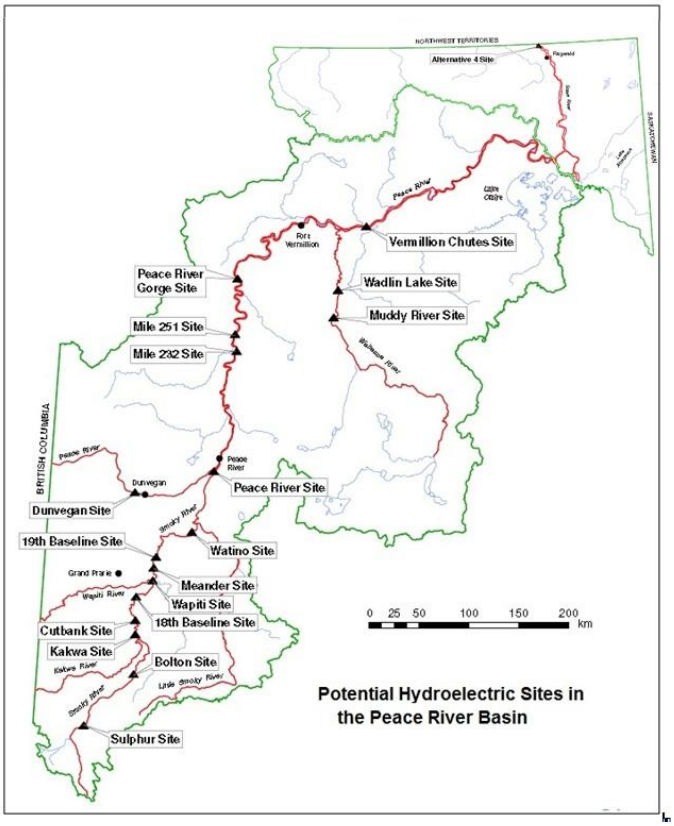
2.8.2 Future

The Peace watershed will face two additional issues in the future. The most important of these will be additional hydroelectric development. Although the Peace River has already been developed for and changed by hydroelectric power projects, additional projects may be developed. As noted previously, the Dunvegan Hydroelectric Project, which is a small, run-of-river project on the Peace River just upstream of the Dunvegan Bridge, has received approval. However, Transalta Utilities has acquired the rights to the project and construction is currently on hold until additional design has been completed. While this project will not change the flow of the river, it will represent a barrier to navigation and fish migration, although the project has been designed to minimize these effects. The project may also change the ice regime of the Peace River.

The Site C hydroelectric project on the Peace River has been proposed by BC Hydro at a location downstream of the confluence of the Moberly River and upstream of the highway bridge near Taylor BC. This project would consist of a 60 metre high earthfill dam that would create a reservoir that would be 83 km in length and cover 9,310 ha. The project would generate 1,100 MW of electricity. The project was originally proposed and approved in the early 1980s, but is being redesigned and will undergo a new environmental and regulatory review. Once in operation, Site C is not expected to appreciably alter the flow of the Peace River because its release pattern will be determined by flow releases from the Williston dam. There may be some reductions in flows during the filling period for the reservoir. There are expected to be changes in the daily flow variations, and there could be changes in river temperatures that affect ice conditions downstream from the dam. There are also likely to be effects on fish habitat, mortality and migration, and design alternatives to minimize these effects are being developed.

A review of other potential hydroelectric sites in the Peace watershed was recently completed by Hatch (2010) for the ERCB. This study identified five potential sites on the Peace River, 10 sites on the Smoky and Wapiti rivers, two sites on the Wabasca River and one site on the Slave River. The study notes that Alberta Power Co. (now ATCO Power) has examined the feasibility of building dams at various sites in the watershed. While a dam at the Vermilion Chutes on the Peace River was determined not to be economic, several sites on the Smoky River could be developed.

A hydroelectric site at Mountain Rapids on the Slave River has been evaluated several times, notably in the late 1970s and early 1980s. More recently, in 2006, ATCO Power and TransCanada started investigating a $5 billion project at the Alternative 4 site that could create as much as 1,350 MW. However, the companies could not reach an agreement with the Smith's Landing First Nation to conduct feasibility studies.



Despite the challenges of developing the hydroelectric potential of the Peace watershed, Hatch (2010) concluded that major projects in the northern basins and smaller projects in the southern basins may be developed in the next 30 years, and could generate as much as 20 percent of the province's ultimate potential power requirements. This would require the construction of two major hydroelectric projects

The second major issue relates to the effects of climate change. Long term forecasts predict increases in temperature and precipitation and more frequent extreme events. The effects of climate change are already being seen in the form of reduced flows from tributaries such as the Smoky and Wapiti rivers. This is due to reduced snowpacks (due to less snow and more rain), that result in lower flows and a reduced probability of ice jams.

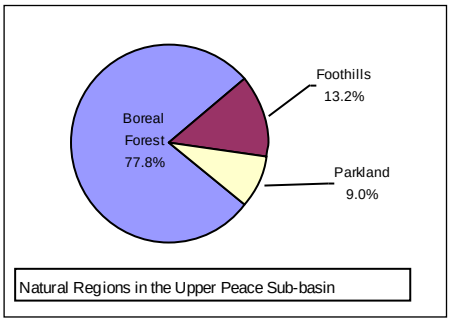
Climate change is also expected to affect the thickness and location of river ice. Although these effects are difficult to quantify, models have been developed for the Peace River to determine potential effects on river ice. Based on the A2 climate change scenario from the Coupled Global Climate Model (CGCM2), the model predicted that the duration of the ice cover at the Town of Peace River would be reduced by an average of 33 days and the maximum ice cover extent was an average of 66 km shorter after climate change, compared to the historical simulation results (Andrishak and Hicks, 2005).

3.0 UPPER PEACE RIVER SUB-BASIN

The Upper Peace River sub-basin consists of lands that drain into the Peace River directly above the town of Peace River. This coincides with the Water Survey of Canada sub-basin 07FD.

3.1 Physiography

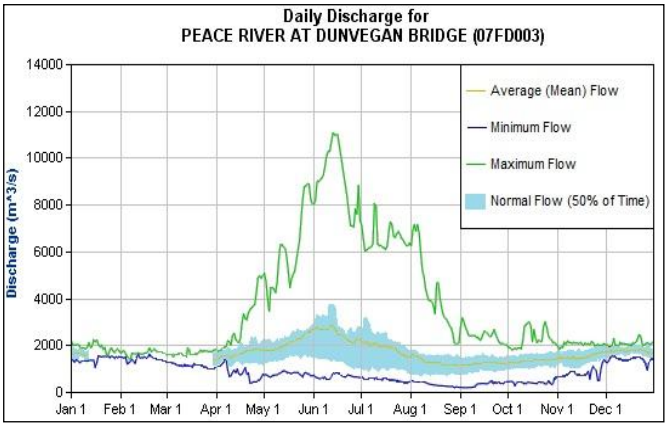
The Upper Peace sub-basin is about 17,660 km² in area and accounts for about 8% of the Peace watershed in Alberta. It is located primarily in the Boreal Forest Natural Region (77.8% of the sub-basin) but includes some areas of the Foothills Natural Region (13.2%) and the Parkland Natural Region (9.0%).



Natural Regions in the Upper Peace Sub-basin

3.2 Hydrology

The Upper Peace sub-basin includes the mainstem of the Peace River from the Alberta boundary to the junction of the Peace and Smoky rivers. There is one gauging station on this reach of the river at the Dunvegan Bridge (07FD003). Average daily flows at this station have been recorded for the period from 1960 to 2010.



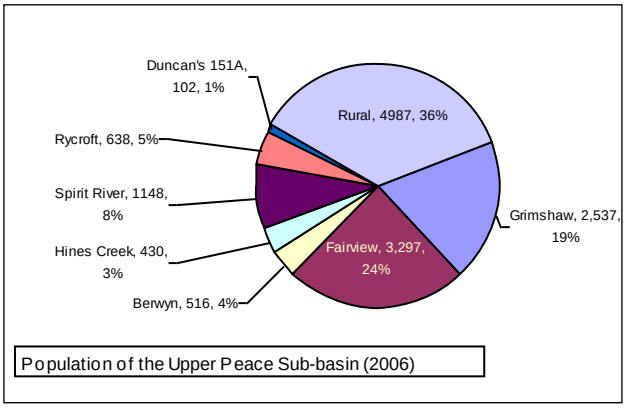
Average daily flows at this station show that the normal flow of the Peace River is less than 4,000 m^3/sec throughout the year and is usually closer to 2,000 m^3/sec. However, maximum flows of about 11,000 m^3/sec have been recorded in the month of June. The relative lack of seasonal variability in flows is due to the regulated flows from the Williston reservoir.

Major tributaries to the Peace River in this sub-basin include the Pouce Coupe River, Clear River, Montagneuse River, Ksituan River, Leith River, Hines Creek, and the Saddle River There are relatively few lakes in this sub-basin. George Lake and Gerry Lake are part of the Hines Creek watershed.

There are 900 km^2 of large wetlands (>5000 ha) in the Upper Peace sub-basin. They cover 5.1% of the land area and account for 5.7% of all large wetland areas in the Peace watershed.

3.3 Socio-Economic Characteristics

In 2006, approximately 13,655 people lived in the Upper Peace sub-basin. About 63% of the population lived in one of two towns (Grimshaw and Fairview) or four villages (Berwyn, Hines Creek, Spirit River and Rycroft). One percent of the population lived on the Duncan's 151A Indian reserve. The other 37% of the population lived in rural parts of the sub-basin, including the municipal districts of Peace No. 135, Fairview No. 136, Spirit River No. 133 and Clearhills No. 21, and the counties of Saddle Hills and Birch Hills.



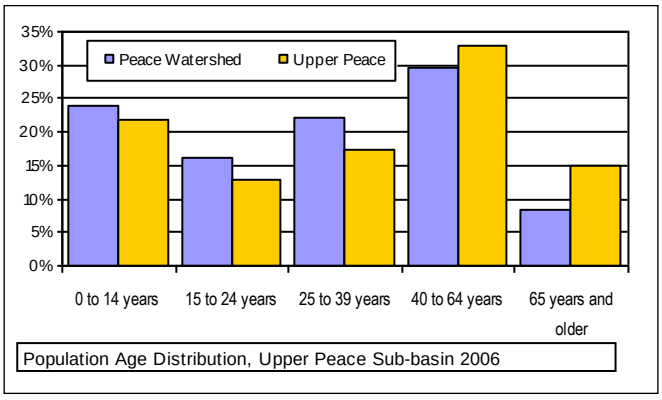
Population of the Upper Peace Sub-basin (2006)

About 8.8% of the sub watershed population consisted of aboriginal people and 10% of these lived on the Duncan's 151A reserve, which is one of two reserves for the Duncan's First Nation.

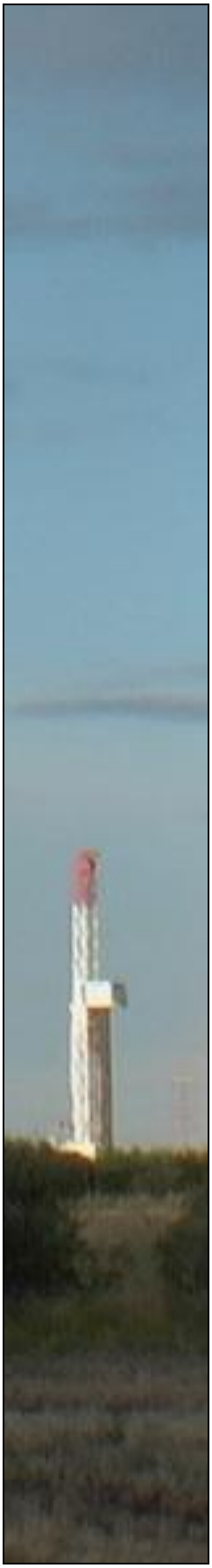
Between 2001 and 2006, the population of the Upper Peace sub-basin decreased by 1.2%. While the populations of Grimshaw, Fairview, Spirit River and Rycroft each increased by between 4.2% and 4.8% during this period, the rural population decreased by 7.9%. Small population decreases also occurred in Hines Creek, Berwyn and Duncan's 151A reserve.

The population of the Upper Peace Sub-basin tends to be older than for the watershed as a whole. In 2006 about 15% of the population was aged 65 years and older, compared to 8% for the Peace Watershed. There was also a higher percentage of people aged 40 to 64 years and lower percentages of people under the age of 40, especially in the 25 to 39 year age category. About 78.1% of the population in the sub-basin was 15 years of age or older and this was slightly higher than for the Peace watershed (76.2%).

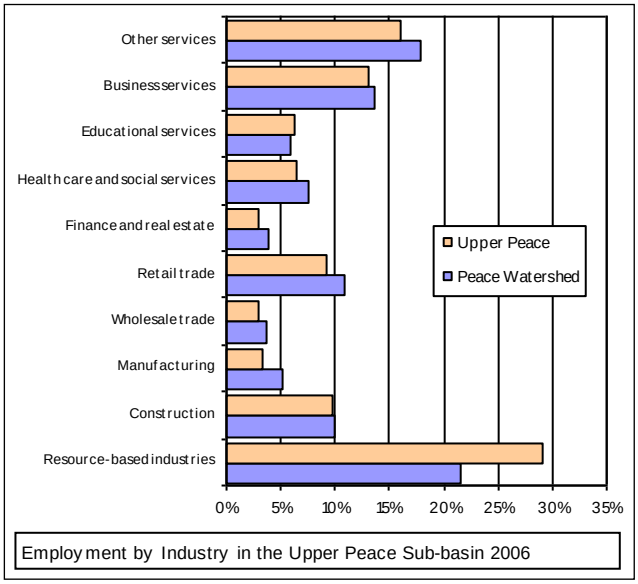
In 2006, 72.8% of the adult labour force in the Upper Peace sub-basin were either working or seeking work (the labour force participation rate) and 3.9% were unemployed. Both the labour force participation rate and the unemployment rate for the watershed were lower than for the Peace watershed.



Population Age Distribution, Upper Peace Sub-basin 2006



About 29% of the labour force in the Upper Peace sub-basin was employed in resource-based industries (including agriculture); this was the highest in the entire Peace watershed and is consistent with the high rural population. For nearly all other industries, this sub-basin had lower percentages of employment than did the overall Peace watershed, with the biggest differences being in the other services and retail trade industries.



Employment by Industry in the Upper Peace Sub-basin 2006

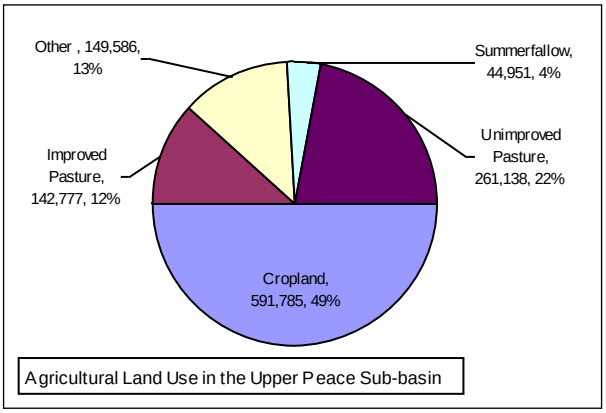
Workers in the Upper Peace sub-basin reported median earnings of $24,126 in 2005. This was 20% lower than for the entire Peace watershed ($29,738).

3.4 Land and Resource Use

About 92% of land in the Upper Peace sub-basin has been disturbed, primarily by agriculture or through forestry operations and oil and gas development.

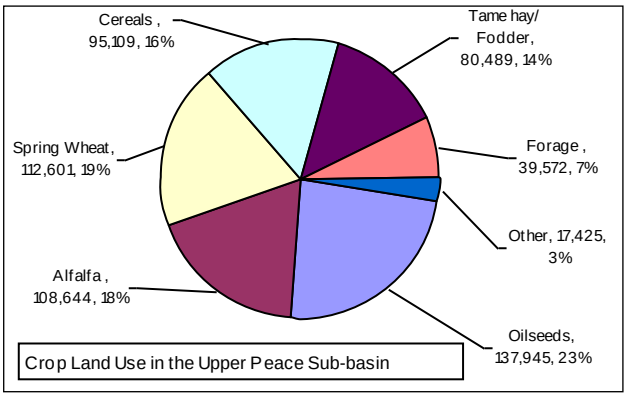
3.4.1 Agriculture

According to the 2006 Census of Agriculture there were 2,558 farms in the Upper Peace sub-basin. These farms covered an area of 1.19 million ha (2.9 million acres); this represents 67% of the sub-basin.



Agricultural Land Use in the Upper Peace Sub-basin

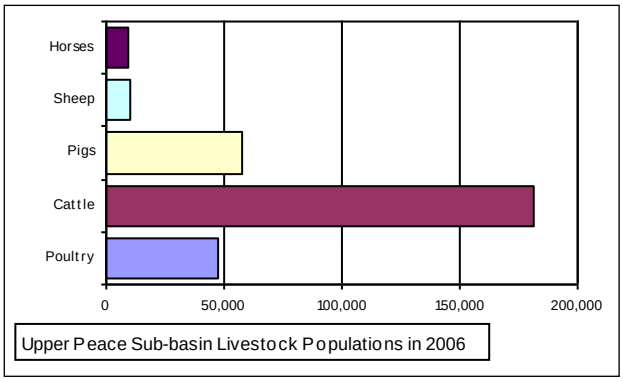
Nearly half of agricultural land consisted of cropland (49%) with unimproved pasture accounting to 22%, improved pasture accounting for 12% and summerfallow accounting for 10%.



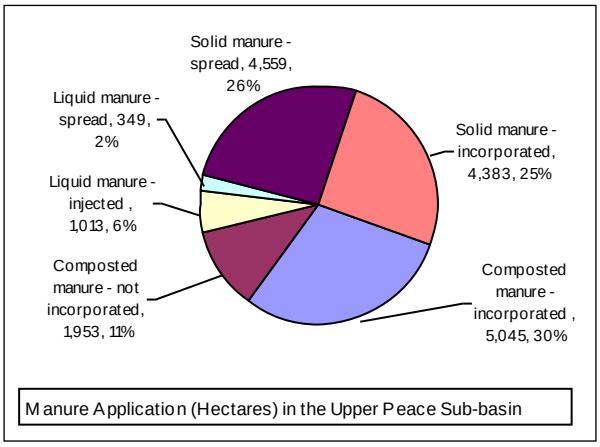
Crop Land Use in the Upper Peace Sub-basin

The most important crops grown in sub-basin include oil seeds (23% of field crops), spring wheat (19%), alfalfa (18%), other grains and cereals (16%) and tame hay/fodder (14%). Twenty eight farms reported using irrigation on 1,325 ha of land, primarily for hay and field crops, with some irrigation of fruits and vegetables.

The majority of the farms in the Upper Peace sub-basin (64%) raised livestock. About 45% of farms raised cattle (averaging 157 animals per farm) and 36% raised horses (10 per farm). Small numbers of farms raised other types of livestock including poultry (8%), hogs (3%), sheep (4%) and goats (2%). In total, there were about 306,000 animals (including poultry) in this sub-basin in 2006. This includes 181,757 cattle (13 cattle per person), 57,448 hogs, 9,900 sheep, 9,230 horses and 763 goats. These animals generated 1.945 million tonnes of manure.



Upper Peace Sub-basin Livestock Populations in 2006



Manure Application (Hectares) in the Upper Peace Sub-basin

In terms of land management, 22% of farms applied manure to 17,300 ha of land, suggesting an average rate of 112 tonnes of manure per hectare. The most common types of manure application included incorporating composted manure (30% of the land area), spreading of solid manure (26%) and incorporation of solid manure (25%).

In addition, 44% of farms used chemical fertilizers on 387,891 ha (66% of cropland).

3.4.2 Forestry

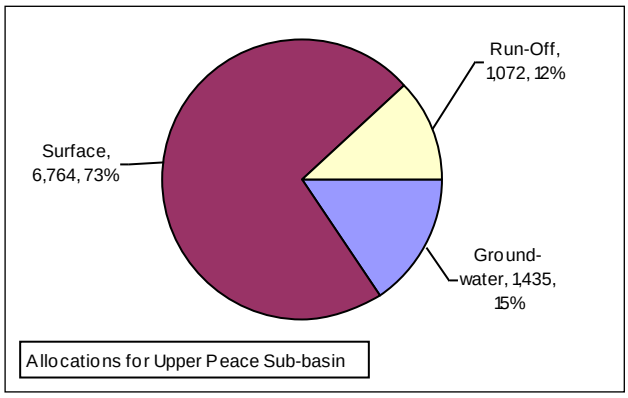
There was one sawmill in the Upper Peace sub-basin (Zavisha Sawmills Ltd.), located near Hines Creek. Parts of three FMAs are located in the Upper Peace. These FMAs have been issued to Weyerhaeuser Forest Products in the south, Canadian Forest Products along the mainstem of the Peace River, and Daishowa-Marubeni International Ltd. in the north.

3.4.3 Oil and Gas

A total of 13,067 oil and gas wells have been drilled in the Upper Peace sub-basin; this represents 21% of all wells drilled in the Peace watershed. There are also 32,390 km of seismic lines and 7,085 km of pipelines. This density of oil and gas activity has resulted in an average disturbance of 6.9 km of linear disturbance per square kilometre of land (excluding agricultural land). This is the most intensive land use disturbance in all of the sub-basins and is more than three times the average for the Peace watershed (2.2 km/km^2).

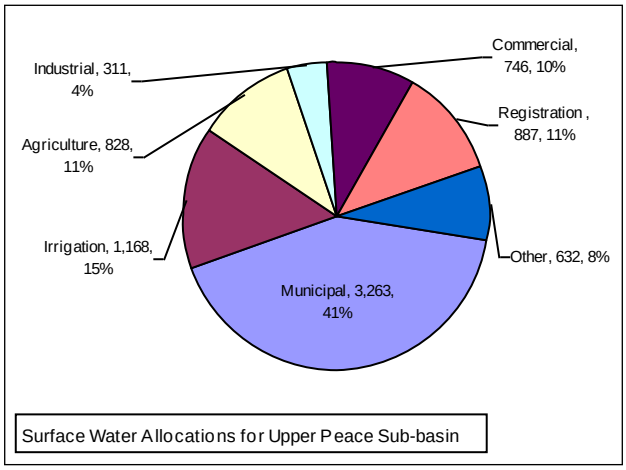
3.5 Water Use

The most recent water licence information indicates that a total of 9,270 dam^3 of water has been allocated for use in the Upper Peace sub-basin. This represents 6% of allocations in the Peace River watershed. These allocations consist primarily of surface water (6,764 dam^3 or 73%) but also include small amounts of groundwater (1,435 dam^3 or 16%) and surface run-off (1,072 dam^3 or 12%).

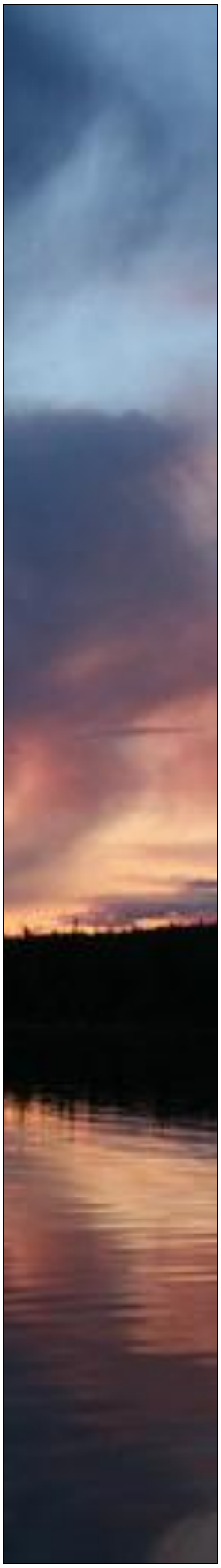


3.5.1 Surface Water

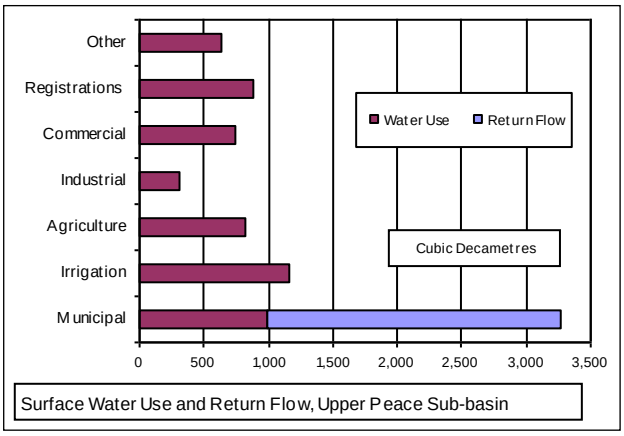
Licensed Use - Municipal water use accounts for the largest portion of surface water allocations in the Upper Peace sub-basin. Allocations for municipal purposes amounted to 3,263 dam^3 or 41% of total allocations. The largest licenses issued for municipal purposes include two licences issued to the Town of Fairview that accounted for 69% of the total for this sector. Large municipal licences were also issued to the Town of Spirit River (10% of municipal allocations), the Village of Rycroft (6%), and the Village of Hines Creek (5%).



Other important sectors in this sub-basin include irrigation, which accounts for 15% of surface water allocations, and registrations and agricultural licences, each of which accounted for about 11% of surface water allocations. The Dunvegan market garden has three licences for irrigation that account for 40% of total allocations for irrigation. Water licences issued for commercial purposes account for 10% of allocations while industrial allocations are fairly small (4%).

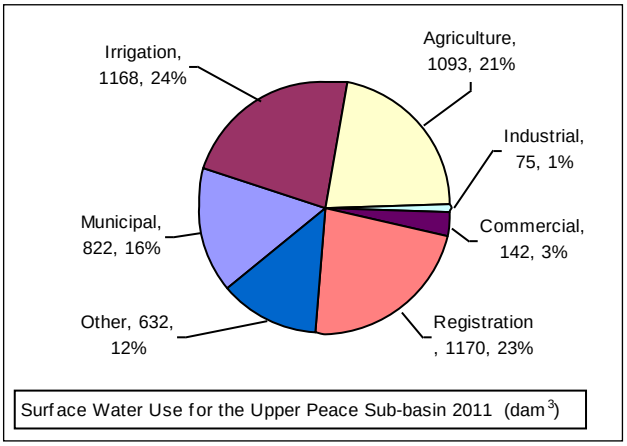


Water allocations include allowances for actual water use and may include expectations for return flow. Only the municipal water licences issued in this sub-basin have a return flow requirement, with the expectation that 70% of withdrawals will be used after use.



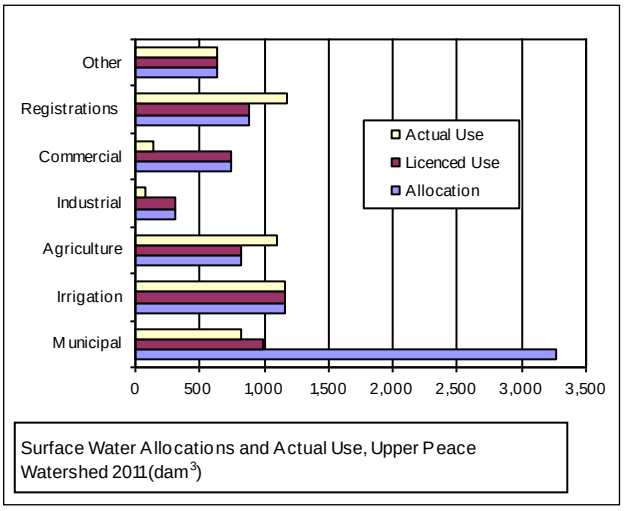
Surface Water Use and Return Flow, Upper Peace Sub-basin

Actual Water Use - Total surface water consumption in the Upper Peace sub-basin in 2011 is estimated to be 5,102 dam^3. This represents 65% of total surface water allocations and 92% of licensed water use. Agricultural water uses are estimated to account for 66% of total surface water use in the Upper Peace sub-basin, including 23% for irrigation, 23% for registrations and 21% for agricultural licences. Municipal use accounted for 16% of water use while other uses accounted for 4%. Water used for commercial and industrial purposes together accounted for 6% of water use.

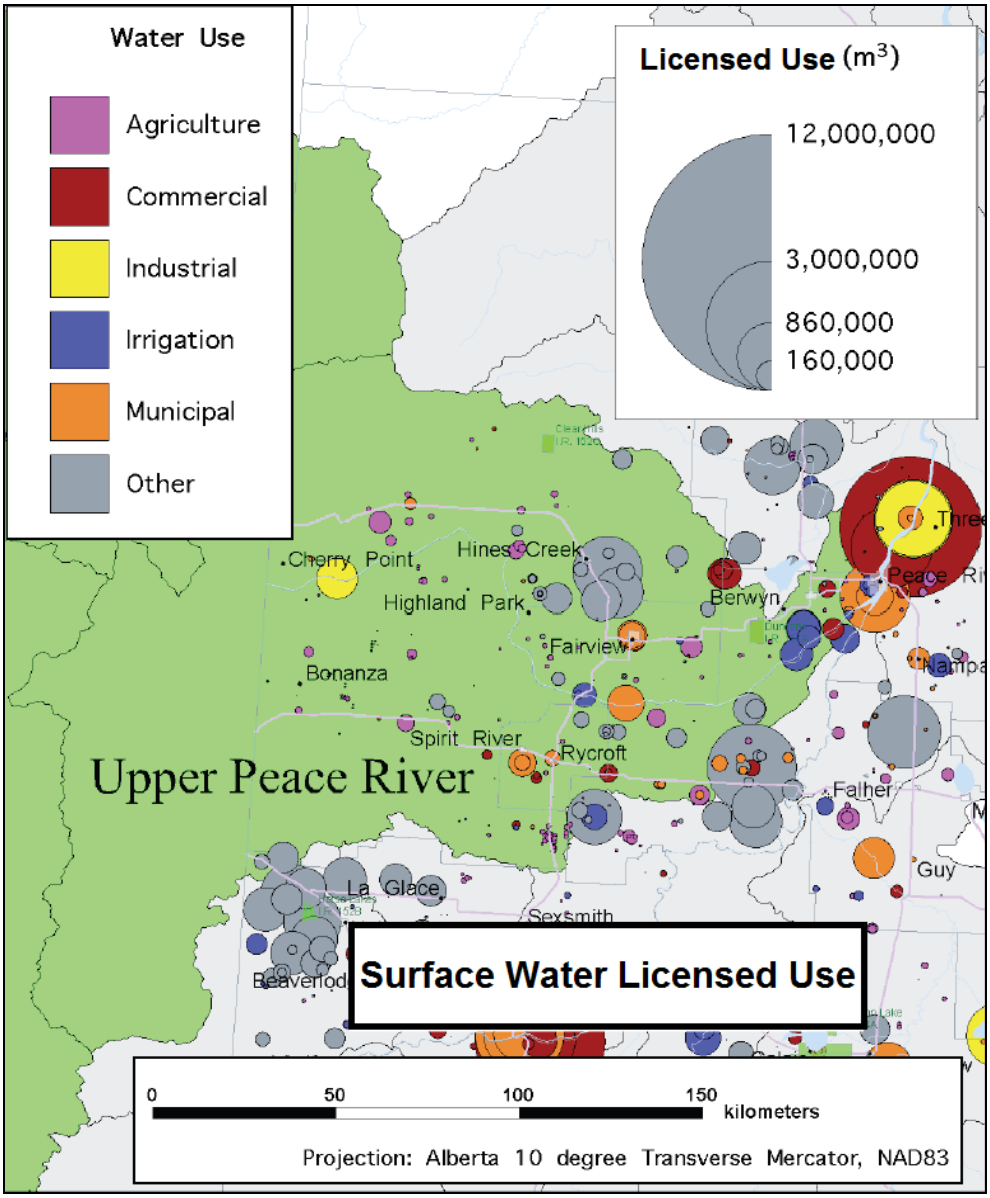


Surface Water Use for the Upper Peace Sub-basin 2011 (dam^3)

There are some differences in terms of the amount of surface water allocated to each of the six sectors, compared to the amount of water that each sector is estimated to have used. The biggest differences are that only 25% of municipal allocations, 24% of industrial allocations and 19% of commercial allocations are actually being used. Estimated surface water use for registrations and agricultural licences exceeds allocations based on the amount of water being consumed by livestock populations in the sub-basin.

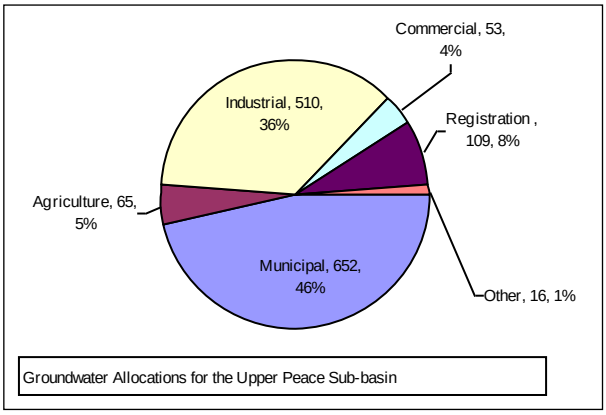


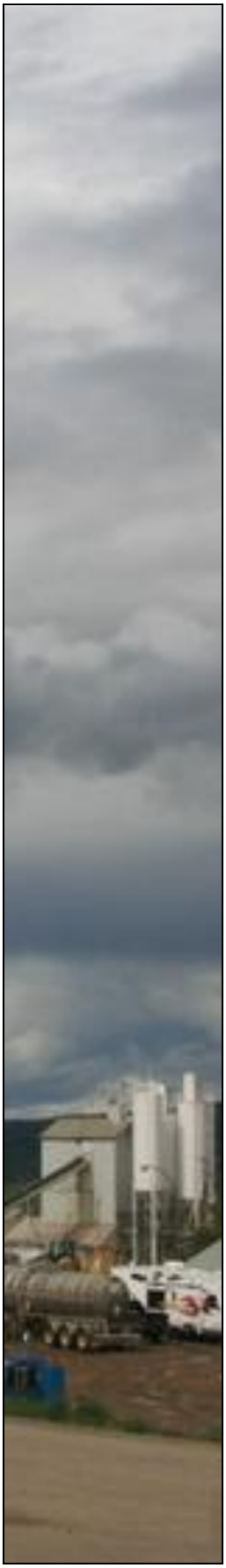
Surface Water Allocations and Actual Use, Upper Peace Watershed 2011(dam^3)



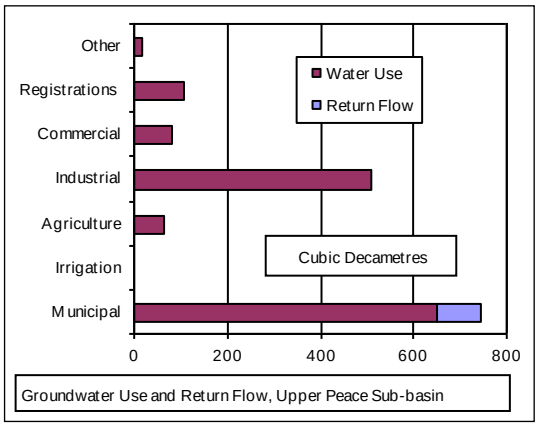
3.5.2 Groundwater

Licensed Use - Municipal water use also accounts for the largest portion of groundwater water allocations in the Upper Peace sub-basin. Allocations for municipal purposes amounted to 652 dam^3 or 46% of total allocations. The largest municipal groundwater licences have been issued to the Whitelaw water cooperative (21% of municipal allocations), the Village of Berwyn (18%), Eureka River (18%), and the Golden Meadows Water Users Ltd. (11%).





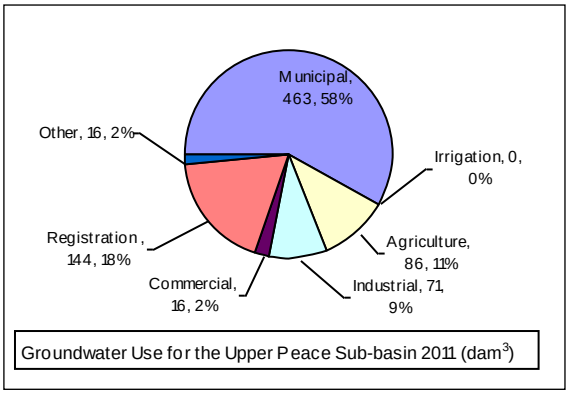
Industrial licences account for 36% of groundwater allocations and have been issued to companies like Husky Oil (4 licences), Talisman Energy (3 licences) and Apache Energy (3 licences) for injection purposes for oil and gas recovery. Small amounts of groundwater have been allocated to the agricultural sector (5% for licences and 8% of registrations) and for commercial purposes (4%).



Groundwater Use and Return Flow, Upper Peace Sub-basin

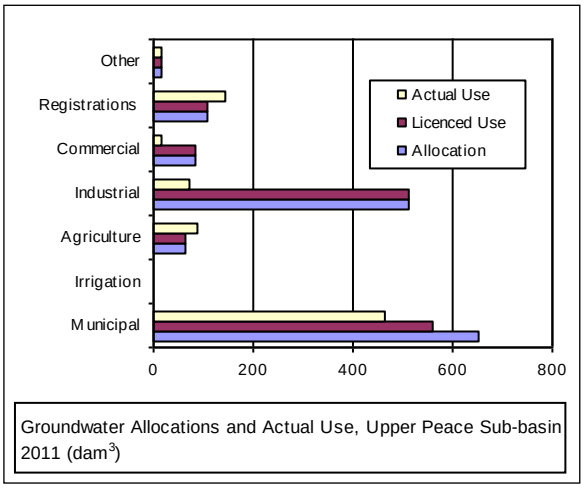
Only municipal water licences issued in this sub-basin have a return flow requirement, with the expectation that 14% of withdrawals will be used after use.

Actual Water Use - Total groundwater consumption in the Upper Peace sub-basin in 2011 is estimated to be 796 dam^3. This represents 56% of total groundwater allocations and 59% of licensed water use. Based on actual water use, municipal water use accounted for 58% of total groundwater use in the Upper Peace sub-basin. Industrial water use accounted for another 9%, while agricultural uses (licences, registrations and irrigation) collectively accounted for 29% of groundwater use. Water used for commercial purposes and other purposes each accounted for 2% of water use.

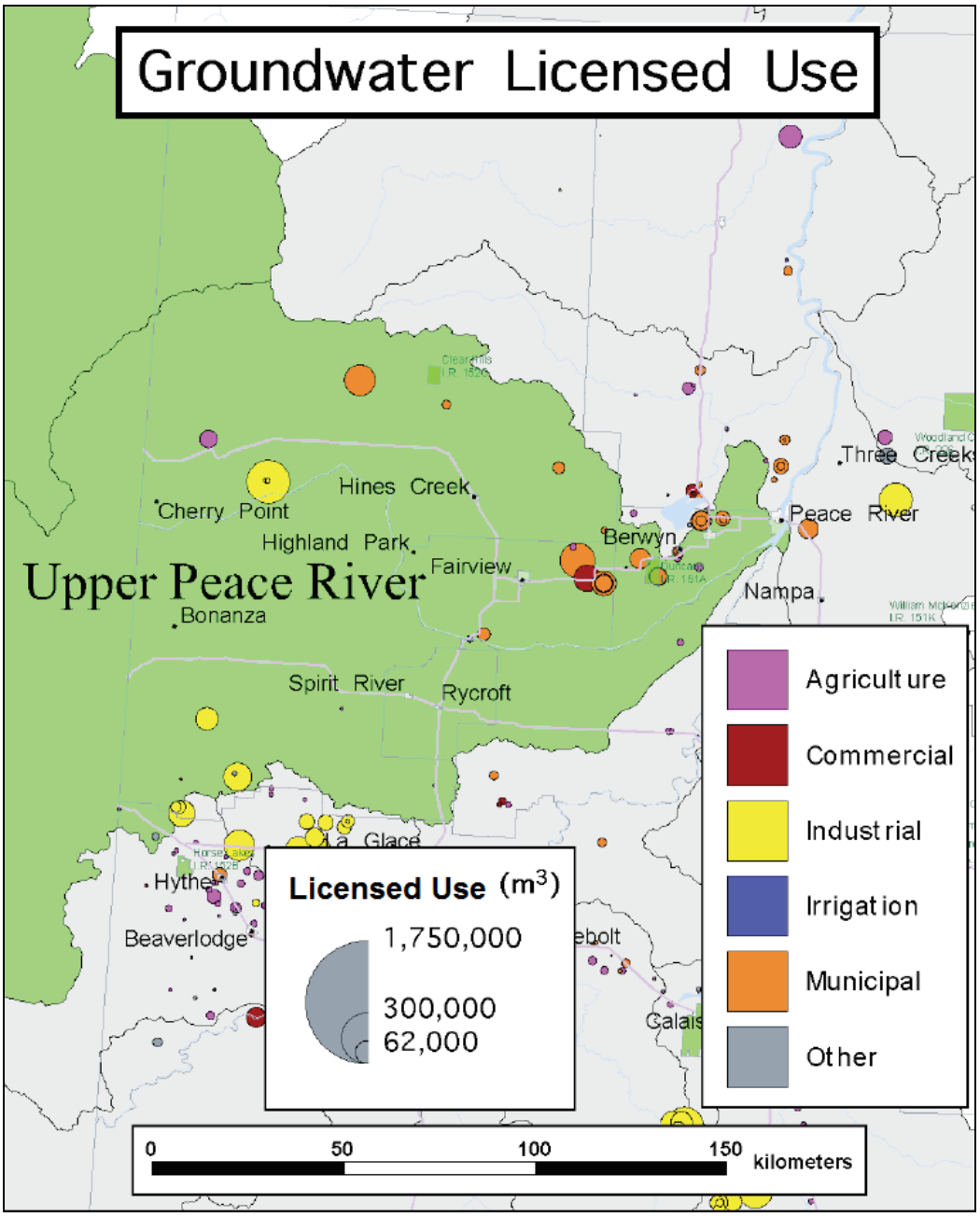


Groundwater Use for the Upper Peace Sub-basin 2011 (dam^3)

There are some differences in terms of the amount of groundwater allocated to each of the six sectors, compared to the amount of water that each sector is estimated to have used. The biggest differences are that only 14% of industrial allocations and 71% of municipal allocations are actually being used. Estimated groundwater use for registrations and agricultural licences exceeds allocations based on the amount of water being consumed by livestock populations in the sub-basin.

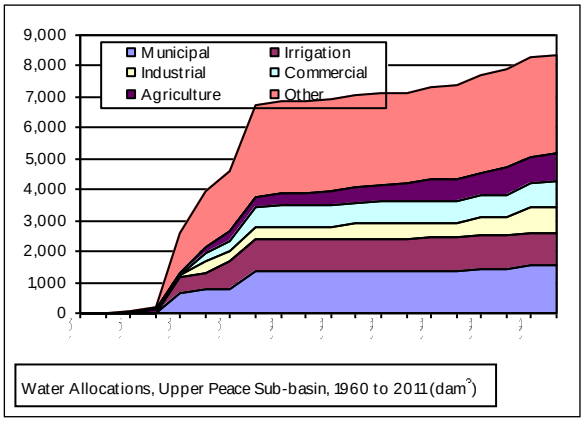


Groundwater Allocations and Actual Use, Upper Peace Sub-basin 2011 (dam^3)



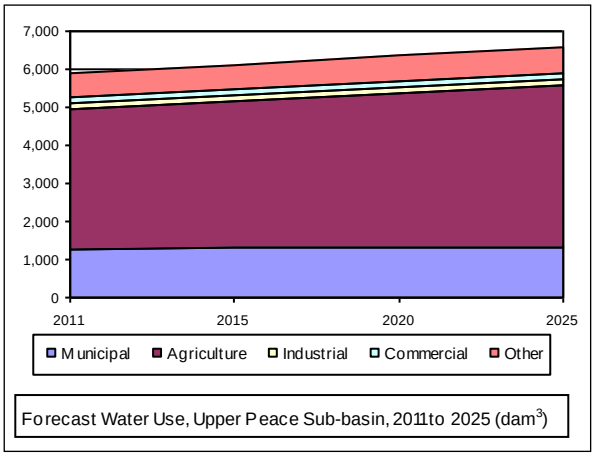
3.5.3 Future Demand

Since 2000 there has been a 22% increase in total water allocations in the Upper Peace sub-basin. This represents an average increase in allocations of about 139 dam^3 per year, with 69% of the increase having occurred since 2006.



Water Allocations, Upper Peace Sub-basin, 1960 to 2011 (dam^3)

Over the period from 2000 to 2011, the increase in allocations was mainly due to allocations issued for agricultural purposes (32% of the increase), industrial purposes (30%), other purposes (16%), municipal purposes (20%), and commercial purposes (9%). There has been no change in allocations of water for irrigation since 2000.



Forecast Water Use, Upper Peace Sub-basin, 2011to 2025 (dam^3)

Over the period from 2011 to 2025, water use in the Upper Peace sub-basin is expected to increase by 12%. There is expected to be minimal population growth in the region during this period, and increased water use for agricultural purposes is expected to the main factor affecting water use. Agricultural water use is expected to increase by 12%, and industrial demand, likely due to increased use of water for oil and gas recovery, is also expected to increase by 12%. Minimal growth in commercial water use or water used for other purposes is expected. The total change in water use is predicted to be 690 dam^3, and increased agricultural demand is predicted to account for 84% of the increase.

3.6 Water Quality

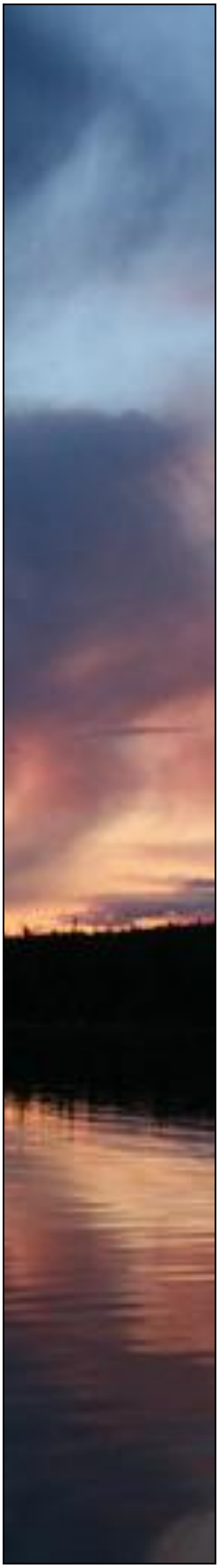
3.6.1 Surface Water

Surface water quality in the Upper Peace sub-basin is impacted by agriculture and forestry operations within the watershed. Agricultural runoff can contribute to lake and stream eutrophication, and can add pesticides and bacteria to surface water

AEW has a long-term river monitoring site on the Peace River at Shaftesbury Crossing. Information from this site is used to calculate the WQI. In 2009/10, water quality at this site was rated as 'good', with concentrations of metals and nutrients occasionally exceeding water quality guidelines.

The quality of water in Hines Creek above Gerry Lake is also monitored. Water quality at this site is affected by agricultural operations. Information from AARD indicates that water quality at this site was also rated as 'good', with levels of bioavailable nutrients being lower than for other streams that are similarly impacted by agriculture.

AEW has conducted water quality studies for a number of rivers and lakes within the sub-basin, either for baseline information, synoptic studies, or short-term monitoring events. Rivers that have been monitored include: Pouce Coupe River, Peace River at Dunvegan Bridge, Peace River above the Smoky River, and Hines Creek. Lakes that have been studied include: Bird's Pond Lake, Cardinal Lake, Stoney Lake, Gerry Lake, George Lake, Jones Lake, Cummings Lake, Clyde Lake, Sandhill Lake, Belloy Reservoir Lake, Codesa Lake, Eaglesham Lake, Boundary Lake, Unnamed Lakes, and Moonshine Lake.



3.6.2 Groundwater

AEW monitors the quality of groundwater in the Upper Peace sub-basin at four locations: two shallow wells (<30 m) and one intermediate depth well (30 – 100m) in the Grimshaw aquifer, east of the Town of Peace River, and at one intermediate depth well near Fairview.

3.7 Water Issues

As this sub-basin is extensively used for agriculture, a key water issue will be the extent to which agricultural activities may affect water quality for both surface and ground water. At present there are 13 cows for every resident of the basin, and livestock generates 1.945 million tonnes of manure. Expansion of livestock herds could increase manure production and, unless manure is managed in accordance with the *Agricultural Operations and Practices Act*, there will be concerns about the quality of surface run-off and potential contamination of groundwater below manure storage facilities. At present, the water quality in tributary streams appears to be acceptable, but this is based on limited monitoring and there is little information on the ecosystem health for tributary rivers.

Another current issue relates to concerns about potential drought and the effects this will have on all water users, and particularly agricultural users. Estimated water use based on current livestock populations exceeds licensed allocations and registrations. This means that, in case of a severe or prolonged drought that may lead to water rationing, there may be insufficient water for unlicensed agricultural users. This potential for shortages is unclear, partly because there is currently no information on water withdrawals and use for licences issued for irrigation or agricultural purposes.

A potential future issue relates to increased activity by the oil and gas industry. High oil prices may lead to increased use of enhanced oil recovery techniques that use fracking. Such activities may lead to more demand for water as a fracking fluid and to concerns about the potential effects of fracking on groundwater quantity and quality, especially in areas with limited surface water resources.

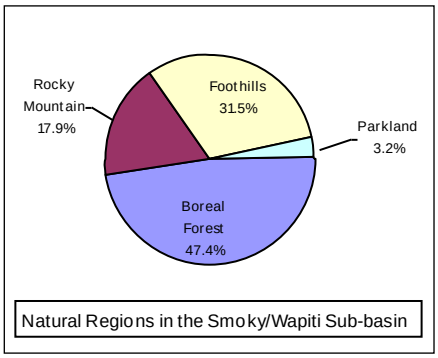
Another future issue relates to the ultimate impacts of the Dunvegan hydroelectric project. As a run-of-river project that will have limited storage, the Dunvegan project will not affect river flows. However, the project could represent a barrier to navigation and fish migration, depending on the effectiveness of project mitigation, and could affect the ice regime downstream. This reach of the Peace River could also be affected by any changes in the flow regime that might occur from development of the Site C hydroelectric project, especially during the period when the reservoir is being filled.

4.0 SMOKY/WAPITI RIVER SUB-BASIN

The Smoky/Wapiti sub-basin consists of lands that drain into either the Smoky or Wapiti Rivers above the confluence of the Smoky and Peace rivers. This coincides with the Water Survey of Canada sub-basin 07G.

4.1 Physiography

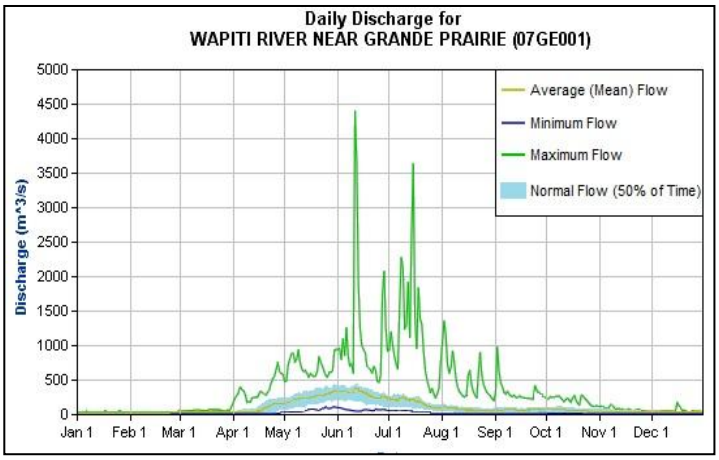
The Smoky/Wapiti sub-basin is about 46,720 km² in area and accounts for about 23% of the Peace watershed in Alberta. It is located primarily in the Boreal Forest Natural Region (47.4% of the sub-basin), but includes some areas of the Foothills Natural Region (31.6% of the sub-basin), with the headwaters of the Smoky River being located in the Rocky Mountain Natural Area (17.9% of the sub-basin). The Smoky/Wapiti sub-basin also includes a small area of the Parkland Natural Region (3.2% of the sub basin).



Natural Regions in the Smoky/Wapiti Sub-basin

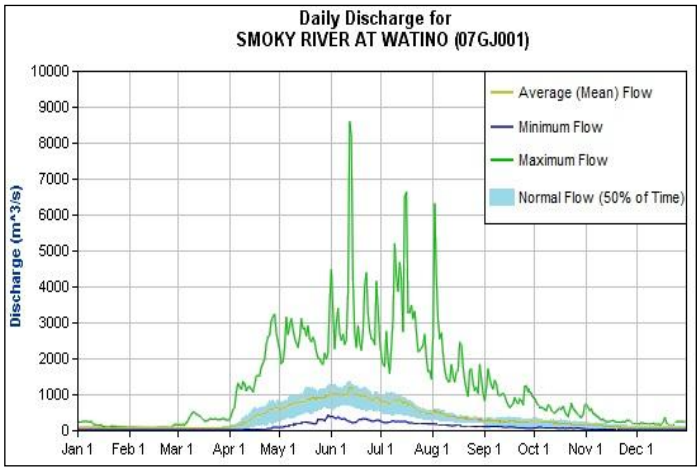
4.2 Hydrology

There are two key gauging stations in the Smoky/Wapiti sub-basin. One is located on the Wapiti River near Grande Prairie (07GE001). Average daily flows at this station have been recorded for the period from 1917 to 2010.



The normal flow of the Wapiti River is usually about 14 m^3/sec throughout the first three months of the year and then increases to 249 m^3/sec in May and 304 m^3/sec in June May and then gradually decreases to 70 m^3/sec in September and October before dropping to 20 m^3/sec in December. The average monthly discharge is 95 m^3/sec. However, over the period of record, there has been considerable variability in flows, with a maximum flow of nearly 4,500 m^3/sec having been recorded in early June. Flows of less than 7.8 m^3/sec have been reported in January through March.

The other is located on the Smoky River at Watino (07GJ001). Average daily flows at this station have been recorded for the period from 1915 to 2010.



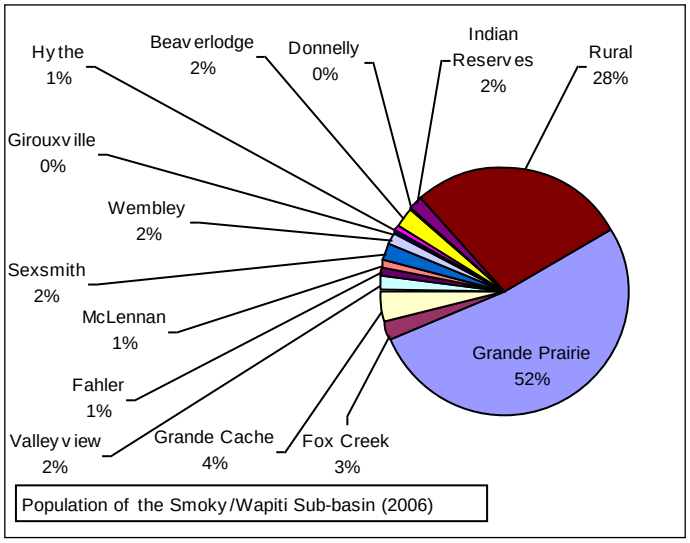
The normal flow of the Smoky River is usually about 50 m^3/sec throughout the first three months of the year and then increases to 344 m^3/sec in April. Flows peak at 995 m^3/sec in June and then gradually decrease to 274 m^3/sec in September before dropping to 66 m^3/sec in December. The average monthly discharge is 339 m^3/sec. However, over the period of record, there has been considerable variability in flows, with maximum flows of more than 8,500 m^3/sec having been recorded in mid-June. Flows of less than 25 m^3/sec have been reported in December through March.

Major tributaries of the Wapiti River include the Narraway River, the Redwillow River (which carries water from the Beaverlodge River) and Bear River. The Wapiti then joins the Smoky River east of Grande Prairie. Major tributaries of the Smoky River above its junction with the Wapiti include the Sulphur, Muskeg, Jackpine and Muddywater rivers (which join the Smoky River near Grande Cache), the Kakwa River and the Cutbank River. Major tributaries below the Wapiti confluence include the Simonette River, Kleskun Creek, Puskwaskau River, Bad Heart River, and Little Smoky River.

Although there are lots of small lakes in the upper reaches of the sub-basin, there are a number of larger lakes in the lower areas. These include Iosegun Lake near Fox Creek, Sturgeon Lake and Snipe Lake near Valleyview, Kimiwan Lake near McLennan and La Glace Lake, Bear Lake and Saskatoon Lake northwest of Grande Prairie. According to land cover information, there are no major wetland areas greater than 5,000 ha in the Smoky/Wapiti sub-basin.

4.3 Socio-Economic Characteristics

In 2006, approximately 90,890 people lived in the Smoky/Wapiti sub-basin; this represents 66.5% of the entire population of the Peace watershed. More than half lived in the City of Grande Prairie. Another 17% of the population lived in one of the eight towns in the sub watershed: Fox Creek, Grande Cache, Valleyview, Fahler, McLennan, Sexsmith, Wembley and Beaverlodge.

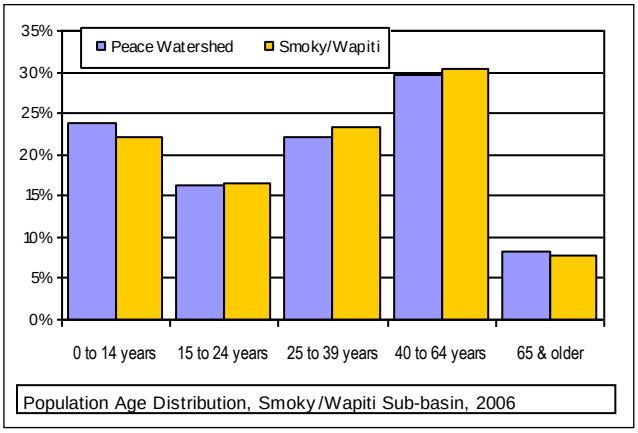


There are three villages (Donnelly, Girouxville, and Hythe) and they accounted for 1.3% of the population. There also three Indian Reserves in this sub-basin (Sturgeon Lake 154, Sturgeon Lake 154A and Horse Lakes 152B) and they also collectively accounted for 1.5% of the population. The other 28% of the population lived in rural parts of the sub-basin, including the municipal districts of Greenview No. 16 and Smoky River 130 and the counties of Birch Hills and Grande Prairie.

About 10.2% of the sub watershed population consisted of aboriginal people and 16% of these lived on the three reserves. The Sturgeon Lake 154 and Sturgeon Lake 154A reserves are two of three reserves established for the Sturgeon Lake Cree Nation while the Horse Lakes 153 reserve was established for the Horse Lake First Nation.

Between 2001 and 2006, the population of the Upper Peace sub-basin increased by 16.3%. Most of this increase occurred in Grande Prairie, which increased by 27.3%. Large increases also occurred in Sexsmith (18.5%), Hythe (41%), the three Indian reserves (16.3%), and the rural areas (9.5%). Most other communities grew at rates of less than 5% although population declines were reported in Falher (-15.1%), Girouxville (-7.8%), Valleyview (-7.1%), Wembley (-3.6%), Fox Creek (-2.5%) and Grande Cache (-1.2%).

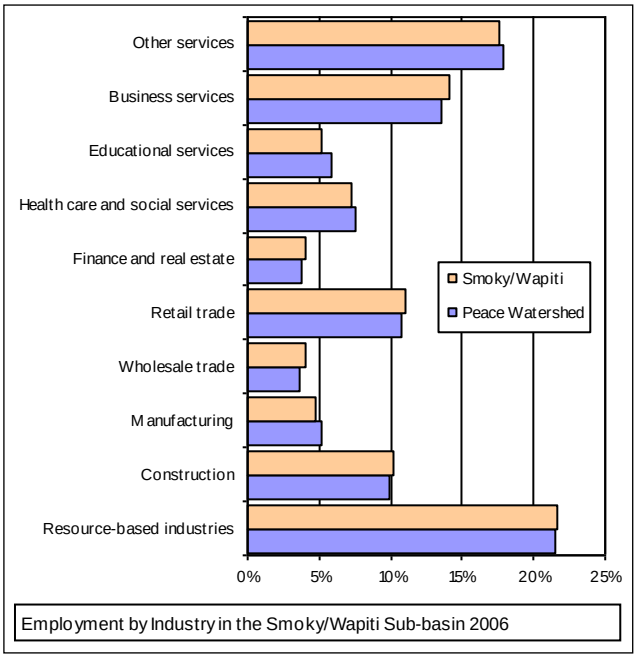
The age characteristics of people in the Smoky/Wapiti sub-basin are similar to those of the watershed as a whole. The biggest difference is that, in 2006, there was a lower percentage of children (under 15 years) in the Smoky/Wapiti sub-basin and a higher percentage of people in the 25 to 39 year age group. About 77.8% of the population in the sub-basin was 15 years of age or older and this was slightly higher than for the Peace watershed (76.2%).



Population Age Distribution, Smoky/Wapiti Sub-basin, 2006

In 2006, 78.7% of the adult labour force in the Smoky/Wapiti sub-basin were either working or seeking work (the labour force participation rate) and 4.1% were unemployed. While the labour force participation rate in the sub-basin was higher than for the Peace watershed (76.5%), the unemployment rate was lower than for the watershed (4.8%).

About 21.6% of the labour force in the Smoky/Wapiti sub-basin was employed in resource-based industries (including agriculture); this was slightly higher than for the entire Peace watershed. The employment profile for the Smoky/Wapiti sub-basin was very similar to that of the entire Peace watershed, primarily because this sub-basin accounted for two-thirds of the entire population of the watershed.



Employment by Industry in the Smoky/Wapiti Sub-basin 2006

Workers in the Smoky/Wapiti sub-basin reported median earnings of $31,864 in 2005. This was 7% higher than for the entire Peace watershed ($29,738) and was the highest in the watershed.

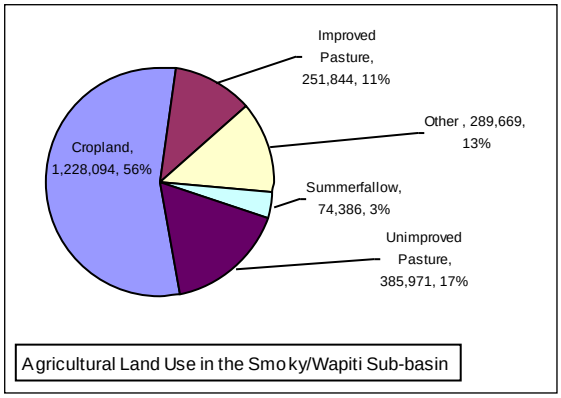
4.4 Land and Resource Use

About 79% of land in the Smoky/Wapiti sub-basin has been disturbed, primarily by agriculture or through forestry operations and oil and gas development.

4.4.1 Agriculture

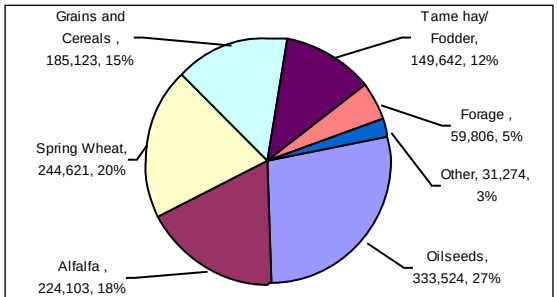
According to the 2006 Census of Agriculture there were 5,376 farms in the Smoky/Wapiti sub-basin. These farms covered an area of 2.23 million ha; this represents 48% percent of the sub-basin.

More than half of agricultural land consisted of cropland (56%) with unimproved pasture accounting for 17%, improved pasture accounting for 11%. The balance consisted of summerfallow (3%) and other agricultural uses (13%).



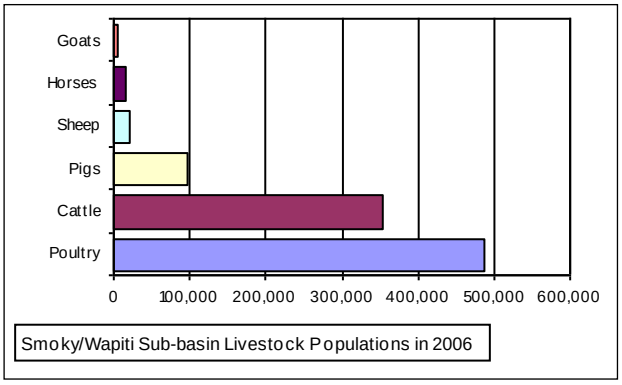
Agricultural Land Use in the Smoky/Wapiti Sub-basin

The most important crops grown in sub-basin include oil seeds (27% of field crops), spring wheat (20%), alfalfa (18%), other grains and cereals (15%) and tame hay/fodder (12%). Forty-one farms reported using irrigation on 797 ha of land, primarily for fruit crops and hay.



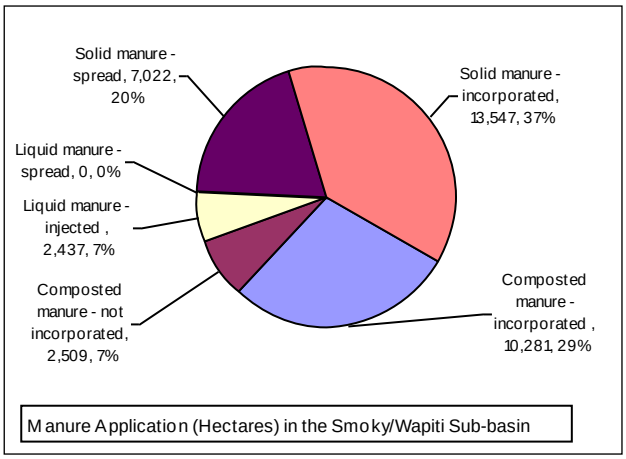
Crop Land Use in the Smoky/Wapiti Sub-basin

The majority of the farms in the Smoky/Wapiti sub-basin (63%) raised livestock. About 43% of farms raised cattle (averaging 152 animals per farm) and 33% raised horses (9 per farm). Small number of farms raised other types of livestock including poultry (7%), hogs (3%), sheep (4%) and goats (2%). In total, there were about 978,000 animals (including poultry) in this sub-basin in 2006. This includes 352,790 cattle, 95,990 hogs, 20,596 sheep, 16,263 horses and 5,478 goats. These animals generated 3.78 million tonnes of manure.



Smoky/Wapiti Sub-basin Livestock Populations in 2006

In terms of land management, 22% of farms applied manure to 37,513 ha of land, suggesting an average rate of 101 tonnes of manure per hectare. The most common types of manure application included incorporation of solid manure (37% of the land area), incorporating composted manure (29% of the land area), spreading of solid manure (20%).



Manure Application (Hectares) in the Smoky/Wapiti Sub-basin

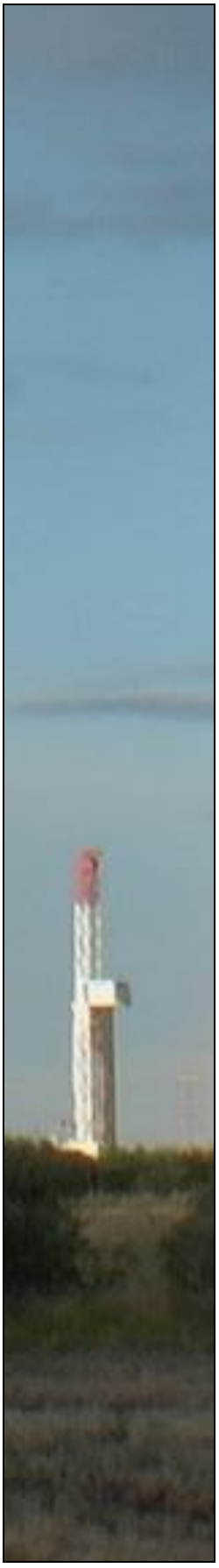
In addition, 43% of farms used chemical fertilizers on 840,064 ha (68% of cropland).

4.4.2 Forestry

In 2012 there were two sawmills in the Smoky/Wapiti sub-basin, including one in Grande Prairie (Canadian Forest Products Ltd.) and one at Grande Cache (Foothills Forest Products Ltd.). There is one pulp mill (the Weyerhaeuser pulp mill) and a panel board operation (Ainsworth Engineered), both of which are located in Grande Prairie. Parts of seven FMAs are located in the Smoky/Wapiti sub-basin. The largest FMAs have been issued to Weyerhaeuser Company Limited and Canadian Forest Products. The southwest corner of the sub-basin includes parts of FMAs issued to ANC Timber Ltd., Blue Ridge Timber Inc., Millar Western Forest Products, and Gordon Buchanan Enterprises/Tolko Industries Ltd. The sub-basin also includes part of an FMA issued to Tolko Industries Ltd. (High Prairie).

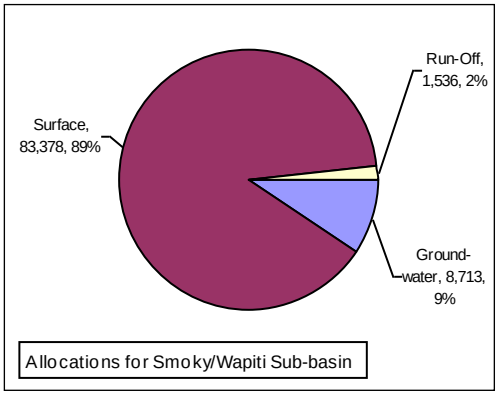
4.4.3 Oil and Gas

A total of 26,331 oil and gas wells have been drilled in the Smoky/Wapiti sub-basin; this represents 43% of all wells drilled in the Peace watershed. There are also 85,050 km of seismic lines and 14,955 km of pipelines. This density of oil and gas activity has resulted in an average disturbance of 4.1 km of linear disturbance per square kilometre of land (excluding agricultural land). This is the second most intensive land use disturbance in all of the sub-basins and is nearly double the average for the Peace watershed (2.2 km/km^2).



4.5 Water Use

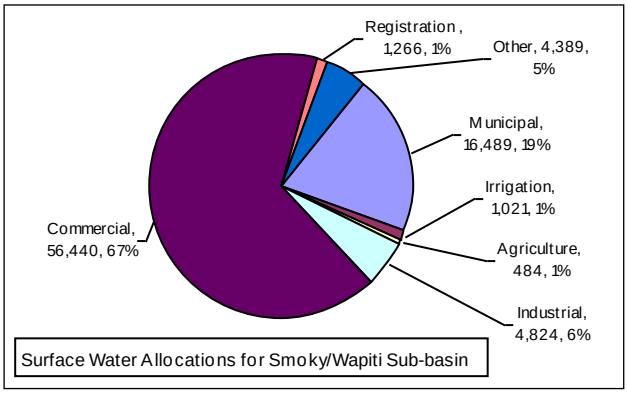
The most recent water licence information indicates that a total of 93,086 dam^3 of water has been allocated for use. This represents 56% of water allocations in the entire Peace River watershed. Allocations in the Smoky/Wapiti sub-basin consist primarily of surface water (83,378 dam^3 or 89%) but also include small amounts of groundwater (8,713 dam^3 or 9%) and surface run-off (1,536 dam^3 or 2%).



4.5.1 Surface Water

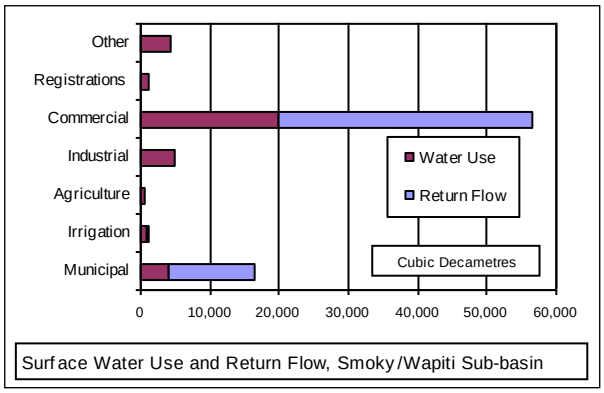
Licensed Use – Commercial water allocations account for the largest portion of surface water allocations in the Smoky/Wapiti sub-basin. Allocations for commercial purposes amounted to 56,440 dam^3 or 67% of total allocations. The largest license issued for commercial purposes was issued to Weyerhaeuser Canada Ltd.; this licence accounts for 72% of total commercial allocations. Another large commercial licence has been issued to Milner Power Inc. for its Grande Cache operation (22% of commercial allocations).

Municipal allocations accounted for 19% of surface water allocations in the Smoky/Wapiti sub-basin. The largest municipal allocation was issued to Aquatera Utilities, which provides water to the City of Grande Prairie, the County of Grande Prairie, the Hamlet of Clairmont, and the Town of Sexsmith. The two licences issued for Aquatera Utilities account for 78% of total municipal allocations. A licence issued to Grande Cache accounts for 8% of municipal allocations.

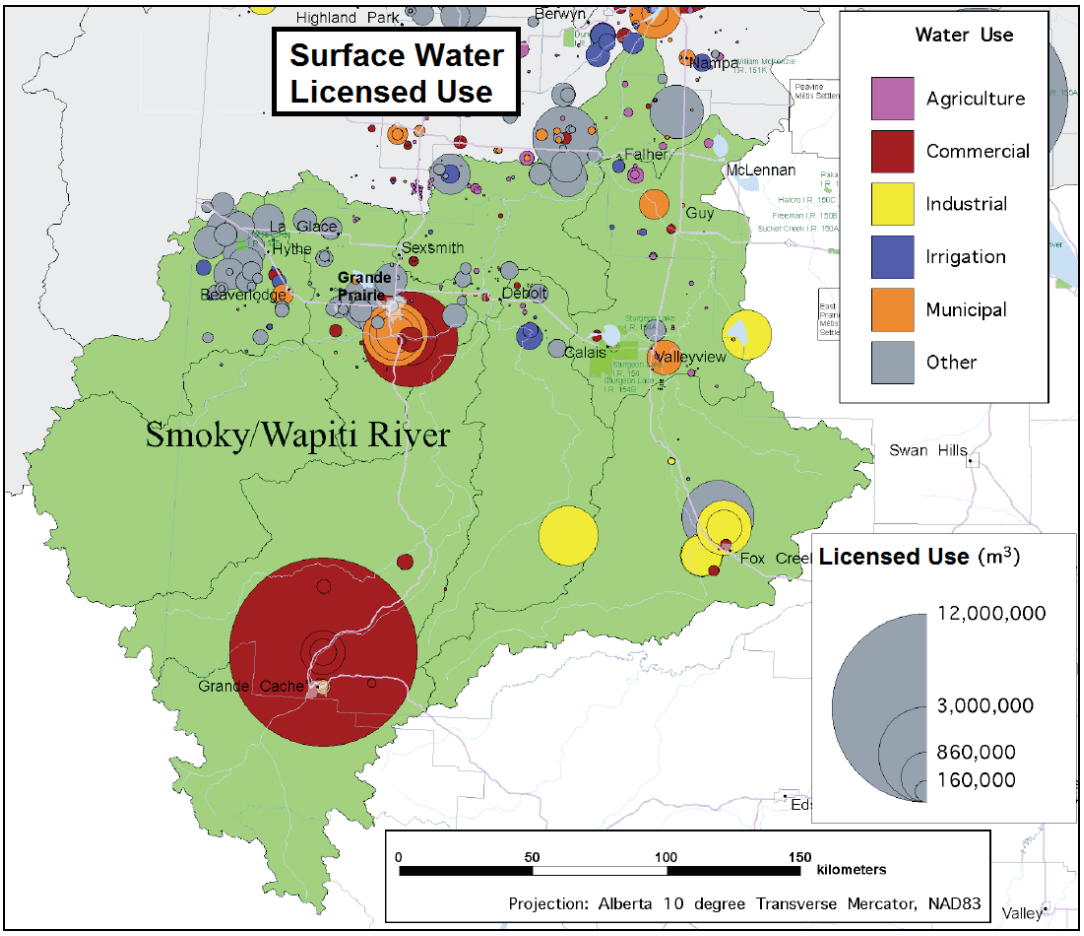


Industrial allocations account for 6% of allocations and include five licences issued for oilfield injection. Allocations for other uses account for 5%, while allocations for irrigation, agriculture and registrations each account for only 1% of surface water allocations.

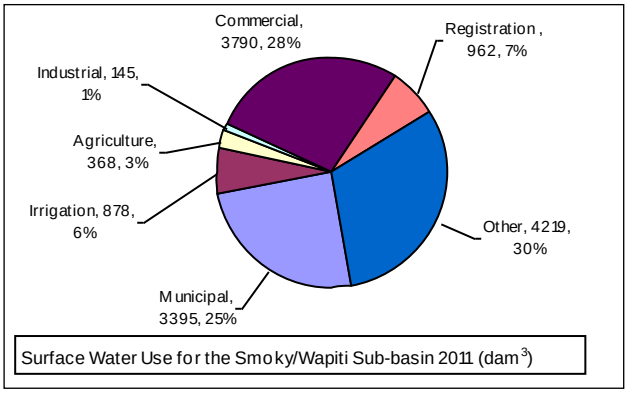
Water allocations include allowances for actual water use and may include expectations for return flow. Expectations for return flows have been included in some licences issued for commercial, municipal, industrial and other purposes. .



Overall, it is expected that 58% of withdrawals will be returned after use, including 65% of water withdrawn for commercial purposes, 75% of water withdrawn for municipal purposes, and 14% of water withdrawn for irrigation purposes.

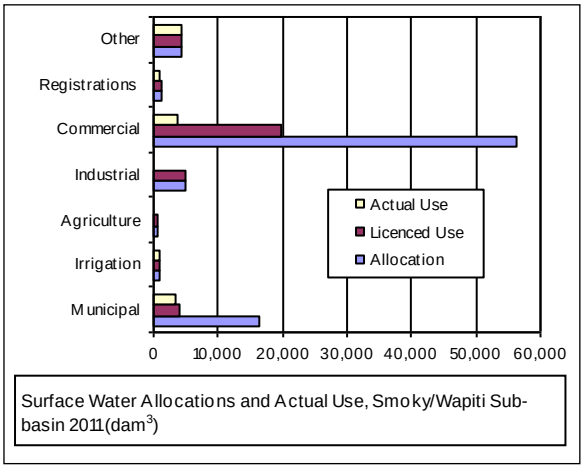


Actual Water Use - Total surface water consumption in the Smoky/Wapiti sub-basin in 2011 is estimated to be 13,756 dam^3. This represents 16% of total surface water allocations and 39% of licensed water use. Commercial water use is estimated to account for 28% of total surface water use in the Smoky/Wapiti sub-basin. Water allocated for other purposes accounted for 30% of estimated water use, while municipal water users accounted for another 25%. Agricultural uses accounted for 16% of total water use, including 6% for irrigation, 7% for registrations and 3% for agricultural licences. Industrial uses accounted for 1% of water use.



Surface Water Use for the Smoky/Wapiti Sub-basin 2011 (dam^3)

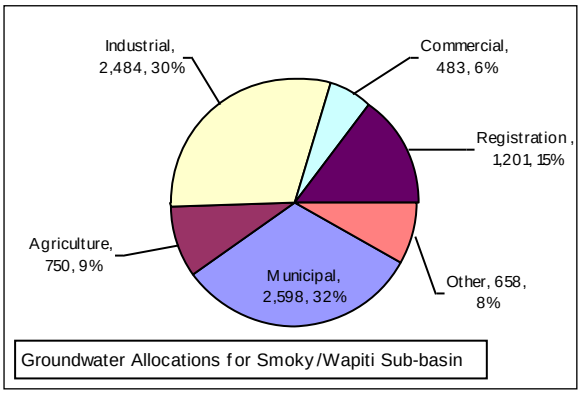
The biggest difference between water allocations and actual water use is that only 7% of commercial allocations are actually being used, and this is because most of the water withdrawn for power production at the Milner generating plant is being returned after use and because the plant withdraws less water than allowed by its licence. Only 21% of water allocations for municipal purposes were actually being used. There were small differences between allocations for agriculture, irrigation and other purposes and the amount of water actually being used.



Surface Water Allocations and Actual Use, Smoky/Wapiti Sub-basin 2011(dam^3)

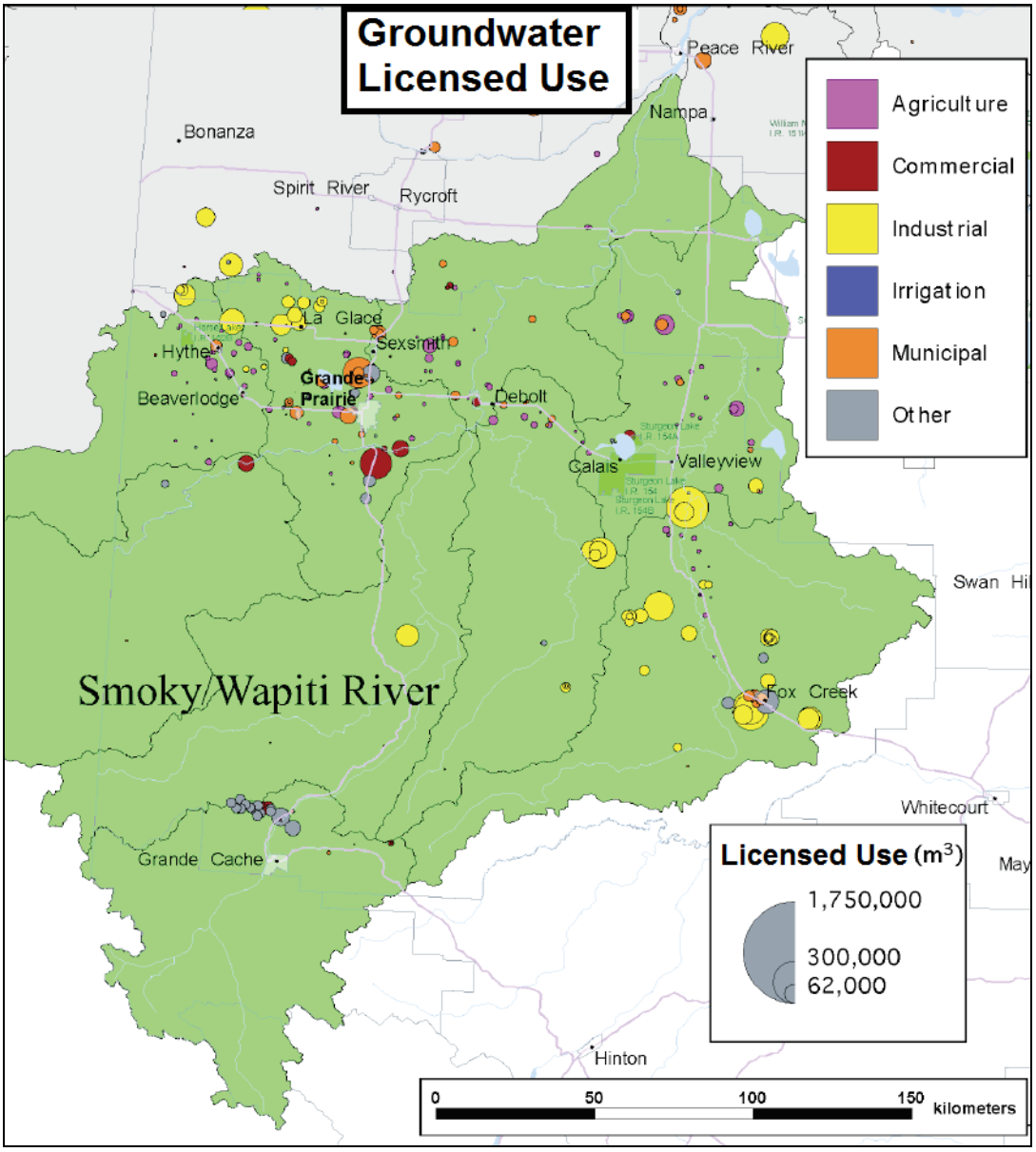
4.5.2 Groundwater

Licensed Use - Municipal water use accounts for the largest portion of groundwater water allocations in the Smoky/Wapiti sub-basin. Allocations for municipal purposes amounted to 2,598 dam^3 or 32% of total allocations. One large licence has been issued to the Town of Fox Creek (41% of the total municipal allocation), with other large municipal licences being issued to Grand Prairie County (13%), the Town of Sexsmith (12%), and the Village of Wembley (6%).

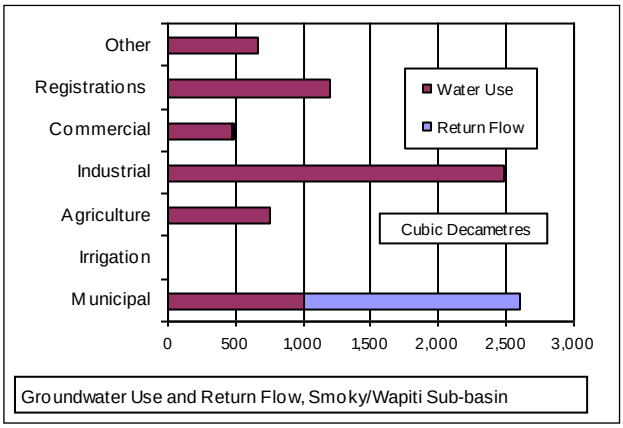


Groundwater Allocations for Smoky/Wapiti Sub-basin

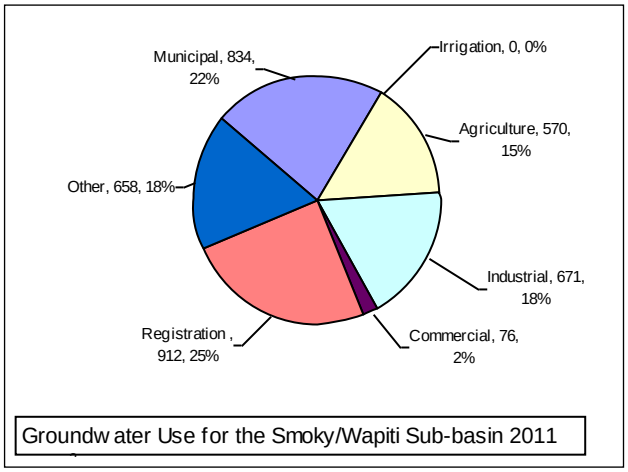
Industrial licences account for 30% of groundwater allocations, primarily for injection for oil recovery. The largest allocations have been issued to Amoco Canada Petroleum Co. Ltd. (25% of total industrial allocations), ATCO Power Valleyview (12%), and ARC Resources (12%). Multiple licences have been issued to Trilogy Energy Ltd. (four licences), Husky Oil (three licences), and Amoco Canada Petroleum Co. Ltd. (two licences), among others. Registrations account for another 15% of groundwater allocations. Small amounts of groundwater have been allocated in licences issued for agricultural (9%), commercial (6%) and other purposes (8%). Large commercial groundwater allocations have been issued to Ainsworth Lumber Co, Ltd. (35% of commercial allocations), Smoky River Coal (13%) and Lehigh Inland Cement Ltd. (10%).



Expectations for return flow have been included in some municipal water licences and a few licences issued for commercial purposes. Overall, it is expected that 20% of groundwater withdrawals will be returned after use, including 61% of water withdrawn for municipal purposes.

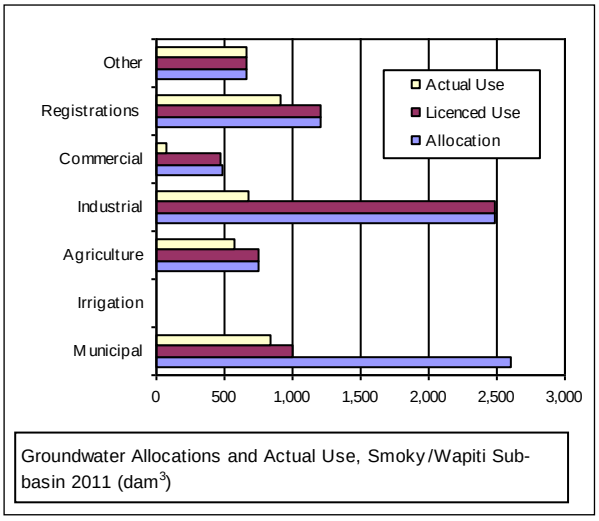


Actual Water Use - Total groundwater consumption in the Smoky/Wapiti sub-basin in 2011 is estimated to be 3,721 dam^3. This represents 46% of total groundwater allocations and 57% of licensed water use. Based on actual water use, municipal water use accounted for 22% of total groundwater use in the Smoky/Wapiti sub-basin. Agricultural water uses accounted for 40% of total water use, including 25% for registrations, and 15% for agricultural licences. Industrial water use accounted for another 18%, while other uses accounted for 18%. Water used for commercial purposes accounted for 2% of total water use.



Groundw ater Use for the Smoky/Wapiti Sub-basin 2011

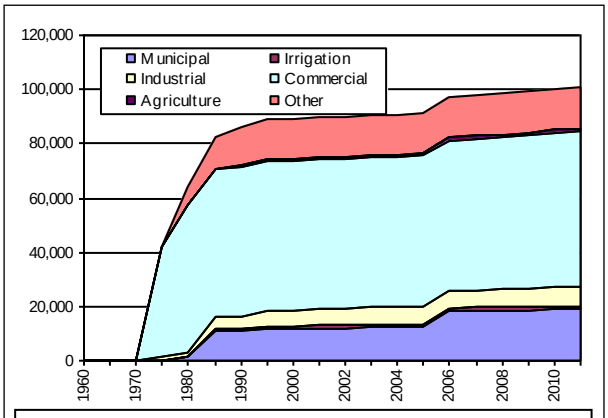
There are major differences in terms of the amount of groundwater allocated for municipal and industrial purposes, compared to the amount of water that they actually use. Only 27% of industrial allocations and 32% of municipal allocations are actually being used. Actual commercial water use is estimated to be 16% of commercial allocations. Estimated groundwater use for agricultural purposes (registrations and licences) was estimated to be 76% of allocations, based on the amount of water being consumed by livestock populations in the sub-basin.



Groundwater Allocations and Actual Use, Smoky/Wapiti Sub-basin 2011 (dam^3)

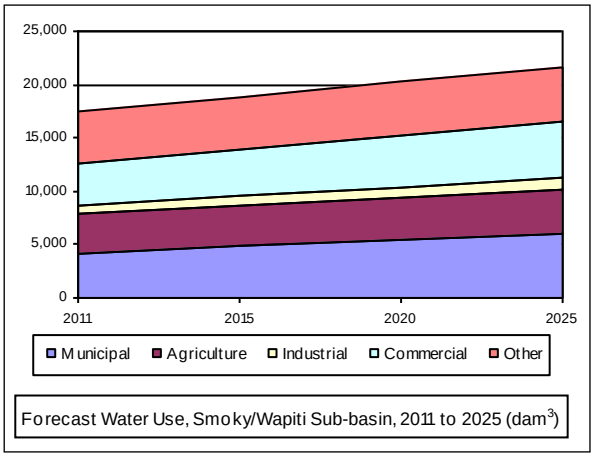
4.5.3 Future Demand

Since 2000 there has been a 13% increase in total water allocations in the Smoky/Wapiti sub-basin. This represents an average increase in allocations of about 1,088 dam^3 per year, with 33% of the increase having occurred since 2006. Over the period from 2000 to 2011, the increase in allocations was mainly due to increased allocations for municipal use (64% of the total increase).



Water Allocations, Smoky/Wapiti Sub-basin, 1960 to 2011 (dam3)

New allocations for commercial purposes accounted for 12% of the increase, industrial purposes accounted for 11% of the increase, while allocations for other purposes accounted for 7% of the increase. Allocations of water for agriculture and irrigation purposes has increased little since 2000, with these uses accounting for 7% of the total change.



Forecast Water Use, Smoky/Wapiti Sub-basin, 2011 to 2025 (dam^3)

Over the period from 2011 to 2025, water use in the Smoky/Wapiti sub-basin is expected to increase by 24%. Continued population growth is expected, although the annual rate of growth is expected to decline over time. Municipal water use is expected to increase by 40% during this period. Commercial water use is also expected to increase by 40%; this is predicated on the assumption that most new commercial development will occur in the part of the watershed with the largest population. There is expected to be some growth in water used for agricultural purposes (16%), for industrial purposes (16%) and for other purposes. The total change in water use is predicted to be 4,225 dam^3, and increased municipal demand is predicted to account for 40% of the increase.

4.6 Water Quality

4.6.1 Surface Water

Surface water quality within the Smoky/Wapiti sub-basin is impacted by agriculture and by mining and forestry operations in the Upper Smoky basin. Agricultural runoff can contribute to lake and stream eutrophication, and the presence of pesticides and bacteria in surface water. While BOD and AOX associated with pulp mill effluent were issues in the Smoky/Wapiti sub-basin, downstream from the mills in Grande Prairie, loadings have decreased as a result of technology upgrades at the mills (See Section 2.7). In addition, there have been some issues with elevated selenium in the surface water downstream of open-pit coal mines near Grande Cache.

AEW's River WQI is calculated using water quality information from three long term monitoring sites in the Smoky/Wapiti sub-basin. These three sites include two sites on the Wapiti River (one at Highway 40 and the other above the confluence with Smoky River) and a site on the Smoky River at Watino. Data for 2009/10 indicate the water quality at all three sites was being 'good', with concentrations of nutrients and some metals occasionally exceeding water quality guidelines.

AARD also conducts water quality monitoring at two agriculturally-impacted sites within the sub basin: on the Kleskun Hills Main Drain and on Grande Prairie Creek. The WQI at both sites was rated as 'marginal' due to high concentrations of nutrients and pesticides, especially at the Kleskun site, and elevated levels of suspended sediment.

AEW has conducted water quality studies on a number of rivers and lakes within the Smoky/Wapiti sub-basin for baseline information, synoptic studies, or short-term monitoring events. Water quality studies have been conducted for the Smoky River at multiple locations within the mine site, above confluences with major creeks and rivers, at Watino, and at the Bezanson Bridge. Water quality studies have also been conducted for the Wapiti River above confluences with major creeks and rivers and upstream and downstream of major effluent discharges, and on Sheep Creek, Muskeg River, Beaverdam Creek, Beaverlodge River, Steeprock Creek, Redwillow River, Spring Creek, Big Mountain Creek, Bear River, Bridlebit Creek, Sturgeon Creek, Woodpecker Creek, and Bear River. Water quality studies have been conducted for the following lakes: South Lake, Spring Lake, Saskatoon Lake, Musreau Lake, Grand Cache Lake, Clairmont Lake, Flyingshot Lake, Goose Lake, Long Lake, Joachim Lake, Pierre Gray's Lake, Boone Lake, Ptarmigan Lake, Wilson Lake, Cutbank Lake, Sturgeon Lake, Kakut Lake, Snipe Lake, Dollar Lake, Swan Lake, Smoke Lake, Wapiti Lake, Lingrell Lake, Two Lake, Trap Lake, Sinclair Lake, Iosegun Lake, and Meekwap Lake.

4.6.2 Groundwater

AEW monitors groundwater quality at five locations in the Smoky/Wapiti sub-basin. There are shallow wells near Hythe and Watino and three intermediate-depth wells near Hythe, Beaverlodge, and Kleskun.

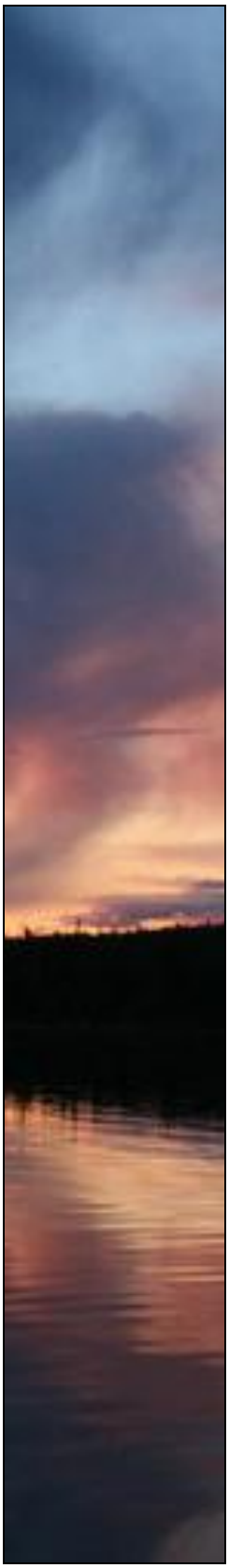
4.7 Water Issues

The effect of agriculture on water quality is already an issue in this sub-basin, with the quality of water in two tributary creeks already being rated as 'marginal'. Expansion of livestock herds could increase manure production and, unless manure is managed in accordance with the *Agricultural Operations and Practices Act*, there will be concerns about the quality of surface run-off and potential contamination of groundwater below manure storage facilities. There is little information on the effects that agricultural operations have had on ecosystem health for other tributary creeks and rivers.

The key concern for this sub-basin relates to anticipated population growth in Grande Prairie, which draws much of its water from the Wapiti River. Increased demands on the river could begin to affect ecosystem health, especially during periods of low flows. These effects could be exacerbated by increased demands for water along the upper reaches of the Wapiti or lower precipitation. Addressing these problems will require completing an instream needs assessment, establishing a water conservation objective for the river, and rationing during low flows. This may cause some users to seek water from other sources.

Another potential future issue relates to increased activity by the oil and gas industry. High oil prices may lead to increased use of enhanced oil recovery techniques and fracking. Such activities may lead to more demand for water as a fracking fluid and to concerns about the potential effects of fracking on aquifer integrity, which may potentially affect both groundwater quantity and quality, especially in areas with limited surface water resources.

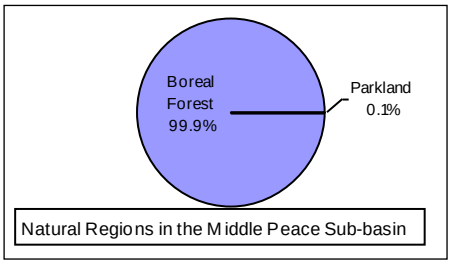
5.0 CENTRAL PEACE RIVER SUB-BASIN



The Central Peace sub-basin consists of lands that drain into the Peace River downstream from the confluence of the Smoky River and upstream of Fort Vermilion. This coincides with the Water Survey of Canada sub-basin 07H.

5.1 Physiography

The Central Peace sub-basin is about 35,035 km² in area and accounts for about 17% of the Peace watershed in Alberta. It is located almost entirely in the Boreal Forest Natural Region (99.9%), but includes a very small area within the Parkland Natural Region (0.1% of the sub-basin).

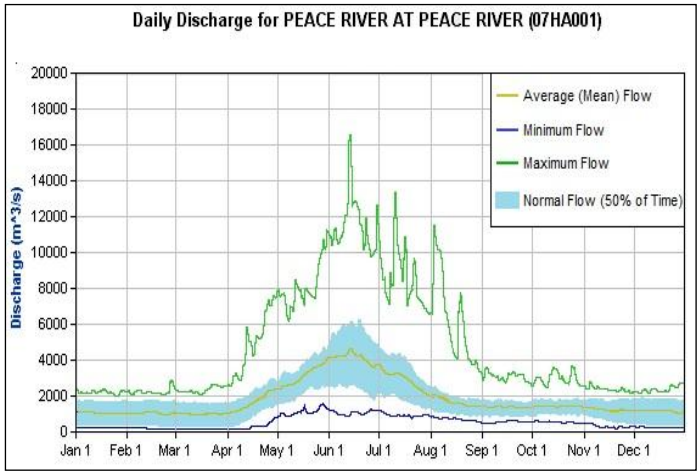


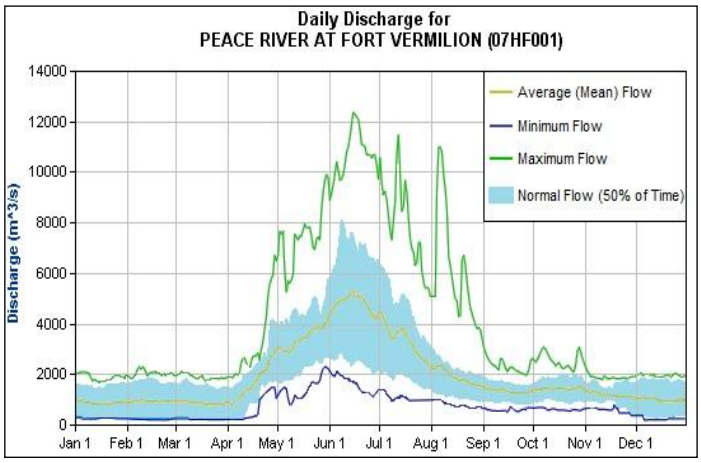
Natural Regions in the Middle Peace Sub-basin

5.2 Hydrology

There are two gauging stations on this reach of the Peace River. One is located just downstream with the junction of the Smoky River near the Town of Peace River (07HA001) while the other is located just above Fort Vermilion (07HF001). Average daily flows at these stations have been recorded for the period from 1915 to 2010.

The average annual flow of the Peace River at the Town of Peace River is 1,830 m^3/sec. However, flows during the first three months of the year are about 1,000 m^3/sec, increasing to a peak of about 4,150 m^3/sec in mid-June. Flows then gradually decrease to about 1,400 m^3/sec in September and October before dropping to about 1,200 m^3/sec in December. However, over the period of record, flows have been highly variable with flows of less than 220 m^3/sec having been reported in March and February and peak flows of more than 16,000 m^3/sec having been recorded in mid-June.



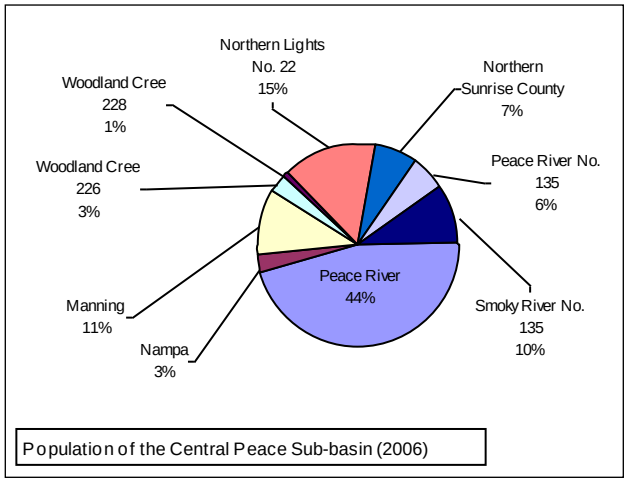


The normal flow of the Peace River at Fort Vermilion is usually about 900 m^3/sec throughout the first three months of the year and then gradually increases to a peak of about 4,800 m^3/sec in mid-June. Flows then gradually decrease to about 2,200 m^3/sec in September and October before dropping to about 1,000 m^3/sec in December. The average monthly discharge is 1,950 m^3/sec. However, over the period of record, there has been considerable variability in flows, with maximum flows of more than 12,000 m^3/sec having been recorded in mid-June. Flows of less than 230 m^3/sec have been reported in March and February.

Major tributaries of the Peace River downstream of the Smoky River confluence include the Heart River, Whitemud River, Cadotte River, Notikewin River, Wolverine River, Buffalo River and the Keg River. There are few large lakes in the sub-basin, with the largest ones including Cardinal Lake near Grimshaw, Cadotte Lake and Bison Lake.

There are 4,390 km^2 of large wetland areas (>5000 ha) in this sub-basin. They cover 12.5% of the land area and account for 27.6% of all large wetland areas in the Peace watershed.

5.3 Socio-Economic Characteristics

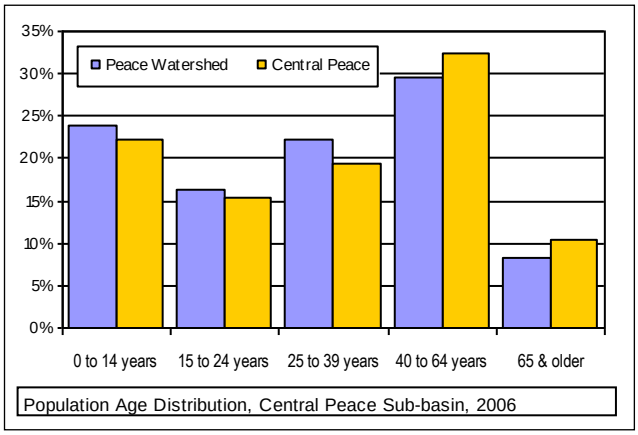


In 2006, approximately 13,890 people lived in the Central Peace sub-basin; this represents 10.2% of the population of the Peace watershed. About 46% of the population lived in the Town of Peace River (6,315 people) while 37% lived in rural parts of the sub-basin, including Northern Sunrise County and the municipal districts of Northern Lights No. 22, Peace River No. 135, and Smoky River No. 130. Another 11% of the population lived in the Town of Manning and 3% lived in the Village of Nampa. The other 4% of the population lived on the Woodland Cree 226 and 228 reserves.

About 17.4% of the sub watershed population consisted of aboriginal people and 24.9% of these lived on the two reserves. The Woodland Cree 226 and 228 reserves are two of four reserves established for the Woodland Cree First Nation.

Between 2001 and 2006, the population of the Central Peace sub-basin decreased by 0.9%. While the population of Peace River increased by 1.2% and the population of Manning increased by 15.5%, the rural population decreased by 7.8%. The on-reserve population grew by 8.2%. The population of Nampa decreased by 3.2%.

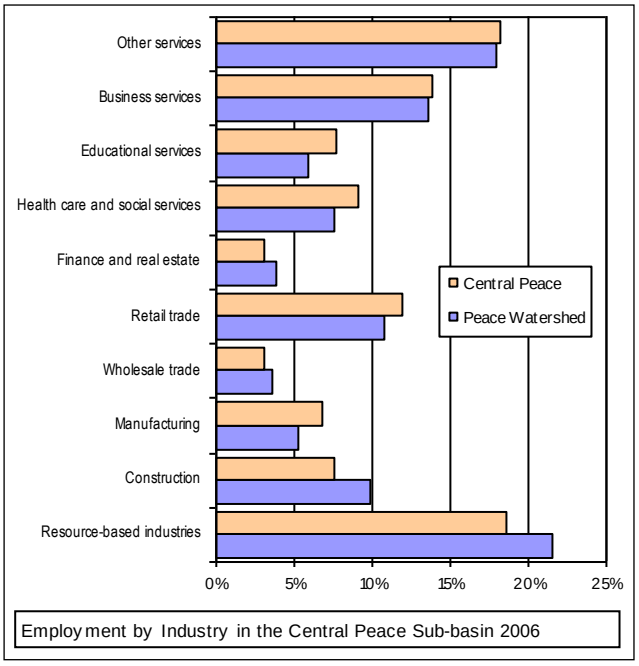
Residents of the Central Peace sub-basin tend to be older when compared to the Peace watershed as a whole. This sub-basin had lower percentages of people under the age of 40 years and higher percentages of people aged 40 years and older. About 77.8% of the population in the sub-basin was 15 years of age or older and this was slightly higher than for the Peace watershed (76.2%).



Population Age Distribution, Central Peace Sub-basin, 2006

In 2006, 77.8% of the adult labour force in the Central Peace sub-basin were either working or seeking work (the labour force participation rate) and 4.7% were unemployed. The labour force participation rate in the sub-basin was higher than for the Peace watershed (76.5%), and the unemployment rate for the sub-basin was slightly lower than for the watershed (4.8%).

About 18.6% of the labour force in the Central Peace sub-basin was employed in resource-based industries (including agriculture); this is slightly lower than for the entire Peace watershed (21.5%). The Central Peace sub-basin had higher percentages of people with experience in the retail trade industry (11.9%), manufacturing industry (6.8%), educational services industry (7.7%), and health care and social services (9.1%). Compared to the overall Peace watershed, this sub-basin had lower percentages of employment in construction industry (7.6%) and finance and real estate (3.1%).



Employment by Industry in the Central Peace Sub-basin 2006

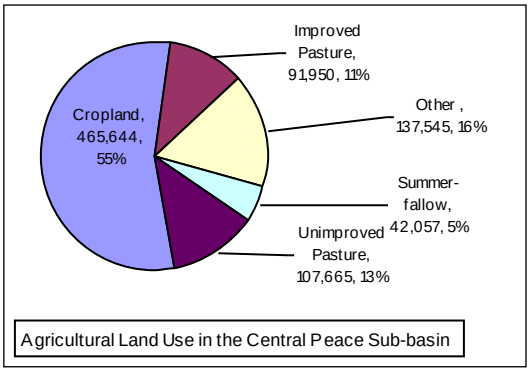
Workers in the Central Peace sub-basin reported median earnings of $29,612 in 2005. This was 0.5% lower than for the entire Peace watershed ($29,738).

5.4 Land and Resource Use

About 66% of land in the Central Peace sub-basin has been disturbed, primarily by agriculture, forestry operations, and oil and gas development.

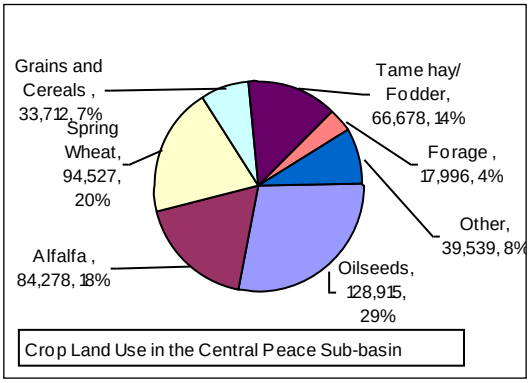
5.4.1 Agriculture

According to the 2006 Census of Agriculture there were 1,878 farms in the Upper Peace sub-basin. These farms covered an area of 0.84 million ha; this represents 24.0% of the sub-basin. More than half of agricultural land consisted of cropland (55%) with unimproved pasture accounting for 13%, and improved pasture accounting for 11%.



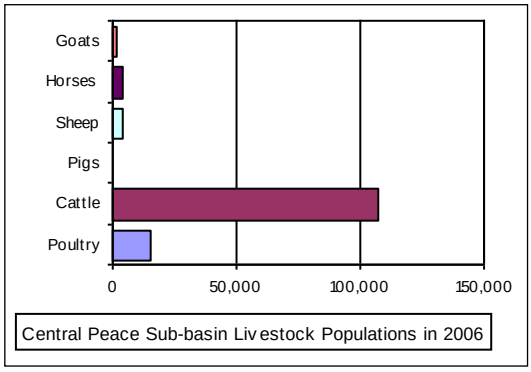
Agricultural Land Use in the Central Peace Sub-basin

The most important crops grown in sub-basin include oil seeds (29% of field crops), spring wheat (20%), alfalfa (18%), tame hay/fodder (14%), and other grains and cereals (7%). Eleven farms reported using irrigation on 10 ha of land, primarily for fruits and vegetables.

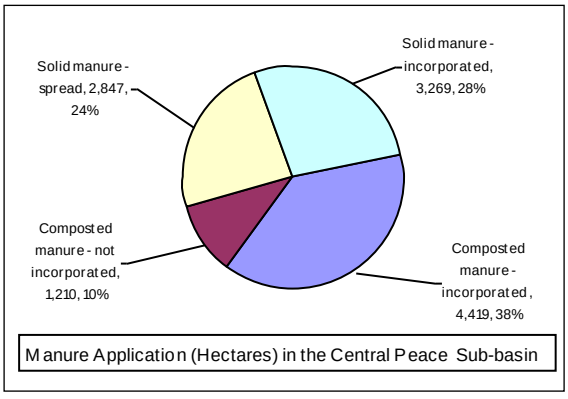


Crop Land Use in the Central Peace Sub-basin

The majority of the farms in the Central Peace sub-basin (56%) raise livestock. About 39% of farms raised cattle (averaging 145 animals per farm) and 28% raised horses (8 per farm). Small number of farms raised other types of livestock including poultry (10%), hogs (4%), sheep (3%) and goats (3%). In total, there were about 134,000 animals (including poultry) in this sub-basin in 2006. This includes 107,182 cattle, 1,073 hogs, 4,277 sheep, 3,937 horses and 1,614 goats. These animals generated 1.11 million tonnes of manure.



Central Peace Sub-basin Livestock Populations in 2006



Manure Application (Hectares) in the Central Peace Sub-basin

In terms of land management, 20% of farms applied manure to 12,630 ha of land, suggesting an average rate of 88 tonnes of manure per hectare. The most common types of manure application included incorporating composted manure (38% of the land area), incorporation of solid manure (28%), and spreading of solid manure (24%).

In addition, 48% of farms used chemical fertilizers on 330,675 ha (71% of cropland).

5.4.2 Forestry

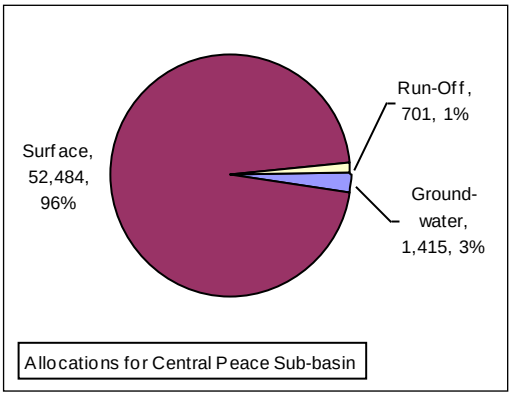
There are three sawmills in the Central Peace sub-basin, including one at Peace River (Paul's Sawmill and Planer), one at Nampa (Boucher Bros. Lumber Ltd.) and one at Manning (Mannining Diversified Forest Products Ltd.). There is also one pulp mill in the sub-basin: the Daishowa-Marubeni International Ltd. pulp mill north of Peace River. Parts of three FMAs are located in the Central Peace sub-basin. The largest FMA has been issued to Daishowa-Marubeni International Ltd., including much of the area east of the Peace River. Part of the FMA issued to Manning Diversified Forest Products is also located in this sub-basin, as is part of the FMA issued to Gordon Buchanan Enterprises/Tolko Industries Ltd.

5.4.3 Oil and Gas

A total of 7,134 oil and gas wells have been drilled in the Central Peace sub-basin; this represents 12% of all wells drilled in the Peace watershed. There are also 69,900 km of seismic lines and 3,670 km of pipelines. This density of oil and gas activity has resulted in an average disturbance of 2.6 km of linear disturbance per square kilometre of land (excluding agricultural land). This is slightly higher the average for the Peace watershed (2.2 km/km^2).

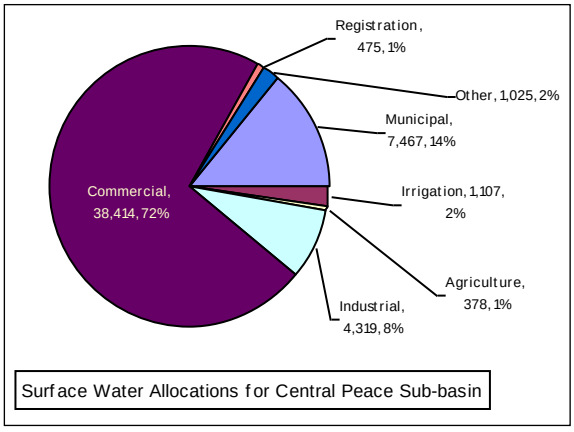
5.5 Water Use

The most recent water licence information indicates that a total of 54,600 dam^3 of water has been allocated for use in the Central Peace sub-basin. This represents 33% of water allocations in the entire Peace River watershed. Allocations in the Central Peace sub-basin consists primarily of surface water (52,484 dam^3 or 96%) but also includes small amounts of groundwater (1,415 dam^3 or 3%) and surface run-off (701 dam^3 or 1%).

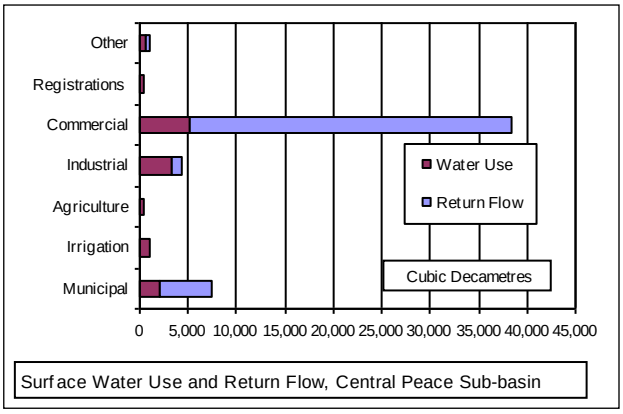


5.5.1 Surface Water

Licensed Use – Commercial water use accounts for the largest portion of surface water allocations in the Central Peace sub-basin. Allocations for commercial purposes amounted to 38,414 dam^3 or 72% of total allocations. Almost all of the water allocated for commercial purposes (96%) is contained in one licence issued to Daishowa-Marubeni International Ltd. Another licence issued for the silica mining and sand processing facility accounts for another 3% of total commercial allocations.



Allocations for municipal use accounts for 14% of surface water allocations. Licences issued to the Town of Peace River account for 77% of total municipal allocations while licences issued to the Town of Manning account for another 8%. Industrial use accounts for 8% of total allocations, and this consists of three licences issued to Shell Canada for injection purposes. Agricultural uses account for 4% of surface water allocations, including 2% for irrigation, 1% for registrations and 1% for agricultural licences. Water allocations for other purposes accounted for 2% of surface water allocations.



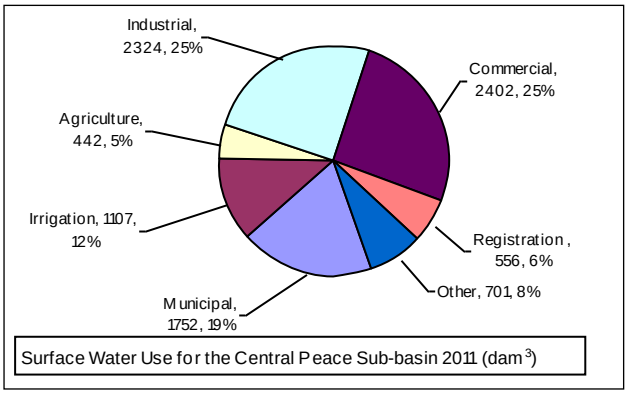
Surface Water Use and Return Flow, Central Peace Sub-basin

Water allocations include allowances for actual water use and may include expectations for return flow. Expectations for return flows have been included in some licences issued for commercial, municipal, industrial and other purposes.

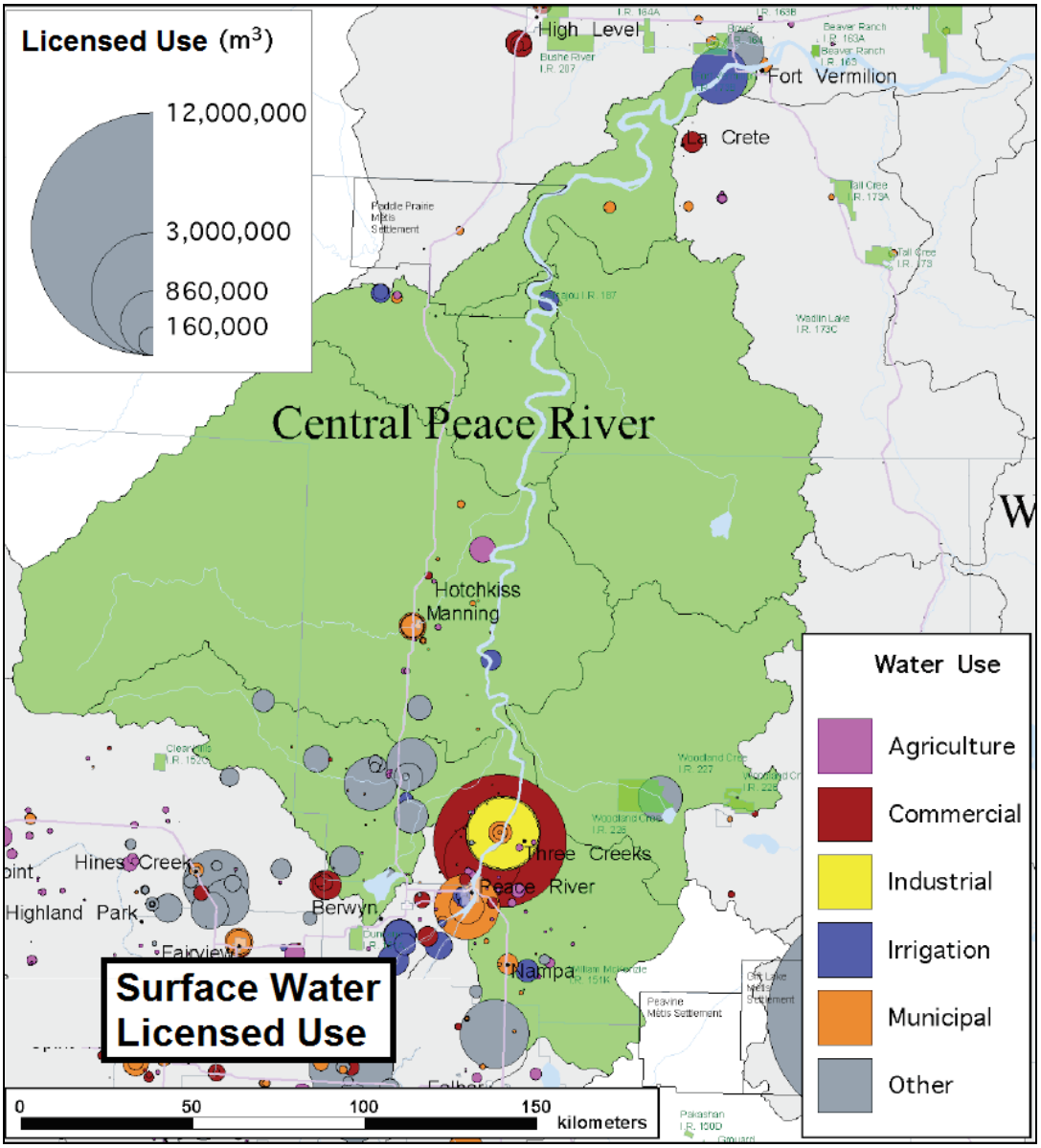
Overall, it is expected that 75% of withdrawals will be returned after use, including 87% of water withdrawn for commercial purposes, 72% of water withdrawn for municipal purposes, 22% of water withdrawn for industrial purposes, and 32% of water withdrawn for other purposes.

Actual Water Use - Total surface water consumption in the Central Peace sub-basin in 2011 is estimated to be 9,282 dam^3. This represents 17% of total surface water allocations and 70% of licensed water use. Commercial water use and industrial water use are each estimated to account for 25% of total surface water use in the Central Peace sub-basin.

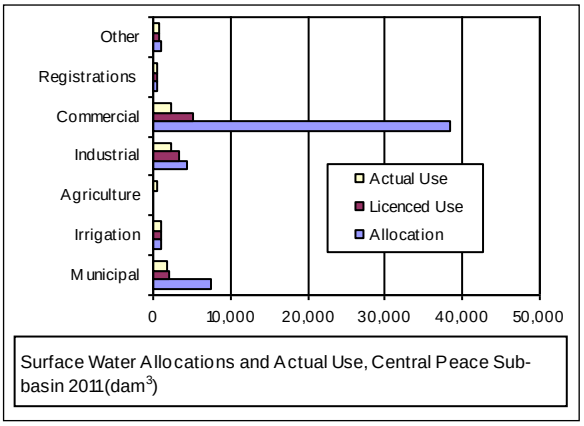
Water allocated for agricultural uses accounted for 23% of total water used, including 12% for irrigation, 6% for registrations and 5% for agricultural licences. Municipal water use accounted for another 19% of total water use. Water used for other purposes accounted for 8% of total water use.



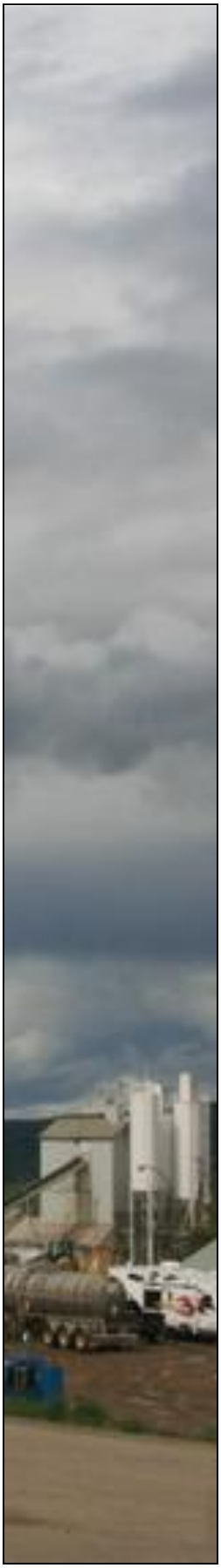
Surface Water Use for the Central Peace Sub-basin 2011 (dam^3)



The biggest difference between water allocations and actual water use is that only 6% of commercial allocations are actually being used, and this is because most of the water withdrawn by the Daishowa-Marubeni International Ltd. pulp mill is being returned after use and the plant was using water below its licensed capacity. Only 23% of water allocations for municipal purposes were actually being used. There were small differences between allocations for agriculture, irrigation and other purposes and the amount of water actually being used.

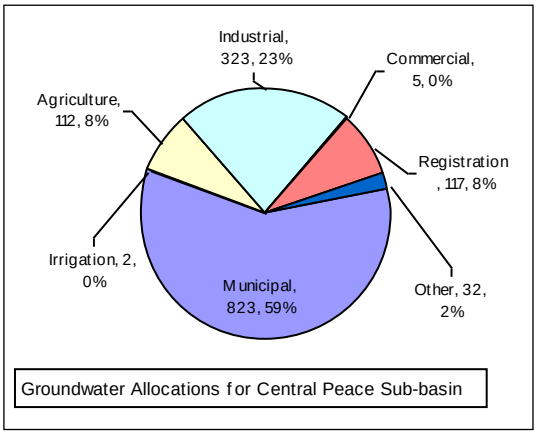


Surface Water Allocations and Actual Use, Central Peace Sub-basin 2011(dam^3)



5.5.2 Groundwater

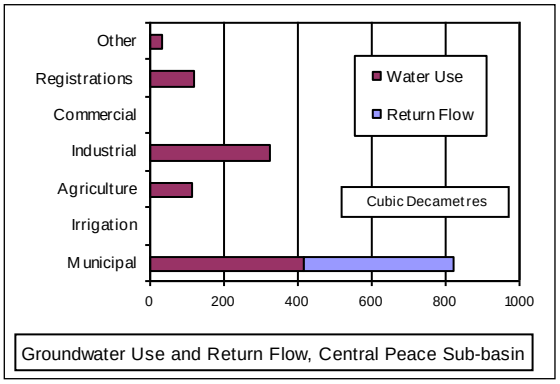
Licensed Use - Municipal water use accounts for the largest portion of groundwater water allocations in the Central Peace sub-basin. Allocations for municipal purposes amounted to 823 dam^3 or 59% of total allocations. A licence issued to the Town of Grimshaw accounts for 58% of total allocations for municipal purposes, while one licence issued to La Crete (which is physically located in the Wabasca sub-basin) accounts for another 18%. Two licences accounting for 11% of municipal groundwater allocations have been issued to the Weberville water Co-op Ltd.



Groundwater Allocations for Central Peace Sub-basin

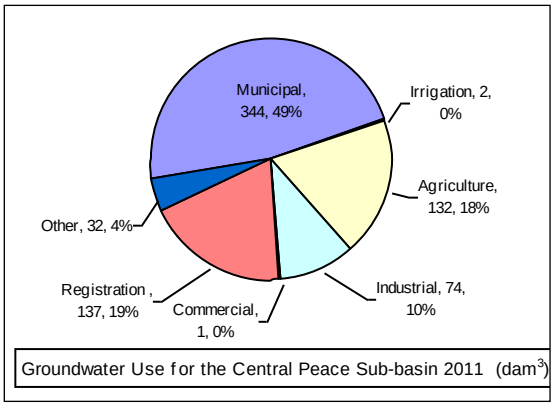
Industrial licences account for 23% of groundwater allocations. A total of seven licences have been issued to companies like Cenovus Energy Inc. (two licences), Baytex Energy Ltd. (one licence) and Amoco Petroleum Co. Ltd. (one licence), among others for injection purposes for oil and gas recovery. Registrations and agricultural licences each account for another 8% of groundwater allocations. Small amounts of groundwater have been allocated for other purposes (2%) as well as for irrigation and commercial purposes (less than 1%).

Expectations for return flow have been included in some municipal water licences and a few licences issued for commercial purpose. Overall, it is expected that 29% of withdrawals will be returned after use, including 50% of water withdrawn for municipal purposes.

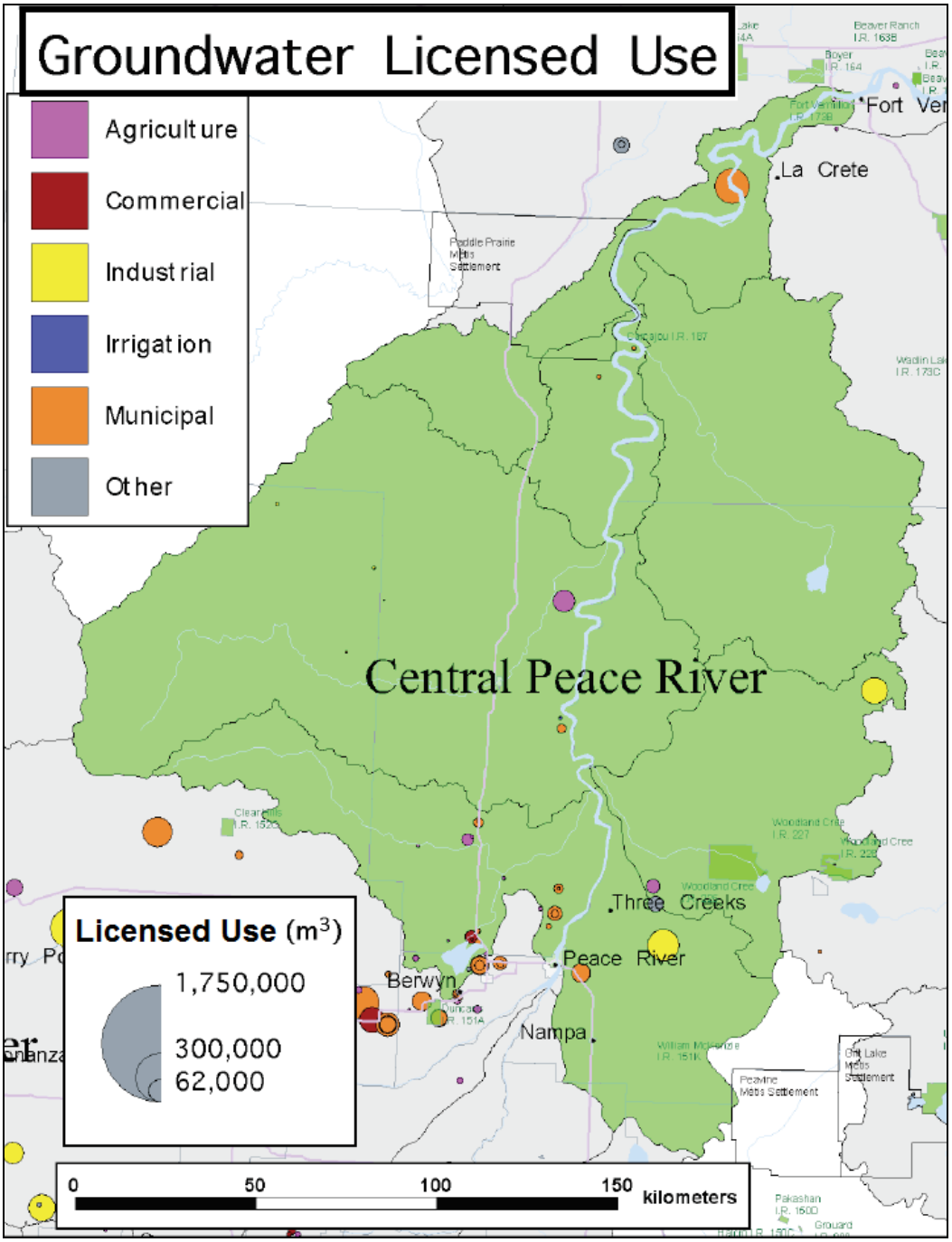


Groundwater Use and Return Flow, Central Peace Sub-basin

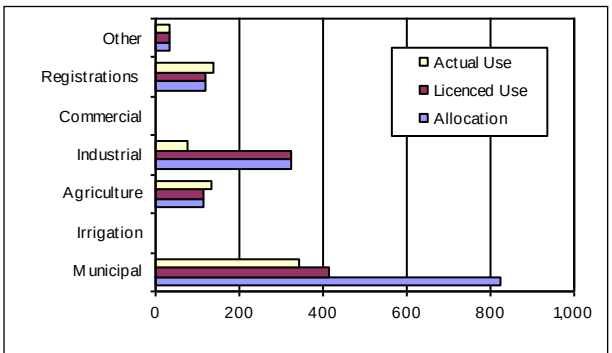
Actual Water Use - Total groundwater consumption in the Central Peace sub-basin in 2011 is estimated to be 723 dam^3. This represents 51% of total groundwater allocations and 72% of licensed water use. Based on actual water use, municipal water use accounted for 49% of total groundwater use in the Central Peace sub-basin. Agricultural water uses accounted for 38% of total water use, including 19% for registrations, and 18% for agricultural licences. Industrial water use accounted for another 10%. Water used for other purposes accounted for 4% of total water use.



Groundwater Use for the Central Peace Sub-basin 2011 (dam^3)

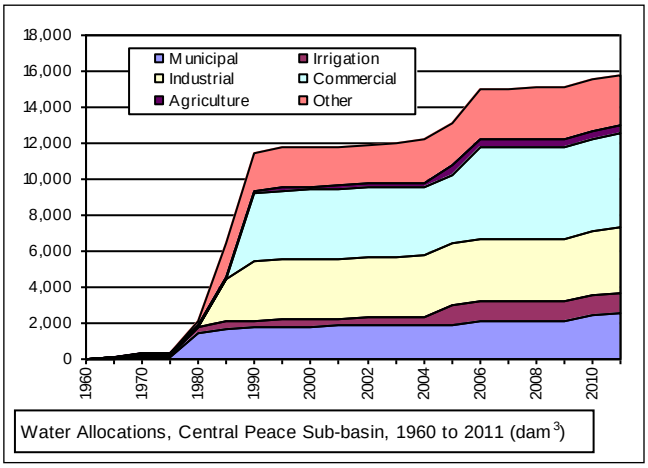


Only 23% of industrial allocations and 83% of municipal allocations are actually being used. Estimated groundwater use for agricultural purposes (registrations and licences) exceeded allocations, based on the amount of water being consumed by livestock populations in the sub-basin.



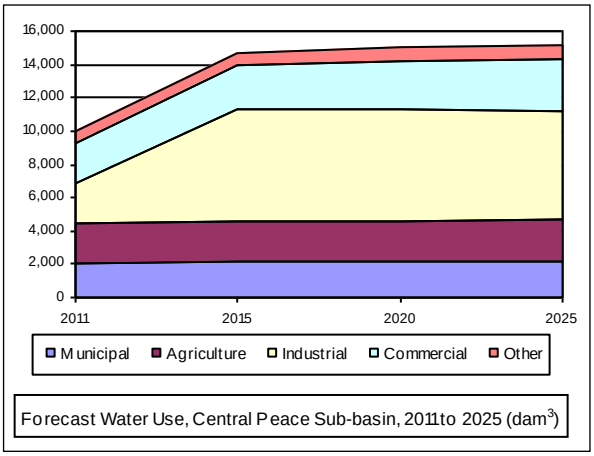
Groundwater Allocations and Actual Use, Central Peace Sub-basin 2011 (dam^3)

5.5.3 Future Demand



Water Allocations, Central Peace Sub-basin, 1960 to 2011 (dam^3)

Since 2000 there has been a 34% increase in total water allocations in the Central Peace sub-basin. This represents an average increase in allocations of about 368 dam^3 per year, with 19% of the increase having occurred since 2006. Over the period from 2000 to 2011, the increase in allocations was mainly due to increased allocations for commercial use (32% of the total increase). New allocations for municipal purposes accounted for 19% of the increase, irrigation accounted for 18% of the increase, while allocations for other purposes accounted for 16% of the increase. There was a relatively small increase in allocations of water for industrial purposes (9% of the increase) while agriculture uses accounted for 7% of the total change.



Forecast Water Use, Central Peace Sub-basin, 2011to 2025 (dam^3)

Over the period from 2011 to 2025, water use in the Central Peace sub-basin is expected to increase by 51%. Most of the change is predicted to be due to a significant increase in the amount of water being used for oil and gas production, especially for in-situ processing of heavy oil associated with the proposed expansion of the Carmon Creek project northeast of Peace River and at other locations. Minimal population growth is expected in the Middle Peace sub-basin, so municipal water use is predicted to increase by 3%. Small changes in agricultural water use (a 7% increase) are also expected. A 33% in commercial water use is also predicted. The total change in water use is predicted to be 5,125 dam^3, and increased industrial demand is predicted to account for 80% of the increase.

5.6 Water Quality

5.6.1 Surface Water

AEW's River WQI is calculated using information from the long term monitoring site on the Peace River at Fort Vermilion. In 2009-2010, water quality was rated 'good' based on concentrations of metals and nutrients occasionally exceeding water quality guidelines. Nutrient levels, and especially particulate phosphorus associated with suspended sediments are relatively high in this reach.

AEW has conducted water quality studies on a number of rivers and lakes within the sub-basin for baseline information, synoptic studies, or short-term monitoring events. Water quality studies have been conducted for Peace River above confluences with major creeks and rivers and upstream and downstream of major effluent discharges. Studies have also been conducted on the Peace River at Fort Vermilion and near Manning, La Crete, and Carcajou and on the Cadotte River, Whitemud River, Notikewin River, Buchanan Creek, Wolverine River, and Keg River. Water quality studies have also been conducted on the following lakes: Figure Eight Lake, Kimiwan Lake, Cadotte Lake, Unnamed Lakes, Haig Lake, Jackpine Lake, Ray Lake, Deadwood Lake, Twin Lake, Sulphur Lake, Nina Lake, Donaldson Lake, and Bison Lake.

5.6.2 Groundwater

AEW monitors groundwater quality at one deep well (>100m) near Cadotte Lake.

5.7 Water Issues

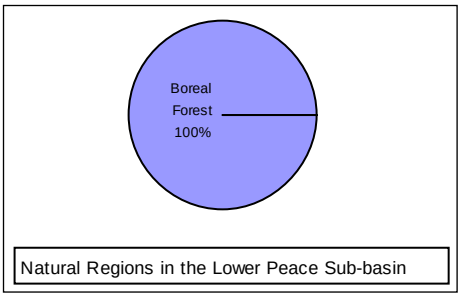
There do not appear to be any significant widespread water quality or quantity issues in this sub-basin, with a relative abundance of water compared to existing demands. The main future issues relate to the potential increase in water demand associated with heavy oil development. However, these demands are still relatively small compared to the average flow of the Peace River and problems might only result if water for industrial development is drawn from smaller tributaries.

6.0 LOWER PEACE RIVER SUB-BASIN

The Lower Peace sub-basin consists of lands that drain into the Peace River downstream from Fort Vermilion and upstream from the confluence with the Slave River. This coincides with the Water Survey of Canada sub-basins 07JF, 07KA, 07KB and 07KC.

6.1 Physiography

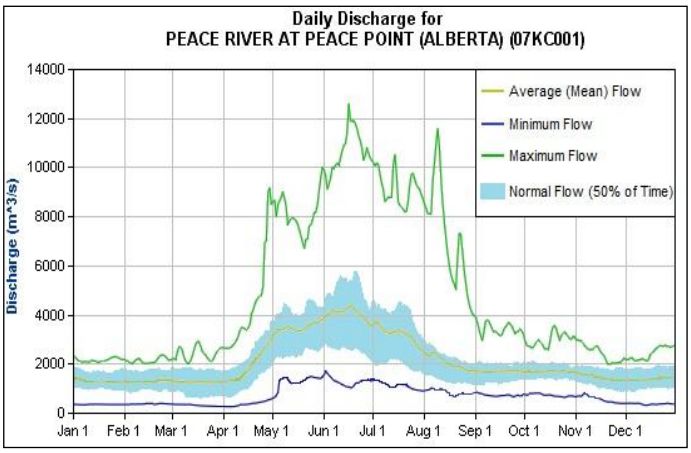
The Lower Peace sub-basin is about 28,960 km² in area and accounts for about 14% of the Peace watershed in Alberta. It is located entirely within the Boreal Forest Natural Region.



Natural Regions in the Lower Peace Sub-basin

6.2 Hydrology

There is one gauging station on this reach of the Peace River at Peace Point (07KC001). Average daily flows at this station have been recorded for the period from 1959 to 2010.

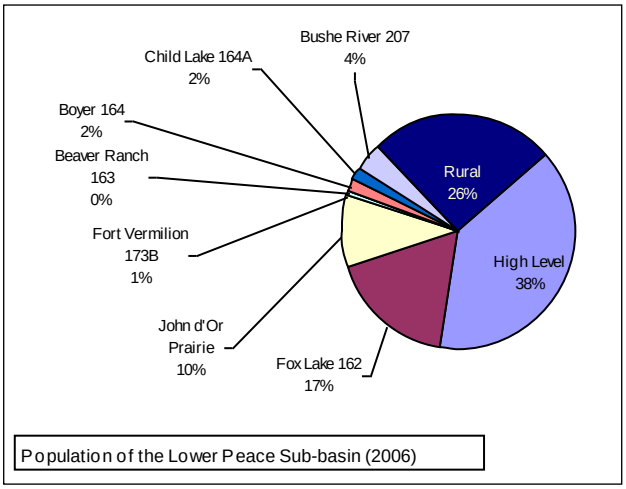


The normal flow of the Peace River at Peace Point is about 1,300 m^3/sec throughout the first three months of the year and then increases to 1,850 m^3/sec in April and peaks at about 4,000 m^3/sec in June and then gradually decreasing to 1,700 m^3/sec in September and October before dropping to 1,400 m^3/sec in December. The average monthly discharge is 2,080 m^3/sec. However, over the period of record, there has been considerable variability in flows, with maximum flows of more than 12,000 m^3/sec having been recorded in late June. Flows of 400 m^3/sec or less have been reported in December through April.

Major tributaries to the Peace River downstream from Fort Vermilion include the Boyer River, Caribou River, Wabasca River, Lawrence River, Mikkwa River (Little Red River), Pakwanutik River, Jackfish River, Claire River, and Baril River. Flows from the Athabasca River enter the Peace River through the Chanel Des Quatre Fourches and Revillon Coupe. Major lakes include Footner Lake near High Prairie, and Margaret, Pitchimi and Wentzel lakes which are located in the Caribou Mountains Wildland Provincial Park along the north edge of the basin. Although Lake Claire drains into the Peace River by way of the Claire River, it is considered to be part of the Wabasca sub-basin. There are about 3,210 km^2 of large wetlands (>5000 ha) in the Lower Peace sub-basin. These wetland areas account for 10.9% of the land base and represent 20.2% of all wetland areas in the Peace watershed.

6.3 Socio-Economic Characteristics

In 2006, approximately 10,125 people lived in the Lower Peace sub-basin; this represents 7.4% of the population of the Peace watershed. About 38% of the population lived in the Town of High Level (3,887 people) while 26% lived in rural parts of the sub-basin, including Improvement District No. 24 and the municipal districts of Northern Lights No. 22 and Mackenzie No. 23. The other 36% of the population lived on the seven Indian reserves in the Lower Peace sub-basin. The largest of the reserves include: Fox Lake 162 (1,753 people) and John d'Or Prairie 215 (1,025 people). Smaller reserves include: Beaver Ranch 163, Fort Vermilion 173B, Boyer 164, Child Lake 164A, and Bushe River 207.

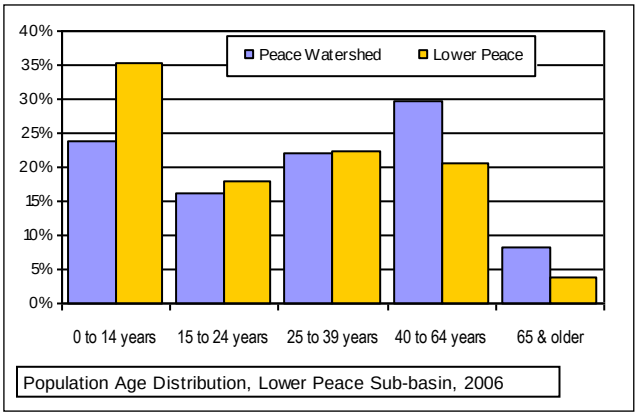


Population of the Lower Peace Sub-basin (2006)

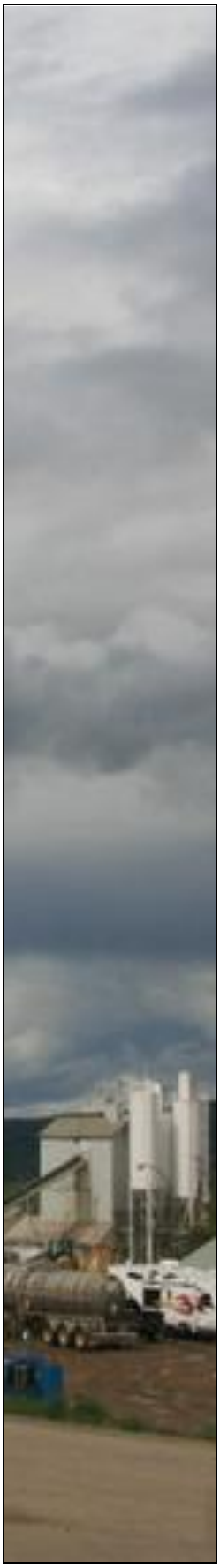
About 45.6% of the sub watershed population consisted of aboriginal people and 76.8% of these lived on one of the seven reserves. The Beaver Ranch 163 and Fort Vermilion 173B reserves are two of seven reserves established for the Tall Cree First Nation. The Boyer 164 and Child Lake 164A reserves were established for the Beaver First Nation. The John d'Or Prairie 215 and Fox Lake 162 reserves are two of three reserves established for the Little Red River Cree. The Bushe River 207 reserve is one of seven reserves established for the Dene Tha'.

Between 2001 and 2006, the population of the Wabasca sub-basin increased by 17.9%. The population of High Level increased by 12.9%, the rural population increased by 11.1% and the on-reserve population increased by 30.1%. The largest increases in the on-reserve population occurred on the Fox Lake 162 reserve (+39.8%), John d'Or Prairie 215 reserve (+20.4%), and Bushe River 207 reserve (+25.8%).

The age characteristics of people in the Lower Peace sub-basin are very different from the Peace watershed as a whole. The biggest difference is that, in 2006, more than one-third (35%) of the population in the Lower Peace sub-basin consisted of children under 15 years; this compares to 24% for the Peace watershed. The Lower Peace sub-basin also had a slightly higher percentage of people in the 25 to 39 year age group, but much lower percentages of people aged 40 years and older.



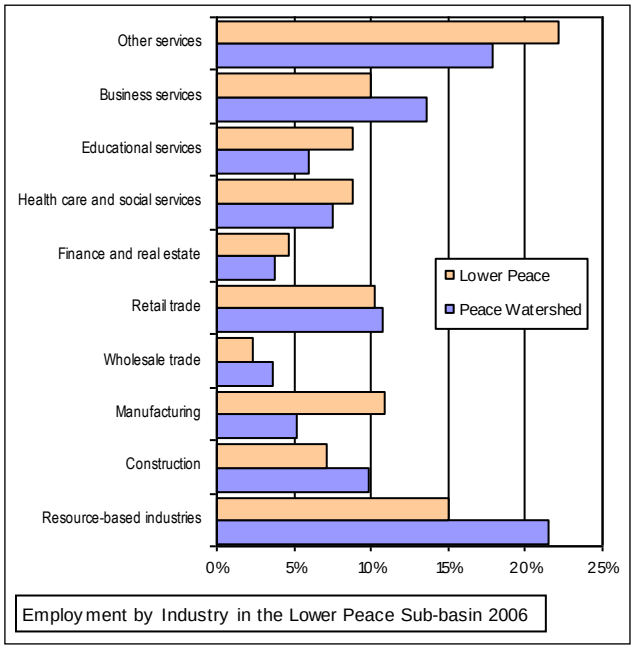
Population Age Distribution, Lower Peace Sub-basin, 2006



About 64.7% of the population in the sub-basin was 15 years of age or older and this much lower than for the Peace watershed (76.2%).

In 2006, 66.6% of the adult labour force in the Lower Peace sub-basin were either working or seeking work (the labour force participation rate) and 6.6% were unemployed. The labour force participation rate in the sub-basin was much lower than for the Peace watershed (76.5%), but the unemployment rate for the sub-basin was slightly higher than for the watershed (4.8%).

About 15.0% of the labour force in the Lower Peace sub-basin was employed in resource-based industries (including agriculture); this much less than for the entire Peace watershed (21.5%) and was the lowest of all the sub-basins. The Lower Peace sub-basin had higher percentages of people with experience in the manufacturing industry (10.9%), educational services industry (8.8%), health care and social services (8.8%) and the other services industry (22.1%). Compared to the overall Peace watershed, this sub-basin had lower percentages of employment in construction (7.1%) and business services (10.0%).



Employment by Industry in the Lower Peace Sub-basin 2006

Workers in the Lower Peace sub-basin reported median earnings of $28,888 in 2005. This was 3% lower than for the entire Peace watershed ($29,738).

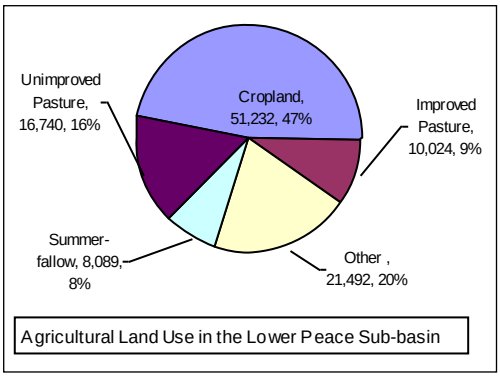
6.4 Land and Resource Use

About 30% of land in the Lower Peace sub-basin has been disturbed, primarily by forestry operations and oil and gas development. One–third of the Lower Peace sub-basin (33.4%) is located in Wood Buffalo National Park.

6.4.1 Agriculture

According to the 2006 Census of Agriculture there were 240 farms in the Lower Peace sub-basin. These farms covered an area of 0.11 million ha; this represents 3.8% percent of the sub-basin.

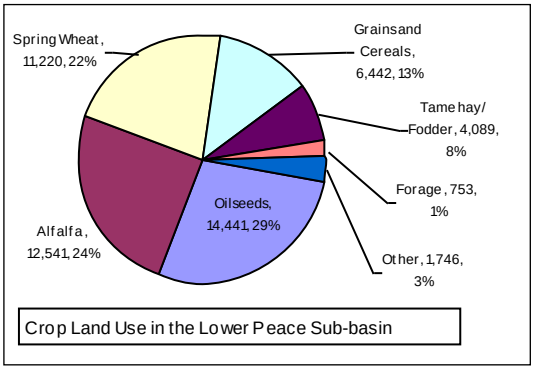
Cropland accounted for slightly less than half of all agricultural land (47%) with unimproved pasture accounting for 16%, improved pasture accounting for 9%.



Agricultural Land Use in the Lower Peace Sub-basin

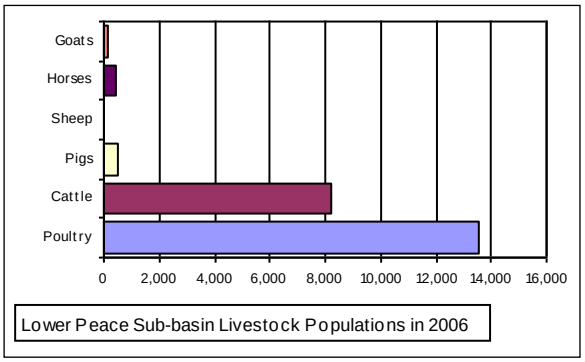
and

The most important crops grown in this sub-basin include oil seeds (29% of field crops), alfalfa (24%), spring wheat (22%), other grains and cereals (13%) and tame hay/fodder (8%). Three farms reported using irrigation on 111 ha of land, primarily for field crops and hay.



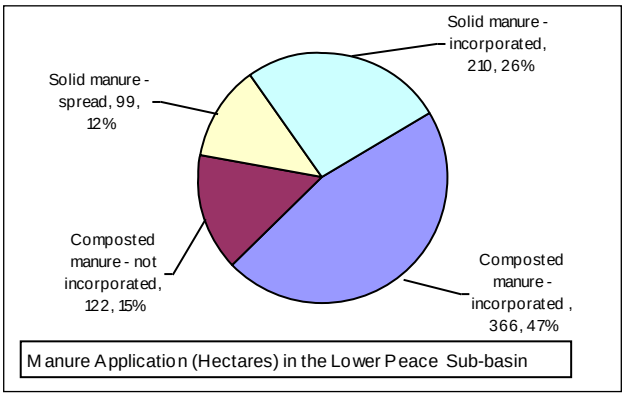
Crop Land Use in the Lower Peace Sub-basin

The majority of the farms in the Lower Peace sub-basin (59%) raise livestock. About 45% of farms raised cattle (averaging 77 animals per farm) and 28% raised horses (6 per farm). Small number of farms raised other types of livestock including poultry (12%), hogs (5%), sheep (2%) and goats (3%). In total, there were about 22,900 animals (including poultry) in this sub-basin in 2006. This includes 8,251 cattle, 502 hogs, 103 sheep, 417 horses and 112 goats. These animals generated 0.01 million tonnes of manure.



Lower Peace Sub-basin Livestock Populations in 2006

In terms of land management, 15% of farms applied manure to 797 ha of land, suggesting an average rate of 113 tonnes of manure per hectare. The most common types of manure application included incorporating composted manure (47% of the land area), incorporation of solid manure (26%), and spreading of composted manure without incorporating (15%).



Manure Application (Hectares) in the Lower Peace Sub-basin

In addition, 41% of farms used chemical fertilizers on 32,165 ha (63% of cropland).

6.4.2 Forestry

There was one sawmill (Tolko Industries Ltd.) and one panel board mill (Footner Forest Products Ltd.) in the Lower Peace sub-basin, both located near High Level. However, both of these facilities are no longer operating. This sub-basin contains part of the FMA issued to Tolko Industries Ltd/Footner Forest Products/La Crete sawmill.

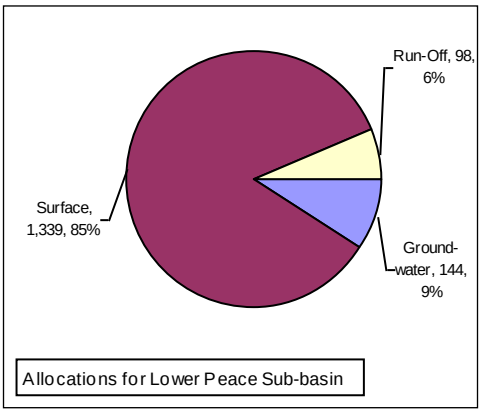
6.4.3 Oil and Gas

A total of 1,769 oil and gas wells have been drilled in the Lower Peace sub-basin; this represents 3% of all wells drilled in the Peace watershed. There are also 16,200 km of seismic lines and 1,870 km of pipelines.

This density of oil and gas activity has resulted in an average disturbance of 0.7 km of linear disturbance per square kilometre of land (excluding agricultural land). This is well below the average for the Peace watershed (2.2 km/km^2).

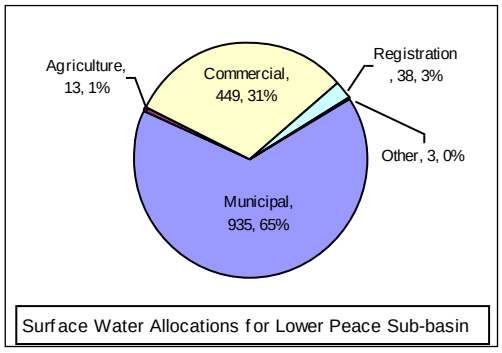
6.5 Water Use

The most recent water licence information indicates that a total of 1,582 dam^3 of water has been allocated for use in the Lower Peace sub-basin. This represents 1% of water allocations in the entire Peace River watershed. Allocations in the Lower Peace sub-basin consist primarily of surface water (1,339 dam^3 or 85%) but also include small amounts of groundwater (144 dam^3 or 9%) and surface run-off (98 dam^3 or 6%).



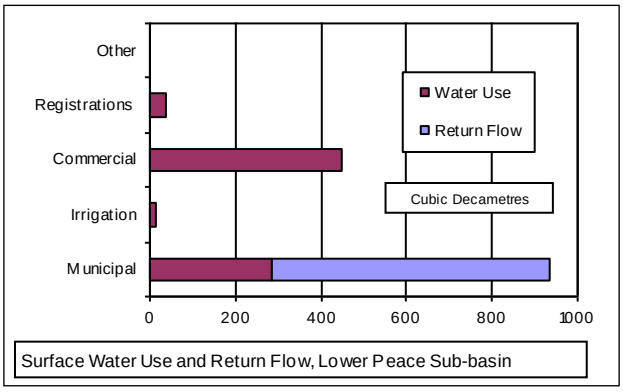
6.5.1 Surface Water

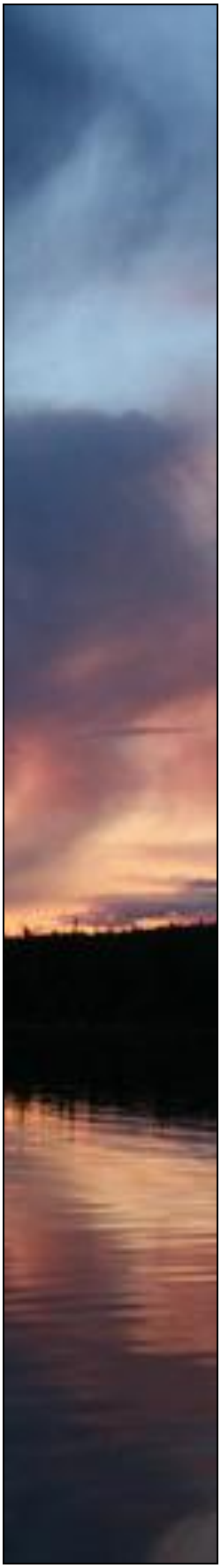
Licensed Use – Municipal water use accounts for the largest portion of surface water allocations in the Lower Peace sub-basin. Allocations for municipal purposes amounted to 935 dam^3 or 65% of total allocations. The largest allocations were issued to the Town of High Level and accounted for 46% of municipal water allocations. Various licences issued to Alberta Municipal Affairs account for another 35% of municipal allocations. Allocations to the Little Red River Band account for another 11% of municipal allocations.

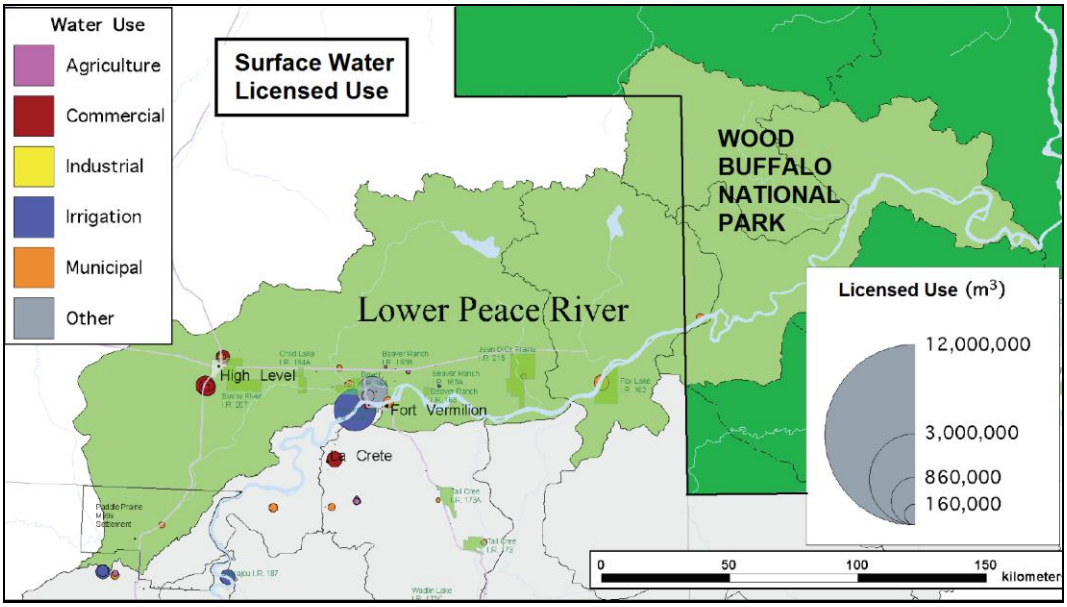


The other important sector in this sub-basin is commercial water use, with allocations of 449 dam^3 or 31% of total allocations. Licences issued to Footner Forest Products (now Ainsworth Lumber Company - High Level) account for 67% of commercial water allocations. Agricultural uses account for 4%, including 1% for agriculture licences and 3% for registrations. Water allocations for other purposes account for less than 1% of surface water allocations.

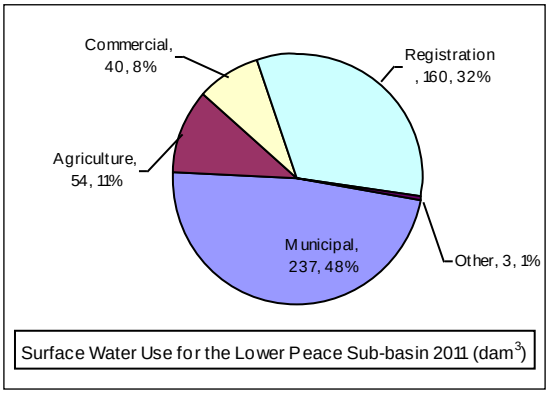
Water allocations include allowances for actual water use and may include expectations for return flow. Expectations for return flows have been included in some licence issued for municipal purposes. Overall, it is expected that 45% of withdrawals will be returned after use, including 69% of water withdrawn for municipal purposes.





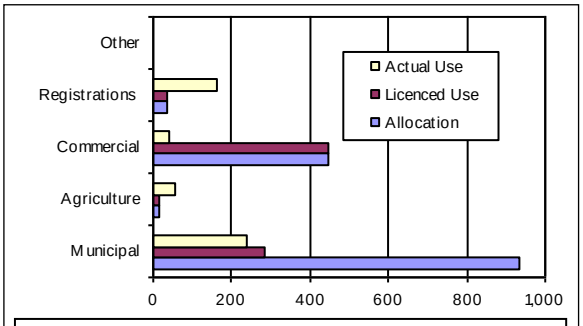


Actual Water Use - Total surface water consumption in the Lower Peace sub-basin in 2011 is estimated to be 494 dam^3. This represents 34% of total surface water allocations and 63% of licensed water use. Municipal water use is estimated to account for 48% of total surface water use in the Lower Peace sub-basin. Water allocated for agricultural uses accounted for 43% of total water use, including 32% for registrations and 11% for agricultural licences. Commercial water use accounted for another 8% of total water use while water used for other purposes accounted for 1% of total water use.



Surface Water Use for the Lower Peace Sub-basin 2011 (dam^3)

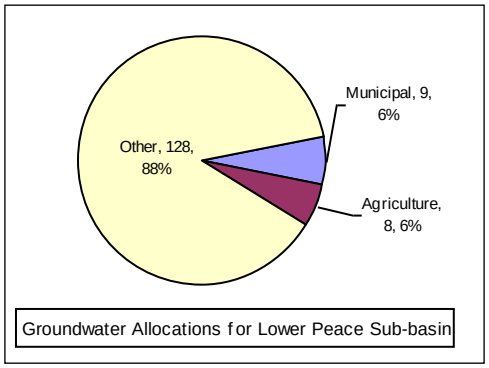
The biggest difference between water allocations and actual water use is that only 8% of commercial allocations are actually being used. Only 25% of water allocations for municipal purposes were actually being used. As shown below, estimated surface water use for agricultural purposes greatly exceeded allocations, based on the amount of water being consumed by livestock populations in the sub-basin.



Surface Water Allocations and Actual Use, Lower Peace Sub-basin 2011 (dam^3)

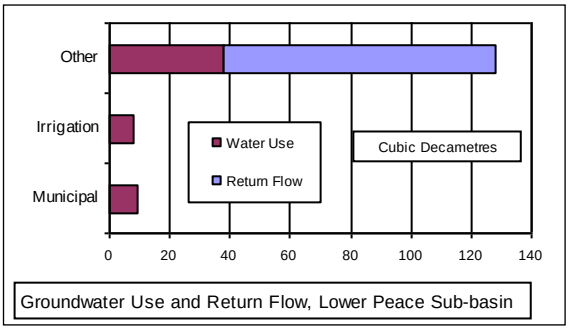
6.5.2 Groundwater

Licensed Use – Two licences issued for other purposes to Ainsworth Lumber Company (formerly Footner Forest Products - High Level) account for the largest portion of groundwater water allocations in the Lower Peace sub-basin. Allocations for other purposes amounted to 128 dam^3 or 88% of total allocations. Small amounts of groundwater have been allocated for municipal purposes (6%) and in agriculture licences (6%).

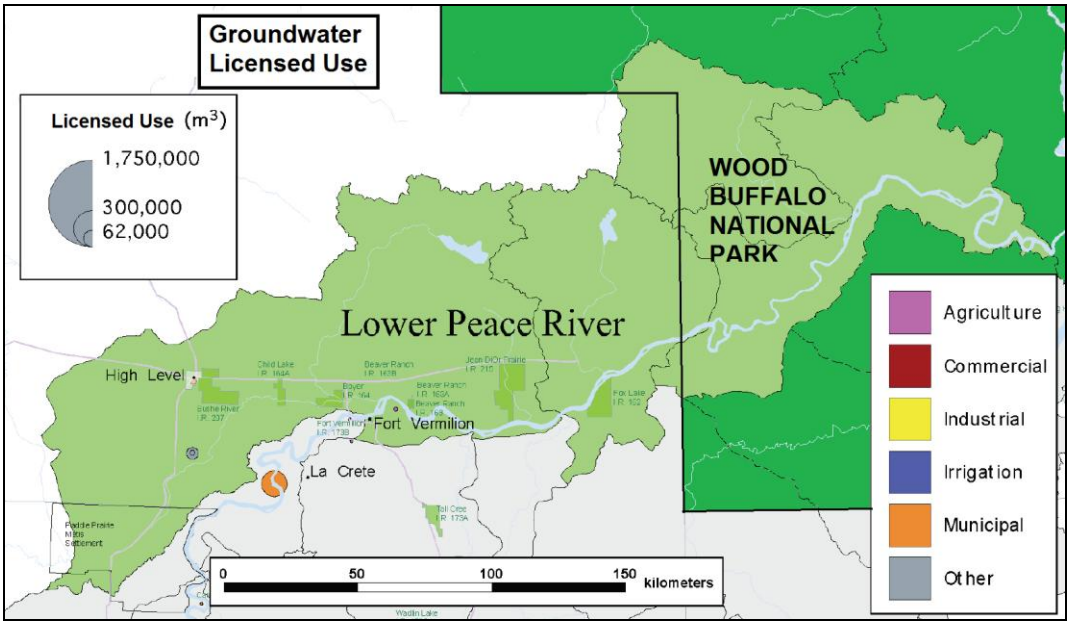


Groundwater Allocations for Lower Peace Sub-basin

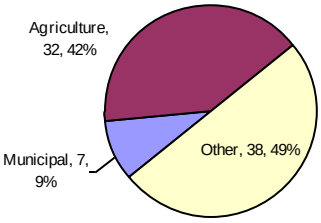
Expectations for return flow have only been included in some water licences issued for other purposes. Overall, it is expected that 62% of groundwater withdrawals will be returned after use, including 70% of water withdrawn for municipal purposes.



Groundwater Use and Return Flow, Lower Peace Sub-basin



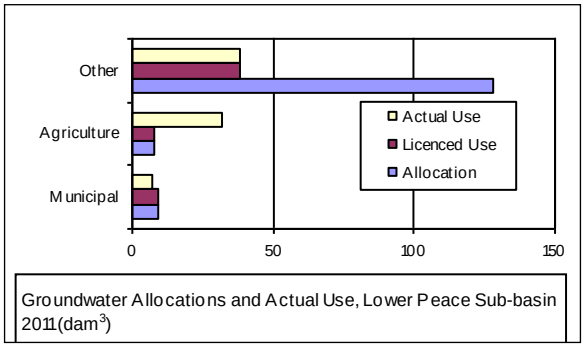
Actual Water Use - Total groundwater consumption in the Lower Peace sub-basin in 2011 is estimated to be 78 dam^3. This represents 54% of total groundwater allocations but 142% of licensed water use.



Groundwater Use for the Lower Peace Sub-basin 2011 (dam^3)

Water used for other purposes is estimated to account for 49% of total water use in the Lower Peace sub-basin. Based on water requirements for livestock populations, agricultural water use is estimated to account for 42% of total water use. Municipal water use accounted for 9% of total groundwater use.

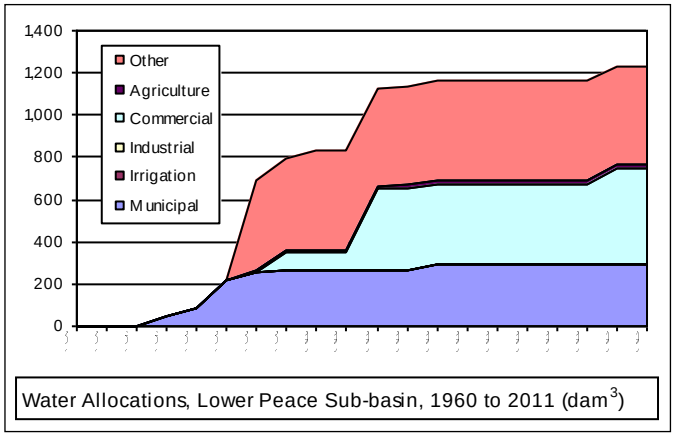
Estimated groundwater use for agricultural purposes greatly exceeded allocations, based on the amount of water being consumed by livestock populations in the sub-basin. For municipal use, actual water use accounted for 83% of allocations and, for other use, actual use accounted for 30% of allocations.



Groundwater Allocations and Actual Use, Lower Peace Sub-basin 2011(dam^3)

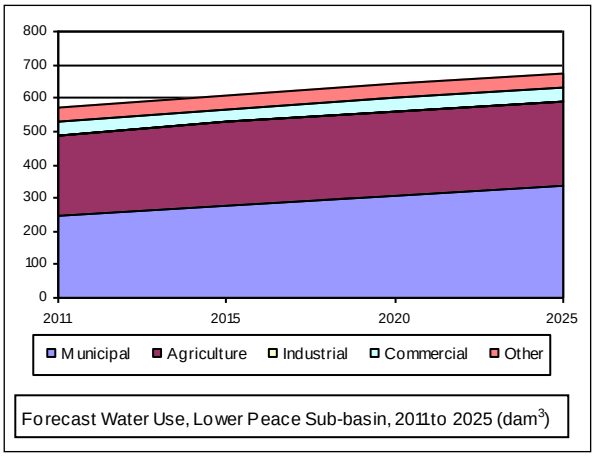
6.5.3 Future Demand

Since 2000 there has been a 49% increase in total water allocations in the Lower Peace sub-basin. This represents an average increase in allocations of about 37 dam^3 per year, with 17% of the increase having occurred since 2006. Over the period from 2000 to 2011, the increase in allocations was almost entirely due to increased allocations for commercial use (92% of the total increase). New allocations for municipal purposes accounted for 6% of the increase. There were no new allocations for irrigation or industrial purposes. Allocations for agriculture and other purposes each accounted for 1%of the total increase in allocations since 2000.



Water Allocations, Lower Peace Sub-basin, 1960 to 2011 (dam^3)

Over the period from 2011 to 2025, water use in the Lower Peace sub-basin is expected to increase by 18%. Based on the relatively young age of the population, a significant population increase is expected and this is predicted to result in a 38% increase in municipal water use. Small increases in water use by agricultural, commercial and other uses are expected. The total change in water use is predicted to be 105 dam^3, and increased municipal demand is predicted to account for 89% of the increase.



Forecast Water Use, Lower Peace Sub-basin, 2011to 2025 (dam^3)

6.6 Water Quality

6.6.1 Surface Water

There is no AEW River WQI rating for the Lower Peace sub-basin because there are no long term monitoring sites on this reach of the river. Aquatic ecosystem studies have suggested that water quality in the lower reach of the Peace River is considered 'fair' due to higher levels of suspended sediment, nutrients, metals, biochemical oxygen demand, and turbidity than in the middle reach of the river.

A study by Environment Canada on surface water quality in Wood Buffalo National Park showed that levels of total phosphorus and nitrogen and total metal concentrations in excess of CCME guidelines were directly related to the naturally high sediment loads in these rivers.

AEW has conducted water quality studies on a number of rivers and lakes in the Lower Peace sub-basin, either for baseline information, synoptic studies, or short-term monitoring events. The rivers that have been monitored include: Peace River above Wood Buffalo Park, Peace River near Peace Point, Boyer River, and Wentzel River. Lakes that have been monitored include: Flemming Lake, Caribou Lake, Rocky Island Lake, Margaret Lake, Unnamed Lakes, Machesis Lake, Wentzel Lake, Semo Lake, and Pitchimi Lake. Environment Canada has a monitoring location at Peace Point on the Peace River within Wood Buffalo National Park.

6.6.2 Groundwater

AEW monitors groundwater at three wells near Le Crete. These include two shallow wells and one intermediate depth well.

6.7 Water Issues

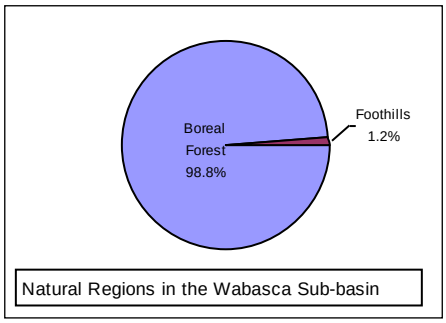
There do not appear to be any significant widespread water quality or quantity issues in the Lower Peace sub-basin. There is a relative abundance of surface water compared to existing demands, although localized shortages may occur if water for current and future activities is being drawn from smaller tributaries. The only foreseeable issue for this sub-basin is that anticipated population growth will necessitate the construction of larger water treatment facilities to accommodate municipal demands.

7.0 WABASCA SUB-BASIN

The Wabasca sub-basin consists of lands that drain into the Wabasca and Mikkwa rivers before they enter the Peace River, as well as lands that drain into Lake Claire and then into the Peace River either directly or through the Chenal des Quatre Fourches. This coincides with the Water Survey of Canada sub-basins 07JA, 07JB, 07JC, 07JD, 07JE, 07KD, 07KE and 07KF.

7.1 Physiography

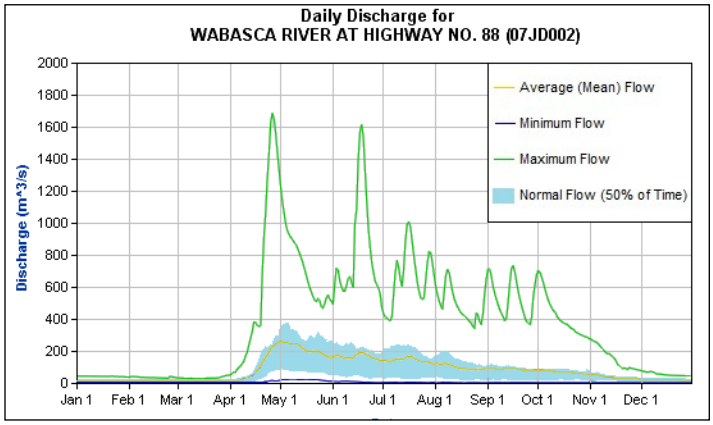
The Wabasca sub-basin is about 66,510 km² in area and accounts for about 32% of the Peace watershed in Alberta. It is located almost exclusively in the Boreal Forest Natural Region (98.6% of the sub-basin), but small parts of the sub-basin (1.2%) are located in the Foothills Natural Region.



Natural Regions in the Wabasca Sub-basin

7.2 Hydrology

There is one gauging station on the Wabasca River at Highway 88 (07JD002). Average daily flows at this station have been recorded for the period from 1970 to 2010.

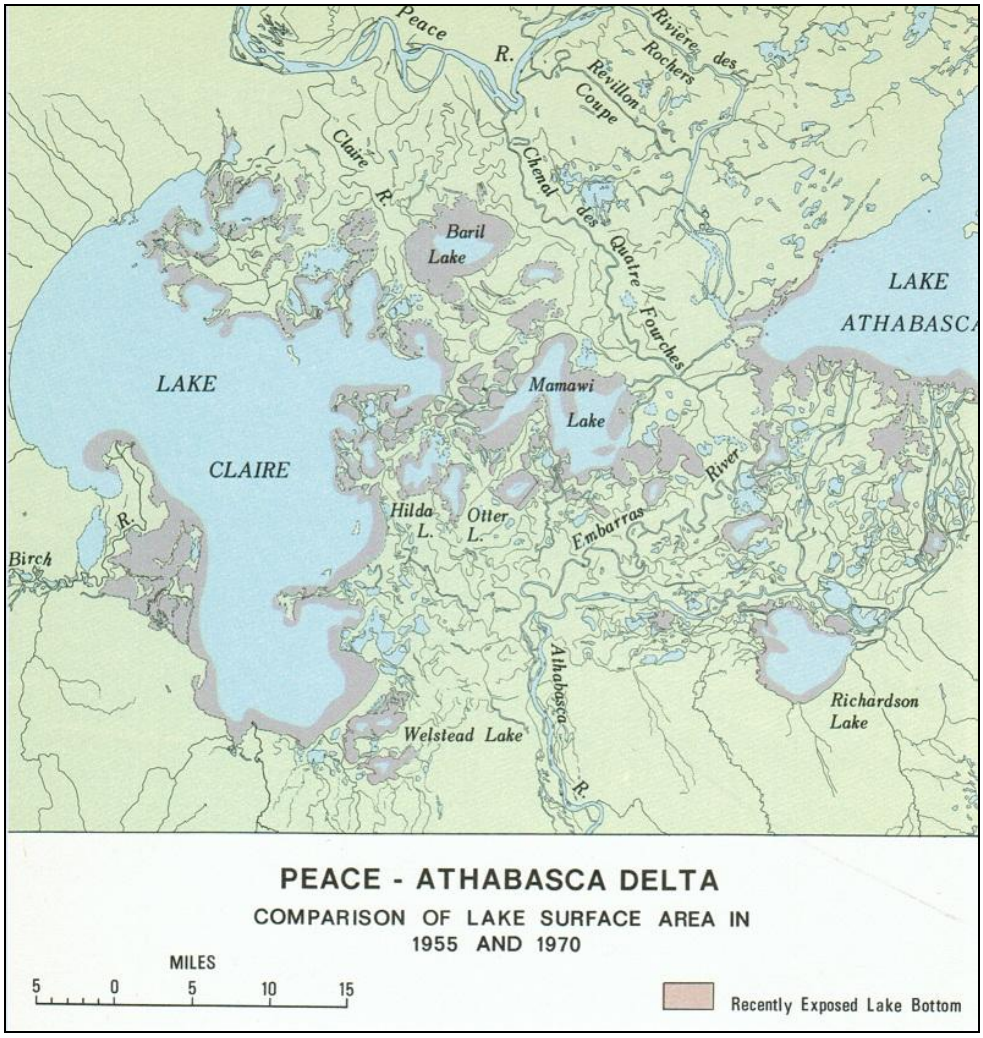


The normal flow of the Wabasca River is usually about 15 m^3/sec throughout the first three months of the year. Flows increase to 95 m^3/sec in April, peak at 219 m^3/sec in May, then gradually decrease to 80 m^3/sec in September and October before dropping to 21 m^3/sec in December. The average monthly discharge is 83 m^3/sec. However, over the period of record, there has been considerable variability in flows, with maximum flows of more than 1,600 m^3/sec having been recorded in late April and mid-June. Flows of less than 0.4 m^3/sec have been reported in March and February.

Major tributaries to the Wabasca River include the Willow River, Muskwa River, Trout River, Wood Buffalo River, Woodenhouse River, Liége River, Panny River, Loon River, Muddy River and Bear River. There are numerous large lakes in the sub-basin. These include North and South Wabasca lakes and Sandy Lake at the upper end of the river. Other large lakes include Utikuma Lake, Lubicon Lake, Muskwa Lake, Loon Lake, Peerless Lake, Graham Lake, Chipewyan Lake, and Wadlin Lake. However, the largest lake in the sub-basin is Lake Claire, which is described in more detail below.

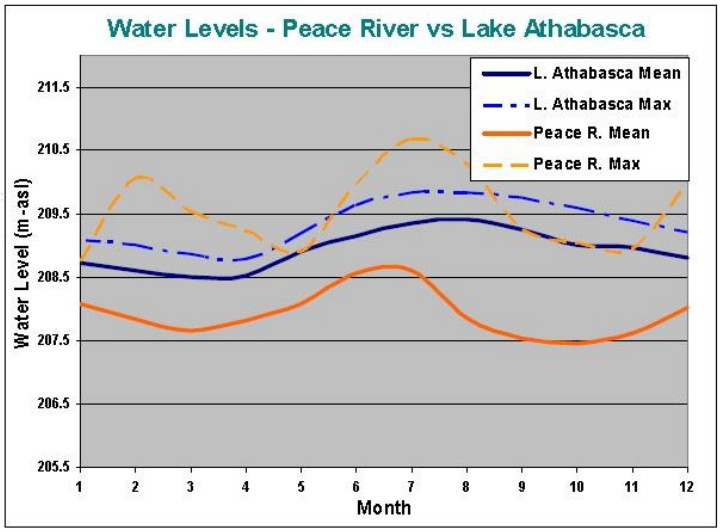
There are about 6,400 km^2 of large wetlands (>5000 ha) in the Wabasca sub-basin. These wetlands account for 9.6% of the land area in the sub-basin and 40.2% of all large wetlands in the Peace watershed.

The Peace-Athabasca Delta (PAD) is located in the Wabasca sub-basin. As noted previously, the delta consists of a flat area between the Peace and Athabasca rivers that consists of numerous lakes and wetlands. Following the completion of the Bennett Dam, there was a noticeable reduction in flows in the Peace River that resulted in less frequent flooding and parts of the PAD began drying up.



The changes in the PAD have been extensively studied to determine the exact causes of and potential solutions for loss of the delta. It is now understood that the PAD was maintained by water from overflow from the Peace River during periods of high flows and/or ice jams, overflow from the Athabasca River, and local runoff.

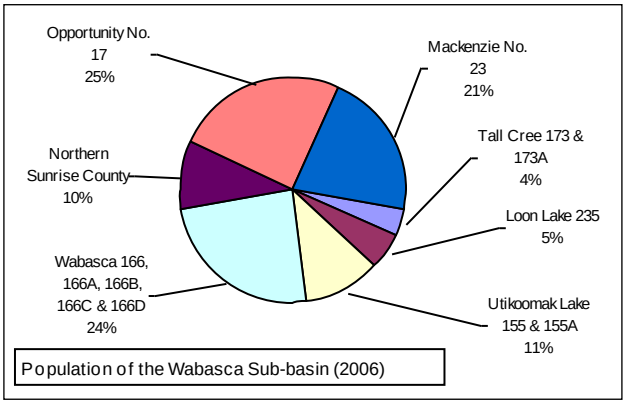
During the winter ice period and the summer peak flow period, water levels within the Peace River can be higher than in most of the PAD and Lake Athabasca as well. The flow in the Peace River overtops its banks, causing the Peace River to flow into Lake Athabasca, and flooding most of the PAD.



While construction and operation of the Bennett Dam has had a major impact on the flow pattern of the Peace River, resulting in lower summer peak flows and higher, climate change is now understood to have played a role. Various studies have been able to assess the flood history of the PAD back to about 1700, and the results suggest that the climate has been warmer and drier during the last 50 years and this has contributed to lower flows and less frequent flooding. Some studies have concluded that climate change has been primarily responsible for fewer ice jams and conditions have been made worse as a result of flow regulation for power production (Figliuzzi and Balachandran, 2009). Other studies have noted that, even with wetter years since 1998, the delta has continued to dry out and it is unclear whether the dam plays any role in reducing the probability of ice-jam floods (MRBB, 2004). However, any further increases in temperature and/or reduced precipitation as a result of climate change may result in even fewer flooding events in the future.

7.3 Socio-Economic Characteristics

In 2006, approximately 8,115 people lived in the Wabasca sub-basin. More than half of population (55%) lived in rural parts of the sub-basin, including Northern Sunrise County and the municipal districts of Opportunity No. 17 and Mackenzie No. 23. The other 45% of the population lived on the10 Indian reserves in the Wabasca sub-basin, including: Tall Cree 173, Tall Cree 173A, Loon Lake 235, Utikoomak Lake, Utikoomak Lake 155A, Wabasca 166 , Wabasca 166A, Wabasca 166B, Wabasca 166C and Wabasca 166D.

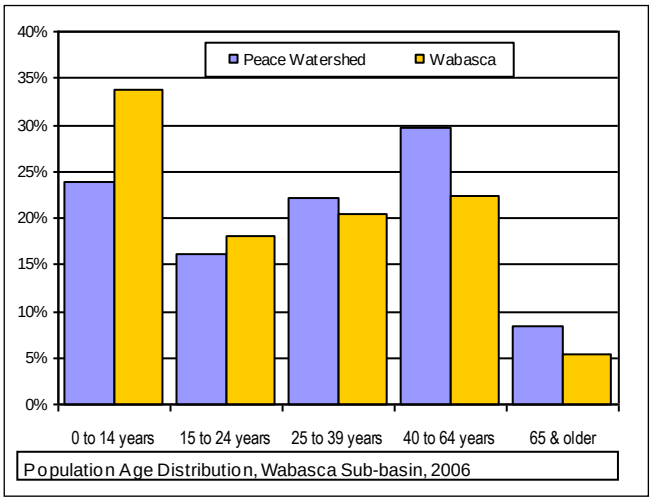


About 66.9% of the sub watershed population consisted of aboriginal people and 63.4% of these lived on one of the 10 reserves. The Tall Cree 173 and 173A reserves are two of seven reserves established for the Tall Cree First Nation. The Loon Lake 235 reserve is one of three reserves established for the Loon River Cree. The Utikoomak Lake 155 and 155A reserves are two of three reserves established for the Whitefish Lake First Nation.

The Wabasca 166,166A, 166B, 166C and 166D reserves are five of seven reserves established for the Bigstone Cree Nation.

Between 2001 and 2006, the population of the Wabasca sub-basin increased by 0.6%. A small decrease in the rural population (-2.3%) was more than offset by a 4.1% increase in the population of the 10 reserves. Large population increases occurred on the Wabasca 166B (34.2%), Wabasca 166A (27.1%) and Tall Cree 173 (16.2%) reserves, while population decreases were reported for the Tall Cree 173A (-32.8%) and Utikoomak Lake 155A (-14.9%) reserves.

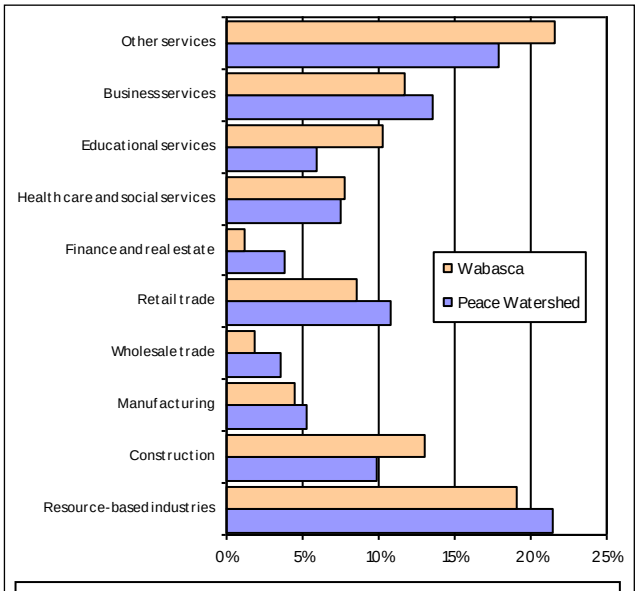
The age characteristics of people in the Wabasca sub-basin are very different from the Peace watershed as a whole. The biggest difference is that, in 2006, more than one-third (34%) of the population in the Wabasca sub-basin consisted of children. This compares to 24% for the Peace watershed. The Wabasca sub-basin also had a slightly higher percentage of people in the 25 to 39 year age group, but much lower percentages of people aged 40 years and older. About 66% of the population in the sub-basin was 15 years of age or older and this much lower than for the Peace watershed (76.2%).



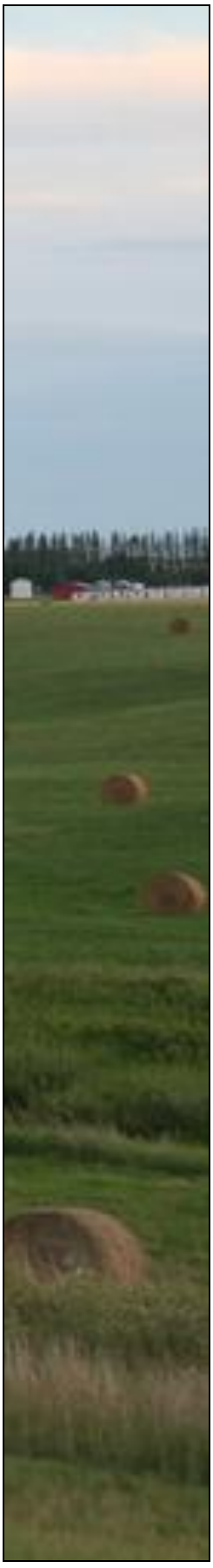
Population Age Distribution, Wabasca Sub-basin, 2006

In 2006, 64.1% of the adult labour force in the Wabasca sub-basin were either working or seeking work (the labour force participation rate) and 15.3% were unemployed. The labour force participation rate in the sub-basin was much lower than for the Peace watershed (76.5%), and the unemployment rate for the sub-basin was higher than for the watershed (4.8%).

About 19.1% of the labour force in the Wabasca sub-basin was employed in resource-based industries (including agriculture); this was slightly less than for the entire Peace watershed (21.5%). The Wabasca sub-basin had higher percentages of people with experience in the construction industry (13.0%), educational services industry (10.3%) and the other services industry (21.6%).



Employment by Industry in the Wabasca Sub-basin 2006



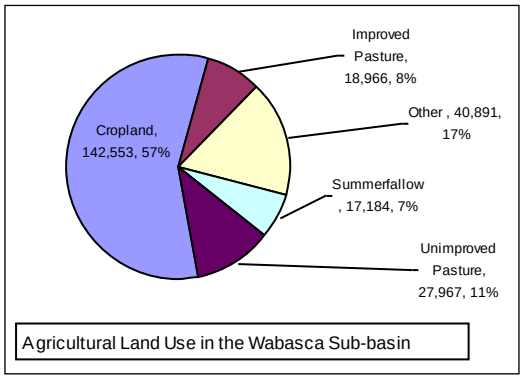
overall Peace watershed, this sub-basin had lower percentages of employment in retail trade (8.6%), finance and real estate (1.2%) and business services (11.7%). Workers in the Wabasca sub-basin reported median earnings of $21,851 in 2005. This was 27% lower than for the entire Peace watershed ($29,738).

7.4 Land and Resource Use

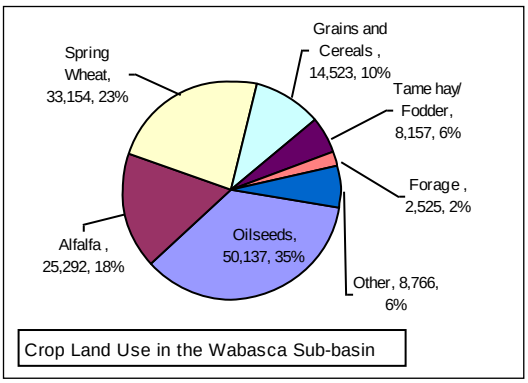
About 51% of land in the Wabasca sub-basin has been disturbed, primarily by forestry operations and oil and gas development. A small portion of the sub-basin (17.6%) is located in Wood Buffalo National Park.

7.4.1 Agriculture

According to the 2006 Census of Agriculture there were 768 farms in the Wabasca sub-basin. These farms covered an area of 0.25 million ha; this represents 3.8% of the sub-basin. More than half of all agricultural land consisted of cropland (57%) with unimproved pasture accounting for 11%, and improved pasture accounting for 8%.



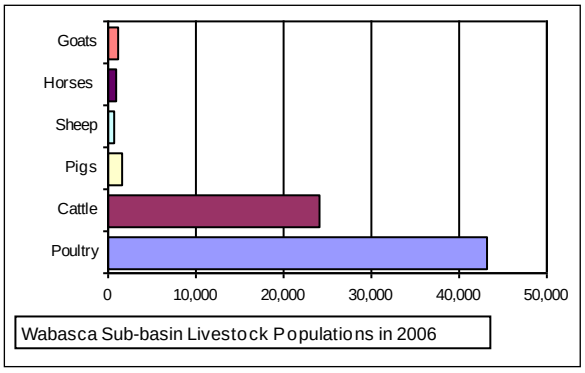
Agricultural Land Use in the Wabasca Sub-basin



Crop Land Use in the Wabasca Sub-basin

The most important crops grown in this sub-basin include oil seeds (35% of field crops), spring wheat (23%), alfalfa (18%), other grains and cereals (10%) and tame hay/fodder (6%). Eight farms reported using irrigation on 111 ha of land, primarily for field crops and hay and fruit crops.

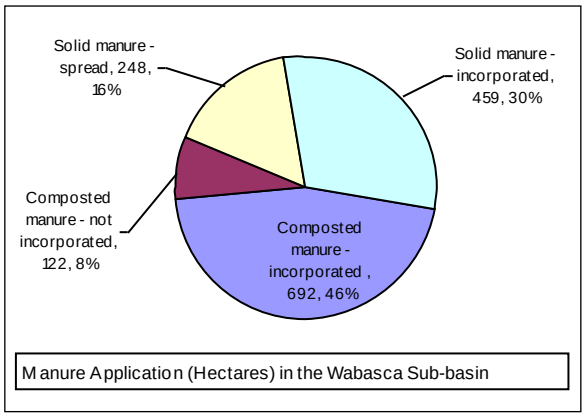
The majority of the farms in the Wabasca sub-basin (60%) raise livestock. About 45% of farms raised cattle (averaging 70 animals per farm) and 26% raised horses (4 per farm). Small number of farms raised other types of livestock including poultry (17%), hogs (8%), sheep (3%) and goats (4%). In total, there were about 71,300 animals (including poultry) in this sub-basin in 2006. This includes 24,040 cattle, 1,582 hogs, 663 sheep, 823 horses and 1,159 goats. These animals generated 0.25 million tonnes of manure.



Wabasca Sub-basin Livestock Populations in 2006

Compared to the

In terms of land management, 14% of farms applied manure to 1,625 ha of land, suggesting an average rate of 154 tonnes of manure per hectare. The most common types of manure application included incorporating composted manure (46% of the land area), incorporation of solid manure (30%), and spreading of solid manure (16%). In addition, 48% of farms used chemical fertilizers on 98,215 ha (69% of cropland).



Manure Application (Hectares) in the Wabasca Sub-basin

7.4.2 Forestry

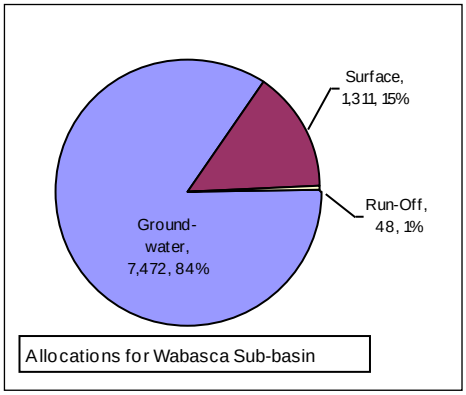
There are three operating sawmills in the Wabasca sub-basin near La Crete (La Crete Sawmills Ltd., Crestview Sawmills Ltd., and Evergreen Lumber Inc.). Parts of four FMAs are located in the Wabasca sub-basin. In the northwest corner of the sub-basin, FMAs have been issued to Daishowa-Marubeni International Ltd. and Tolko Industries Ltd/Footner Forest Products/La Crete sawmill. The southeast portion the sub-basin contains parts of FMAs issued to ALPAC Forest Products Ltd. and Tolko Industries Ltd/Wanderwell Contractors Ltd/West Fraser.

7.4.3 Oil and Gas

A total of 13,550 oil and gas wells have been drilled in the Wabasca sub-basin; this represents 22% of all wells drilled in the Peace watershed. There are also 105,870 km of seismic lines and 6,635 km of pipelines. There are more seismic lines in the Wabasca sub-basin than in any of the other sub-basins. This density of oil and gas activity has resulted in an average disturbance of 1.7 km of linear disturbance per square kilometre of land (excluding agricultural land). This is below the average for the Peace watershed (2.2 km/km^2).

7.5 Water Use

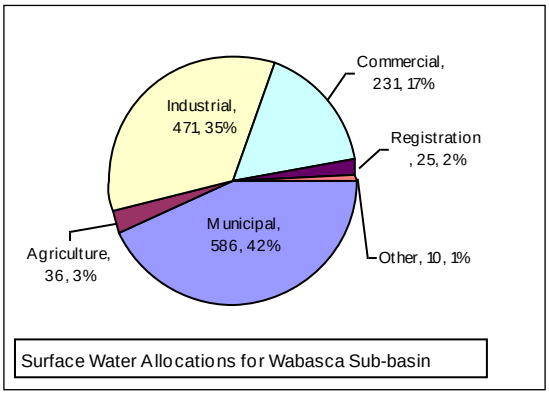
The most recent water licence information indicates that a total of 8,829 dam^3 of water has been allocated for use in the Wabasca sub-basin. This represents 5% of water allocations in the entire Peace River watershed. Allocations in the Wabasca sub-basin consist primarily of groundwater (7,472 dam^3 or 84%) but also include some surface water (1,311 dam^3 or 15%) and surface run-off (48 dam^3 or 1%).



Allocations for Wabasca Sub-basin

7.5.1 Surface Water

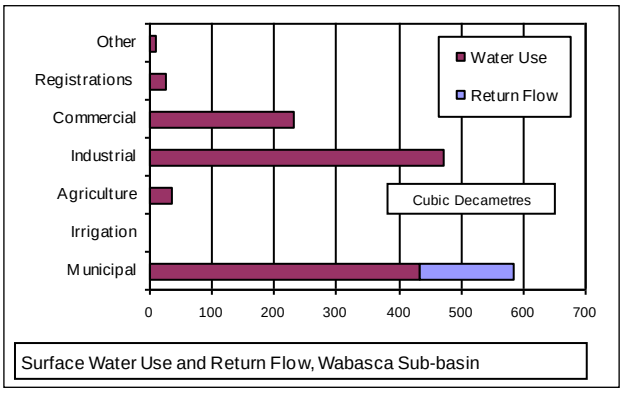
Licensed Use – Municipal water use accounts for the largest portion of surface water allocations in the Wabasca sub-basin. Allocations for municipal purposes amounted to 586 dam^3 or 42% of total allocations. Allocations for the Hamlet of Red Earth Creek accounted for 28% of total municipal allocations, while allocations for the Hamlet of Wabasca accounted for another 23%. Various allocations to Alberta Municipal Affairs accounted for 27% of total municipal allocations.



Surface Water Allocations for Wabasca Sub-basin

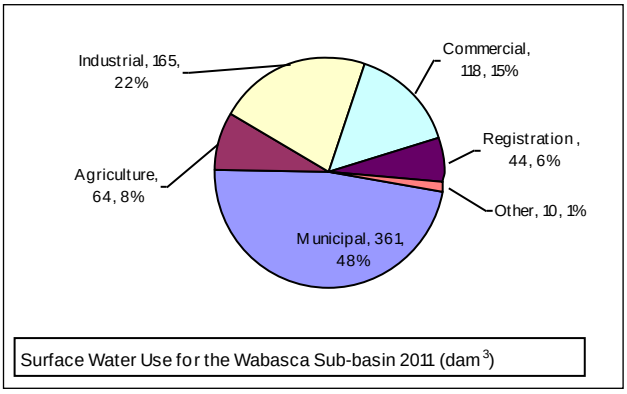
Industrial water use, with allocations of 471 dam^3, accounted for 35% of total surface water allocations. This consisted of licences issued to Kerr-McGee Canada Ltd and Argo Energy Ltd. for oilfield injection purposes. Allocations for commercial purposes accounted for 17% of the total, with allocations to two golf courses accounting for 70% of commercial allocations. Agricultural uses accounted for 5%, including 3% for agricultural licences and 2% for registrations. Water allocations for other purposes accounted for 1% of surface water allocations.

Water allocations include allowances for actual water use and may include expectations for return flow. Expectations for return flows have been included in some licences issued for municipal purposes. Overall, it is expected that 11% of withdrawals will be returned after use, including 23% of water withdrawn for municipal purposes.

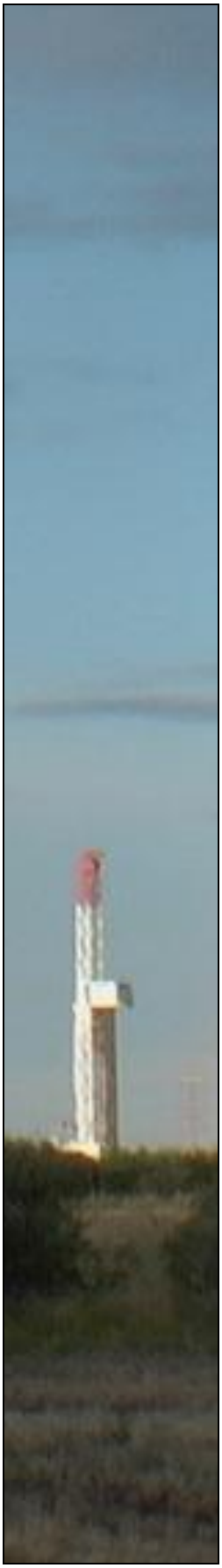


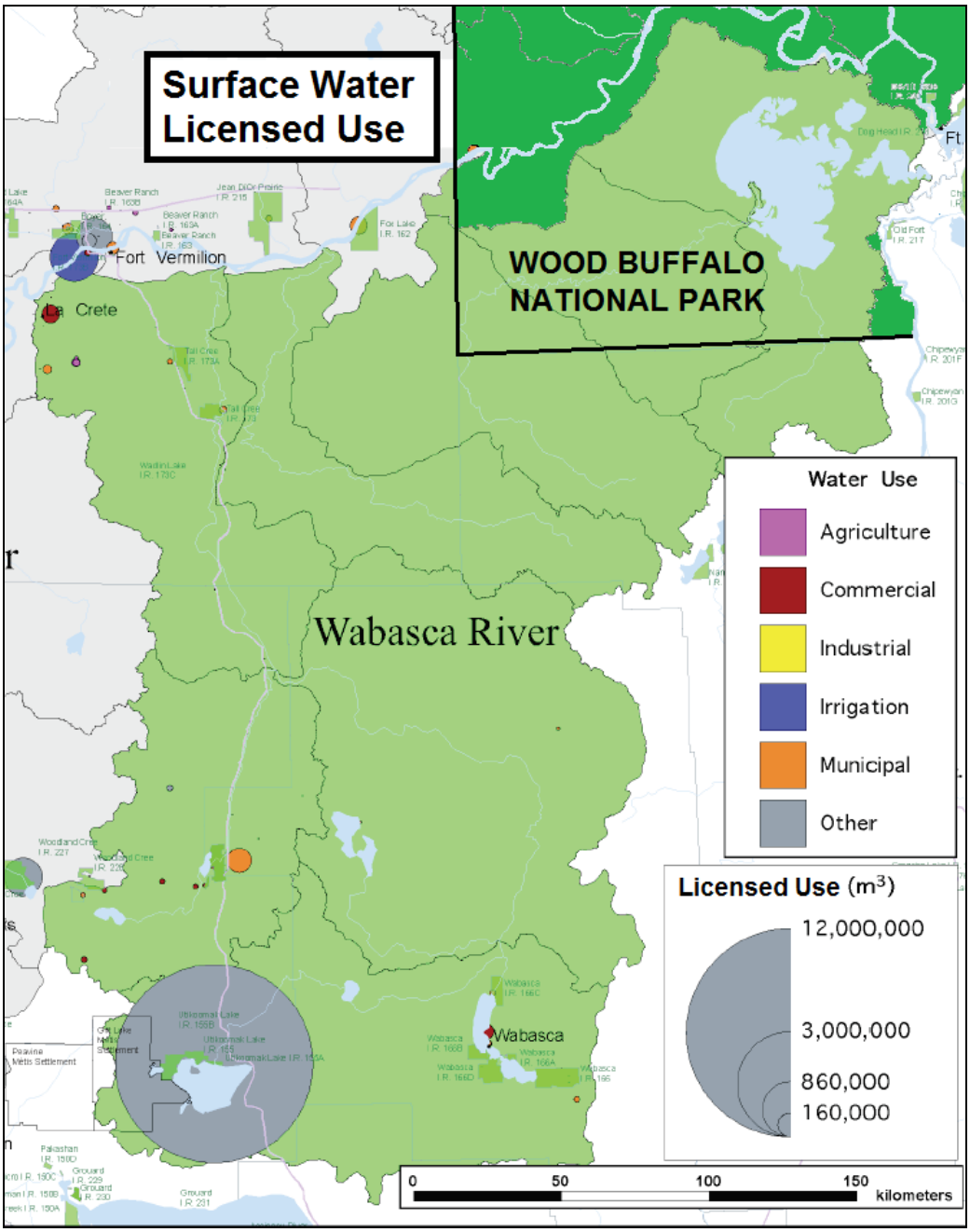
Surface Water Use and Return Flow, Wabasca Sub-basin

Actual Water Use - Total surface water consumption in the Wabasca sub-basin in 2011 is estimated to be 761 dam^3. This represents 56% of total surface water allocations and 63% of licensed water use. Municipal water use is estimated to account for 48% of total surface water use in the Wabasca sub-basin. Industrial and commercial water use accounted for 22% and 15% of total water use, respectively. Water allocated for agricultural uses accounted for 14% of total water use, including 6% for registrations and 8% for agricultural licences. Water used for other purposes accounted for 1% of total water use.

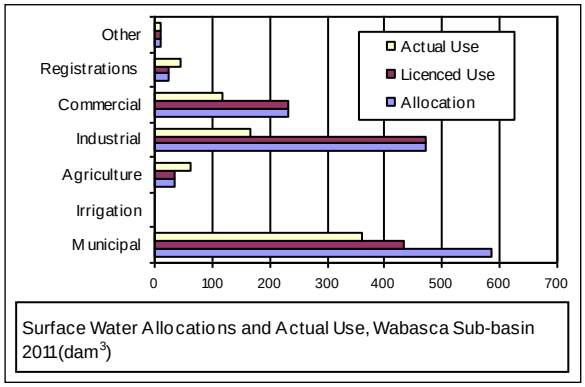


Surface Water Use for the Wabasca Sub-basin 2011 (dam^3)

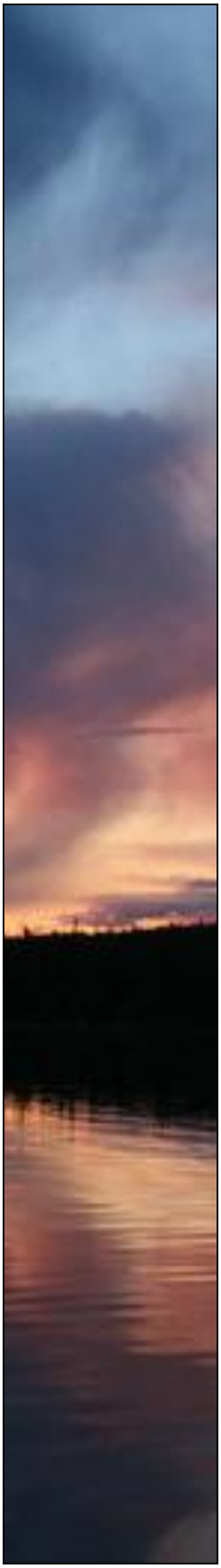




The biggest differences between water allocations and actual water use are that only 35% of industrial allocations and 51% of commercial water allocations are actually being used. Only 62% of water allocations for municipal purposes were actually being used. Estimated surface water use for agricultural purposes exceeded allocations, based on the amount of water being consumed by livestock populations in the sub-basin.

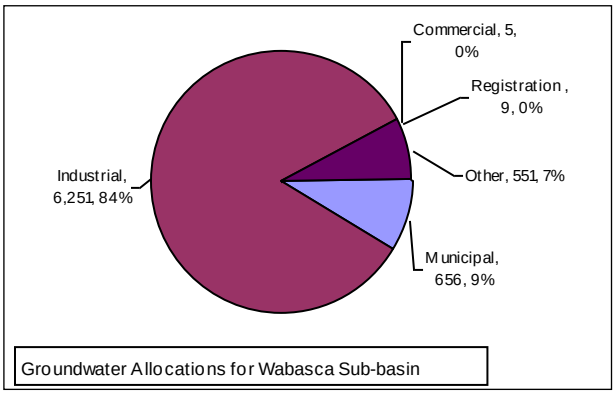


Surface Water Allocations and Actual Use, Wabasca Sub-basin 2011(dam^3)



7.5.2 Groundwater

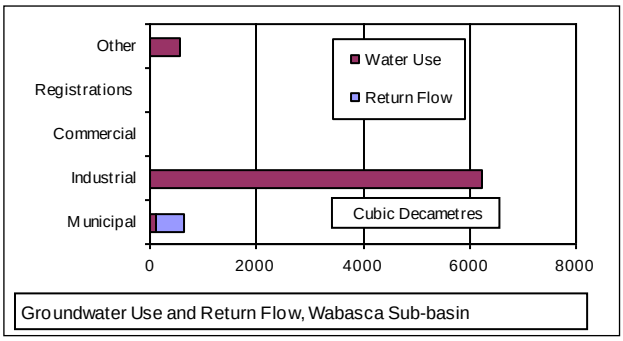
Licensed Use – Licences issued for industrial purposes account for the largest portion of groundwater water allocations in the Wabasca sub-basin. Allocations for industrial purposes, primarily oilfield injection, amounted to 6,251 dam^3 or 84% of total allocations. Various licences issued to Canadian Natural Resources for injection at its Brintnell, Gift Lake and Wabasca projects accounted for 71% of industrial allocations. Allocations to various other operators, including Cenovus Energy Inc., accounted for the balance of industrial allocations.



Groundwater Allocations for Wabasca Sub-basin

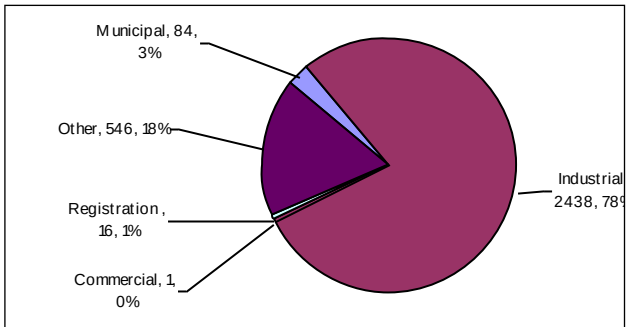
Small amounts of groundwater have been allocated for municipal purposes (9%) and for other purposes (7%). Groundwater allocations for commercial purposes and for registrations each account for less than 0.1% of total allocations.

Expectations for return flow have only been included in some water licences issued for municipal purposes. Overall, it is expected that 8% of groundwater withdrawals will be returned after use, including 84% of water withdrawn for municipal purposes.

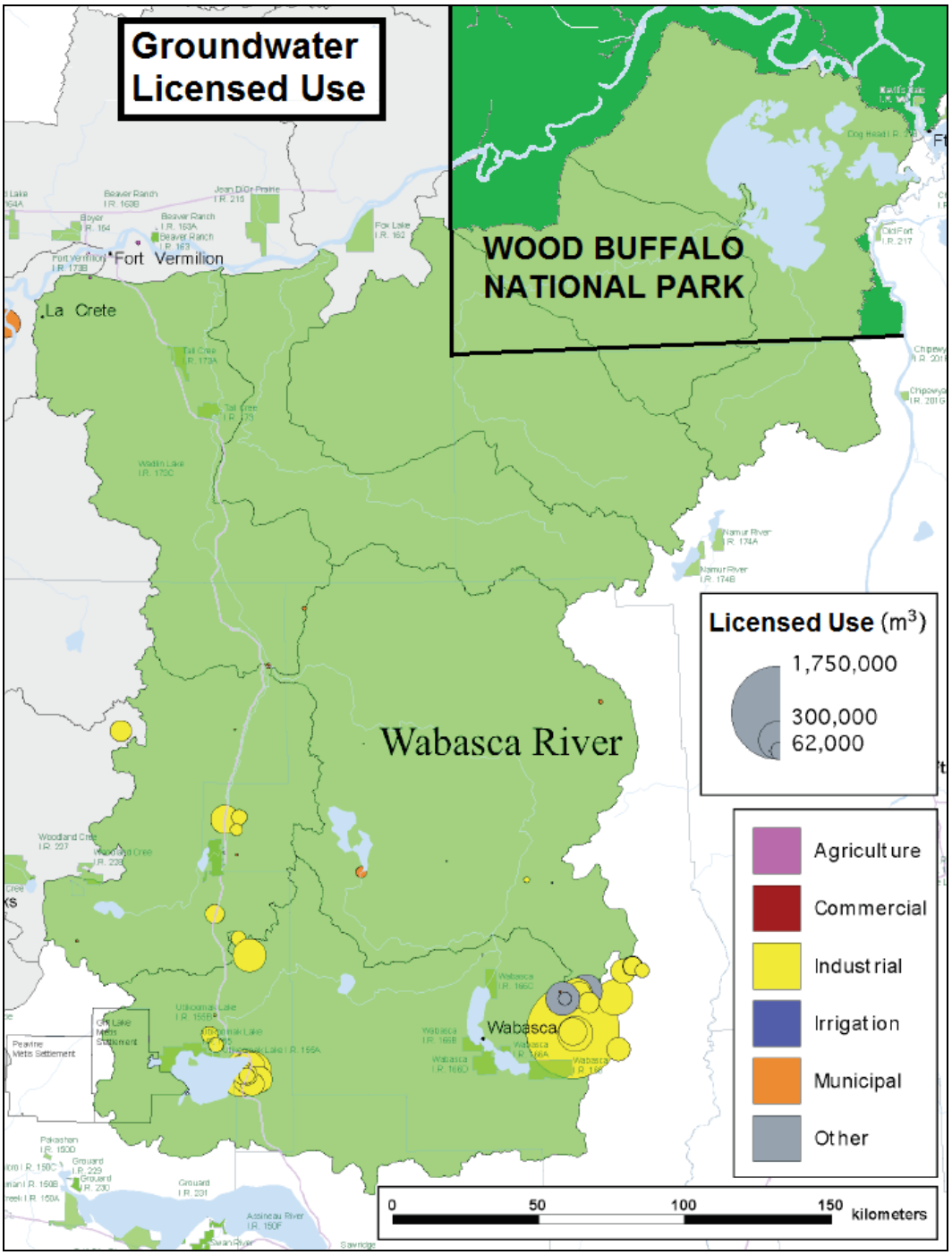


Groundwater Use and Return Flow, Wabasca Sub-basin

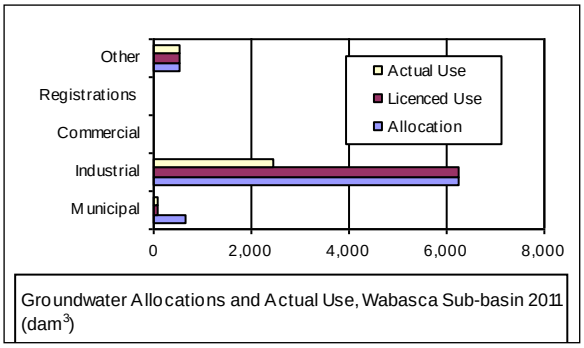
Actual Water Use - Total groundwater consumption in the Wabasca sub-basin in 2011 is estimated to be 3,084 dam^3. This represents 41% of total groundwater allocations and 45% of licensed water use. Water used for industrial purposes is estimated to account for 78% of total water use in the Wabasca sub-basin. Water allocated for other purposes accounted for 18% of total water use. Water allocated for municipal purposes accounted for 3% of total groundwater use while water used for agriculture (registrations) and commercial purposes accounted for the remaining 1% of actual water use.



Groundwater Use for the Wabasca Sub-basin 2011 (dam^3)

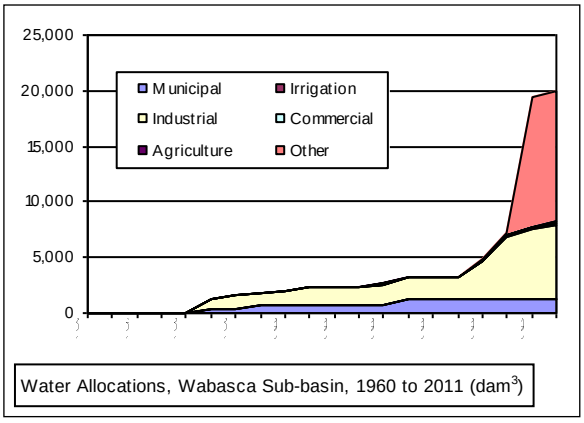


Actual industrial water use is estimated to have accounted for 39% industrial groundwater allocations. Actual water use accounted for 83% of municipal allocations and 100% of allocations for other purposes.



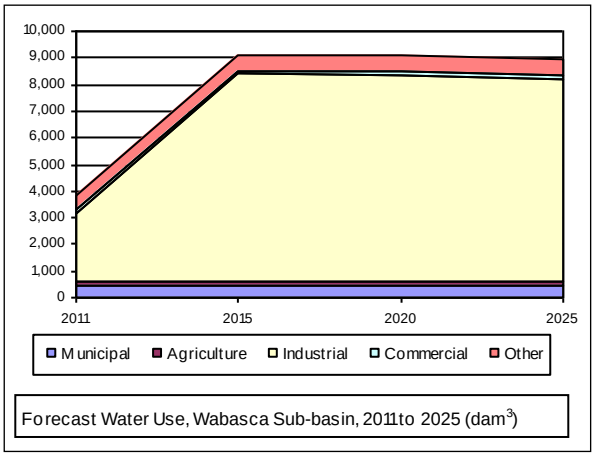
Groundwater Allocations and Actual Use, Wabasca Sub-basin 2011 (dam^3)

7.5.3 Future Demand



Water Allocations, Wabasca Sub-basin, 1960 to 2011 (dam^3)

Since 2000 there has been an 873% increase in total water allocations in the Wabasca sub-basin. This represents an average increase in allocations of about 1,627 dam^3 per year, with 93% of the increase having occurred since 2006. Over the period from 2000 to 2011, the increase in allocations was mainly due to increased allocations for other purposes (66% of the total increase) and for industrial purposes (30%). New allocations for municipal purposes accounted for 3% of the increase, while new allocations for commercial purposes accounted for 1% of the increase. There were no new allocations for irrigation or agricultural industrial purposes.



Forecast Water Use, Wabasca Sub-basin, 2011to 2025 (dam^3)

Over the period from 2011 to 2025, water use in the Wabasca sub-basin is expected to increase by 132%. Almost all of the change is predicted to be due to a significant increase in the amount of water being used to oil and gas production, especially for in-situ processing of heavy oil using steam. Minimal population growth is expected in the Wabasca sub-basin, so municipal water use is predicted to increase by 6%. Small changes in agricultural water use (a 3% increase) are also expected, as is a 26% increase in commercial use, although total commercial use will remain quite small. The total change in water use is predicted to be 5,090 dam^3, and increased industrial demand is predicted to account for 98% of the increase.

7.6 Water Quality

7.6.1 Surface Water

There is no WQI rating for the Wabasca sub-basin because there are no AEW long term monitoring sites. There has been little water quality monitoring in this sub-basin within the past 10 years.

AEW has conducted water quality studies on a number of rivers and lakes within the sub-basin for baseline information, synoptic studies, or short-term monitoring events. Water quality studies have been conducted for the Wabasca River, Teepee Creek, Mikkawa River, Boyer River, Birch River, Mamawi River, Chenal des Quatre Fourches, and Prairie River. Lakes monitored for water quality include: Wood Buffalo Lake, Kamaskikowik Lake, Teepee Lake, Corn Lake, Unnamed Lake, Carrot Lake, Ois Lake, God's Lake, Chipewyan Lake, W. Ceroici Lake, Alytraik Lake, Talbot Lake, Wadlin Lake, Sawmill Pond and Jean Lake.

In its 2011 report titled "An Integrated Oil Sands Environmental Monitoring Plan", Environment Canada recommended that the main rivers within the sub-basin (the Wabasca River, the Mikkiwa River, and the Birch River) be included within the expanded geographic scope of monitoring in the Lower Athabasca.

7.6.2 Groundwater

AEW does not monitor any groundwater wells within the Wabasca sub-basin. Some information on groundwater quality is likely available within any environmental assessments completed for major oil and gas construction projects in the area.

7.7 Water Issues

At the present time there appear to be no specific water quality or quantity issues in the Wabasca sub-basin. However, oil sands development is occurring in the upper reaches of the Wabasca River and some of its major tributaries and there are concerns about the potential effects of this development on water quality. As noted above, there are recommendations that these rivers be included in monitoring plans for the oil sands. There may also be concerns about how increased development of the oil sands, especially the use of in-situ thermal (steam) technology, will increase the demand for water. The water use forecasts for this sub-basin suggest that demand will increase by 132% over the period to 2025 with increased industrial demand accounting for 98% of the increase.

The other issue for this sub-basin remains the health of the Peace-Athabasca delta. As discussed earlier, both climate change and the effects of the flow regulation associated with hydroelectric development on the Peace River in BC have contributed to major changes in the delta, specifically the loss of perched basins and wetlands as a result of fewer ice jam flood events. The development of additional hydroelectric capacity on the Peace River at Site C is not expected to change the existing flow regime because the project would be operated as a run-of-river facility. However, filling of the reservoir will result in lower downstream flows, and this could further reduce the frequency of ice-jam events. It is expected that these hydrologic effects will be a key issue during public hearings to determine whether the proposed project is in the public interest.

8.0 SLAVE RIVER SUB-BASIN

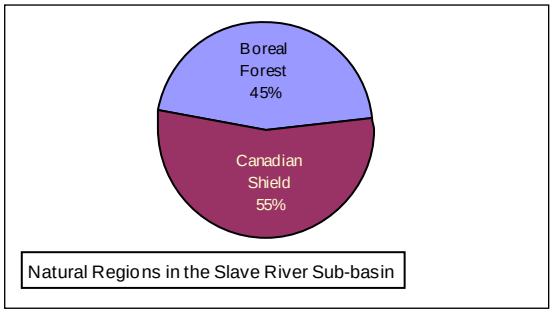
The Slave River sub-basin consists of lands that drain into the Slave River downstream from the confluence with the Peace River down to the Alberta-Northwest Territories boundary. This coincides with the Water Survey of Canada sub-basin 07N.

8.1 Physiography

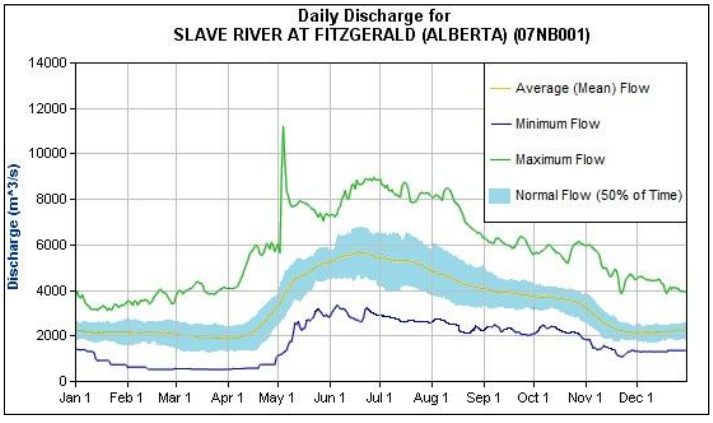
The Slave River sub-basin is about 11,630 km² in area and accounts for about 6% of the Peace watershed in Alberta. It is located primarily in the Canadian Shield Natural Region 54.6%, while the remainder is located in the Boreal Forest Natural Region (45.4%).

8.2 Hydrology

There is one gauging station on the Slave River at the Fitzgerald (07NB001). Average daily flows at this station have been recorded for the period from 1921 to 2010.



Natural Regions in the Slave River Sub-basin



The normal flow of the Slave River is usually about 2,000 m^3/sec throughout the first four months of the year. It then increases to nearly 6,000 m^3/sec during June before gradually decreasing to 4,000 m^3/sec in September and October. Normal flows continue to drop, to 2,000 m^3/sec in December. However, over the period of record, there has been considerable variability in flows, with a maximum flow of about 11,000 m^3/sec having been recorded in early May and low flows of less than 1,000 m^3/sec in February and March.

There are numerous small tributaries to the Slave River, the largest of which include the Hornaday, Bocquene and Dog rivers. A large part of the sub-basin drains into the Salt River which enters the Slave River downstream from Fort Smith in the NWT. There are numerous small lakes in the sub-basin, especially in the Canadian Shield Natural Region on the east side of the Slave River.

There are 1,015 km^2 of large wetlands (>500 ha) in the Slave sub-basin. This represents 7.5% of the total area of the sub-basin and accounts for 6.4% of all wetlands in the Peace watershed.

8.3 Socio-Economic Characteristics

The Slave River sub-basin is sparely populated. Although there are four Indian Reserves in the sub-basin, three of these (Devil's Gate 220, Cornwall Lake 224 and Charles Lake 225) are not populated. All three reserves were established for the Mikisew Cree First Nation.

The fourth reserve, Thebathi 196, is located on the Slave River just south of the NWT boundary at what is also known as Fitzgerald. In 2006, it had a population of 15 people, down from 21 people in 2001. The reserve is one of 10 reserves established for the Smith's Landing First Nation which is based in Fort Smith NWT and had a registered population of 324 people as of December 2011.

There is also a small rural population of about 70 people in Improvement District No. 24. Thus, the overall population of the Slave sub-basin in 2006 was about 85 people.

No additional socio-economic information on this population has been released by Statistics Canada because of the small population size.

8.4 Land and Resource Use

About 41% of the Slave sub-basin is located in Wood Buffalo National Park. Only 4.1% of land in this sub-basin has been disturbed, primarily as a result of clearing for trails and winter roads.

8.4.1 Agriculture

There is no agriculture in the Slave River sub-basin.

8.4.2 Forestry

There is no forestry in the Slave River sub-basin. None of the area has been included in any FMAs.

8.4.3 Oil and Gas

There are 200 kilometres of seismic lines in the Slave sub-basin. No oil or gas wells have been drilled.

8.5 Water Use

No licences or registrations have been issued for any uses in the Slave River sub-basin. While residents of the Thebathi 196 reserve use water for domestic purposes, the source of this water is unknown.

8.6 Water Quality

8.6.1 Surface Water

There is no AEW River WQI rating for this sub-watershed because there are no long term monitoring sites on the Slave River. Aquatic ecosystem studies have suggested that water quality conditions in the Slave River are similar to those of the lower Peace River; water quality is considered to be 'fair' as a result of higher levels of suspended sediment, nutrients, metals, biochemical oxygen demand, and turbidity than are found in the upper reaches of the Peace River.

A study by Environment Canada on surface water quality in Wood Buffalo National Park showed similar results for the Slave River and the Lower Peace River. Concentrations of total phosphorus, nitrogen, and total metal were found to be directly related to the naturally high sediment loads in these rivers.

AEW has conducted water quality studies on a number of rivers and lakes in the Lower Peace sub-basin, either for baseline information, synoptic studies, or short-term monitoring events. The rivers that have been monitored include the Rivière des Rochers and the Slave River upstream of confluences with major creeks and rivers, and upstream of the border crossing. Lakes that have been monitored include: Unnamed Lakes, Barrow Lake, Fletcher Lake, Bocquene Lake, North Leland Lake, Tulip Lake, and Myers Lake. Environment Canada has a monitoring location on the Slave River at Fitzgerald, within Wood Buffalo National Park.

8.6.2 Groundwater

AEW does not monitor any groundwater wells within the Slave sub-basin**.**

8.7 Water Issues

At the present time there appear to be no specific water quality or quantity issues in the Slave River sub-basin. However, as water in the Slave River comes from both the Peace and the Athabasca rivers, there are concerns about potential effects on water quality along the mainstem of the Slave River, associated with industrial activities in both the Athabasca and Peace basins.

The main issue for this sub-basin is the potential for hydroelectric development on the Slave River. As noted earlier, this potential has been evaluated for several sites since the late 1970s. While the most recent investigations have stalled because the Smiths's Landing First Nation would not agree to having feasibility conducted in the area, there will always be interest in developing 'green' power from hydroelectric projects to meet Alberta's future power demands. ATCO still sees the Slave River as being a key element of its northern hydro energy corridor and, as recently as January 2012, indicated that construction of two new north-south power lines will assist with its plan to construct an 800-megawatt plant on the Slave River, although the project is currently on hold (Calgary Herald, 2012).

9.0 CONCLUSIONS

As noted at the outset, the objective of this study was to summarize what is currently known about water quantity, water quality, water use and potential water supply and quality issues throughout the Peace watershed. This information is needed by the MPWA to identify ongoing and future management issues that it will attempt to address and to inform basin residents and others about how water and how it is being managed affects them and their community.

9.1 Discussion

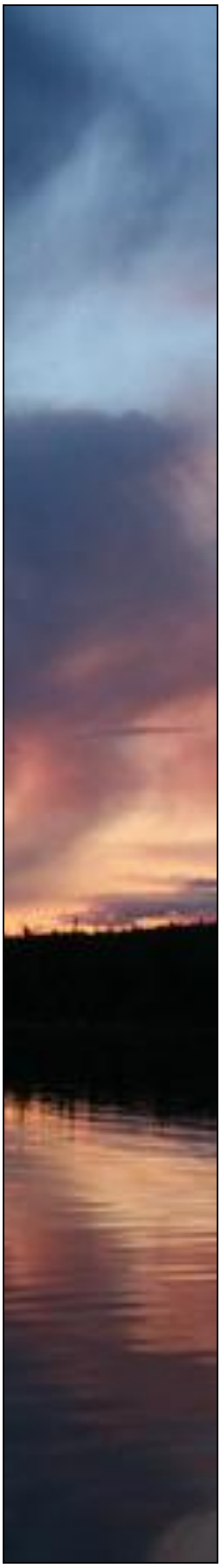
The information presented in this report suggests that available, published information is generally sufficient to provide an overview of water quantity, quality and water use in the watershed for the six sub-basins. The analysis suggests that, in general terms, there are no current significant water management issues in the watershed, except perhaps at a very local level, and that management regimes are evolving to address land and resource practices that could adversely affect water quality or quantity. Compared to other parts of Alberta, the Peace watershed currently has a very small population and the existing levels of agricultural, commercial and industrial development do not appear to have significantly affected the water resources in the watershed.

This may start to change in the near future, however. Industrial growth, especially related to development of heavy oil resources in the region, continued intensification of agriculture, and expected population growth will place more demands on the watershed. While these additional demands will be minor in terms of the mainstem of the Peace River, there could be significant effects on its tributaries. Of particular concern are increased population growth and agricultural intensification in Smoky/Wapiti sub-basin and industrial development in the Wabasca sub-basin. In the absence of information about the current health of these aquatic ecosystems, more information will be needed to fully understand the effects of potential future development and to implement strategies and measures to protect, maintain and potentially enhance the health of these tributary rivers.

For the mainstem of the Peace River, the future challenges relate to the potential effects of future hydroelectric development. While river flows are unlikely to be further affected by this development, there is uncertainty about how additional dams and structures will affect the ice regime, fish populations and migration, and populations of other aquatic biota. Available information suggests that, to date, our understanding of ecosystem health comes from a few studies undertaken to assess the effects of specific projects, such as the pulp mills, and there has been no systematic attempt to document the functionality or health of aquatic ecosystems throughout the watershed.

9.2 Data Gaps

This conclusion begs the question of what other information would be helpful for the MPWA in supporting its vision of the Peace watershed as a healthy, sustainable watershed that supports social, environmental and economic objectives.



The key data gap for the Peace watershed appears to the lack of more comprehensive and systematic information about the aquatic health of rivers, lakes and streams throughout the watershed. If the MPWA is to achieve its vision for the watershed, it will need better information about aquatic health. Without knowledge of existing conditions, it is will not be possible to assess the potential effects of development on environmental sustainability. There is currently a lack of information about the fisheries resources of the watershed or about other aquatic biota. And without a detailed understanding of current conditions, it will not be possible to determine whether perceived changes in these resources are the result of current or future development activities or to develop appropriate strategies for addressing the changes.

The need for more information on aquatic health is probably of greatest concern for the Wapiti River. In terms of current municipal and commercial demands, the Wapiti is the most heavily utilized water body in the watershed. While there is currently "good" information on aquatic health in the Wapiti River, water quality and sediment quality are both rated "fair". The extent to which the river can support additional demands without further compromising aquatic health is not known. Consequently, studies should be undertaken to determine a flow regime that will sustain the health of the river, including the determination of instream flow requirements.

There are a number of instances where this assessment of current conditions in the watershed could have benefitted from additional information. For example, we could not find information related to forest harvesting activities, in terms of location or spatial extent, and this would have added to the current understanding of land disturbances in the watershed. Similarly, we could only identify information for large wetland areas (greater than 5,000 ha) and more detailed information would be desirable so that potential effects of climate change on smaller wetlands could be monitored. While neither type of information was absolutely necessary to support this assessment, it would have added to the general understanding of conditions in the watershed.

Similarly, it would have been beneficial to have had better information about actual water use by licensees. While water use reports were provided by the largest water users, there are still some important gaps. For example, water use information was not provided by irrigators or agricultural water users or by some municipalities. There was also no information on return flows for most municipalities; this can be important where municipalities are using groundwater and treated wastewater is then returned to surface water bodies, thereby augmenting surface water supplies. In addition, there were a number of instances where reported water withdrawals exceeded licensed allocations and it is not clear whether this was because of a reporting error or actually represents overuse.

The status of licences issued for "other" purposes is also problematic. It is not clear whether these licences are transferring water from one water body to another, or represent actual water consumption. In some cases the volumes of water being allocated to "other" purposes is quite large so clarification of the natures of these uses would provide a better understanding of actual water use in the watershed.

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APPENDIX A - WATER MANAGEMENT FRAMEWORK

Various provincial and federal laws, policies and agreements determine how water in the Peace watershed is used and managed. A brief summary of the most important of these is provided below.

A.1 Provincial Legislation and Policies

A.1.1 Alberta Water Act

The Alberta *Water Act* establishes the rules by which water can be taken and used. All surface water and groundwater in Alberta is owned by the Crown, but the Crown can allocate the right to use water to individuals. Four types of water rights exist

- Domestic water rights allow people living adjacent to surface water or above groundwater were allowed to use water for household purposes without needing a licence.
- Registrations were issued for traditional agricultural use and allow the withdrawal and use of up to 6,250 m^3 of water per year for agricultural purposes.
- Water licences were issued for all other types of water uses.
- Exempted agricultural use allows farmers to use up to 6,250 m^3 of water without requiring a registration or a licence.

During times of water shortages, domestic water rights have the highest priority. For water users with registrations or licences, priority is determined on basis of seniority, as determined by the date the licence was first issued or water was first used by traditional agricultural uses. This is also known as "first in time, first in right". Exempted agricultural use does not have priority over the other uses.

Water licences are issued for a specific purpose and specify the maximum amounts of water that can be withdrawn and consumed, and may contain additional terms and conditions describing when, where and how the water may be diverted. Prior to 1998, when the *Water Act*, came into force, water licences were issued in perpetuity and were tied to a specific project or piece of land, so the licence would automatically be passed on to subsequent owners. Since 1998, water licences have been issued for a fixed period of time, but will be renewed as long as water conservation objectives in the basin are being met or it is not counter to the public interest. The Alberta *Water Act* also provides the opportunity for licences to be transferred to other projects or lands as long as there are no adverse impacts on the environment or other water users

Other important aspects of the Alberta *Water Act* include:

- the Government can reserve water that is not currently allocated to maintain the natural integrity of riparian and aquatic habitat.
- natural water bodies and/or their aquatic environments can be protected through the establishment of water conservation objectives (WCOs)
- Water cannot be transferred between major basins unless authorized by a special Act of the Legislature.
- Licences will not be issued for any activity that would allow water (other than municipal or process water) to be transferred outside Canada unless authorized by a special Act of the Legislature.

With respect to groundwater, the Alberta Government has put into place the regulatory framework for protecting aquifers from over-use and physical damage or impairment. Guidelines developed for this purpose include:

- the Groundwater Evaluation Guideline
- the Water Conservation and Allocation Guideline
- the Subdivision Report Requirements under Section 23 of the *Water Act* for Subdivision Development,
- the Guide to Industrial Approval Applications
- the Standard for Baseline Water-Well Testing for Coalbed Methane/Natural Gas in Coal Operations

More details on aquifer protection guidelines can be found by navigating to: http://environment.alberta.ca, then following the tabbed links: water>Legislation. Alberta Environment and Water provides a repository for water well drillers' reports at: http://environment.alberta.ca. Individual water well information can be found by following the links: water>reports/data/Alberta Water Well Information Database

A.1.2 Water for Life: Alberta's Strategy for Sustainability

This strategy was developed in 2003 and contained commitments to ensure safe drinking water, maintain and protect aquatic ecosystems, and manage water to support sustainable economic development. It focused on three core areas:

- Providing the knowledge and research necessary to manage water effectively.
- Developing partnerships among citizens, communities, industries and governments to actively manage Alberta watersheds, include the creation of WPACs.
- Practicing water conservation to accommodate future consumptive demands for water while maintaining health aquatic ecosystems. This included a commitment to improve water use efficiency and productivity in 2015 by 30 per cent over 2005 levels.

The Water for Life policy was renewed in 2008.

A.1.3 Alberta Environmental Protection and Enhancement Act (AEPEA)

AEPEA requires industries and municipalities to acquire an approval that regulates discharges to surface waters. Individuals are prohibited from releasing substances into the environment that exceed the limits set out in approvals or in the regulations, whichever is more stringent. The *Potable Water Regulation* sets the standards for the operation of drinking water treatment systems in Alberta and uses the health-related parameters of the Canadian Drinking Water Guidelines. Alberta Environment routinely monitors surface water quality and provides annual provincial water quality reports using the Alberta Surface Water Quality Index. Water quality is assessed against scientifically-derived standards for protection of aquatic life, agricultural uses (stockwatering and irrigation), and recreational and aesthetic purposes.

A.1.4 Agricultural Operation Practices Act (AOPA)

AOPA regulates the management and application of manure to help protect surface and groundwater. All proposals for new or expanding confined feeding operations above specified animal population thresholds must demonstrate compliance with the regulations before they can proceed.

A.1.5 Alberta Fisheries Act

Alberta is responsible for controlling use of fish resources in the province and sets the limits for commercial and recreational fishing and fish farming. Alberta released its fish conservation strategy in 1998 and key guiding principles include no net loss of the productive capacity of habitats, maintaining fish populations through natural reproduction wherever possible, and maintaining the biological diversity of the fish fauna

A.1.6 Alberta Public Lands Act

The Crown owns the beds and shores of all permanent and naturally occurring bodies of water and all naturally occurring rivers, streams, watercourses and lakes in Alberta, including permanent or semi-permanent wetlands. Under this legislation, riparian landowners can only disturb or modify shorelines if they receive prior authorization. In general, the public has the right to use shorelines for recreational purposes.

A.1.7 Alberta Wetland Policy

An interim policy on wetland management in the settled area of Alberta was issued in 1993. The goal of the policy was to sustain the social, economic and environmental benefits that functioning wetlands provide, now and in the future. In 2005, the Alberta Water Council established the Wetland Policy Project Team to develop recommendations for a new wetland policy, including an implementation plan for the Government of Alberta. Following extensive consultation, the Team submitted its final report to the Board of Directors of the Council and final decision was delayed so that members had sufficient time to ratify the documents within their individual sectors. Eventually, two sectors indicated that they could not fully support all of the idea and actions recommended by the project team. A copy of the proposed policy and response letters from parties that did not support the policy were transmitted to the Minister of Environment. A wetland restoration and policy guide was released by Alberta Environment in 2007. In reviewing land development applications under the Water Act, priority will be given to avoiding impacts on wetland area whenever possible. However, when this is not an option, developer must explore how they can reduce impacts to the wetland area or, if this is not possible, how they can compensate for the disturbance. Compensation for the loss of naturally occurring wetlands will be required when an approval to impact a wetland is issued under the Water Act, and when the regulator has decided the most appropriate action is to restore a wetland.

A.2 Federal Legislation and Policies

A.2.1 Fisheries Act

The Federal Fisheries Act regulates any activity that may affect fish movement or fish habitat. Any activity that results in the harmful alteration, disruption or destruction of fish habitat, without prior authorization or according to regulations, is prohibited. The deposition of any deleterious substance in water frequented by fish is prohibited except where allowed under regulations. The guiding principle for habitat conservation is based on “no net loss” such that unavoidable losses resulting from economic development can be offset by habitat replacement or rehabilitation.

A.2.3 Navigable Waters Protection Act

Any proposed structure that might interfere with navigation must be reviewed and approved by the Minister of Transportation before it can be constructed. Navigable water is described as any body of

water capable of being navigated by floating vessels of any description for the purpose of transportation, commerce or recreation.

A.2.3 Pulp and Paper Effluent Regulations

The Pulp and Paper Effluent Regulations (PPER) were established under the Fisheries Act in 2004. The regulations were established to protect fish, fish habitat, and the use of fisheries resources. Part of the regulations established an Environmental Effects Monitoring (EEM) program to provide information on the potential effects of effluent from pulp and paper mills on fish populations, fish tissue, and benthic invertebrate communities. This information will provide Environment Canada with the information necessary to assess the adequacy of the PPER. The EEM programs are designed to achieve national uniformity in monitoring effects, while taking into consideration site-specific factors.

Pulp and paper mills in Canada have completed four sequences of monitoring and interpretation phases known as "cycles". These were completed in 1996 (Cycle 1), 2000 (Cycle 2), 2004 (Cycle 3), 2007 (Cycle 4) and 2010 (Cycle 5). The 6th EEM cycle for pulp and paper is due on April 1, 2013. Assessments of each cycle are performed to determine whether effects were observed, and identify the magnitude, extent, and potential cause of the effect. When effects are identified, the EEM program calls for identification of the source of the effects and the potential causative chemicals. This phase of monitoring is caused "Investigation of Cause" (IOC). Further work on eliminating or reducing the effects, especially if the source can be identified, are called "Investigation of Solution" (IOS) studies.

The guidelines for performing EEM studies are outlined in Environment Canada's *2010 Pulp and Paper Environmental Effects Monitoring (EEM) Technical Guidance Document.* Typically, EEM is performed by environmental consultants for pulp and paper mills to submit to Environment Canada.

A.3 Transboundary Agreements

Where rivers flow across provincial or territorial borders, water quantity and quality can be managed through trans-boundary agreements.

A.3.1 Mackenzie River Basin Transboundary Master Agreement.

In July 1997, the governments of Canada (represented by the Minister of the Environment and the Minister of Indian Affairs and Northern Development), British Columbia, Alberta, Saskatchewan, the Northwest Territories, and the Yukon entered into the Mackenzie River Basin Transboundary Master Agreement. The six governments committed to work together to create a cooperative forum to inform about and advocate for the maintenance of the ecological integrity of the entire Mackenzie River watershed. The Agreement adopted four principles for cooperative management. These include equitable utilization, prior consultation, sustainable development, and maintenance of ecological integrity. The agreement also includes principles for cooperative management of the aquatic ecosystem, a description of the administrative system to be used to facilitate the Board's business and identify its duties, provisions for neighbouring jurisdictions to negotiate bilateral, water management agreements, and a dispute resolution mechanism.

The Mackenzie River Basin Board (MRRB) was established to implement the Master Agreement. While the board is not a regulatory or licensing board, and has no legal or policy basis to regulate resources used in any of the jurisdictions, it may influence regulatory decision made in the jurisdictions by providing factual materials (such as the State of the Aquatic Ecosystem Reports) to inform development decision

makers, participating in and influencing pre or post regulatory processes (such as planning, regional or cumulative environmental impact assessments process, or ministerial reviews of sensitive decisions), and by appearing as "friend of the tribunal" in deferral, provincial, and territorial public hearings to advocate for the principles endorsed in the Master Agreement.

The MMRM prepared a state of the aquatic environment report for the Mackenzie River basin in 2003.

A.3.2 Alberta and British Columbia Bilateral Water Management Agreement

The Mackenzie River Basin Transboundary Master Agreement requires neighbouring jurisdictions to negotiate detailed bilateral water management agreements to address water issues at jurisdictional boundaries on transboundary streams and to provide parameters on the quality, quantity, and flow of water. Alberta and British Columbia have been in the process of negotiating a bilateral water management agreement for some time. A memorandum of agreement between the two provinces was signed in 2004 and a series of background reports was prepared in support of negotiations (BC Ministry of the Environment and Alberta Environment, 2009) and was presented to negotiators for both jurisdictions at a 2007 workshop.