UNIVERSITY OF ALBERTA
School of Business

BUEC 663 – NRE Capstone

Water Use & Policy Challenges in Alberta

(Within the Context of Energy Development and Environmental Regulation)

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1.0 Introduction

Containing up to 300 billion barrels of oil, Northern Alberta's unconventional oil sands rival the conventional reserves of Saudi Arabia. With up to $100 billion invested in oil sands recover over the next ten years, Alberta is predicted to become Canada's economic juggernaut for the next quarter-century.[1] Against this backdrop, is a growing population base of over three million people, industrial and agriculture expansion, all of which are competing for Alberta's scarce water resources. Combined with Alberta's historical droughts, and the uncertainty of Global Warming, many environmental coalitions are now calling for a moratorium on incremental oil sands project approvals until we have a clear assessment what water resources are relative to what projected consumption will be.[2]

Source: Syncrude 2007

Used in upstream extraction and processing, the oil and gas industry has a tremendous thirst for water. And, while agriculture remains the largest user of provincial water resources, in many northern Alberta watersheds, the oil and gas sector has become the primary consumer. Given the oil sands proximity to the Athabasca River, many are calling this an environmental "hotspot" since much of the water used in the oil and gas sector becomes contaminated and/or is not returned to the watershed from which it was taken.[3]

Source: Ice Field Helicopter Tours 2007

As the steward of natural resources, clearly government has the responsibility of determining the cumulative impacts of oil and gas activity and ensuring the sustainability of our water resources for future generations.

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[1] Letourneau, Jim, KWR Special Report. "Labor Shortages in the Resource Sector" retrieved Nov 17, 2006. <http://kwrintl.com/library/2006/Laborhshortages.htm>

[2] Reuters Environmental News. "Water Controversy may douse Alberta Oil Sands Boom". Planet Ark. Retrieved January 17, 2007. <www.planetark.com/dailynewsstory.cfm/newsid/16683/story.htm>

[3] Woynillowicz, Dan "Troubled Waters, Troubling Trends – Summary Report – Pembina Institute, May 2006

2.0 Water Resources in Alberta

Alberta, when compared with other provinces of Canada, is a relatively dry place. While Alberta has about 10% percent of Canada's population, and 7% of its land area, Alberta is only endowed with about 2% of Canada's fresh water resources.[4]

2.1 Surface Water

Alberta's surface water resources are mainly stored in glaciers, lakes and man-made reservoirs that eventually flow through the province's rivers and streams. Alberta's lakes range from small, landlocked lakes, to very deep lakes that cover hundreds of square kilometers and have relatively stable water levels.

Table 1: Largest Lakes in Alberta[5]

Largest Lakes in Alberta			
	Area (km^2)		Area (km^2)
Lake Athabasca (Sask./Alta.)	7770	Winefred Lake	123
Lake Claire	1405	Gordon Lake	116
Lesser Slave Lake	1160	Buffalo Lake	99.0
Primrose Lake (Sask./Alta.)	434	Pigeon Lake	98.0
Bistcho Lake	415	North Wabasca Lake	97.9
Cold Lake (Alta./Sask.)	373	Pakowki Lake	96.2
Utikuma Lake	288	Gull Lake	84.2
Lac La Biche	234	Wabamun Lake	81.8
Mamawi Lake	160	Peerless Lake	81.6
Beaverhill Lake	139	Margaret Lake	78.9
Calling Lake	138	Chip Lake	74.6
Sullivan Lake	130	Baril Lake	71.7

Rivers that originate or flow through Alberta eventually end up in one of three continental divides. The Arctic Ocean via the Mackenzie River Basin (almost 87%), Hudson Bay via the Nelson or Churchill River Basins (13%), and the Gulf of Mexico via the Missouri-Mississippi River Basin (0.1%).[6] Alberta's six largest rivers account for 87.16% of the province's total water discharge (see Appendix 1).

[4] "Water in Alberta". 2005. Alberta Goverment.
<http://www3.gov.ab.ca/env/water/gwsw/quantity/waterinalberta/index.html>
[5] "Lakes" 2005. Alberta Government.
<http://www3.gov.ab.ca/env/water/GWSW/quantity/learn/what/SW_SurfaceWater/SW1_lakes.html>
[6] "Rivers". 2005. Alberta Government.
<http://www3.gov.ab.ca/env/water/GWSW/quantity/learn/what/SW_SurfaceWater/SW2_rivers.html>

However, the volume of water that flows in these continental river basins varies greatly. Appendix 2 exhibits the mean annual river discharges in Alberta.

2.2 Ground Water

Groundwater is water that is found under the ground surface in the spaces between rocks, soils, and overburden (pore space),[7] and is an important component of Alberta's water resources. The largest source of potable water in Alberta is in the High Plains close to the Foothills, buried in deep, pre-glacial gravels and sand-filled bedrock channels. The quantity of groundwater in storage is estimated to be less than 40,000 km³. The total volume of potable groundwater in the province is around 5.5 billion dam³, in which only approximately 16,000,000 dam³ is considered recoverable in a sustainable volume.[8]

2.3 Allocations in Northern & Southern Alberta

In Alberta, water resources are not distributed evenly across the Province. The majority of Alberta's water is resources are in the lower demand areas of the northern Peace River drainage basin which flows northward through the Mackenzie River. In the south, the South Saskatchewan River basin contains only 13% of Alberta's water, but has 88% of Alberta's population and a large irrigated agricultural land base.[9] The median annual unit runoff map (see Appendix 3) reflects the province's precipitation regime (wettest-driest areas). Known for its cyclical droughts, in the absence of incremental storage dams (to capture and store spring run-off), southern Alberta's water resources are considered to be totally allocated.

3.0 The Athabasca River

The Athabasca River is the longest river in Alberta, winding 1,538 kilometers through the province. The river is subject to low flow periods in the winter months from November to March with

[7] "Ground Water Introduction". 2006. Alberta Government.
<http://www3.gov.ab.ca/env/water/GWSW/quantity/learn/what/GW_GroundWater/GW1_introduction.html>
[8] Ibid.
[9] "Water in Alberta". 2005. Alberta Goverment.
<http://www3.gov.ab.ca/env/water/gwsw/quantity/waterinalberta/index.html>

mean flows of 169 cubic meters per second.[10] The rivers in-stream flow needs (IFN) represent the minimum water flow that is needed to sustain the rivers ecosystem. Alberta Environment issued An Interim Framework: In-stream Flow Needs and Water Management System for Specific Reaches of the Lower Athabasca River to address the issue of withdrawals from the river during low flow periods. Currently, 10% of the rivers low-flow volumes are allocated. The framework lists various zones for different flow conditions and also provides recommendations.

Table 2: Summary of Alberta Environment's Interim Framework[11]

Zones	Environmental Implication	Management Action
Greens	Flows are sufficient-impacts to aquatic ecosystems are negligible	All licensees operate normally and operate within the conditions of their licenses.
Yellow	Potential Short term impacts on ecosystem.	Voluntary conservation practices to meet a 'target' of a 10% (of available flow) total maximum diversion rate (i.e. 10-20 cubic meters/second) Recent and new licenses may include conditions that mandate incremental reductions.
Red	Impacts on aquatic ecosystem are expected. Increased duration and frequency may threaten ecological sustainability.	Mandatory reductions and use of storage. Move towards a cumulative diversion rate target-may be 6 cubic meters /second. Applies to all licenses in a variety of ways
Black	Unsustainable	To be determined based on CEMA recommendations

4.0 Petroleum Industry Water Use

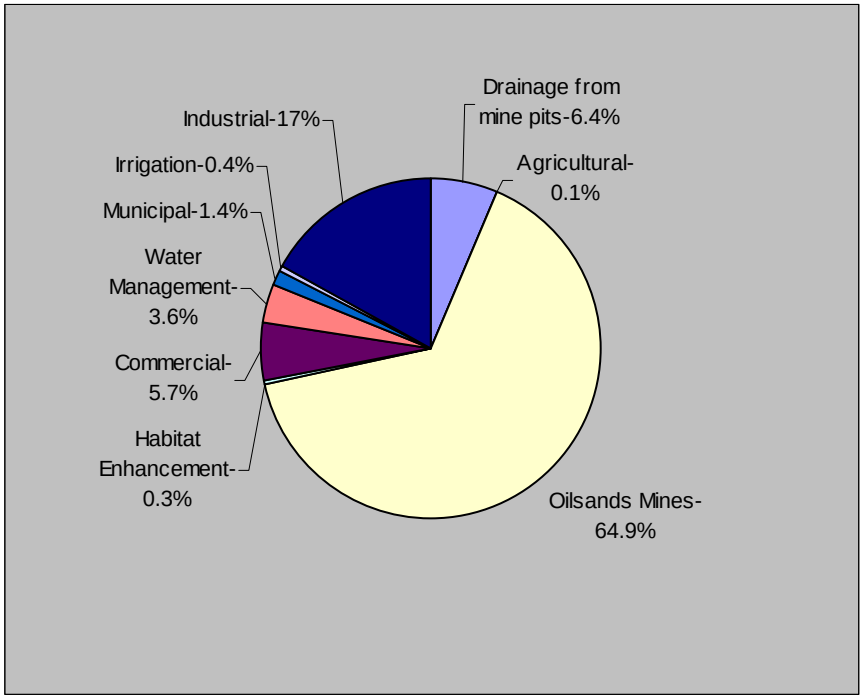
Mining operations have major impacts on water including the removal of overburden and the draining of wetlands. The aquifer that lies under the bitumen is drained to prevent flooding of the mines.

[10] Woynillowicz, Dan, et al. "Down to the last drop: The Athabasca River and Oil Sands", Oil Sands Issue Paper No. 1. March 2006. The Pembina Institute. <http://www.pembina.org/pdf/publications/LastDrop_Mar1606c.pdf>
[11] Ibid.

Approximately 2 to 4.5 cubic meters of water is required to produce 1 cubic meter of crude oil from the mining of bitumen.[12] Mining uses both recycled and surface water, mostly from the Athabasca River. In situ operations reuse about 95% of the water used for steam. However, between 0.2 and 0.5 cubic meters of additional groundwater is required for every cubic meter of bitumen produced thermally.[13]

Currently, approved oil sands projects are licensed to use 370 million cubic meters of water a year from the Athabasca River or about 1 percent to of the river flow. Oil sands operations are the largest users of water from the river with 65% of the water withdrawals.[14]

Figure 1: Athabasca River Water Use[15]



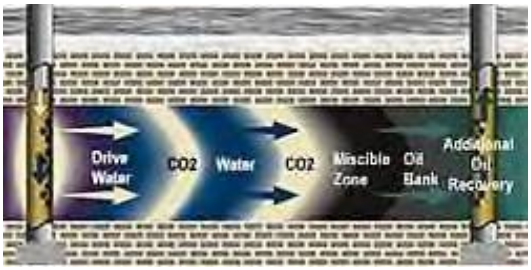
[12] "Canada's Oil Sands: Opportunities and Challenges to 2015. Questions and Answers" 2006. National Energy Board.<http://www.neb.gc.ca/energy/EnergyReports/EMAOilSandsOpportunitiesChallenges2015_2006/EMAOilSandsOpportunities2015Canada2006_e.pdf>
[13] Ibid.
[14] Woynillowicz, Dan, et al. "Down to the last drop: The Athabasca River and Oil Sands", Oil Sands Issue Paper No. 1. March 2006. The Pembina Institute. <http://www.pembina.org/pdf/publications/LastDrop_Mar1606c.pdf>
[15] Chris Schwarz, "Syncrude leads in efficiency plans". Edmonton Journal. July 29, 2004

As Figure 6 denotes, while there are many users of water in Alberta, it is the oil & gas industry, especially for enhanced oil recovery (EOR) processes, that is receiving the most public attention (criticism). Besides water used in processing and refining, the two largest categories of water use in enhanced oil recovery processes are: 1) conventional enhanced oil recovery; and, 2) unconventional thermal enhanced oil recovery.

4.1 Conventional EOR

Conventional EOR is a process in which saline or non-saline water is injected to displace the remaining oil from a reservoir. The process is called "secondary" if only water is injected. However, in some cases an additional liquid or gas injectant is used and the process is called "tertiary". The liquid produced is a mixture of oil and saline water which is normally present in the oil reservoir.[16]

Figure 2: Conventional "Tertiary" Enhanced Oil Recovery Process using carbon dioxide[17]

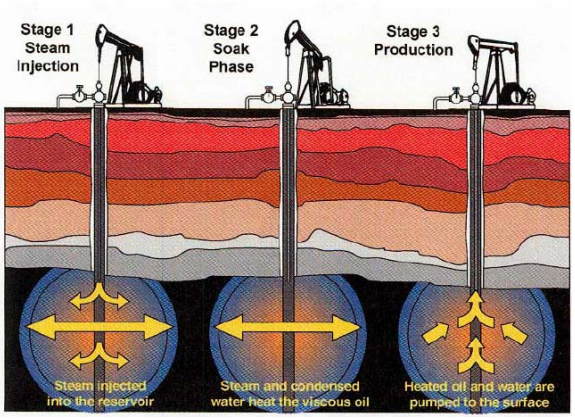


4.2 Unconventional Thermal EOR

Unconventional Thermal EOR is a process that injects steam directly into oil sands deposits or conventional heavy oil pools. There are two types of thermal enhanced oil recovery processes: 1) Cyclic steam stimulation (CSS) and, 2) Steam-assisted gravity drainage (SAGD). The old "huff and puff" process researched by Imperial Oil in 60's and 70's developed into today's CSS process. This process involves an injection of high pressure steam through a vertical well, followed by a soaking stage which increases the flow of bitumen and a production stage consisting in pumping out the bitumen.

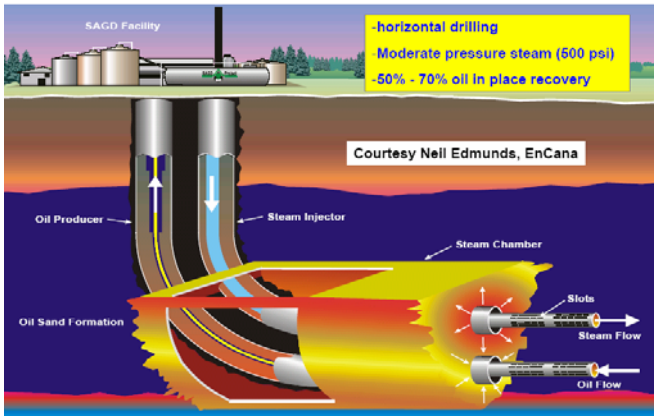
[16] "Enhanced Oil Recovery and CO2 Injection". Renewable Energy Technologies. <http://www.cogeneration.net/enhanced_oil_recovery.htm>
[17] Ibid.

Figure 3: A CSS Well Schematic[18]



A SAGD process is used for in-situ recovery in the Athabasca region and it has been used in large-scale operations since 2001.[19] A SAGD operation involves horizontal well pairs drilled from the same pad as long as 1000 meters into the oil sands deposit at about 5 meters apart vertically.

Figure 4: A SAGD Schematic [20]



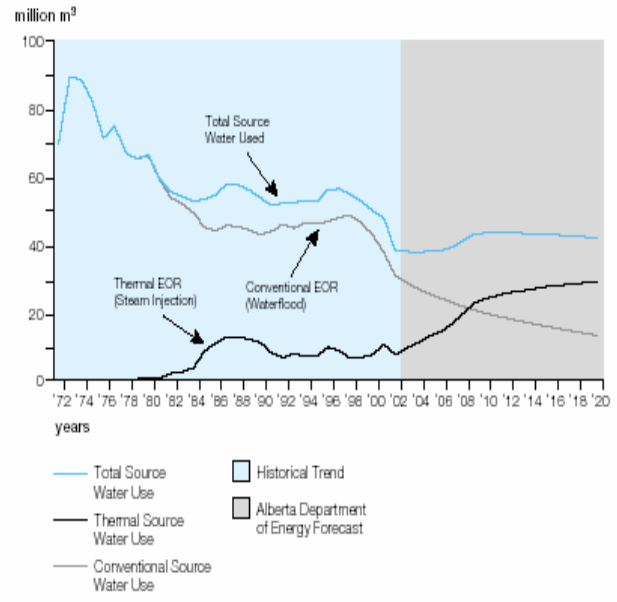
Steam is injected through the top well and the bitumen pumped out through the bottom well.

In 2001, the volume of water diverted for the purpose of EOR was 47.5 million cubic feet, 37.1 million cubic meters (78.1%) of non-saline and 10.4 million cubic meters (21.9%) of saline water. The fresh, non-saline water came from two sources: surface water (26.9 million cubic meters, 72.5%) and

[18] "Canadian Oil Sands: Development and Future Outlook". 2005. Alberta Energy Research Institute; <http://www.aeri.ab.ca/sec/new_res/docs/National_Academies_Workshop.pdf>
[19] Canada's Oil Sands - Opportunities and Challenges to 2015. National Energy Board, 2004
[20] "Canadian Oil Sands: Development and Future Outlook". 2005. Alberta Energy Research Institute; <http://www.aeri.ab.ca/sec/new_res/docs/National_Academies_Workshop.pdf>

groundwater (10.2 million cubic meters, 21.9%). The industry trend during the last 30 years has been a decrease in the total water usage for conventional EOR. Water usage from unconventional EOR has remained relatively constant.[21] Analysts of EOR water use indicate that the forecasting of future water requirements for injection is difficult since conventional oil production is decreasing but bitumen production is increasing. Using the best available information, Alberta energy has forecasted a slightly declining water usage in EOR for the next 15 years.

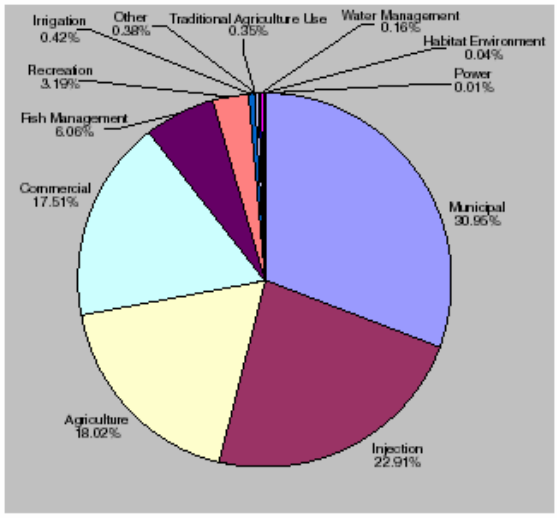
Figure 5: EOR Water Use [22]

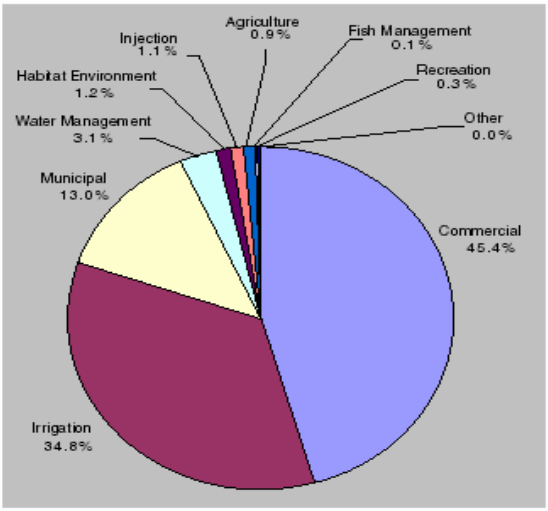


There are over 8,600 licenses and registrations allowing the diversion of groundwater in Alberta. The total quantity licensed for EOR represents 23% of the total quantity licensed for all purposes. Of the 15,300 licenses for the diversion of surface water, 181 licenses allow the diversion of surface water for EOR and the total quantity represents only 1.1% of the licensed total. [23]

[21] "Water and Oil: an overview of the use of water for enhanced oil recovery in Alberta". 2004. Government of Alberta. < http://www.waterforlife.gov.ab.ca/docs/water_oil_info_booklet.pdf >
[22] Ibid.
[23] "Use of Water by Alberta's Upstream Oil and Gas Industry". 2002. Canadian Association of Petroleum Producers. <http://www.capp.ca/raw.asp?x=1&dt=NTV&e=PDF&dn=56487>

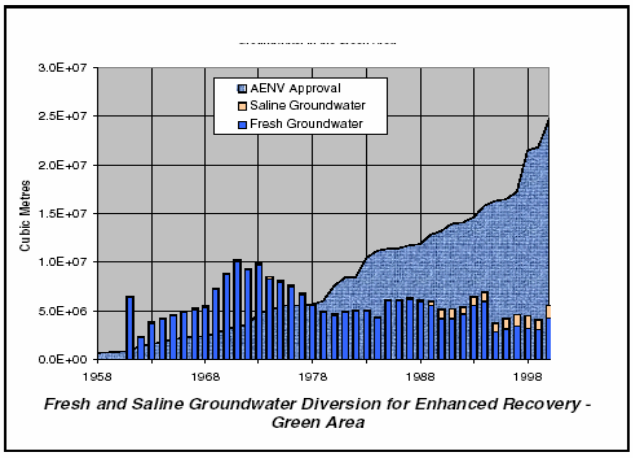
Figure 6: Surface Water and Groundwater Allocation in Alberta[24]

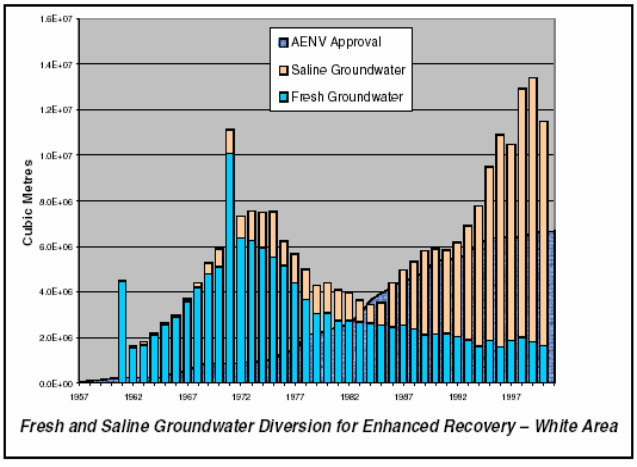




Based on the volumes reported to the Alberta Energy and Utilities Board (AEUB), the quantity of fresh groundwater diverted in the last year is much less than the quantity licensed. This was made possible because oil companies have started to use saline water which is not licensed.[25] Figure 7 shows the groundwater diversion for the Green Area and White Area of the province (see Appendix 4).

Figure 7: Fresh and Saline Groundwater Diversion for Enhanced Oil Recovery





[24] Ibid.
[25] Ibid.

Furthermore, more companies are recovering and reusing the produced water so that only 17% (47.5 million cubic meters) of 276.4 million cubic meters of water injected for EOR, was newly sourced water (saline and non-saline) in 2001.[26]

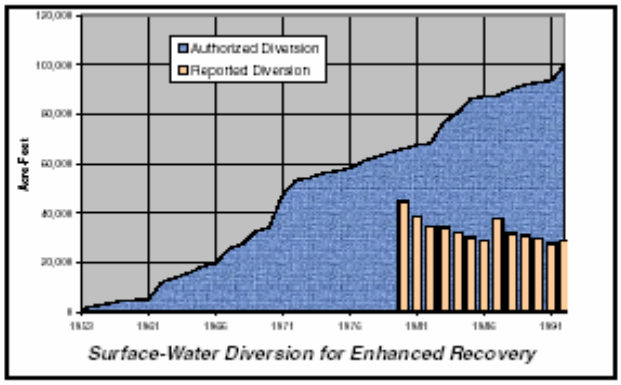


Figure 8: Surface Water Diversion for EOR

As Figure 8 illustrates, even surface water diversion for EOR is on a decreasing trend, and represents less than half of the licensed water. In 2001, fresh water used for EOR represents:

- 0.029% of average stream flow in Alberta;
- 0.014% of the annual volume returning to the atmosphere due to evapo-transpiration; or
- 0.011% of average annual precipitation that falls on Alberta; or
- 0.25% of the annual amount that recharges groundwater.[27]

4.3 Coalbed Methane Water Use

Besides water use in EOR, unconventional Coalbed Methane (CBM) has recently received criticism because of its potential to contaminate provincial freshwater resources. Saline groundwater is a byproduct of the majority of CBM reserves found in Alberta. And, while the saline water can be used for fractioning the coalbed and/or re-injected back down deep disposal wells, the risk of migration into freshwater aquifers or spillage into surface water bodies is a realistic threat.

5.0 Provincial Regulation and Policy

Defined by the Canadian Constitution (1867), the provinces have jurisdiction over matters that are local in nature including local works and undertakings, property and civil rights, and management of

[26] "Use of Water by Alberta's Upstream Oil and Gas Industry". 2002. Canadian Association of Petroleum Producers. <http://www.capp.ca/raw.asp?x=1&dt=NTV&e=PDF&dn=56487>
[27] "Water and Oil: an overview of the use of water for enhanced oil recovery in Alberta". 2004. Government of Alberta, <http://www.waterforlife.gov.ab.ca/docs/water_oil_info_booklet.pdf >

non-renewable and renewable natural resources. In Alberta, the provincial government has delegated the regulation of its water resources to the department of Alberta Environment. Water use for oil and gas operations is regulated through a system of licensing and monitoring. Operators must apply to Alberta Environment for a license under the Water Act before undertaking any activity that may disturb ground or surface water and before taking or removing water.[28]

5.1 The Water Act

In Alberta, water has been traditionally allocated on the "first-in-time, first-in-right" principle for both surface and ground water. This allows the owners of the first licenses issued to access the full amount of water issued before newer licensees have access, regardless of use. Furthermore, water licenses granted under this principle have no expiry date. However, licenses issued under the Water Act are now issued for a fixed period. For example, current oil sands water licenses are issued for a period of 10 years. Licenses are granted for volumes of water that will sustain normal operations, with temporary licenses issued for the initial start up period where more water is required. Licenses issued under previous legislation, were for the full volume required at start up, and were grandfathered under the new legislation. The Water Act allows for the transferring of water rights along with 10% of the transferred water being withheld in order to meet in-stream flow needs.[29] However, the act does not address the issue of grandfathered licenses or priorities for competing demands when a transfer is requested.

5.2 Water for Life: Alberta's Strategy for Sustainability

In terms of policy, the Government of Alberta also has an inclusive water strategy called "Water for Life: Alberta's Strategy for Sustainability"; the public document serves as a framework to implement improvements in Alberta's water use. One of the key goals of this strategy is reliable and quality water supplies for a sustainable economy with an overall 30 percent improvement in water use by the year

[28] "Doing Business in Alberta: Overview of Canadian Legal System Related to Oil Sands Activities". 2006. Blake, Cassels & Graydon LLP. <www.blakes.com>
[29] Griffiths, M. & Woynillowicz, D. "Oil and Troubled Waters: Reducing the impact of the oil and gas industry on Alberta's water resources". 2003. The Pembina Institute.
<http://www.pembina.org/pdf/publications/OilandTroubledWaters.pdf>

2015.[30] One of the stated benchmarks is a requirement by the oil industry to recycle its water use under Alberta Environments Water Recycling Guidelines.

5.3 Alberta's Water Conservation and Allocation Policy for Oilfield Injection

Under the government's "Alberta's Water Conservation and Allocation Policy for Oilfield Injection" is a requirement that all applicants evaluate alternative sources of water before applying for a fresh water license.[31] The main purpose of the strategy is to reduce the use of fresh water for oilfield injection in areas of water shortages and associated increased demand (see Appendix 5). In cases where no alternative exists, a risk assessment is performed that weighs the environments risks against economic gains.[32] Current permanent license holders are encouraged to abide by the policy and its guidelines.

6.0 Stakeholder Viewpoints

6.1 Environmentalists

Given the expansion of upstream petroleum activities, the number of stakeholders concerned with the sustainability of Alberta's water resources are as large as they are diverse. While there is no doubt the burgeoning oil and gas sector is a huge economic bonanza to Alberta, environmentalists are suggesting that both industry and government are ignoring the potential irreversible cumulative long-term impacts (negative externalities) of depleting and/or contaminating Alberta's fresh water resources. Given the rapid pace of oil sands development and seemly no existence value placed on maintaining our riparian areas, Mary Griffins of the Pembina Institute (an environmental think-tank) suggests "*the current oil sands rush has led to the allocation of large volumes of water before scientific studies have shown how much water is needed to maintain a healthy ecosystem.*"[33]

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[30] "Water for Life: Alberta's Strategy for Sustainability". 2003. Government of Alberta. <http://www.waterforlife.gov.ab.ca/docs/strategyNov03.pdf>
[31] "Water Conservation and Allocation Policy for Oilfield Injection". 2006. Government of Alberta <http://www.waterforlife.gov.ab.ca/docs/Oilfield_Injection_Policy.pdf>
[32] Ibid.
[33] Raynolds, M. "Presentation to the Oil Sands Multi-stakeholder Committee". 2006. The Pembina Institute. < http://www.pembina.org/pdf/publications/Oilsands_PCP_Marlo_Edm.pdf>

With the expansion coalbed-methane development, water contamination has also become a serious concern since most of Alberta's coal reserves are associated with saline water. David Eggen (Alberta's NDP Environmental Critic) indicates saline water can cause irreparable damage in two ways: 1) saline water can migrate from the gas wells and contaminate shallow freshwater aquifers; 2) if saline water brought to the surface is not properly treated/disposed, contamination of our surface lands and/or water is undoubted. With more than 600,000 (90%) rural Albertans relying on groundwater for their cattle, crop irrigation, and household use, clearly the safe supply of Alberta's potable water is at risk. For this reason, Alberta's NDP has also called for a moratorium on incremental coalbed drilling until a sustainable management framework is put in place.[34]

6.2 Industry

As a key spokesman for the upstream petroleum producers, the Canadian Association of Petroleum Producers (CAAP) states that their industry is committed to the responsible use of water. CAAP adds further that provincial water use policy has been in place since 1931, (updated in 1999) and that petroleum operators are well regulated through a system of licensing and monitoring to ensure compliance.[35] Albeit self-serving, cynics might say CAAP fails to acknowledge the potential cumulative effects of the rapid increase in unconventional oil and gas activities - concentrated in pockets throughout the province - with the potential to create environmental "hotspots".

6.3 Government

Suggesting a bias for energy development, even the provincial government in its "Water and Oil: an overview of the use of water for enhanced oil recovery in Alberta" argues that enhanced oil recovery only uses 4.6% of licensed water allocations versus 46% for agriculture. Moreover, the government states that total water use for the petroleum industry is declining.[36] While petroleum producers claim that they

[34] Eggen, D. "Moratorium on coalbed-methane drilling needed to cool frenzy" Edmonton Journal December 22, 2006

[35] "Use of Water by Alberta's Upstream Oil and Gas Industry". 2002. Canadian Association of Petroleum Producers. <http://www.capp.ca/raw.asp?x=1&dt=NTV&e=PDF&dn=56487>

[36] "Water and Oil: an overview of the use of water for enhanced oil recovery in Alberta". 2004. Government of Alberta, <http://www.waterforlife.gov.ab.ca/docs/water_oil_info_booklet.pdf >

are prepared to follow the principals of Alberta's Sustainable Development Policy (balancing the three pillars of society: environmental, economy and society needs), the provincial government has only recently acknowledged that it has failed to envision the explosion in unconventional petroleum activities; establishing a provincial a special advisory panel to study this issue – the group's report/recommendation is expected to be presented to the provincial government in June 2007.[37]

With recent polls indicating that the environment is the single most important issue for Canadians, and critics claiming the provincial government is rubber-stamping oil sands development, it is quite possible that political pressures may eventually cause the positive theory of government (motivation to keep political office) to synchronize with the normative (in society's best interest) approach of public policy. Even the federal government has entered into the foray after reports were made that U.S. energy interests are pushing for a five-fold increase in oil exports from Alberta's oil sands. In response, a spokesperson for the Prime Minister's Office indicated that the Conservatives have no interest in streamlining environmental assessments to hasten oil sands development *"Canada's natural resources will be developed but that will not be done at the expense of the environment."*[38]

7.0 Recommendations and Conclusions

There is no doubt that an improved regulatory regime is needed to promote the efficient use of water resources and reduce the use and disturbance of freshwater where possible. In order to protect Alberta's water resources, there must be a clear, scientific based policy. To accommodate a renewed vision, it is imperative research be conducted to attain data on low flow rates and determine the minimum water levels that are required to maintain healthy aquatic ecosystems.

One common recommendation is off-stream storage of water. For example oil sands operators could pump water from the Athabasca River during times of high flow and flood low lying areas as storage. Industry could then access the stored water during times of low flow without compromising the

[37] Simpson, Jeffery "Oil sands vision, red herrings and a sea of Platitudes" Globe and Mail September 20, 2006
[38] The Calgary Press "Conservatives won't put oil sands production into hyper-drive for U.S." Edmonton Journal Janurary 19, 2007

ecological integrity of the river. In 2004, Golder Associated Ltd conducted a feasibility study of off-stream water storage and concluded that *"Water supply storage could be developed to supply 100% of raw water needs in winter so that river withdrawals are limited"*.[39] While this can be a good short-term solution to winter withdrawals, it does not address the problem of new oil sands projects placing incremental demands on the Athabasca River year-round.

A second recommendation is to improve the conservation of water use by improving current technologies, including a concerted focus on water recycling. Some oil sands operators have already demonstrated it is possible to reduce the amount of water they use to extract bitumen. Syncrude, for example, was able to decrease water use by 8.4 percent from 2004 to 2005.[40] It is apparent the petroleum industry is actively researching ways to minimize their impact on the environment, and be socially responsible. Nonetheless, unless improvements are a mandatory part of operations, then it is left up to each individual company to try and reach some unknown standard. Clearly, improved monitoring and research is needed so that reasonable pre-determined standards form the foundation of a sustainable water policy.

A final recommendation is a mandatory restriction on water use for allocations already in place. Whereas Alberta Environment's interim framework failed to place restrictions on water use during low flow periods (i.e. drought) the Pembina Institute recommends that no water be withdrawn from the river (halt oil sands withdrawal) when the red zone (vulnerable – low flow) is reached. This will limit or halt oil sands production until the river returns to normal flows. In implementing such a policy, each oil sands player would have an incentive to make conservation improvements and design contingency plans to sustain operations based on the potential restrictions.

Notwithstanding the petroleum industry and government's claim that water use on a provincial basis has remained relatively constant or even declined, this is not the case in the Athabasca watershed.

[39] "Water and Oil: an overview of the use of water for enhanced oil recovery in Alberta". 2004. Government of Alberta. <http://www.waterforlife.gov.ab.ca/docs/water_oil_info_booklet.pdf >
[40] "Environmental Aspects of Oil Sands Development". 2006. Canadian Association of Petroleum Producers <http://www.capp.ca/raw.asp?x=1&dt=PDF&dn=105401>

Oil sands operations are not using their total allocation of water under current licenses, however with the rapid pace of new development, what will happen when operators draw their total allocations from the river? While a moratorium on the incremental oil sands projects may not be the answer, it is clear that the government of Alberta must take a step back and consider the long term consequences and impact on Alberta's water supply.

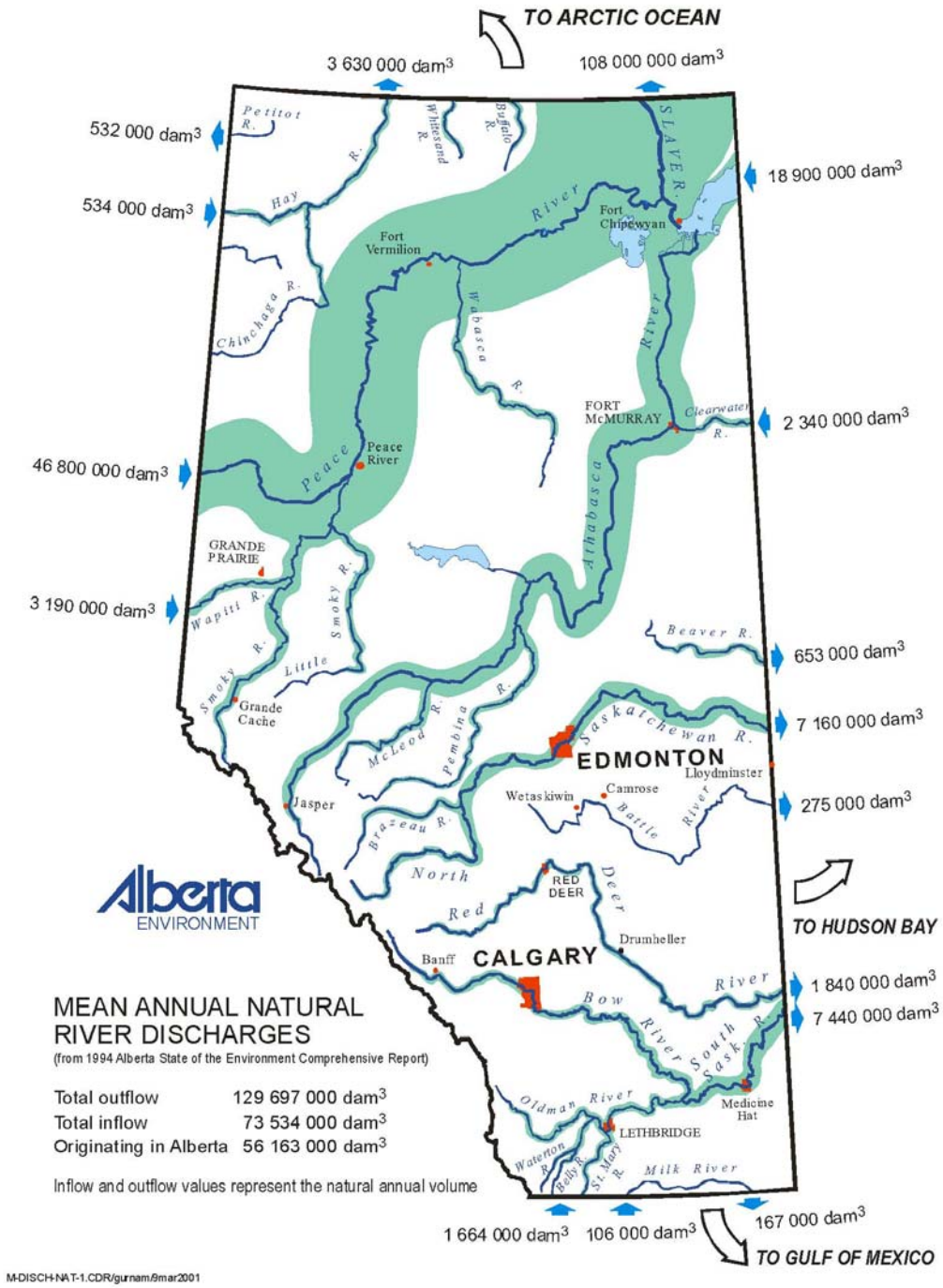
8.0 Appendices

Appendix 1: The 20 Largest Rivers in Alberta[41]

	20 Largest Rivers in Alberta	Comments	Mean Annual Natural River Discharge in millions of m^3	Historical Minimum Discharge in millions of m^3	Historical Maximum Discharge in millions of m^3
1	**Slave**	Flows from Alberta to Northwest Territories	107 726	83 400	155 000
2	Peace	Tributary to Slave	66 614	44 100	108 000
3	Athabasca	Flows to Lake Athabasca Tributary to Slave	22 287	15 000	34 900
4	Smoky	Tributary to Peace	10 958	5 910	18 500
5	**South Saskatchewan**	Flows from Alberta to Saskatchewan	7 425	3 754	13 851
6	**North Saskatchewan**	Flows from Alberta to Saskatchewan	7 277	4 384	12 923
7	Bow	Tributary to South Saskatchewan	3 951	2 358	7 243
8	Clearwater (near Fort McMurray)	Tributary to Athabasca	3 758	1 790	6 800
9	**Hay**	Flows from Alberta to Northwest Territories	3 564	630	7 840
10	Oldman	Tributary to South Saskatchewan	3 462	1 416	7 116
11	Wapiti	Tributary to Smoky	3 080	1 610	5 320
12	Wabasca	Tributary to Peace	2 762	298	7 880
13	Lesser Slave	Tributary to Athabasca	2 084	522	4 690
14	**Red Deer**	Flows from Alberta to Saskatchewan	1 837	758	4 635
15	Brazeau	Tributary to North Saskatchewan	1 615	829	2 670
16	McLeod	Tributary to Athabasca	1 525	700	2 638
17	Little Smoky	Tributary to Smoky	1 521	515	3 060
18	Birch	Flows to Lake Claire Tributary to Slave	1 293	344	2 767
19	Christina	Tributary to Clearwater	1 165	267	2 943
20	Berland	Tributary to Athabasca	1 130	518	1 723
Colour Index by Major Basin:					
Slave River and its tributaries					
South Saskatchewan River and its tributaries					
North Saskatchewan River and its tributaries					
Other Major Basin					

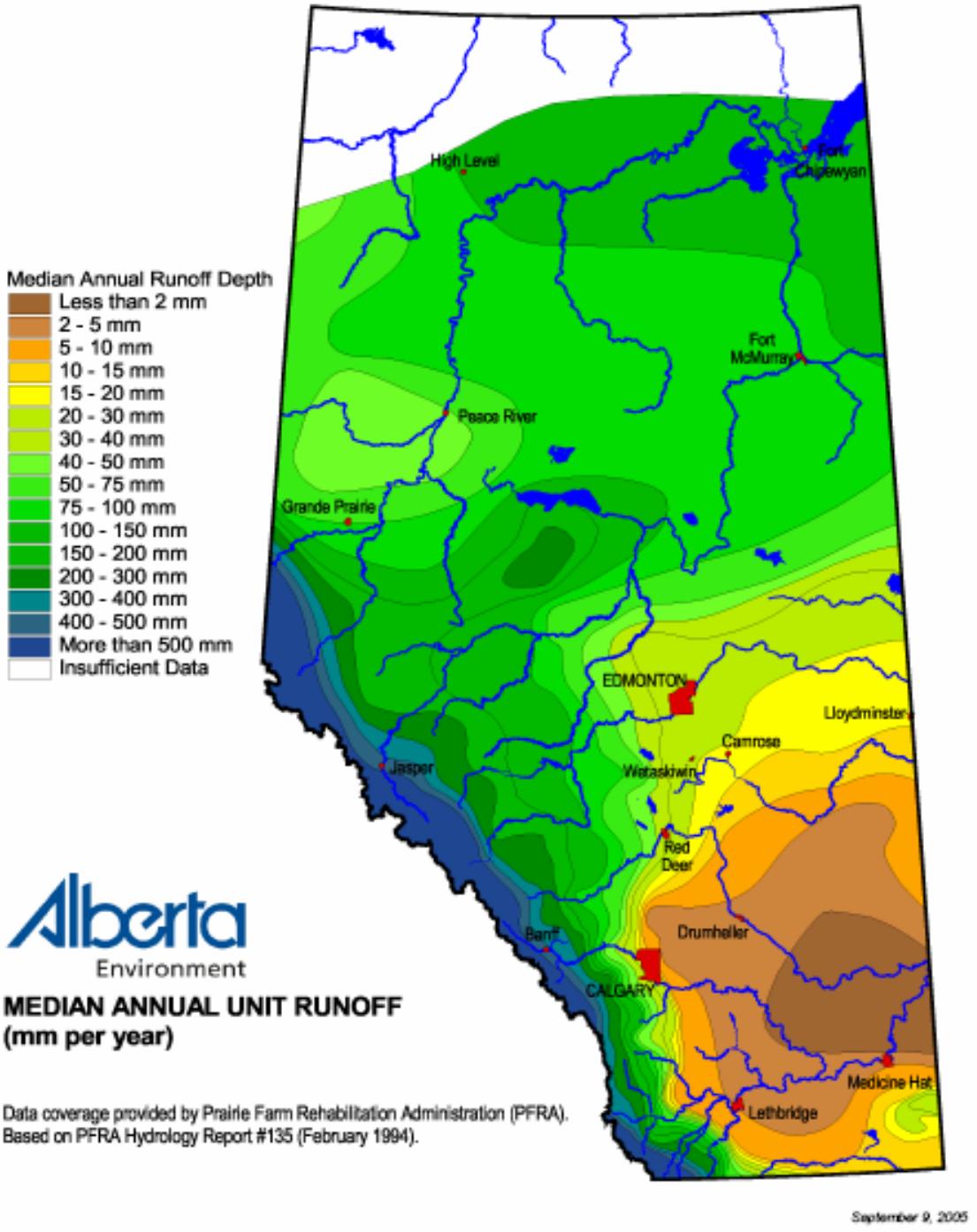
[41] "Rivers". 2005. Alberta Government. <http://www3.gov.ab.ca/env/water/GWSW/quantity/learn/what/SW_SurfaceWater/SW2_rivers.html>

Appendix 2: Figure-1 Mean Annual River Discharge map[42]



[42] "Alberta's Water Resource". 2003. Alberta Government. <http://www3.gov.ab.ca/env/water/reports/water_overview.html>

Appendix 3: Median annual unit runoff map[43]

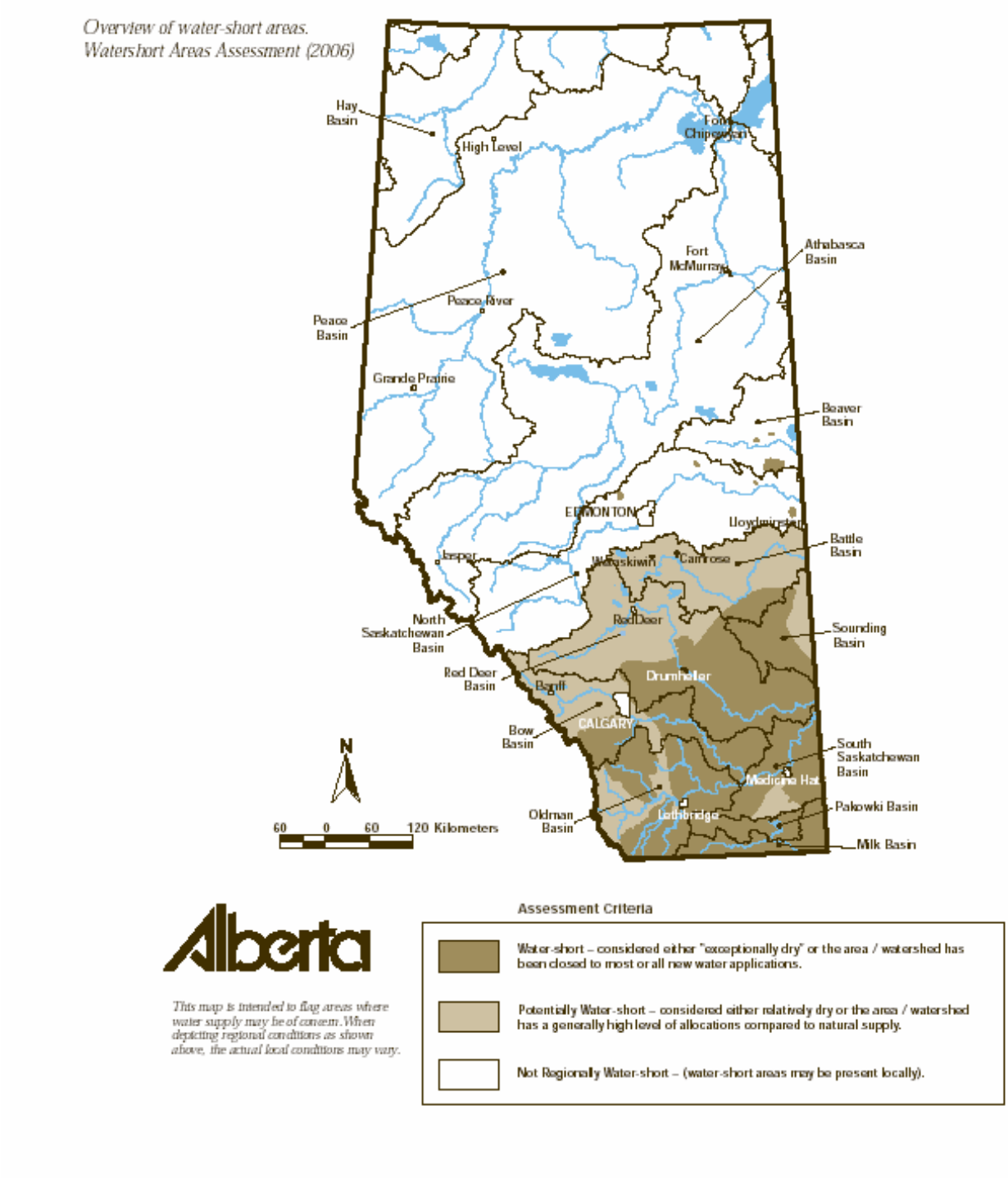


[43] Government of Alberta <http://www3.gov.ab.ca/env/water/GWSW/quantity/learn/what/SW_SurfaceWater/SW3_surface_runoff.htm>

Appendix 4: The Green and White Zone of the province[44]

[44] "Water and Oil: an overview of the use of water for enhanced oil recovery in Alberta". 2004. Government of Alberta. <http://www.waterforlife.gov.ab.ca/docs/water_oil_info_booklet.pdf>

Appendix 5: Overview of Watershort Areas of Alberta[45]



[45] "Water Conservation and Allocation Policy" 2006. Government of Alberta. <http://www.waterforlife.gov.ab.ca/docs/Oilfield_Injection_Policy.pdf>