INDUSTRIAL WATER USE IN SASKATCHEWAN

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EXECUTIVE SUMMARY

Water is fundamental to human life and the ecosystems that support that life. The importance and value of water becomes even more significant in semi-arid southern Saskatchewan. Indeed, in the southern part of the province the only reliable supplies of surface water originate in the Rocky Mountains of Alberta. As Saskatchewan grows, water use will be important not only to meet social and environmental needs, but also to further economic development. Water use for industrial purposes is the primary focus of this report.

This report describes the water licensing regime in Saskatchewan and identifies surface water and groundwater allocations for each of the major river basins in the province. Major water use categories include municipal, domestic, irrigation, industrial, and 'other'. The allocations for industrial water use are further broken down into specific categories such as oil and gas, mining, manufacturing, intensive livestock operations and so on. The report discusses issues related to present and future water uses in the province. It closes with an overview of the impacts of industrial water use in the province.

Water allocation in the province is shown in the Table S1. Because some allocations are not entirely used, the largest industrial consumers of surface water today are mining, cooling water, manufacturing and intensive livestock operations. The largest groundwater consumers are the oil and gas industry and intensive livestock operations. The oil industry tends to use non-potable water from deep aquifers.

Table S1. Industrial Water Allocation in dam^3 from Surface and Groundwater by Major Basin in Saskatchewan.

Source / Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water	Misc.
Souris		30			12 653		
Souris	11 897	136	584		10 033	78	
Missouri		182			6843		
Missouri	1053	1062	231		5500	5	
Cypress	317					1	
Cypress	3206	1772	49			75	
Old Wives		17 507	191		155		
Old Wives	168	191	384			102	
Qu'App.		2889	91		401	14	
Qu' App.	5420	4909	1321	111		249	473
S. Sask.		13 309	103	127	427 106	6000	
S. Sask.	7010		530	172		62	

Source / Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water	Misc.
N. Sask.		2219	231	4	220	76 610	
N. Sask.	20 413			12		590	379
Sask.		400	90			410	15
Sask.		60	115	12		79	2
Church.		6308		9		850	
Church.		1845	117			910	
Athabas.		3270					
Athabas.		62					
Assinib.			102				
Assinib.	463		511			10	
L. Wpgo.			512			397	
L. Wpgo.			216			185	
Surface	317	46 114	1320	140	447 378	84 282	15
Ground	49 630	10 037	4058	307	15 533	2345	854

Note: Surface water is shown first then groundwater.

Although significant quantities of surface and groundwater are allocated to industrial purposes in Saskatchewan each year, it must be kept in mind that the largest single water consumer in the province is irrigated agriculture. Consumption for 'other' purposes also exceeds industrial consumption. 'Other' consumption pertains to operation of structures for water management and wildlife conservation.

The provincial database of water licences is an excellent source of information and is accurate. Saskatchewan assesses water use charges to non-agricultural industrial users who do not draw their water supplies from municipal sources. These charges are highest for withdrawal of surface water from the South Saskatchewan and Qu'Appelle basins.

Although water users are asked to report water withdrawals, the data on these withdrawals is incomplete. The only users reporting regularly are those industrial users who must pay water charges. There is no routine data on actual water consumption in the province. This situation tends to be the norm in Canada. There is some anecdotal and other evidence to support the contention that water withdrawals and hence water consumption in the province is less, in some cases much less, than the licensed allocation.

Water use represents a significant proportion of available surface water supply in the South Saskatchewan, Qu'Appelle, Missouri, Cypress Hills and Old Wives basins. Of these, only the South Saskatchewan basin can be considered to have reliable flows. Flows in the other basins vary considerably within any year and between years.

There are several improvements to the Saskatchewan industrial water licensing procedures that could be considered. First, the province could be more diligent in ensuring that licence holders report water withdrawals. Monthly reporting is probably not required except where there are concerns about available supplies. An annual report would be sufficient for most purposes. In addition to reporting water withdrawals, reporting of return flows would allow detailed analysis of water consumption. This level of reporting could be considered for all licence holders, irrespective of purpose. In the case of industrial water use, there are considerations of competitive advantage and corporate confidentiality to consider. While the results of water use reports should be publicly available, they should be aggregated to alleviate privacy concerns.

Secondly, it would be reasonable to consider water charges for all industrial users even agriculture users. There appears to be no compelling reason why intensive livestock operations, for example, should not be subject to user charges. Consideration could also be given to increasing the water charges for surface water from all the water-short basins in the province. That is, all the major basins from the South Saskatchewan and Qu'Appelle basins south to the international boundary. Consideration could be given as well to basing charges on water consumed rather than water withdrawn should this information becomes available. In general, water charges that encourage appropriate use and conservation should be supported. At present, charges for water having total dissolved solids greater than 4000 mg/L are very low thus encouraging the use of non-potable water where feasible.

A cursory examination of present industrial uses and the potential for increased use indicates that some industrial expansion could take place within the scope of existing licences, especially if more attention was paid to water conservation. In general, increased water use could be considered from most major basins, the exception being the southern basins where one half of the median flow is fully allocated.

Considering the environmental effects of industrial water use, it would be appropriate for Saskatchewan to conduct detailed examinations of in-stream flow needs for streams where water withdrawals represent a significant part of available supplies. A pilot project that would establish procedures for future use would be very desirable.

The province could also consider studies pertaining to the cumulative effects of certain developments. This would include ecological and other effects on major reservoirs such as Lake Diefenbaker as well as the cumulative effects on both land and water from practices as manure spreading or spoil piling. The effects of a single project may be adequately covered as part of environmental assessment but the cumulative effects of several projects are often not assessed.

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INTRODUCTION

Water is fundamental to human life and the ecosystems that support that life. The importance and value of water becomes even more significant in semi-arid southern Saskatchewan. Indeed, in the southern part of the province the only reliable supplies of surface water originate in the Rocky Mountains of Alberta. As Saskatchewan grows and becomes more industrialized, water use will be important not only to meet social and environmental needs, but also to further economic development. Water use for industrial purposes is the primary focus of this report.

R. Halliday & Associates Ltd. was asked to identify existing industrial consumptive and non-consumptive uses of water and what that demand means in terms of available supplies. Existing and potential water uses should be considered. The company was also asked to provide and overview of the ecological, social and health impacts of industrial water use in the province.

This report describes the water licensing regime in Saskatchewan and identifies surface water and groundwater allocations for each of the major river basins in the province. The allocations for industrial water use are further broken down into specific categories such as oil and gas, mining, manufacturing, intensive livestock operations and so on. The report discusses issues related to present and future water uses in the province. It closes with an overview of the impacts of industrial water use in the province.

Saskatchewan contains portions of three major continental drainage basins: the Mississippi, Arctic and Hudson Bay basins. This report uses the 14 major basins identified in the Saskatchewan water licensing database. Other Saskatchewan publications use 13 major basins. The difference is the Cypress Hills (North Slopes) basin, which is treated separately in the water licensing database and is usually included in the South Saskatchewan basin in other provincial publications. The major basins generally used in Saskatchewan are shown in Figure 1. The reference numbers for each basin are shown in Table 1.

Table 1. Basin Reference Numbers for Map

Reference Number	Major Basin	Sub-basin	Reference Number	Major Basin	Sub-basin
1	Souris	Lower Souris	16	N. Saskatchewan	Eagle Creek
2	Souris	Upper Souris	17	L. Winnipegosis	Lake Winnipegosis
3	Missouri	Big Muddy	18	Saskatchewan R.	Carrot River
4	Missouri	Poplar River	19	N. Saskatchewan	Battle River
5	Missouri	Milk River	20	Saskatchewan R.	Saskatchewan R.
6	Old Wives	Old Wives	21	N. Saskatchewan	N. Saskatchewan
7	South Saskatchewan	Swift Current Creek	22	Churchill River	Beaver River
8	South Saskatchewan	Cypress Hills North Slope	23	Churchill River	Churchill R.
9	Assiniboine	Assiniboine	24	Churchill R.	Reindeer/Wollaston

10	Qu'Appelle	L. Qu'Appelle	25	Athabasca	Athabasca River
11	Qu'Appelle	Wascana Creek	26	Athabasca	Black River
12	Qu'Appelle	Moose Jaw River	27	Athabasca	Lake Athabasca
13	South Saskatchewan	South Saskatchewan	28	Kasba Lake	Kasba Lake
14	Qu'Appelle	U. Qu'Appelle	29	Tazin Lake	Tazin Lake
15	Qu'Appelle	Quill Lakes			

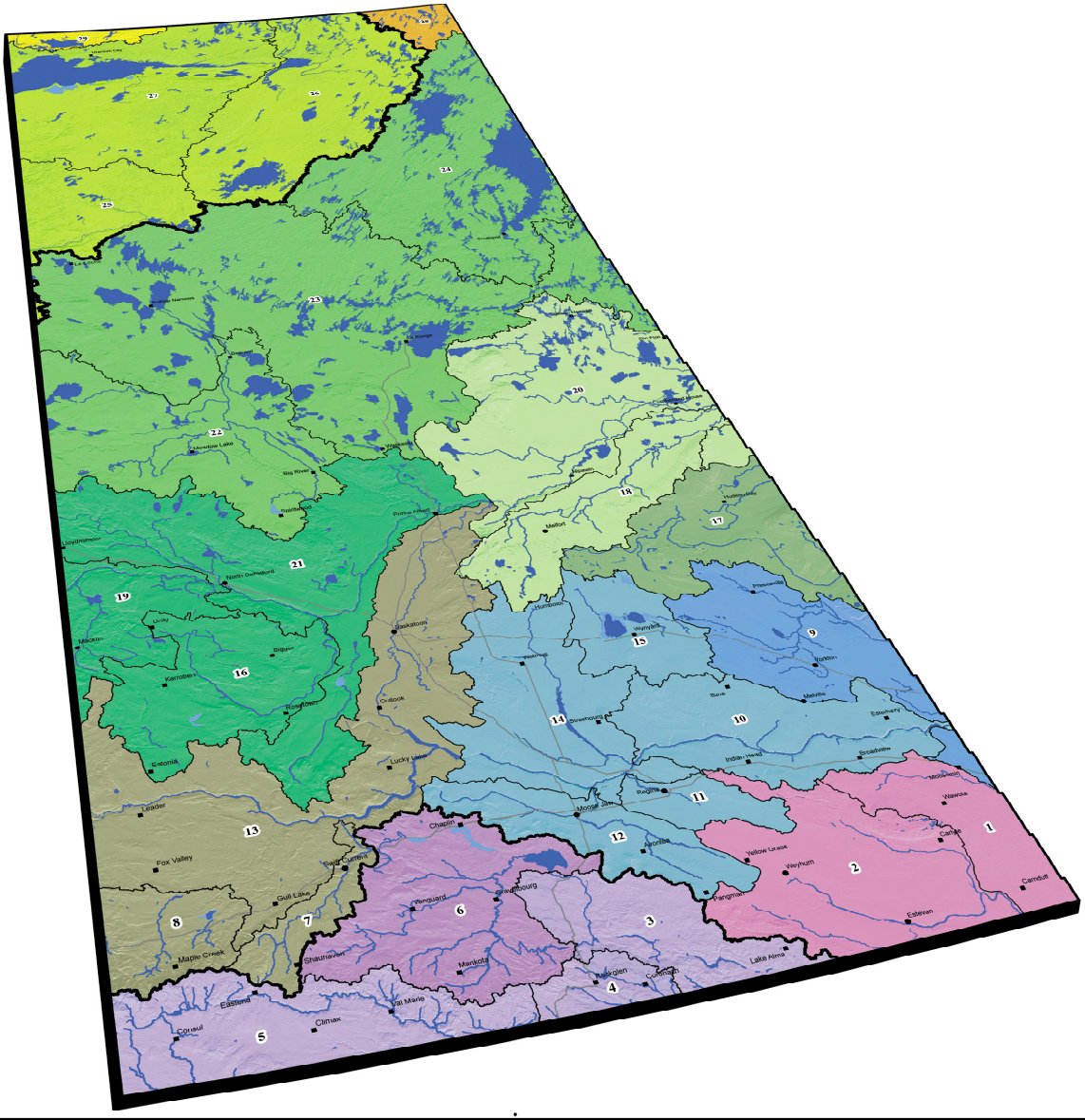


Figure 1. Major River Basins in Saskatchewan.

WATER LICENSING

Although natural resources management, including water management, is the constitutional responsibility of provincial governments, water management in Saskatchewan involves a web of interests: international, national, provincial, First Nation, regional and local governments, environmental non-government organizations, and others. Consider, for example that the waters of the Milk River tributaries and the Souris River and its tributaries are subject to the international *Boundary Waters Treaty*. Similarly, streamflows at interprovincial boundaries are subject to the *Master Agreement on Apportionment* between the federal government and the three prairie provincial governments. Federal lands within Saskatchewan, such as National Parks, First Nation reserves, and Canadian Forces bases also introduce complexity, as do federal responsibilities related to agriculture and fisheries. Most people in the province live in cities yet protecting source water for cities involves rural administrations.

When settlers first arrived in the west, water users were subject to the riparian doctrine of British common law. That is, water rights belonged to the owner of the land adjacent to the stream. Under riparian doctrine any water used must be returned to the stream substantially unchanged in quantity or quality. This doctrine assumes an abundant supply of water, something that cannot be guaranteed in the semi-arid west. In 1894, *The North-west Irrigation Act* vested all water rights in the federal Crown and introduced the doctrine of prior allocation.[1] That is, the Crown could grant exclusive water rights on a first come, first served basis, priority being indicated by the date of application. With secure title to water, early water users such as irrigators and hydroelectric power developers could then proceed with major investments knowing that water would be available to support their developments. The full water needs of later licencees may be met only under favourable flow conditions, but the right is established and the risk involved is clear. During low flow periods water diversions may be reduced in reverse order of licence seniority. The water licensing system in each of the four western provinces is largely based on the doctrine of prior allocation while the eastern provinces adhere largely to riparian doctrine. The essence of western water law is captured in the phrase, "first in time, first in right". There are subtle differences in the application of western water law between Canada and the United States and among the western provinces.

The federal government issued the first water licences in Saskatchewan in 1894 under the authority of the *North-west Irrigation Act*. These early licences tended to be for irrigated agriculture. Following the resource transfer agreement in 1930 the licences are now issued under provincial legislation. The *Saskatchewan Watershed Authority Act* came into force in 2005. The act established the Saskatchewan Watershed Authority and stated that its mandate is to manage, control and protect the water resources, watersheds and related lands by regulating water development and water use. The Act provides for regulations concerning groundwater exploration, use and the abandonment of wells, administration of water rights, construction and operation of drainage works, and assuring the proper use and development of shorelines in designated Reservoir

Development Areas. Under the Act, domestic users (household or on-farm) do not require a licence for uses less than 5000 m^3/y provided there are no constructed diversion works. This is a vestige of riparian doctrine. New licences are issued for specified periods, usually 20 years. The province retains the right to cancel licences under certain conditions. One of these conditions is that the licence must be used for the purpose stated in the licence. There is no provision in Saskatchewan law for licence holders to transfer licences to other water users.

Saskatchewan no longer has legislated water use priorities although the allowance of 5000 m^3/y could be taken to imply a "right" to a certain minimal annual quantity of water. This quantity is more that the annual need to sustain normal human uses, however. A more likely approximation would be 2000 m^3/y. The 5000 m^3/y figure implies both human uses and some use by livestock.

Water use is a broad term that includes use of water for any activity, economic or otherwise. Water use can include the withdrawal or diversion of water from a source, or the water can be put to some use in place. Examples of water use in various sectors include: agriculture (for irrigation and watering livestock), municipal services (including urban residential, commercial and industrial use), industrial (primarily mining, oil and gas), energy (thermal and hydro-electric), recreational (boating or golf courses) or environmental (instream flows or sustaining wetlands). Water uses may be considered consumptive or non-consumptive. For example, water used in watering livestock is almost entirely consumed while that used in cooling may be almost entirely returned to the water body. Saskatchewan considers the likely consumption of water for a specific use in its licensing process. This is based on the usual consumption by various water use sectors.

Saskatchewan water licences are registered by purpose and type – a more specific identification of the purpose. Examples of purposes include irrigation, municipal, industrial and other. The 'other' purpose has a strong environmental goods and service component, although it can include additional uses. 'Other' purposes may include lake stabilization, fisheries, and habitat enhancement. In rare cases Saskatchewan may identify a licence as multi-purpose. The Saskatoon Southeast Water Supply System is one such licence.

Under the 2006 regulations of the *Saskatchewan Watershed Authority Act*, the province defines industrial use as

> *the use of water by any industry, including industries that are involved with processing, mineral exploration, mining, oil and gas exploration and recovery, manufacturing, gravel washing, hydraulic pressure testing and thermal power generation.*

Note that Saskatchewan includes oil and gas licences in its industrial sector. In Alberta these licences are placed in a separate petroleum sector. Industries obtaining their water supply from urban water distribution systems are not licensed separately. The province assesses water charges for industrial uses except when water is used for primary

agricultural production, including intensive livestock operations. As well, water charges are not assessed (but licences are issued) when the water had total dissolved solids greater than 4000 mg/L and is obtained from the Blairmore or deeper groundwater formations. Current industrial water charges are set out in a 2008 policy statement.[2] Industrial users taking water from the South Saskatchewan River, Lake Diefenbaker, Buffalo Pound Lake and the Qu'Appelle River pay much larger charges than other industrial users. Industrial users are required to report withdrawals monthly. In general this requirement is not rigorously enforced, except in the case of those users paying water charges.

Industries that receive their water supply directly from municipal water works systems are covered by the municipal licence and do not have to obtain a water licence or report water use. Their water supply will be metered by the municipality. They may have to operate their own sewage treatment system or be assessed higher sewage charges, depending on the nature of their effluent.

Saskatchewan identifies licences as water originating from surface water or groundwater and categorizes the water as coming from sub-basins in one of 14 major basins. This structure is shown in Table 2. Groundwater licences are also filed by major basin, but indicate the aquifer from which the water supply is obtained. The Saskatchewan water licences will be discussed by major basin in this report.

Table 2. Identification of Major Basins for Granting of Water Licences.

SASKATCHEWAN WATER LICENCES				
Major Basin Number 1				**Souris River Basin**
	Sub-basin			***Name***
	24			Souris River
	50			Lower Souris River Group
	51			Lower Souris - Pipestone Creek
	68			Long Creek
	69			Moose Mountain Creek
	70			Yellow Grass Ditch Section
	71			Tatagwa Lake
Major Basin Number 2				**Missouri River Basin**
	Sub-basin			***Name***
	01			Lodge Creek
	02			Battle Creek
	03			Frenchman River
	12			McRae Creek
	13			Woodpile Creek
	14			Lyons Creek
	15			Coteau Creek
	16			White Water Creek
	17			McEachern Creek
	18			Horse Creek
	19			Rock Creek
	20			East Poplar River
	21			Poplar River
	22			West Poplar

	39			Wildhorse Lake
	40			Climax Group
	41			Taits Lake
	42			Bluff Creek
	43			Coal Creek
	44			Paisley Brook
	45			Big Muddy Lake
	46			Missouri Group
	49			Green Lake
Major Basin Number 3				**Cypress Hills (North Slope) Basin**
	Sub-basin			***Name***
	04			Many Island Lake
	05			Bigstick Lake
	06			Hay Creek
	07			Crane Lake
	08			Skull Creek
	09			Antelope Lake
	36			Great Sandhills Group
Major Basin Number 4				**Old Wives Lake Basin**
	Sub-basin			***Name***
	11			Old Wives (Johnstone) Lake
	37			Willowbunch Group
	38			Rush Lake
	48			Shoe Lake Group
	52			Upper Wood River
Major Basin Number 5				**Qu'Appelle River Basin**
	Sub-basin			***Name***
	23			Qu'Appelle River
	27			Quill Lakes
	47			Little Manitou Lake
	72			Wascana
	73			Moose Jaw River
	74			Buffalo Pound Lake
	75			Last Mountain Lake
Major Basin Number 6				**South Saskatchewan River Basin**
	Sub-basin			***Name***
	10			Swift Current Creek
	30			South Saskatchewan River
	54			Coteau Group
	55			Luck Lake
Major Basin Number 7				**North Saskatchewan River Basin**
	Sub-basin			***Name***
	25			Manito Lake
	29			North Saskatchewan River
	53			Whitebear Lake
	56			Goose Lake Group
	58			Kindersley Lake Group
	59			Whiteshore Lake
	60			Redberry Lake
	76			Eagle Creek
	77			Muddy Lake
	78			Battle River

	79			Birling Creek
	80			Big Gully Creek
	81			Pipestone Creek
	82			Monnery River
	83			Englishman River
	84			Turtlelake River
	85			Jackfish River
	86			Sturgeon River
	87			Spruce River
	88			Garden River
Major Basin Number 8				**Saskatchewan River Basin**
	Sub-basin			***Name***
	26			Lenore Lake Group
	28			Carrot River
	67			Saskatchewan River
Major Basin Number 9				**Churchill River Basin**
	Sub-basin			***Name***
	34			Churchill River
	61			Beaver River
	63			Reindeer River
	64			Wollaston Lake
Major Basin Number 10				**Lake Athabasca Basin**
	Sub-basin			***Name***
	35			Athabasca River
	62			Clearwater River
Major Basin Number 11				**Assiniboine River Basin**
	Sub-basin			***Name***
	31			Assiniboine River
Major Basin Number 12				**Lake Winnipegosis Basin**
	Sub-basin			***Name***
	32			Swan Lake
	33			Red Deer River (Saskatchewan)
	57			Overflowing River
Major Basin Number 13				**Tazin River Basin**
	Sub-basin			***Name***
	65			Tazin River
Major Basin Number 14				**Kasba Lake Basin**
	Sub-basin			***Name***
	66			Kasba Lake

If there is a reservoir associated with a surface water licence, information concerning the surface area and capacity of the reservoir is available. Most surface water licences indicate whether the water is obtained from the gross or effective drainage area. The effective drainage area is the area of a drainage basin that would contribute to flow one year in two (in a median year). That is, a project taking water from the effective drainage area would reduce downstream flows at least half the time. A project that is not in the effective drainage area would reduce downstream flows less than half the time. Even if a water source is not connected to the main stream, removing water from that source may affect the local hydrology. For example, by reducing groundwater re-charge.

Figure 2 shows the generalized geological and hydrogeological setting in southern Saskatchewan. The province has been glaciated several times over many thousands of years. This glaciation has left Quaternary deposits up to 300 m in depth on top of the bedrock. These deposits consist of sands, gravels, silts and clay and contain potable groundwater that may be licensed for many users. The Hatfield buried valley aquifer is one such example. Bedrock aquifers such as the Eastend to Ravenscrag and Judith River formations may also contain potable water. The deeper bedrock aquifers such as the Blairmore formation are highly mineralized and are considered non-potable. With reference to Figure 2, the Blairmore formation is in the lower Cretaceous and is at about the same depth as the Mannville aquifer.

Saskatchewan water licences from groundwater identify the aquifer from which the water will be obtained. Quaternary sources are identified as 'glacial'. It is important to emphasize that the fact that the groundwater licences are filed by river basin is an administrative convenience. Aquifers do not coincide with surficial drainage features.

That said, there are some communities that draw their water supplies from groundwater systems that are directly connected to nearby streams. Pumping from groundwater, in effect, results in draw down of surface water by the same amount. Banff, Alberta is one such example.

One other consideration pertaining to water consumption from groundwater is that when the water pumped from the groundwater system is not completely consumed, the return flow often is to the surface water system. One example would be small communities that use groundwater for domestic supply and empty their sewage lagoons to the surface water system.

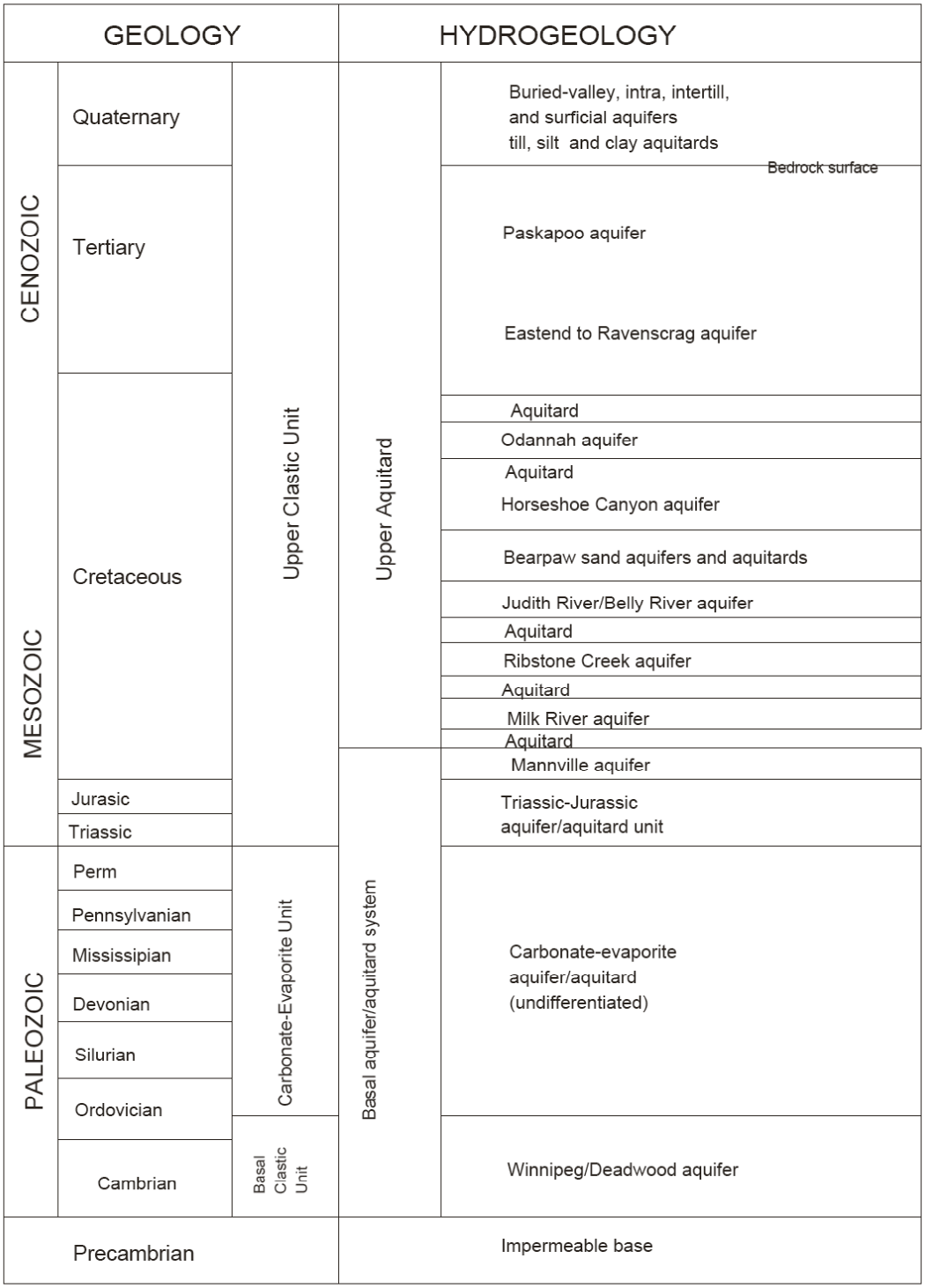


Figure 2. Generalized Geological and Hydrogeological Setting of the Western Canada Sedimentary Basin.[3]

The annual quantity of water allocated under a licence includes the amount that is expected to be consumed or lost, and any return flow. The database of Saskatchewan water licences is very detailed and provides sufficient information to conduct a thorough review of licences for all purposes. Actual water withdrawals and consumption are

usually less than the licensed allocation. Simply adding up water allocations will result in an over-estimation of water consumption.

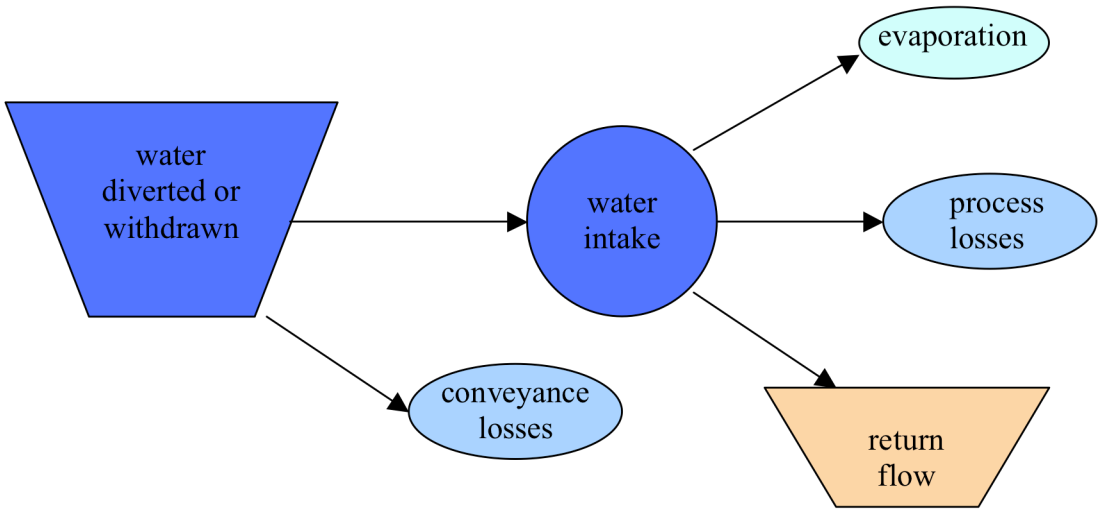
The units used in allocating water in prairie Canada and in this report are cubic decametres or dam^3. This is 1000 m^3 or one million litres. Water flowing at a rate of one cubic metre a second would produce a volume of over 30,000 dam^3 in a year.

In water-short basins, Saskatchewan will allocate no more than the median flow of the stream, that is, the flow that will occur one year in two. It should be kept in mind that, in the southern half of the province the Saskatchewan River system represents the only reliable surface water supply. This mountain-fed river has a very reliable flow. In comparison, the streams that rise on the prairie have unreliable and often erratic flows.

WATER USE

The terminology related to water use varies from one agency or practitioner to the other. In this report the term water allocation is used to identify the quantity of water set aside under Saskatchewan law for a particular purpose by a specified user. The allocation may include a consumptive use component and a return flow that would be available to downstream users. Water withdrawal or water diversion is the quantity of surface or groundwater that a water user removes from the aquatic system. Water consumption is water consumed by a user that does not return to the aquatic system. Water consumption includes losses to seepage or evaporation. Return flow is the difference between water withdrawal and water consumption. These concepts are illustrated in Figure 3.

In considering the figure, it must be kept in mind that the quantity of water diverted or withdrawn is not the same as the quantity allocated under a licence. In some cases it will be substantially lower than the licensed allocation. Conveyance losses are most commonly associated with surface water licences as water may be conveyed by a ditch from the point of diversion to the point of use. Groundwater extraction most often involves piped systems so there are no conveyance losses other than leakage. Industrial water uses often involve considerable recirculation and re-use of water. Some water will be lost during such processes thus requiring top-up water from the water supply. The process losses are considered as consumption. Finally, water will evaporate from any free surface. Any evaporation from reservoirs, or other impoundments such as tailings ponds, associated with a water licence is deemed to be consumption. Evaporation represents a considerable portion of water consumption for lake stabilization and habitat enhancement projects.



Water Consumption = Water Diverted - Return Flow
and
Water Consumption = Conveyance Losses + Evaporation + Process Losses

Figure 3. A Definitional Illustration of Water Use Terms

When it is feasible to do so this report will present information on overall water consumption in a major basin as a proportion of the recorded flow or, in some cases, the naturalized flow in that basin. The naturalized flow is the resulting flow when water uses are added to the recorded flow. It is a better indication of water supply than the recorded flow. Naturalized flows are available for the North and South Saskatchewan rivers, the Souris River, and the eastern tributaries of the Milk River.

Water Use Trends

In 1982, the Prairie Provinces Water Board reported on a four-year study of historical and current water uses in the Saskatchewan-Nelson Basin.[4] This *Water Demand Study* examined water use in 1978 in the following sectors: municipal, industrial, agriculture, power generation, recreation, and environmental. These sectors are further broken down so that, for example, agriculture includes irrigation, stock watering and rural domestic uses. The study used the concepts of water withdrawal, water consumption and return flows and provides detailed water use data both by sub-basin and by province. It therefore forms an important benchmark for subsequent water use studies. Since that time the province of Alberta has examined current water uses and future water demands, particularly for the South Saskatchewan River Basin where irrigation water demands are high.[5]

Several studies examine future water use in the Saskatchewan River Basin in Alberta.[6,7] Generally these studies take a business as usual approach in projecting water use some 20 years into the future. They do not make any assumptions concerning adoption of water conservation measures. On the other hand, the current policy of the Alberta government is to improve water use intensity. Even then, it is likely that at some future time Alberta will come closer to using its entitlement to water from the South Saskatchewan River under the *Master Agreement on Apportionment*.

This report will consider some water use projections for the province of Saskatchewan. An attempt will be made to identify the degree of uncertainty in these projections.

WATER ALLOCATION AND CONSUMPTION BY MAJOR BASIN

This part of the report discusses water allocation and consumption by major basin as identified by the Saskatchewan Watershed Authority. The water allocation figures are taken from the province's water licensing database and can be considered very reliable. Based on that database, categories of water allocation by industrial sector have been determined. Although there are some minor subjective interpretations by this writer, the industrial water allocation figures are also deemed reliable. Sub-sectors of industrial water allocation include oil and gas, mining, manufacturing and process water, cooling, aquaculture, intensive livestock, and miscellaneous. An example of miscellaneous is water bottling. The figures for industrial water allocation by sub-sector by major basin will be provided in this report.

Considering water consumption, the province has relatively little information on the quantity of water diverted or withdrawn annually or the quantity that is consumed. As mentioned earlier, some assumptions about water losses and return flows are built into the water rights allocations. Based on assumptions by this writer, water consumption information can be developed by industrial sub-sector. Numerical data will not be provided as there would represent little more than an informed opinion. Instead illustrations will be provided indicating the relative distribution of consumption by sub-sector. More precise water consumption information may be prepared based on the methodology used by AMEC in considering water use in Alberta.[8] Such a level of effort is beyond the scope of this report.

Major Basin One – Souris River Basin

The 29 302 km^2 Souris basin lies in southeastern Saskatchewan. The river originates near Regina and flows southeast to the international boundary, entering the United States near Sherwood, ND. It is joined by a major tributary, Moose Mountain Creek, before it enters the United States. Long Creek is another important tributary. The river is regulated by a number of dams and diversions. The natural flow of the Souris River is apportioned equally between Canada and the United States.

The total water allocation in the Saskatchewan portion of the Souris River basin is 88 287 dam^3 from surface water, based on 626 licences, and 29 435 dam^3 from groundwater, based on 392 licences. Surface water allocation exceeds the median natural flow of the Souris River at Sherwood. The allocations from surface and groundwater are shown in Figure 4. Most of the surface water allocation relates to dams on the Souris River, Long Creek and Moose Mountain Creek. The majority of the groundwater licences are for industrial purposes.

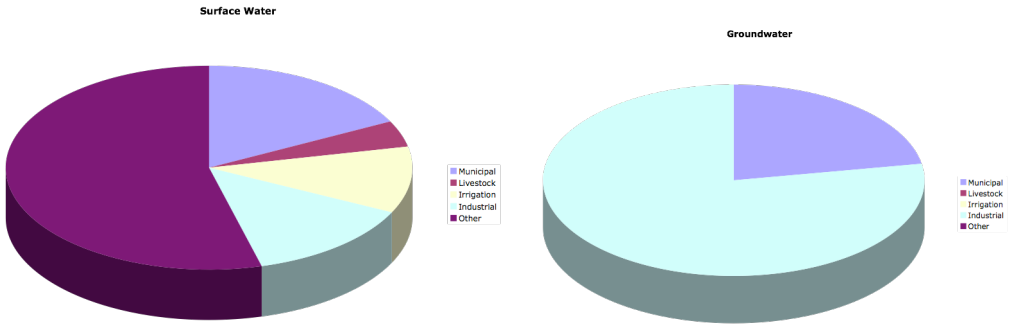


Figure 4. Surface and Groundwater Allocations from the Souris River Basin

Table 3 shows industrial allocations in the basin. Virtually all of the industrial use from surface water is cooling water for the Boundary and Shand generating stations near Estevan. The cooling water groundwater licences are not currently being used. Groundwater was pumped during drought years in the the 1980s to provide cooling water when surface water supplies in Boundary reservoir were depleted. A significant groundwater user is the oil and gas industry. Water from the deep non-potable Blairmore formation is used for oil recovery. Intensive livestock operations, mining and manufacturing use relatively small quantities of groundwater

Table 3. Industrial Water Allocation for the Souris River Basin in dam^3.

Source / Use	Oil and Gas	Mining	Intensive Live-stock	Aqua-culture	Cooling	Manufacturing or Process Water	Misc.
Surface		30			12 653		
Ground	11 897	136	584		10 033	78	

Major Basin Two – Missouri River Basin

The 27 224 km^2 Missouri basin in Saskatchewan consists of several tributaries of the Missouri River in the south-west part of the province. These include the Frenchman River, Battle Creek, Lodge Creek, as well as the Poplar River and Big Muddy Creek. These streams flow separately into the United States to eventually join the Missouri River and then the Mississippi River, which flow to the Gulf of Mexico. The natural flows of these streams, except for Big Muddy Creek, are apportioned between Canada and the United States. The Frenchman River and Battle and Lodge creeks are apportioned equally during the irrigation season. The apportionment of the Poplar River is more complex.[9] Battle Creek, Lodge Creek and Middle Creek, a Lodge Creek tributary, are also apportioned between Alberta and Saskatchewan.[10]

There are 2536 surface water licences allocating 99 956 dam^3 and 104 groundwater licences allocating 9079 dam^3 in the Missouri basin. The allocations exceed the median

natural flow of the streams. Figure 5 shows the distribution of licences. Irrigation is the largest surface water use while industrial use is the largest groundwater use.

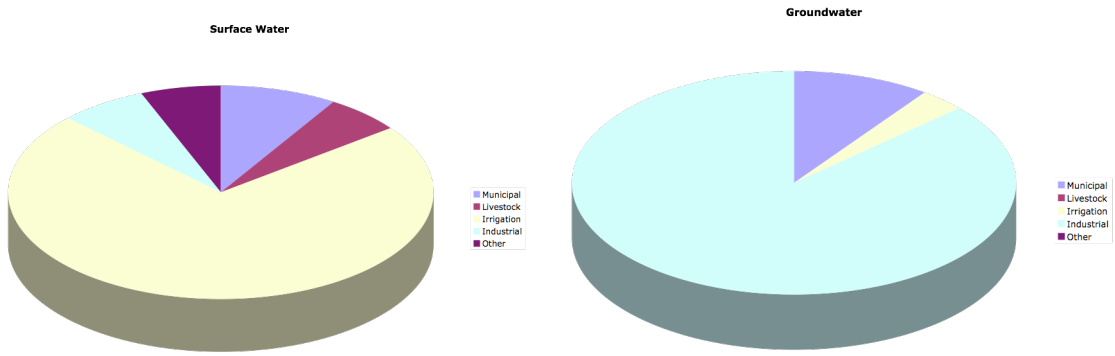


Figure 5. Surface and Groundwater Allocations from the Missouri Basin.

Table 4 shows industrial allocations in the basin. The most significant industrial use from surface water relates to the Poplar River power station. The groundwater licences also relate to the generating station. During drought years groundwater has been pumped to supplement surface water for system cooling. Groundwater, primarily from non-potable sources, is also used for oil recovery. The mining use relates to a sodium sulphate mine.

Table 4. Industrial Water Allocation in the Missouri River Basin in dam^3.

Source / Use	Oil and Gas	Mining	Intensive Live-stock	Aqua-culture	Cooling	Manufacturing or Process Water	Misc.
Surface		182			6843		
Ground	1053	1062	231		5500	5	

Major Basin Three – Cypress Hill (North Slope) Basin

The Cypress Hills basin comprises a number of small streams such as Maple Creek that originate on the north slopes of the Cypress Hills in the southwest part of the province.

There are 991 surface water licences allocating 25 973 dam^3 and 126 groundwater licences allocating 6854 dam^3. This basin is highly allocated. Figure 6 shows the distribution of licences.

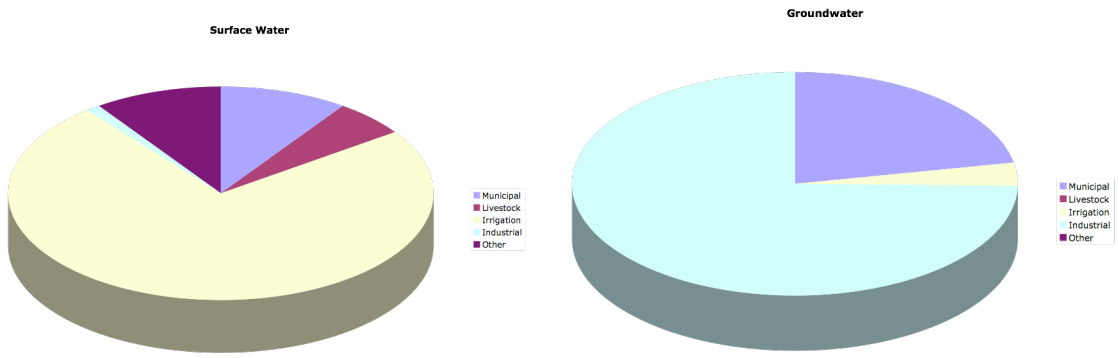


Figure 6. Allocations from Surface and Groundwater in the Cypress Hill Basin

Industrial water uses are shown in Table 5. Industrial water use from surface water in this basin is minimal as the oil and gas licence is inactive. Oil and gas is the largest groundwater use but much of the groundwater used in oil recovery is from non-potable sources. The other relatively large use is mining.

Table 5. Industrial Water Allocation in the Cypress Hills Basin in dam^3.

Source / Use	Oil and Gas	Mining	Intensive Live-stock	Aqua-culture	Cooling	Manufacturing or Process Water
Surface	317					1
Ground	3206	1772	49			75

Major Basin Four – Old Wives Lake Basin

Old Wives Lake is a terminal lake in southwestern Saskatchewan. Notukeu Creek, Wiwa Creek and Wood River are the principal contributing streams to this 17 591 km^2 basin. There are 2818 surface water licences allocating 112 482 dam^3 and 155 groundwater licences allocating 3028 dam^3 in this basin. This basin is also highly allocated. Figure 7 shows the distribution of licences.

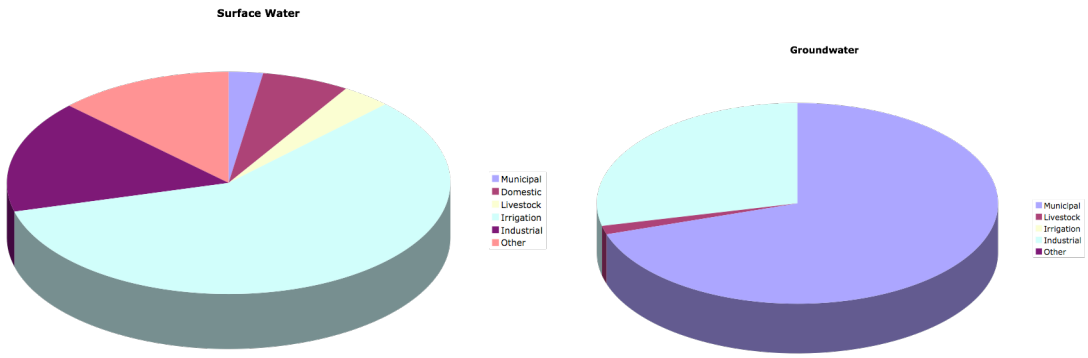


Figure 7. Allocations from Surface and Groundwater in the Old Wives Basin.

Industrial water use in the basin is shown in Table 6. The dominant use of industrial surface water is mining. Much smaller uses include intensive livestock and cooling water for railways. Groundwater use for industrial purposes is small. Of these uses the largest is intensive livestock followed by mining, oil recovery and manufacturing.

Table 6. Industrial Water Allocation in the Old Wives Basin in dam^3.

Source / Use	Oil and Gas	Mining	Intensive Live-stock	Aqua-culture	Cooling	Manufacturing or Process Water
Surface		17 507	191		155	
Ground	168	191	384			102

Major Basin Five – Qu'Appelle River Basin

The 58 795 km^2 Qu'Appelle River basin extends from the Qu'Appelle Dam on Lake Diefenbaker to the Saskatchewan-Manitoba boundary. Wascana Creek and the Moose Jaw River are important tributaries. The basin contains several recreational lakes including Last Mountain Lake, the Fishing Lakes and Crooked and Round lakes. Flows in the Qu'Appelle River and lake levels are sustained by a diversion from Lake Diefenbaker. There are 1598 surface water licences allocating 199 171 dam^3 and 728 groundwater licences allocating 41 998 dam^3 in the basin. It is important to note that some of these licenses allocate water diverted from the South Saskatchewan River. The waters of the Qu'Appelle River are apportioned equally between Saskatchewan and Manitoba under the Prairie Provinces Water Board *Master Agreement on Apportionment*. Because of the significant diversion from the South Saskatchewan River, comparing licensed allocations to the natural flow is not instructive. Licensed allocations from the basin are shown in Figure 8.

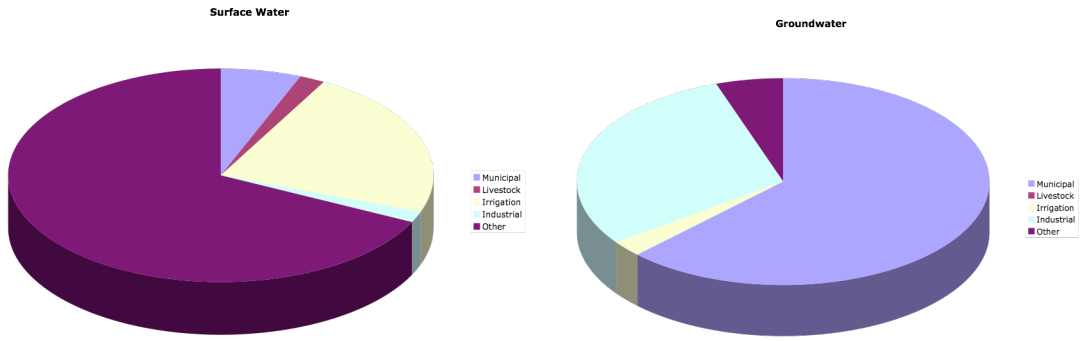


Figure 8. Allocations from Surface and Groundwater in the Qu'Appelle Basin.

Industrial water use is shown in Table 7. The largest industrial use from surface water relates to potash mining. The licence for cooling water relates to cooling the Legislative Building from Wascana Lake. There is some use from surface water for intensive livestock operations. The largest industrial water use from groundwater is for oil and gas. About 70 percent of the licensed industrial allocation relates to the Co-op Refinery in Regina. The remaining allocation is for washing of natural gas storage caverns. This is a one-time consumptive use. The next largest allocation is for mining, primarily potash mining. Other groundwater uses include intensive livestock, manufacturing and aquaculture.

Table 7. Industrial Water Allocation in the Qu'Appelle Basin in dam^3.

Source / Use	Oil and Gas	Mining	Intensive Live-stock	Aqua-culture	Cooling	Manufacturing or Process Water	Eth-anol
Surface		2889	91		401	14	
Ground	5420	4909	1321	111		249	473

Major Basin Six – South Saskatchewan River Basin

The South Saskatchewan River Basin originates in the Rocky Mountains. The river itself is formed by the confluence of the Bow and Oldman rivers in Alberta and flows east to the Alberta-Saskatchewan boundary. Just beyond the boundary, the river is joined by the Red Deer River, which also originates in the Rocky Mountains. Swift Current Creek is an important Saskatchewan tributary. The basin in Saskatchewan covers 49 286 km^2, including the Cypress Hills (North Slopes) drainage.

As an eastward flowing stream, the waters of the South Saskatchewan River are apportioned between Alberta, Saskatchewan and Manitoba. Because water use in Alberta is considerable, the arrangements pertaining to water apportionment are more complex than those pertaining to other streams covered by the *Master Agreement on Apportionment*. Although the naturalized flow is apportioned equally between the two provinces, Alberta is entitled to a prior allocation of the South Saskatchewan River to

meet its historic water needs. Because of water demands in Alberta, the province has capped water allocation in the Bow and Oldman river basins. The province has also instituted a conservation flow on the South Saskatchewan River of 42.5 m^3/s. This is the same quantity that is required under the Master Agreement under normal streamflow conditions. That flow is supplemented by flows in the Red Deer River. In a typical year Alberta delivers 78.3 percent of the combined natural flow of the South Saskatchewan and Red Deer rivers to Saskatchewan. Saskatchewan is also committed to releasing 42.5 m^3/s from Gardiner Dam. The normal summer target flow is 60 to 150 m^3/s. Under the Master Agreement Saskatchewan is required to pass on one half of the water received from Alberta plus one half of the water that arises in Saskatchewan to Manitoba. The flow arising in Saskatchewan is small – about two percent of the total flow.

Figure 9 illustrates annual water consumption from surface water for the entire South Saskatchewan River Basin from the Rocky Mountains to The Forks – the confluence of the North and South Saskatchewan rivers just east of Prince Albert. Various water uses are compared to the median annual flow. Much of the water use is in Alberta. Irrigated agriculture is clearly the largest water consumer. The 'other' sector includes a significant allocation related to evaporation from Lake Diefenbaker. There are two cases where significant quantities of water are diverted out of the South Saskatchewan River Basin. One relates to a diversion from the St. Mary River, a South Saskatchewan River tributary, to the Milk River within Montana. The other is the Qu'Appelle diversion. The South Saskatchewan River is the only reliable source of water in the southern part of the province. As such it is used to meet many water needs.

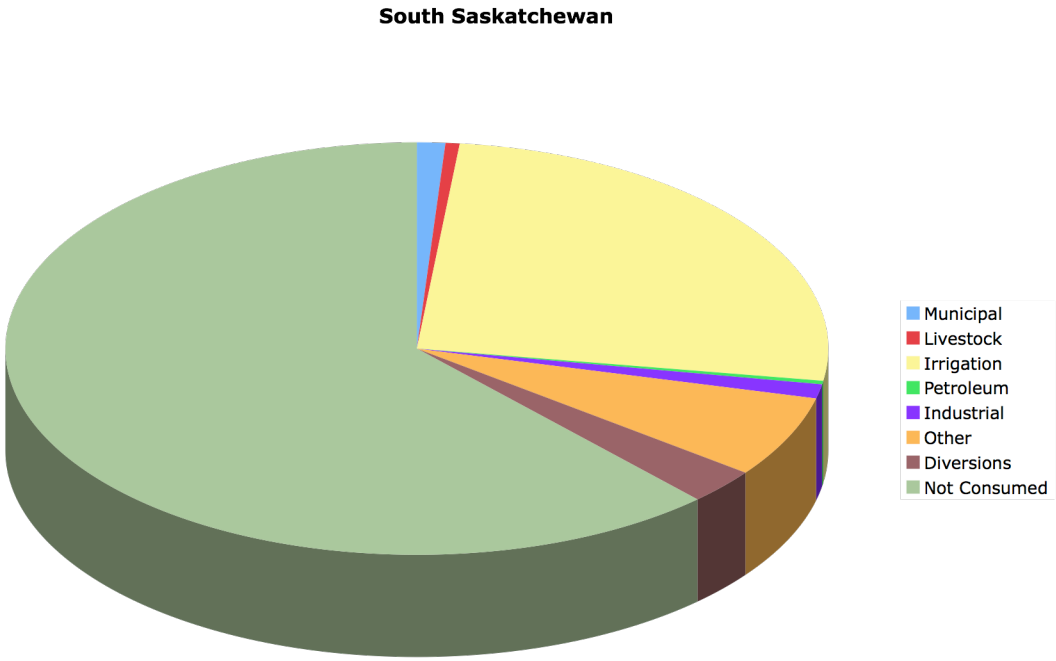


Figure 9. Surface Water Consumption for the Entire South Saskatchewan River Basin

Turning now to water allocation in the Saskatchewan part of the basin, which includes a few water licences on the Red Deer River before it joins the South Saskatchewan River, the total water allocation from surface water, based on 2250 licences, is 1 281 516 dam^3 and from groundwater, based on 350 licences, is 14 912 dam^3. The licensed allocations from both surface and groundwater are shown in Figure 10. A large proportion of the annual allocation is devoted to industrial use, including oil and gas. There is one significant diversion from Lake Diefenbaker: the Qu'Appelle Diversion. The licensed annual surface water diversion is 139 348 dam^3.

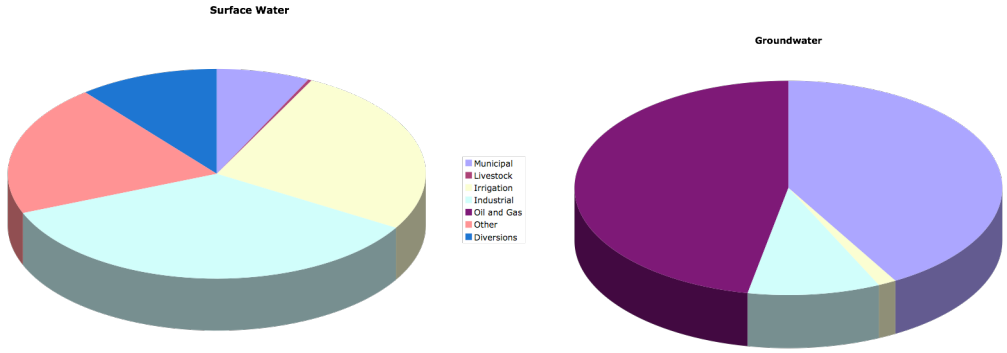


Figure 10. Annual Water Allocations for the South Saskatchewan River Basin.

About 90 percent of the industrial surface water allocation in the basin consists of a single licence for 427 108 dam^3 for cooling water for the Queen Elizabeth Generating Station in Saskatoon. Only 75 000 dam^3 of this annual allocation is withdrawn and about 3750 dam^3 is consumed. (The station uses a 'once-through' cooling system.) A portion of the water diverted to the Saskatoon South-East Water Supply System (SSEWSS) supplies potash mines. Some 11 470 dam^3 can be considered industrial use. (Nearly all of the water diverted to the SSEWS is consumed within the South Saskatchewan River Basin. Any return flow finds its way to Last Mountain Lake in the Qu'Appelle River Basin.) Some of the water diverted through the Qu'Appelle Diversion is used for industrial purposes including mining and fertilizer production. The licensed diversion, based on summing all the licences issued is 165 000 dam^3 while the average diversion over the last 20 years is 78 840 dam^3. Although there is no specific information concerning industrial water consumption in the South Saskatchewan River Basin, one can conservatively assume that the Queen Elizabeth Generating Station consumes a negligible quantity of water and that other industrial users consume their entire allocation.

Considering industrial groundwater consumption, over 80 percent of consumption relates to the oil and gas industry, and much of that consumption is in the Swift Current Creek sub-basin. Some of the groundwater consumption is from non-potable deep aquifers. The next largest users are mining, intensive livestock operations and aquaculture in that order. In the absence of detailed information, one can assume that all the industrial users consume their annual allocations. This can be considered a conservative assumption.

Water consumption estimates for the South Saskatchewan River Basin are shown in Table 8. Water used by the oil and gas industry is often from non-potable sources. Mining use relates primarily to potash mines. The figures include water use by the potash mine and a fertilizer plant near Belle Plaine.

Table 8. Industrial Water Allocation the South Saskatchewan River Basin in dam^3.

Source Use	Oil And Gas	Mining	Intensive Livestock	Aquaculture	Cooling	Manufacturing or Process Water	Misc.
Surface		13 309	103	127	427 106	6000	
Ground	7010		530	172		62	

Major Basin Seven – North Saskatchewan Basin

The 63 606 km^2 North Saskatchewan River originates in the Columbia Ice Fields in Banff National Park in the Rocky Mountains and flows generally eastward across Alberta into Saskatchewan. It joins the South Saskatchewan River at The Forks near Prince Albert. As an eastward flowing river, the North Saskatchewan River is subject to the *Master Agreement on Apportionment* administered by the Prairie Provinces Water Board. Under the agreement, Alberta may retain one half of the naturalized flow of the river, passing the other half to Saskatchewan. Saskatchewan, in turn, may retain one-half of the water received from Alberta plus one-half of the water rising in Saskatchewan and pass the remainder on to Manitoba.

As indicated in Figure 11, water consumption in the entire North Saskatchewan Basin from the Rocky Mountains to The Forks is small compared to the median annual flow. Water consumption in the basin is roughly equivalent to the evaporative loss from Lake Diefenbaker in the South Saskatchewan Basin. Administration of apportionment is relatively simple for the reliable flows of the North Saskatchewan River. It should be noted, however, that two North Saskatchewan River tributaries, Battle River and Eyehill Creek, cross the interprovincial boundary. That being the case, the much less reliable flows of these two streams are apportioned separately. Interprovincial apportionment of these tributaries can be a concern during low flow conditions.

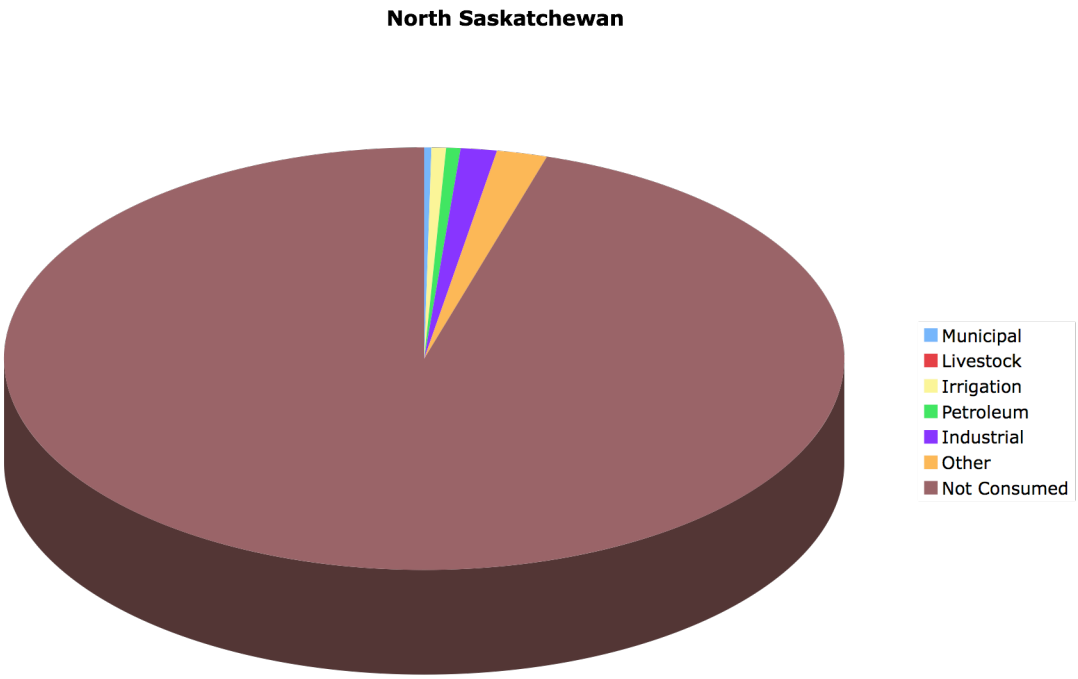


Figure 11. Surface Water Consumption for the Entire North Saskatchewan River Basin.

Considering water use in the North Saskatchewan River Basin in Saskatchewan, there are 1621 licences allocating 83 253 dam^3 from surface water and 704 licences allocating 22 257 dam^3 from groundwater. More than 90 percent of the industrial surface water allocation consists of the licence for the Weyerhauser plant, now inactive, at Prince Albert. The relatively large allocation to the 'other' sector relates to water management structures and structures for lake stabilization for recreation and wildlife habitat. Groundwater allocations are dominated by oil and gas uses. Municipal withdrawals from groundwater often are returned to the surface water system. The licensed allocations for both surface and groundwater are shown in Figure 12.

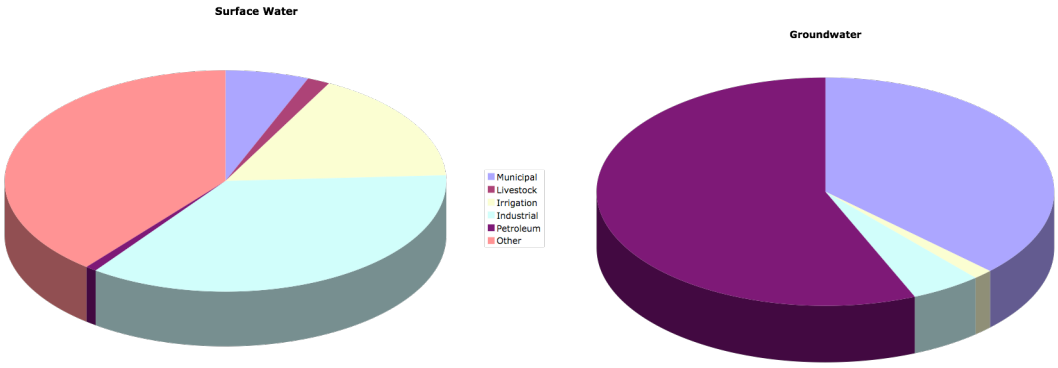


Figure 12. Annual Water Allocations for the North Saskatchewan River Basin

Industrial water consumption estimates are shown in Table 9. Oil and gas accounts for most of the currently active water consumption in the basin. The activity tends to be in the western part of the basin in the Battle River, Manitou Lake and Kindersley Lakes sub-basins. Non-potable water is often used. Most of the industrial water consumption is from groundwater. All identified industrial users, except Weyerhauser, are considered to be using their entire allotments. The surface water allocation to Weyerhauser is 76 538 dam^3. (Domtar now owns the Weyerhauser facility.) There is one ethanol plant in the basin with an annual groundwater allocation of 350 dam^3 and some bottled water operations. These are included in Table 8 under miscellaneous.

Table 9. Industrial Water Allocation for the North Saskatchewan River Basin in dam^3.

Source Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water	Misc.
Surface		2219	231	4	220	76 610	
Ground	20 413			12		590	379

Major Basin Eight – Saskatchewan Basin

The 59 267 km^2 Saskatchewan River basin is formed by the confluence of the North and South Saskatchewan rivers near Prince Albert. The river flows east through the Saskatchewan River Delta, which straddles the Saskatchewan-Manitoba boundary, to Lake Winnipeg. The Carrot River, which joins the Saskatchewan River in Manitoba, is included in this basin. The river is highly regulated by upstream dams. SaskPower maintains a 75 m^3/s minimum flow below E. B. Campbell Dam. As eastward flowing streams, the Saskatchewan River and its transboundary tributaries such as the Carrot River are subject to the *Master Agreement on Apportionment* administered by the Prairie Provinces Water Board. Saskatchewan must pass on to Manitoba one-half of the naturalized flow received from Alberta plus one-half of the naturalized flow arising in Saskatchewan. Water consumption in the Saskatchewan River and its transboundary tributaries upstream of the interprovincial boundary is not sufficient to pose apportionment problems.

Water allocation in the river reach and the associated drainage basin from The Forks to the interprovincial boundary consists of 257 licences for 383 808 dam^3 from surface water and 171 licences for 9222 dam^3 from groundwater. The distribution of surface and groundwater licences is shown in Figure 13. Much of the relatively large allocation for the 'other' sector from surface water relates to operation of many Ducks Unlimited Canada projects in the Saskatchewan River Delta and elsewhere in the basin. The

relatively large allocation from the 'other' sector from groundwater relates to dewatering operation at SaskPower dams, primarily Nipawin Dam.

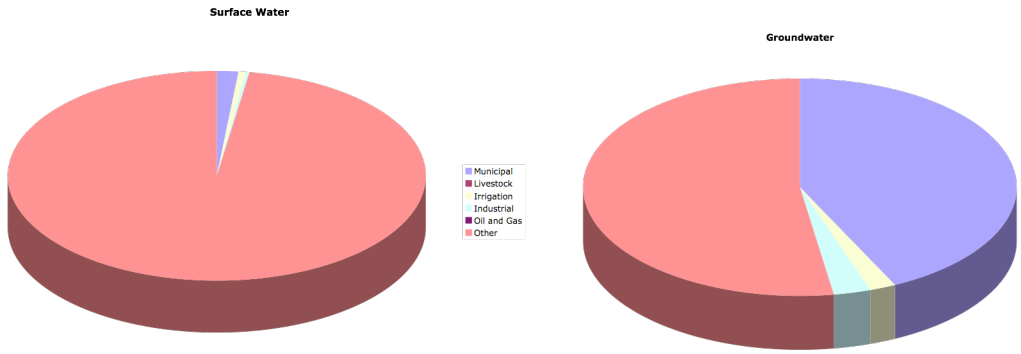


Figure 13. Annual Water Allocations in the Saskatchewan River Reach

Industrial water consumption estimates for the Saskatchewan River reach are shown in Table 10. Overall consumption is very small compared to available supplies. It can be assumed that all licence holders use their entire allotment. The miscellaneous use from groundwater is for water bottling.

Table 10. Industrial Water Allocation in the Saskatchewan River Reach in dam^3.

Source / Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water	Misc.
Surface		400	90			410	15
Ground		60	115	12		79	2

Major Basin Nine – Churchill River Basin

The 187 995 km^2 Churchill River basin extends from La Loche near the Alberta boundary and crosses the Manitoba boundary on its way to Hudson Bay. Important tributaries include the Beaver and Reindeer rivers. This basin contains myriad lakes, notably Lac La Ronge and Reindeer Lake. The Island Falls generating station regulates flows into Manitoba. The river is subject to the PPWB *Master Agreement on Apportionment*; consumptive water uses in the basin are small. There are 167 surface water licences in the basin allocating 171 083 dam^3. Most of this allocation relates to Ducks Unlimited Canada projects. There are 161 groundwater licences in the basin that allocate 4987 dam^3. Most of this is for industrial uses. Figure 14 shows water allocation in the Churchill basin.

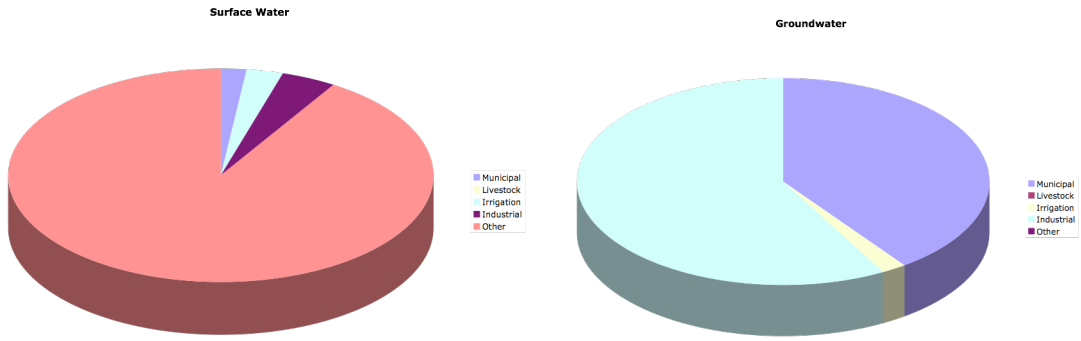


Figure 14. Surface and Groundwater Allocations in the Churchill Basin.

Industrial water use is shown in Table 11. The principal use from both surface and groundwater is mining. The other significant use relates to the Meadow Lake pulp mill. There is a minor use of surface water for aquaculture and of ground water for intensive livestock operations. It is possible that the use of groundwater in mining may be just de-watering water while the groundwater use at Meadow Lake could be an alternate supply when surface water is not available.

Table 11. Industrial Water Allocation in the Churchill River Basin in dam^3.

Source / Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water
Surface		6308		9		850
Ground		1845	117			910

Major Basin Ten – Lake Athabasca Basin

The 113 373 km^2 Lake Athabasca basin extends from the Wollaston Lake area near the Manitoba boundary through the Fond du Lac system to Lake Athabasca, which straddles the Alberta-Saskatchewan boundary. Outflows from Lake Athabasca form the Slave River, which flows to Great Slave Lake. Another stream in the basin, the Clearwater River, flows west to join the Athabasca River in Alberta. The only water uses in this basin are for mining and municipal purposes. There are 14 surface water licences in the basin allocating 4168 dam^3 and 6 groundwater licences allocating 148 dam^3. Industrial water uses are shown in Table 12.

Table 12. Industrial Water Allocation in the Lake Athabasca Basin in dam^3.

Source / Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water
Surface		3270				

Source Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water
Ground		62				

Major Basin Eleven – Assiniboine River Basin

The 17 695 km^2 Assiniboine River basin lies along the Manitoba boundary north of the Qu'Appelle River. (The Qu'Appelle River joins the Assiniboine in Manitoba.) Lake of the Prairies created by Shellmouth Dam backs water across the boundary. The River is subject to the PPWB *Master Agreement on Apportionment*. There are 243 surface water licenses allocating 27 152 dam^3 and 166 groundwater licences allocating 10 051 dam^3 in the basin. The distribution of licences is shown in Figure 15. The 'other' category consists of primarily Ducks Unlimited Canada waterfowl conservation projects and water management licences for reservoirs.

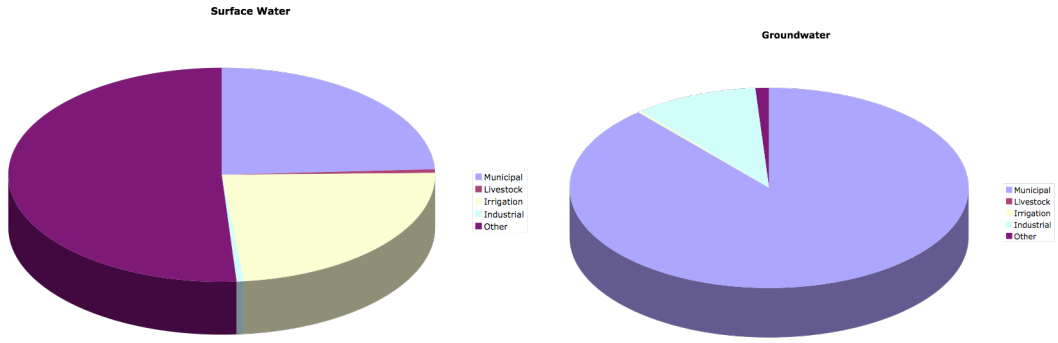


Figure 15. Allocations from Surface and Groundwater in the Assiniboine Basin.

Table 13 shows the allocations for industrial uses. The only allocation from surface water is for intensive livestock operations. The oil and gas allocation from groundwater is for gas storage cavern washing – a one-time use. There are some groundwater allocations for intensive livestock operations and a small allocation for manufacturing.

Table 13. Industrial Water Allocation in the Assiniboine Basin in dam^3.

Source Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water
Surface			102			

Source Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water
Ground	463		511			10

Major Basin Twelve – Lake Winnipegosis Basin

The 18 711 km^2 Lake Winnipegosis basin lies along the Manitoba boundary between the Assiniboine basin and the Saskatchewan River basin. It includes streams such as the Red Deer River and the Overflowing River. There are 113 licences from surface water allocating 37 764 dam^3 and 99 groundwater licences allocating 1867 dam^3. Figure 16 shows the allocation of surface and groundwater in the basin.

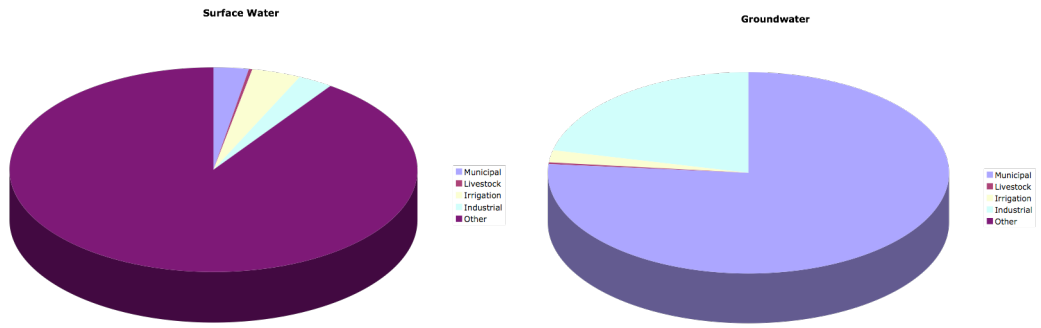


Figure 16. Allocations from Surface and Groundwater in the Lake Winnipegosis Basin.

Table 14 shows the allocations for industrial water use. The largest water use from both surface and groundwater is intensive livestock operations. The manufacturing use largely pertains to the forest industry. Some of these facilities are now closed.

Table 14. Industrial Water Allocation in the Lake Winnipegosis Basin in dam^3.

Source Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water
Surface			512			397
Ground			216			185

Major Basin Thirteen – Tazin River Basin

The 4001 km^2 Tazin River basin lies in northern Saskatchewan to the north of Lake Athabasca. The Tazin River flows north to join the Taltson River, a tributary to Great Slave Lake. Tazin Lake is regulated for hydropower generation. There are no licensed water uses in this basin.

Major Basin Fourteen – Kasba Lake Basin

The 5435 km^2 Kasba River basin is in the extreme northeast of Saskatchewan. The basin is sparsely populated and is dominated by the Selwyn Lake upland. There are no licensed water uses in this basin.

Summary and Discussion

Table 15 summarizes the industrial water uses in Saskatchewan. As can be seen by the illustrations of overall water use earlier in this report, industrial users are by no means the largest water consumers in the province. There are no firm figures for water consumption, as opposed to water use, in Saskatchewan. In general, one can assume that the 'other' uses – primarily water management and waterfowl conservation – consume almost all the water diverted and irrigated agriculture consumes about 80 percent of water diverted. On the other hand, municipal users consume less than 10 percent of water diverted.

It is evident from Table 15 that the largest surface water allocation is devoted to cooling water, primarily for thermal power stations. The total figure is misleading, however, on account of the very large licence (427 108 dam^3) for the Queen Elizabeth Station in Saskatoon. This is the only station that uses once-through cooling rather than evaporative cooling. Taking this use out of the totals leaves the impression that the largest water use is for manufacturing purposes, most of this in the forest industry. Again, one large licence (76 538 dam^3 for the Weyerhauser plant in Prince Albert) can cause misinterpretation. Because of the difficult financial circumstances of the forest industry, the Weyerhauser plant and other smaller facilities have been closed. The largest current industrial user of surface water in the province therefore is likely mining, uranium mining in the north and potash mining in the south. If one assumes that, with the exception of the two licences previously discussed, all licence holders use their entire allocation, mining, cooling water, manufacturing, and intensive livestock operations are the largest consumers of surface water in Saskatchewan. Based on more detailed water use studies conducted in Alberta and knowledge of some specific licences in Saskatchewan, this writer feels that water withdrawal in Saskatchewan is less than the licensed allocation. Personal communication with the Saskatchewan Watershed Authority indicates that some industrial users may withdraw as little as 10 percent of their annual allocations. Actual water consumption for industrial purposes will be somewhat less than the quantity withdrawn, but the surface water withdrawn for most industrial purposes in Saskatchewan tends to be entirely consumed.

In general, hydroelectric production consumes very little water although it significantly alters the flow patterns of the river, reducing summer flows and increasing winter flows.

Figure 17 illustrates this for the South Saskatchewan River at Saskatoon. The overall decrease in flow is the result of upstream water consumption, primarily for irrigated agriculture. Consumption for hydroelectric operations pertains to evaporative losses from reservoirs. This is usually small, the only exception in the province being the loss from the surface of Lake Diefenbaker – some 200 000 dam^3 annually. Technically, a portion of this loss could be assigned to power generation.

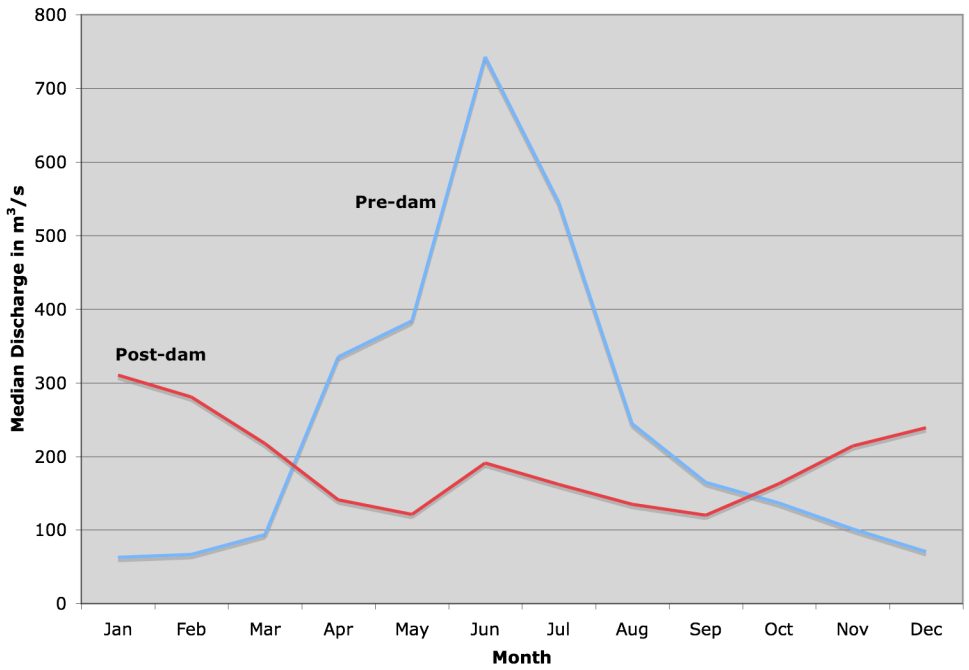


Figure 17. Effects of River Regulation on the South Saskatchewan River at Saskatoon

Considering groundwater use, Table 14 indicates that the largest single water use is in the oil and gas industry, primarily in oil recovery. Much of the groundwater used for this purpose is from non-potable deep aquifers. The principle water use by the gas industry tends to be for storage cavern washing – a one-time, as opposed to annual, use. The next largest use of groundwater is in cooling at SaskPower generating stations and other cooling applications such as railways. The use of groundwater for cooling by SaskPower at Boundary and Coronach reservoirs is as a back-up source when surface water supplies are low. The use of groundwater by SaskPower in most years is therefore nil. The next largest use is in mining, but many of the groundwater licences pertaining to mining are for de-watering and little or no water is consumed. Another relatively large user of groundwater is intensive livestock operations. Smaller users include manufacturing, aquaculture, ethanol production and bottled water. As was the case for surface water, little data exist on actual water consumption.

Table 15. Summary of Industrial Water Allocation in Saskatchewan in dam^3.

Source Use	Oil And Gas	Mining	Intensive Livestock	Aqua-culture	Cooling	Manufacturing or Process Water	Misc.
Souris		30			12 653		
Souris	11 897	136	584		10 033	78	
Missouri		182			6843		
Missouri	1053	1062	231		5500	5	
Cypress	317					1	
Cypress	3206	1772	49			75	
Old Wives		17 507	191		155		
Old Wives	168	191	384			102	
Qu'App.		2889	91		401	14	
Qu' App.	5420	4909	1321	111		249	473
S. Sask.		13 309	103	127	427 106	6000	
S. Sask.	7010		530	172		62	
N. Sask.		2219	231	4	220	76 610	
N. Sask.	20 413			12		590	379
Sask.		400	90			410	15
Sask.		60	115	12		79	2
Church.		6308		9		850	
Church.		1845	117			910	
Athabas.		3270					
Athabas.		62					
Assinib.			102				
Assinib.	463		511			10	
L. Wpgo.			512			397	
L. Wpgo.			216			185	
Surface	317	46 114	1320	140	447 378	84 282	15
Ground	49 630	10 037	4058	307	15 533	2345	854

Note: Surface water is shown first then groundwater.

Based on this review it is evident that large industrial water users in Saskatchewan tend to be oil industry, mining or forestry operations. The use of non-potable deep aquifers in oil recovery may constitute mining of groundwater, but the time period of use from any one aquifer is short enough that long-term effects are unlikely. Note, for example, that overall water use for conventional oil recovery is now declining in Alberta.

Saskatchewan has one oil refinery and one heavy oil upgrader facility. The current concentration of such facilities in 'Refinery Row' near Edmonton, Sarnia and Montreal makes it unlikely that a new operation would be placed in Saskatchewan. Expansion of the two existing facilities could be contemplated, however.

One company, Oilsands Quest, believes it has located a commercially viable oils sands deposit, known as Axe Lake, in the province on the Alberta boundary adjacent to Alberta deposits. The deposit is too deep to strip mine so *in situ* recovery methods would be required. This requires injection of steam to soften the bitumen and separate it from sand particles so that the bitumen can be pumped to the surface. Depending on the process used and physical properties of the deposit the quantity of water required is up to one-half barrel for each barrel of bitumen.[11] (Recovery operations using strip mining require much greater quantities of water per barrel of bitumen.) Additional water is required to process the bitumen once it is brought to the surface. In Alberta, the trend is to using non-potable groundwater for *in situ* recovery. This would likely be the case in Saskatchewan as well.

The other energy-related water use pertains to power generation. Saskatchewan currently depends on coal-fired thermal stations for much of its power. The stations near Estevan and the one near Coronach are sited in water short areas close to coal supplies. In drought years water needs for evaporative cooling have been met by pumping groundwater. The province has devoted considerable attention to continued use of coal-fired generating stations with carbon capture and storage facilities aimed at reducing greenhouse gas emissions. It is likely that the present coal-fired stations will be decommissioned at the end of their life and that they could be replaced with new units that use carbon capture and storage. Because of the energy requirements for carbon capture and storage, the quantity of water required per unit of commercial power produced would increase. A new generating station could employ air cooling at some additional cost if surface water supplies under climate change were too unreliable.

A new energy proposal in the province is the Bruce Power proposal for a nuclear generating station on the North Saskatchewan River. Such a station would use evaporative cooling. A 9000 dam^3 cooling pond would be constructed near the station. Make up water would be pumped at 2.6 m^3/s.[12] This is a significant quantity of water, roughly equivalent to the Weyerhauser licence at Prince Albert, as the pumping would be continuous. Compared to the flow of the North Saskatchewan River the quantity is relatively small, about one-tenth of one percent of the annual flow of the river.

Mines have a finite life, although the potash resources of Saskatchewan appear almost limitless. There are fairly serious proposals for three greenfield potash mines in the province and existing mines continue to expand. (A greenfield industrial project is one on previously undeveloped land, as opposed to an expansion of an existing project.) A potash mine may use several thousand cubic decameters of water a year. Increased water use by the potash industry, even if water conservation measures are in place, appears certain. Water use by uranium and other northern mines tends to be small in comparison to available supplies. Increased mining activity in the north is unlikely to be a source of stress on water quantity.

Forestry operations can continue forever if sustainable practices are used. The associated water needs can therefore continue forever. Given the current state of the forest industry in Canada, proposals for new developments anywhere in Canada are non-existent.

Considering future water use in Saskatchewan, the most optimistic development scenario would be re-opening of currently closed facilities at some time in the future. Existing water licences should be sufficient to cover the needs of the industry for some time to come.

It would be reasonable to assume increases in agricultural industrial water use, including intensive livestock operations. Livestock operations tend to use all the water that is withdrawn, but there are opportunities for water conservation. For example, the use of the ball-bite drinkers in hog operations reduces water consumption by 35 percent with no detrimental effect on the animals and had secondary benefits such as reduced manure output.[13]

There is relatively little large-scale food processing in Saskatchewan. These industries tend to locate near larger centres to ensure a supply of workers. It is likely that the water needs of such industries could be met by the existing allocations of most of the cities in the province.

There are currently five wheat-based ethanol plants and one biodiesel canola plant in the province. Grain-based ethanol production is controversial and would not exist without large subsidies. At some point these subsidies may be transferred to more suitable purposes such as ethanol from waste. (Iogen Corp. is currently considering a $250 million cellulosic ethanol plant near Prince Albert.) If present Canadian policy of including five-percent ethanol in automobile fuel is continued ethanol production in Canada would have to increase by about 50 percent, or imports of ethanol could be allowed. No matter what the future of the industry, any single ethanol plant does not consume large quantities of water and the number of plants in the province is unlikely to increase by more than 50 percent.

Any examination of future industrial water use in the province is unquestionably speculative and prone to error. One can assume that there will be increased numbers of potash and other mines that will demand significant water supplies. Other industrial uses of water may also continue to increase. One can also assume that intensive livestock operations may continue to expand. Any one operation does not use much water, but if concentrated in one area, may have cumulative water quantity effects. Any projection of future industrial water use should also take into account the source. Water use by the oil industry will be most likely from non-potable sources and, in the case of conventional oil, relatively short term. Water developments that propose the use of open conveyance channels to move water from a source to the point of use entail significant water losses. Such proposals, in particular, require a careful analysis of the potential effects on donor waters and on receiving waters, if all the water is not consumed at the point of use.

Water use from the river basins in the southern part of the province, such as the Souris or Missouri basins is high relative to the reliable supply. Water supplies in these basins may be particularly vulnerable to climate change effects on runoff, much more so than the mountain-fed North and South Saskatchewan rivers. The South Saskatchewan River, although subject to the PPWB *Master Agreement on Apportionment*, could be depleted in Alberta even more that it currently is. In the next 20 years the effects of increased water

consumption in Alberta and Saskatchewan in that basin will likely be more significant than the effects of climate change itself. From a Saskatchewan perspective, greater emphasis must be placed on water conservation for all aspects of water use, including industrial water use. The Saskatchewan policy of higher charges for industrial water taken as surface water from the South Saskatchewan and Qu'Applelle river systems encourages conservation in basins that are somewhat water short. Increased water charges or institution of water use charges for other industrial sectors could be considered in other southern basins.

One essential element of any approach to water conservation is to increase current knowledge of existing water use. At present, little is known about actual water withdrawals in comparison to licensed allocations although it is generally understood that annual withdrawals are less – in some cases, far less – than licensed quantities. Even less is known about actual consumption of water. It has been said that, "if you're not measuring it, you're not managing it". Like most Canadian jurisdictions, Saskatchewan is not measuring it.

IMPACTS OF INDUSTRIAL WATER USE

The impacts of industrial water use should be considered in the context of overall water use. Water withdrawals and the infrastructure required to effect those withdrawals lead to changes in both the timing and quantity of streamflows. These changes in turn influence water quality, riparian habitat and biological productivity. Water use should not be seen as entirely negative. A major water use in Saskatchewan is in replenishing and restoring wetlands. Water use sustains cities and agricultural use sustains the farm economy. Industrial uses also provide economic development and jobs.

Water withdrawals from surface waters do raise questions concerning the need for specified in-stream flows needed to sustain aquatic ecosystems. The effects of water withdrawals or river regulation on elements such as water quality, fish habitat, riparian vegetation and channel maintenance should be considered.[14] Streamflows that emulate natural conditions are desirable, but not always achievable for streams where human uses are significant. The analyses required to determine in-stream flow needs are complex and, for the most part, this work has not been done for Saskatchewan streams. As a step in that direction, a few streams have minimum flow requirements or requirements for seasonal flushing flows.

Groundwater pumping can deplete aquifers. Sustainable yield of aquifers is an important consideration in water licensing and use. Shallow aquifers are particularly vulnerable to climate effects and can be drawn down considerably during drought years. In general, Saskatchewan aquifers are used in a sustainable fashion. The spectre of groundwater mining as exemplified by the Ogallala Aquifer in the United States Great Plains does not exist.

Considering the ecological, social and health impacts of industrial water use in the province, with some exceptions water quantity is not the primary issue. Water consumption is such that foreseeable needs can be met if water is managed wisely. The principle negative effect of industrial use, *per se*, is on water quality. These effects can occur in two ways, directly through contamination by industrial effluents and indirectly through land use changes.

Typical environmental contaminants related to water quality include bacteriological, metals, pesticides, and nutrients. Industries in urban centres may use the municipal sewer system to dispose of their wastes thus allowing them to be treated in conventional wastewater treatment facilities. Large quantities of industrial wastewater would overwhelm a municipal system. In those cases, industries must install their own treatment facilities to allow treatment prior to releasing effluents to the environment. These systems must be operated and maintained correctly to prevent plant ‘upsets’ that would release harmful materials to the environment.

Under the *Canadian Environmental Protection Act* (CEPA) facilities that release pollutants to land, air or water or that otherwise dispose of or transfer substances for recycling are required to report annually on their activities through an on-line National

Pollutant Release Inventory. The inventory covers more than 300 substances. In 2007 almost 600 Saskatchewan sites reported. Most of these were energy or agriculture related. Until recently, mining tailings were not subject to CEPA on the basis that they could be further reprocessed and therefore did not constitute waste. A recent Federal Court ruling has overturned that interpretation. Mining companies will be required to submit their data, starting with 2006 data. In the United States mines constitute a small proportion of industrial facilities, but account for almost 25 percent of pollutant waste.

The streams and lakes of southern Saskatchewan are naturally eutrophic so a continuing concern is introduction of additional nutrients to the aquatic ecosystem. Saskatoon, for example has installed advanced nutrient removal in its wastewater treatment facility. Industrial effluents may add to the nutrient problem. For example, manure from intensive livestock operations can be disposed of by spreading on the land. Lack of attention to buffer strips or lack of maintenance of buffer strips could lead to direct runoff to surface waters. Nutrients spread on the land may also contaminate surficial groundwaters. Nitrate contamination of the Abbotsford Aquifer in the lower Fraser Valley of British Columbia has been attributed to the supply of "free" poultry manure to raspberry growers in the area.[15]

Mine tailings represent another concern. Tailings ponds must be designed, constructed, operated and maintained to high standards as any failure can lead to extensive environmental damage. The current version of the *Canadian Dam Safety Guidelines* is a good starting point.[16] Some mining operations propose a "sacrificial lake" approach to managing tailings. This can be a low risk solution.

Considering the social and health effects of industrial water use, water development is generally seen as important to economic growth and job creation. Water developments often have a rural development component and are often pursued for that purpose alone. A thorough discussion of social and health effects pertaining to industrial water use is beyond the scope of this report. More often than not, these effects can be more directly related to the industrial development itself, rather than the water use by that development. It would be more appropriate to consider such effects by industrial sector rather that water use. For example social and health effects of potash mining or intensive livestock development.

CONCLUSIONS

Significant quantities of surface and groundwater are allocated to industrial purposes in Saskatchewan each year. That said, it must be kept in mind that the largest single water consumer in the province is irrigated agriculture and that water management consumption also exceeds industrial consumption. Water management consumption often includes a wildlife habitat component.

The provincial database of water licences is an excellent source of information and is believed to be accurate. The database is organized by major drainage basins and many sub-basins. In the case of licences from groundwater, the aquifer is specified where applicable.

Saskatchewan assesses water use charges to non-agricultural industrial users who do not draw their water supplies from municipal sources. These charges are highest for surface water from the South Saskatchewan and Qu'Appelle basins.

Although water users are asked to report water withdrawals, the data on these withdrawals is incomplete. The only users reporting regularly are those industrial users who must pay water charges. There is no routine data on actual water consumption in the province. This situations tends to be the norm in Canada. There is some anecdotal and other evidence to support the contention that water withdrawals and hence water consumption in the province is less, in some cases much less, than the licensed allocation.

Based on the available information, mining, cooling water, manufacturing, and intensive livestock operations are the largest industrial consumers of surface water in Saskatchewan. The largest user of groundwater in the province is the oil and gas industry. Most of the groundwater used in oil recovery operations, however, is non-potable water from deep aquifers. Water use represents a significant proportion of available surface water supply in the South Saskatchewan, Qu'Appelle, Missouri, Cypress Hills and Old Wives basins. Of these, only the South Saskatchewan basin can be considered to have reliable flows. Flows in the other basins vary considerably within the year and between years.

There are several improvements to the Saskatchewan industrial water licensing procedures that could be considered. First, the province could be more diligent in ensuring that licence holders report water withdrawals. Monthly reporting is probably not required except where there are concerns about available supplies. An annual report would be sufficient for most purposes. In addition to reporting water withdrawals, reporting of return flows would allow detailed analysis of water consumption. This level of reporting could be considered for all licence holders, irrespective of purpose. In the case of industrial water use, there are considerations of competitive advantage and corporate confidentiality to consider. While the results of water use reports should be publicly available, they should be aggregated to alleviate privacy concerns.

Secondly, it would be reasonable to consider water charges for all industrial users even agriculture users. There appears to be no compelling reason why intensive livestock operations, for example, should not be subject to user charges. Consideration could also be given to increasing the water charges for surface water from all the water-short basins in the province. That is, all the major basins from the South Saskatchewan and Qu'Appelle basins to the international boundary. Consideration could be given as well to basing charges on water consumed rather than water withdrawn should this information becomes available. In general, water charges that encourage appropriate use and conservation should be supported. At present, charges for water having total dissolved solids greater than 4000 mg/L are very low thus encouraging the use of non-potable water where feasible.

A cursory examination of present industrial uses and the potential for increased use indicates that some industrial expansion could take place within the scope of existing licences, especially if more attention was paid to water conservation. In general, increased water use could be considered from most major basins, the exception being the southern basins where one half of the median flow is fully allocated.

Considering the environmental effects of industrial water use, it would be appropriate for Saskatchewan to conduct detailed examinations of in-stream flow needs for streams where water withdrawals represent a significant part of available supplies. A pilot project that would establish procedures for future use would be very desirable.

The province could also consider studies pertaining to the cumulative effects of certain developments. This would include ecological and other effects on major reservoirs such as Lake Diefenbaker as well as the cumulative effects on both land and water from practices as manure spreading or spoil piling. The effects of a single project may be adequately covered as part of environmental assessment.

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