WATER QUANTITY IN THE SOUTH SASKATCHEWAN RIVER SUB-BASIN

SEAWA Watershed Report 2010-9

SEAWA Web-based State of the Watershed Report

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Introduction

This report reviews water quantity in the South Saskatchewan River Sub-Basin. Included are sections on the general hydrology, water supply, and water use in the South Saskatchewan River Sub-Basin, as well as an examination of flood and drought management. These areas are examined in an effort to determine the state of the South Saskatchewan River Sub-Basin.

Summary

The South Saskatchewan River is the only major river in the South Saskatchewan River Sub-Basin. Originating at the confluence of the Oldman and Bow Rivers, the South Saskatchewan River flows east across Alberta and Saskatchewan, eventually draining into Hudson's Bay. The South Saskatchewan River Sub-Basin encompasses a portion of the South Saskatchewan River that runs between its origin and a region of Saskatchewan east of the Alberta-Saskatchewan border.

Several small tributaries drain runoff in the region to a number of reservoirs, lakes, and the main stem of the South Saskatchewan River. Three major creek watersheds drain through the City of Medicine Hat, including Ross Creek, Bullshead Creek, and Seven Persons Creek, and feed into the river. The majority of tributaries in the region drain the Cypress Hills area.

Naturally occurring lakes in the region are rare and can turn into dry, alkali flats in times of drought. The development of irrigation throughout Alberta led to the construction of several reservoirs in the region, many of which are linked to the St. Mary River Irrigation District irrigation network. District irrigation and private irrigation are used to supply water for agriculture and other uses.

The South Saskatchewan River Sub-Basin has the smallest ratio of effective to gross drainage area, annual precipitation, and median natural flow contribution of the four Sub-Basins that make up the South Saskatchewan River Basin. The South Saskatchewan River follows a natural flow regime with high flows during runoff events, rising to a peak in June due to mountain snowmelt, and subsequent low flows in winter. The mean annual natural flow of the South Saskatchewan River at Medicine Hat is 7,002,000 dam^3, but this value can vary considerably.

Annual runoff from the tributaries in the region is highly variable and unreliable. Flows in the tributaries draining Cypress Hills are small, usually less than 3 m^3/s. Flows are usually greatest in March and April as spring temperatures clear the prairies of snow. In dry years, streams can have little or no flow.

The St. Mary River Irrigation District supplies approximately 166,000 acres of land in the South Saskatchewan River Sub-Basin with water from the Oldman River Sub-basin. The Town of Bow Island uses water from the St. Mary River Irrigation District for domestic purposes. Part of the main canal of the District runs through the South Saskatchewan River Sub-Basin and ends near Medicine Hat with a capacity to run 10 m^3/s of water.

Reservoirs located throughout the region store water for a variety of purposes. The largest reservoirs are a part of the St. Mary River Irrigation District and have capacities in the tens of thousands of dam^3. Reservoirs that are not a part of the District have a considerably smaller capacity: Elkwater Lake and Bullshead Reservoir have capacities exceeding 1,000 dam^3, while the rest have capacities under 1,000 dam^3. Reservoirs have allowed the development of irrigation despite dry conditions, however extended periods of drought can drain reservoir levels.

Alberta Environment adopted the current Water Management Plan in August 2006. The plan reflects a balance between protecting the aquatic environment and water allocation of rivers in the South Saskatchewan River Basin. Under the plan, the South Saskatchewan River Sub-basin is effectively closed to new allocations of water in an effort to limit risk to water users and the aquatic environment. Water allocations can be obtained through existing water allocation transfers.

Alberta's Water Act is a legislative tool facilitating the conservation and management of water in Alberta. The Water Act regulates the diversion of water from surface and groundwater sources through a variety of methods including water allocations. Allocations are based on a First in Time, First in Right (FITFIR) system. Senior (older) water license holders are entitled to their allocation of water before more junior (newer) water license holders, regardless of purpose.

Instream Flow Needs (IFN) is the amount of water, flow rate, water level, or water quality that is required in a river or other body of water to sustain a healthy aquatic environment. The determination and implementation of this value in Alberta has come under consideration in the management of water. Instream Flow Needs gives water management planers a target to reach to help maintain the health and diversity of aquatic environments.

In 2005, existing allocations allowed a maximum of 281,971 dam^3 of water to be withdrawn for use in the SSRSB. These licenses assumed 205,316 dam^3 would be used and included a return flow allowance of 76,655 dam^3. The majority of allocations were for municipal purposes (60%), with agriculture accounting for 27%, 7% for industry, and less than 3% for each of the other major water use sectors: Commercial, Petroleum, and other. In terms of actual use, it is estimated that 66,112 dam^3 of water were used in 2005, 32% of the water use allowed in existing licenses and registrations. The agricultural sector accounted for 41% of total water use, while industrial use accounted for 27%.

The governments of Alberta, Saskatchewan, Manitoba, and Canada adopted the Master Agreement on Apportionment in 1969, which provided a formula for the sharing of waters of eastward flowing interprovincial streams. Under the agreement, Alberta must ensure a portion of water in rivers and streams flowing into Saskatchewan exceeds a minimum amount. Since the Master Agreement on Apportionment came into effect in 1969, Alberta has exceeded the minimum flow required under the agreement every year.

Alberta Environment administrates flood and drought management in Alberta. An advisory and warning system is currently in place, and is meant to alert residents who may be affected by flooding. Heavy flooding of tributaries in the South Saskatchewan River Sub-Basin outlined the importance of flood management practices. In 2010, Alberta Environment developed the Agriculture Drought Risk Management Plan (ADRMP) as a risk management approach to droughts in Alberta. The 2001-2002 drought in Canada showed the importance of effective management of water resources in the event of an extended drought.

Discussion

1. General Hydrologic Characteristics of the South Saskatchewan River Sub Basin

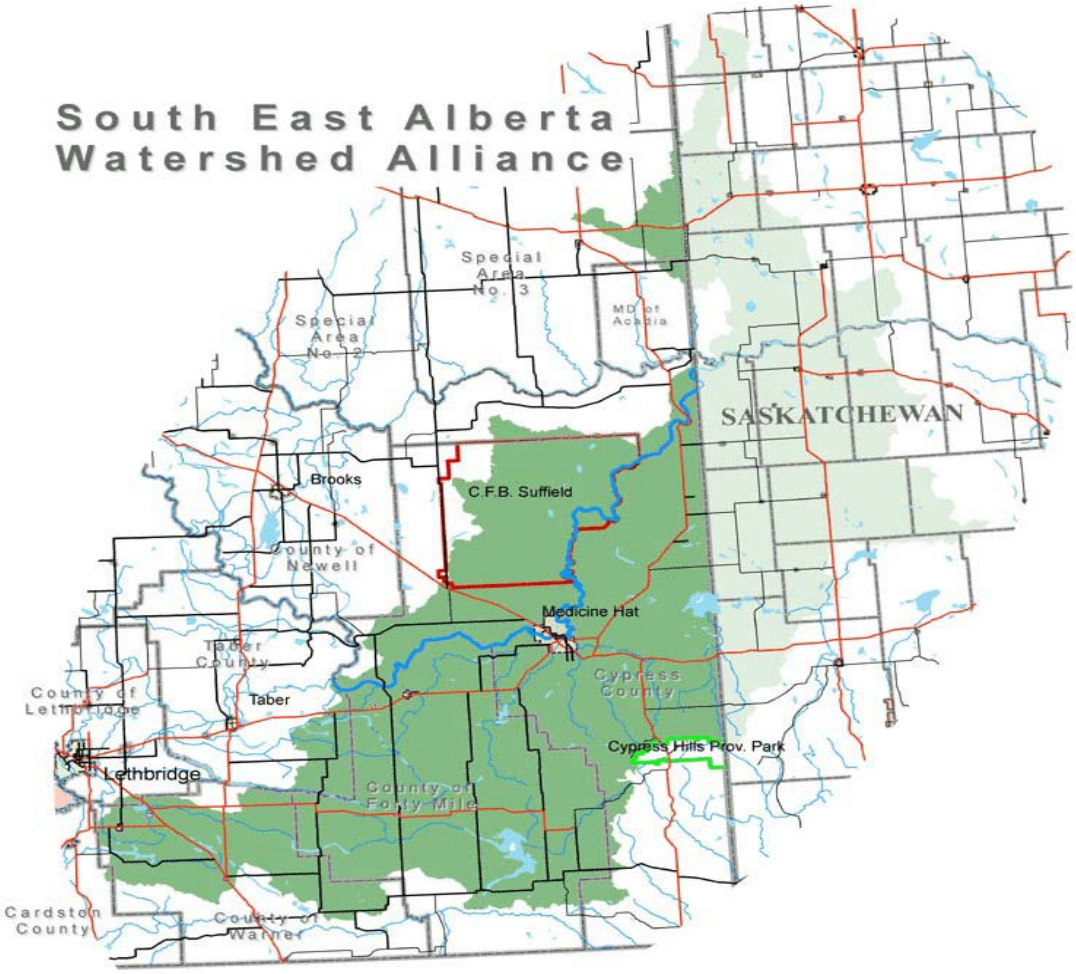
    a. South Saskatchewan River

    The South Saskatchewan River (SSR) is the primary source of water for residents of the South Saskatchewan River Sub-Basin (SSRSB). It has three major tributaries. The Bow River, which originates on the Bow Glacier north of Lake Louise, and the Oldman River, which originates in the mountains west of Pincher Creek, join together to form the South Saskatchewan River. The Red Deer River originates east of Lake Louise ski area in Banff National Park and joins the South Saskatchewan River east of the Alberta-Saskatchewan border. The river is dammed approximately 100 kilometers south of Saskatoon, creating Lake Diefenbaker. Past Lake Diefenbaker, the river flows through Saskatoon, and eventually junctions with the North Saskatchewan River before draining into Lake Winnipeg and eventually Hudson's Bay via the Nelson River. [35 37]

    The SSRSB encompasses the stretch of the South Saskatchewan River that runs between the confluence of the Bow and Oldman rivers, the confluence of the South Saskatchewan and Red Deer rivers, and a region of Saskatchewan east of the Alberta-Saskatchewan border. The region is composed almost entirely of prairie grasslands, with the river flowing through a wide, deep valley. Within the aforementioned stretch, the river drops from an elevation of 740 metres to around 600 metres. [8 43]

Water from the river is used for different human activities. The largest users of water include municipalities and agriculture practices such as irrigation. Other human activities that use water from the basin include commercial activities like golfing and parks and recreation, industry, oil and gas production, and habitat enhancement projects. [7] [8] In 1969 the governments of Alberta, Saskatchewan, Manitoba and Canada entered into a Master Agreement on Apportionment, for the sharing of eastward flowing interprovincial streams. The South Saskatchewan River is a major focus of the agreement between the governments of Alberta and Saskatchewan. [20]

Figure 1.1: South Saskatchewan River Sub-Basin [44]

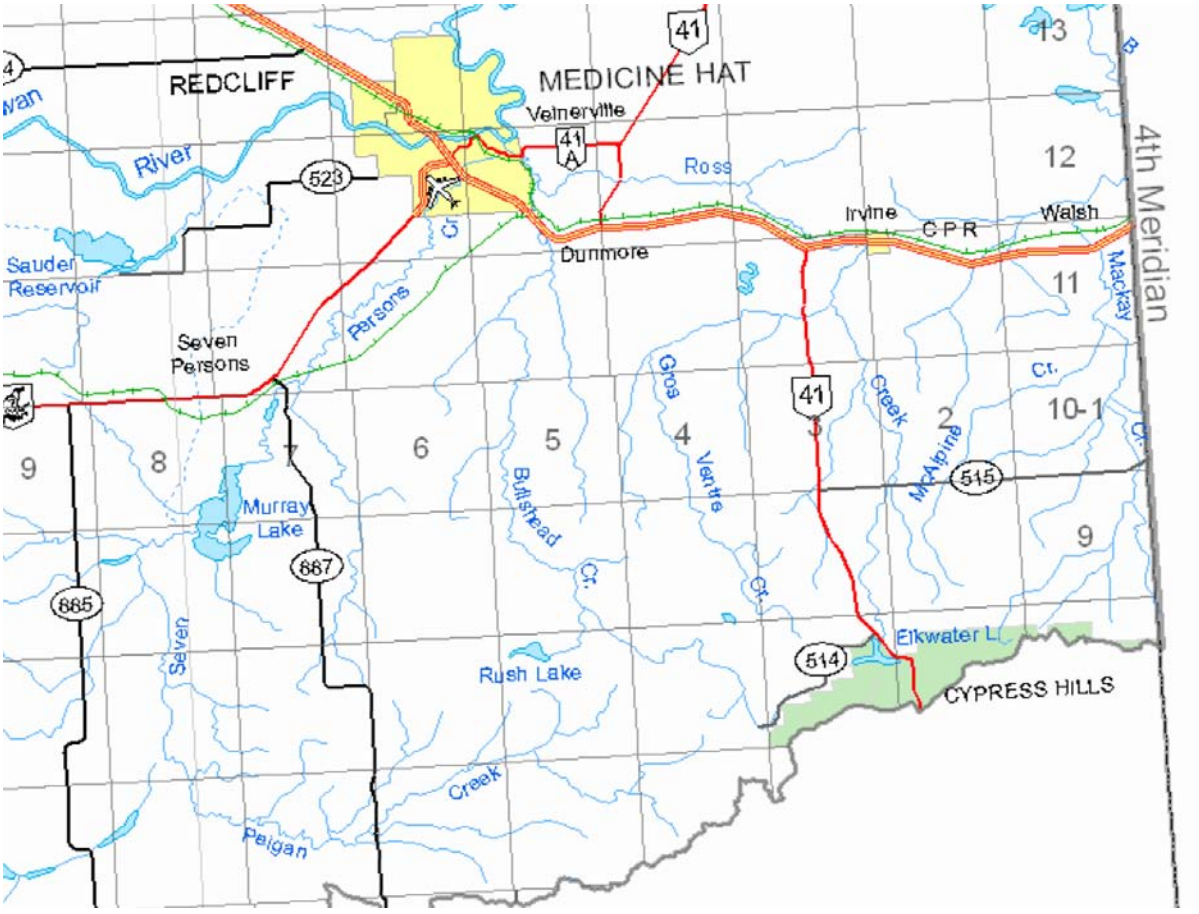


See Figure 1.2 in the appendix for a map of the river basins in Southern Alberta.

b. Tributaries in the South Saskatchewan River Sub-Basin

Several small tributaries drain runoff in the region to a number of reservoirs, lakes, and the main stem of the South Saskatchewan River. Runoff from the Cypress Hills area, located in the southeastern corner of the basin, flows toward either the South Saskatchewan River, Many Island Lake, or Pakowki Lake. [39] Three major creek watersheds drain through the City of Medicine Hat into the South Saskatchewan River; Ross Creek, Bullshead Creek, and Seven Persons Creek. [36]

Figure 1.3: Tributaries in the South Saskatchewan River Basin [30]



i. Ross Creek serves as the outlet to Elkwater Lake, flowing north toward Irvine, then west into Medicine Hat. Gros Ventre Creek joins into Ross Creek before Irvine, while Bullshead Creek joins into Ross Creek near Medicine Hat. Within Medicine Hat, Ross Creek and Seven Persons Creek

junction before flowing into the South Saskatchewan River, less than one kilometer downstream. Licenses allow the withdrawal of water from the creek for agricultural, municipal and irrigation purposes. [30] Alberta Environment identified the Ross Creek valley as a Nationally Significant Area in an effort to protect biological diversity throughout the province. [14] [36]

ii. Gros Ventre Creek originates in Cypress Hills west of Elkwater Lake. The creek flows north and joins with Ross Creek before running into Irvine. In 1950, a joint operation between the federal and provincial governments saw the construction of the Cavan Lake headworks system. A canal 6.4 kilometers in length conveys water from Gros Ventre Creek into Cavan Lake for use in the Ross Creek Irrigation District. [16] [32] Water from the creek is used for agricultural and irrigation purposes. [30]

iii. Bullshead Creek originates in Cypress Hills west of Elkwater Lake. The creek drains runoff from Cypress Hills in a north-northwest direction and joins with a small tributary from Rush Lake before flowing toward Medicine Hat. Bullshead Reservoir is located on the creek close to Cypress Hills. Water from the creek is used for agricultural activities and irrigation. [30]

iv. Seven Persons Creek originates south of Murray Lake. After draining into Murray Lake, the creek continues northeast into Medicine Hat, where it joins with Ross Creek before draining into the South Saskatchewan River. The creek is used for agricultural practices and irrigation. Seven Persons Creek flows have been regulated since 1955. [21] [30]

v. Peigan Creek drains a region of Cypress Hills near Buffalo Lake, 20km west of Elkwater Lake. The creek runs west before flowing into Seven Persons Creek. Similarly to other creeks in the basin, it is used for agricultural activities and irrigation. The Alberta Fish and Game Association has denoted a 640-acre section of the coulee drained by Peigan Creek a conservation area to protect riparian habitat. [5] [30]

vi. McAlpine Creek and Mackay Creek drain an area of Cypress Hills east of Elkwater Lake north toward Many Island Lake. McAlpine Creek flows into Mackay Creek south of Walsh. After running beside Walsh, Mackay Creek flows northeast before joining into Boxelder Creek east of the Alberta-Saskatchewan border. [30]

vii. Boxelder Creek drains a region of Cypress Hills east of MacKay Creek north toward Many Island Lake. Much of the creek is in Saskatchewan. After joining with Mackay Creek, Boxelder Creek continues into Many Island Lake, a terminal lake. [30] [43] As an interprovincial stream, Boxelder creek is subject to the Master Agreement on Apportionment

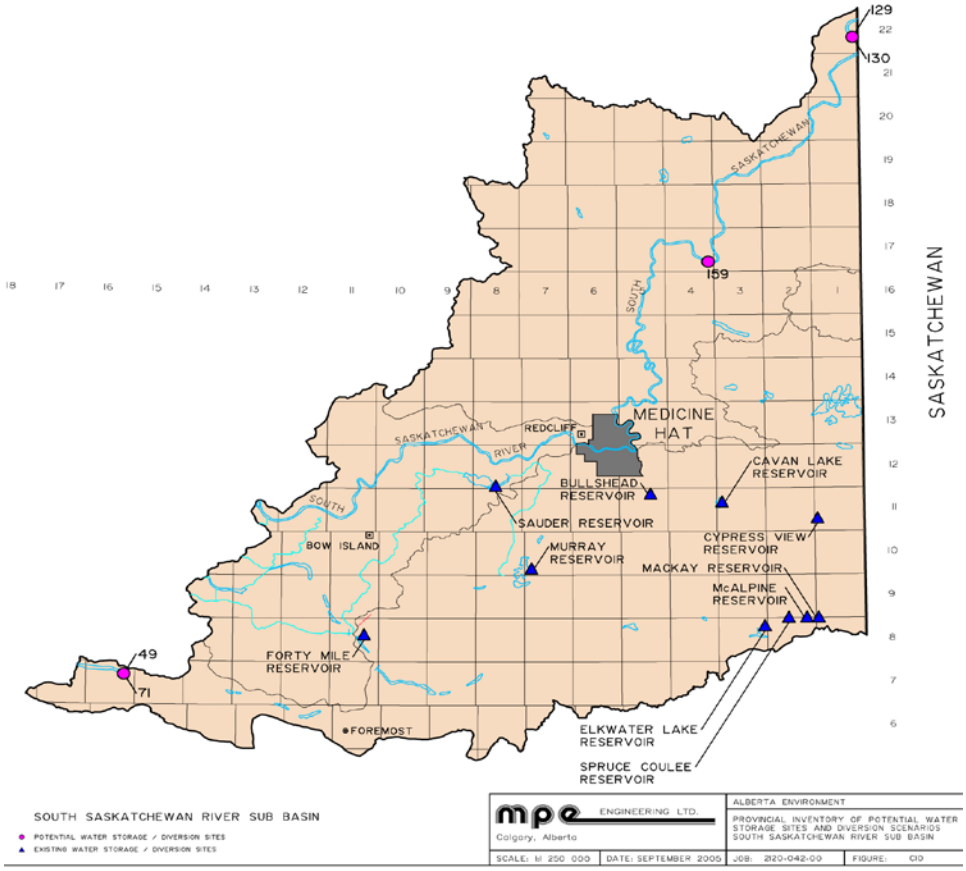
(Government of Alberta, 1969). However, since Alberta's consumptive water use of Boxelder Creek is insignificant compared to the natural flow of water into Saskatchewan, the creek is not subjected to apportionment monitoring. [20]

c. Lakes and Reservoirs

Southern Alberta, with a relatively hot and dry climate, has few natural lakes. In years of drought, these lakes, like Many Island Lake or Pakowki Lake, can turn to dry, alkali flats.

The development of irrigation in the area in the early 1900's saw the construction of several reservoirs throughout the region. Reservoirs allow the storage of excess water for use in times of low precipitation or drought. This allowed the development of irrigation despite a lack of naturally occurring water storage sites. While aiding the operation of agriculture, the reservoirs in the region have also provided residents with opportunities for recreation, and have created new habitat for wildlife. [37]

Figure 1.4: Reservoirs in the South Saskatchewan River Sub-Basin [23]



*Milk River Ridge Reservoir, Granlea Reservoir, and Ambrose Reservoir are not included. There may be more water storage sites in the area not highlighted in the map.

Large coulees present in the region provide an efficient means of storing water. Erosive action caused by lake drainage during the Laurentide glaciation formed many of these coulees. The small, modern day streams that flow through these large coulees are often referred to as "under fit streams" by geomorphologists. Reservoirs can be created in these coulees by using upstream and downstream dams, effectively trapping water within the deep valleys. This method of water storage often carries a smaller environmental impact than storage developments on larger streams due to less extensive aquatic and riparian eco-systems present on these "under fit streams". Coulees formed by glaciation in the SSRSB include Etzikom Coulee, Forty Mile Coulee, Pakowki or Pendand d'Orielle Coulee, Seven Persons Coulee, and Middle Coulee. Of these coulees, Middle Coulee, Forty Mile Coulee, and Seven Persons Coulee have been dammed to form Milk River Ridge Reservoir, Forty Mile Reservoir, and Murray Reservoir respectively. [8] [37]

i. Fort Mile Reservoir was commissioned in 1988, and was constructed by damming Forty Mile Coulee. The reservoir holds water for use in the St. Mary River Irrigation District (SMRID), and is fed with excess water from the main SMRID canal. Located north of Foremost, Forty Mile Reservoir is a long, narrow reservoir with a length of 10.1km. The maximum depth is 25m, and the reservoir's capacity is 86,440 dam^3. [28] It is used during dry years to supply enough water to the area north and east of the reservoir without rationing. [4] [37]

ii. Elkwater Lake is a recreational lake located in the northwest corner of Cypress Hills Provincial Park, 65 km southeast of Medicine Hat. Historically, the area was used by Plains Indians for hunting and fishing, and was a regular drinking spot for ungulates from the Cypress Hills area. White settlers reached the lake in 1883 and constructed a lumber mill on the north shore, floating logs across the water. Logging ceased in 1912 when most of the lumber had been removed. Cypress Hills Provincial Park was originally established as Elkwater Resort in 1929, and after ownership was transferred to the province in 1945, the area was designated a provincial park in 1951. [37]

The watershed of Elkwater Lake resides mostly in Cypress Hills Provincial Park. The Cypress Hills are a plateau 145 km long and between 25 km and 40 km wide, rising 760 m above the surrounding plains. The hills are the highest point of land in Canada between Labrador and the Rocky Mountains. Elkwater Lake formed in a depression at the base of the hills. The lake has a target elevation of 1226.36 m, and since 1978 the maximum range in changing water levels

is 0.98 m. The main inflows are diffuse runoff from the surrounding area and numerous underground springs. Ross Creek flows from the northern bay toward Medicine Hat. [37]

Outflow from the lake has been controlled since 1908. Alberta Environment replaced the older head gate system with a drop inlet spillway, with a maximum discharge rate of 4.79 m^3/second. Outflow is controlled to meet the needs of the fisheries resource and water users both downstream and on the lake. [37]

More information on Elkwater Lake can be found in the Atlas of Alberta Lakes.

iii. Milk River Ridge Reservoir is an off-stream reservoir located in the southwest corner of the SSRSB, in the Pakowki Lake sub-basin. The Prairie Farm Rehabilitation Administration constructed it in 1956 for use as an off-stream storage and balancing reservoir in the SMRID. Alberta Environment assumed ownership in 1974 and now operates the reservoir in cooperation with the SMRID. Most of the outflow flows north and east to supply water for irrigation and municipal and domestic use as far east as Medicine Hat, while a small portion of outflow supplies water to an area east of the reservoir. [37]

Aside from natural drainage, inflow to Milk River Ridge Reservoir enters via a canal on the west end of the reservoir. The water in this canal is diverted from the St. Mary, Belly, and Waterton rivers to St. Mary Reservoir before passing through Jensen Reservoir on the way to Milk River Ridge Reservoir. The reservoir is 17.7 km long, with a maximum width of 1.6 km. There are two basins: the west has a maximum depth of 16.5 m, and the east has a maximum depth of 14.0 m. The mean depth is 8.4 m. The reservoir has a capacity of 125,000 dam^3, making it the third largest of 12 major reservoirs used by the SMRID, behind St. Mary and Chin reservoirs. [37]

More information on Milk River Ridge Reservoir can be found in the Atlas of Alberta Lakes.

iv. Tyrrell Lake is located in the southwest corner of the SSRSB, east of Milk River Ridge Reservoir. It is an elongate saline lake lying in a shallow coulee on flat plains. Historically, the water level has fluctuated considerably. In the 1930s, the lake became a dry mud flat. The 1950s saw the construction of a canal from Milk River Ridge Reservoir to stabilize levels, but drainage near the lake proved inadequate in wet years, leading to flooded farmland. Prolonged droughts caused the water level to drop, jeopardizing valuable waterfowl habitat present in the marshes near the lake. In 1985, Tyrrell Lake became the first *Wetlands*

for Tomorrow project in Alberta. Canals and structures were built to allow the water level in the lake and surrounding marshlands to be stabilized. [37]

Tyrrell Lake has a large natural drainage basin of 122 km^2, mostly west and south of the lake. Water enters the lake through runoff; either from precipitation or irrigation return flows. Additionally, water released from Milk River Ridge Reservoir flows through Middle Coulee and is diverted into the south end of Tyrrell Lake. The lake is 5 km long, has a maximum width of 1.2 km, and a mean depth of 3.8 m. Water flows from the lake into a wetland, then north to Etzikom Coulee and east to Pakowki Lake. [37]

More information on Tyrrell Lake can be found in the Atlas of Alberta Lakes.

v. Bullshead Reservoir is located south of Medicine Hat. The reservoir is filled primarily by the small tributaries that drain the Cypress Hills, and it has a capacity of 1,846 dam^3. Water released from the reservoir connects into Bullshead Creek. A pipeline located at the outlet of the reservoir, installed in 2002, feeds the Bullshead Water Coop, licensed for non-potable water for domestic use. Prior to the pipeline's construction, in the fall of every year, Alberta Environment released around 400-450 acre-feet of water to service 15-20 farms for stock-water purposes. With the instillation of the pipeline, around 200 acre-feet of water are released every fall to service 50 farms. The pipeline has eliminated evaporative and seepage losses by eliminating the exposure of water to permeable creek beds and open air, thereby boosting efficiency. This water is used for domestic purposes. There are downstream licensed water users who use Bullshead Creek for private irrigation, but these licenses are dependant on natural flows; water is not released from Bullshead Reservoir for irrigation. [24]

vi. Sauder Reservoir, also known as Rattlesnake Lake, is located 24 km west of Medicine Hat. It is a part of the SMRID irrigation network; as such it is filled with water from the Oldman River Basin, not the SSRSB. It has a capacity of 37,780 dam^3. [28] Water released from Sauder Reservoir flows in the SMRID main canal, travelling south to Murray Lake. [1] The Alberta Fish and Game Association leases approximately 4 km of the reservoir shoreline to maintain waterfowl habitat. [6]

vii. Murray Lake Reservoir is the last large reservoir in the SMRID network. It receives inflow from the SMRID main canal out of Sauder Reservoir, and has a capacity of 30,615 dam^3. [28] The outlet of Murray Lake, Seven Persons Creek, flows north and joins with Ross Creek before flowing into the South Saskatchewan River in Medicine Hat.

viii. Pakowki Lake is a large intermittent lake located 25 km east southeast of Foremost. The lake receives inflow from Tyrrell Lake through Etzikom Coulee, and has no outflow. Under extremely high water levels, Pakowki Lake will drain into the Milk River Basin. [33] Years of drought can lead to low water levels in the lake, turning the area into a dry, alkali flat. The lake is significant for congregations of waterfowl and shorebirds. On July 4, 1996, over 61,135 waterfowl were counted, while a count on September 15th of the same year gave 29,000 waterfowl. [33] Pakowki Lake is designated an Important Bird Area by Bird Studies Canada and Nature Canada. More information on Pakowki Lake and the species of birds that frequent the area can be found on the Important Bird Areas website.

ix. Many Island Lake, like Pakowki Lake, is a shallow, intermittent lake. Located northeast of Medicine Hat, it receives inflow from Boxelder Creek out of Cypress Hills, and has no outflow. In times of drought, the lake may turn into a dry, alkali flat. [37]

x. Chappice Lake is a permanent saline lake 20 km northeast of Medicine Hat and 15 km southeast of the South Saskatchewan River. The lake is shallow at less than 1 m of depth, with a surface area of 2.1 km^2. The major source of water recharge is from shallow groundwater flows. There are no surface outflows, but analysis of groundwater below the lake indicated there is groundwater outflow. Important Bird Areas Canada (IBA Canada) has identified Chappice Lake as a critical staging area for migrating shorebirds as well as a nesting area for piping plover. Chappice Lake was designated as an Important Bird Area in 1998. [12]

    More information on the lake can be found in the IBAs conservation plan for Chappice Lake.

Along with the larger reservoirs and lakes discussed above, there are other water storage sites spread throughout the SSRSB. Typically developed and operated by the Government of Alberta, these works are meant to secure water supplies for irrigation, support the overall economy, and provide recreation for residents of the watershed. Five of these projects, including Elkwater Lake and Bullshead Reservoir, are highlighted in Table 1.1.

Table 1.1: Provincial Water Management Projects within the SSRSB [8]

Projects	Works	Licensed Purpose	Priority Date
Granlea Reservoir	Dam	Domestic, stock water.	1960/03/21
Ambrose Reservoir	Dam	Stock water.	1970/09/28
Cavan Lake Headworks	Weir, canal, damn, dykes	Irrigation, domestic, recreation.	1951/03/02
Elkwater Lake Reservoir	Dam	Stabilization.	1918/12/06
Bullshead Reservoir	Dam	Stock water, domestic.	1961/07/19

d. Irrigation Networks

In the early settlement of Southern Alberta, farmers were drawn to the easily cultivated soils of the prairie and the long, warm growing season. The limiting factor to the success of farming in the region was water. The lack of natural lakes, low precipitation, and low flow in creeks and rivers would not support large-scale farming in the region. The obvious solution was irrigation, allowing the use of water when and where it was available, and storing it for later use. Irrigation in Alberta started in the late 1800s with small privately owned projects. By 1920, private companies, including the Canadian Pacific Railway, had built extensive canal and reservoir systems such as Chestermere Lake and Little Bow Lake Reservoir. These projects provided around 178,000 acres of land near Calgary irrigation. Development of the irrigation network in Southern Alberta continued through the twentieth century, and by 1990, the South Saskatchewan River Basin contained 8 on stream reservoirs, 17 large off stream reservoirs, 22 smaller reservoirs, and 8,000 km of major or local canals. [37]

There are 13 irrigation districts that supply 90% of irrigated land in Alberta. In 2009, these districts irrigated 1,254,916 acres of land. Of the 13 districts, Ross Creek Irrigation District (RCID) and the St. Mary River Irrigation District (SMRID) irrigate land in the SSRSB. [3] [37] Figure 1.5 in the appendix contains a map of Alberta's 13 irrigation districts.

i. Much of the water used for district irrigation in the SSRSB comes from the Oldman River Basin, through the SMRID. Around 35% of the water taken from the Oldman River Basin is used to irrigate land in the SSRSB. [37] The SMRID had its beginnings at the turn of the 19th century as a diversion of water from the St. Mary River for the purpose of irrigation. Though private and government efforts, the St. Mary Project, as it was initially known, developed throughout the 20th century. In 2010, the SMRID was Canada's largest irrigation district, delivering water

through 2060 km of canals and pipelines to 372,000 acres of land. The SMRID Main Canal has a length of 283 km and runs from the start of the system through to Medicine Hat. [46] Reservoirs used by the SMRID that lie in the SSRSB include Milk River Ridge Reservoir, Forty Mile Reservoir, Sauder Reservoir, and Murray Lake Reservoir. Approximately 166,000 acres of land are irrigated in the South Saskatchewan River Sub Basin by the SMRID. [11]

More information on the history and operation of the SMRID can be found on the SMRID website.

ii. The Ross Creek Irrigation District (RCID) is a small operation based out of Cavan Lake, east of Medicine Hat. The district operates 26 km of conveyance works and in 2009 irrigated 800 acres of land. [46]

iii. Private irrigation is a common practice in the SSRSB. Rather than relying on irrigation districts for water, private irrigators use individual projects like flood or pivot irrigation to water land. These projects are licensed to an individual, a group of producers, or to private or public lands (i.e. golf courses or parks). Alberta Agriculture and Rural Development reviews the feasibility of the projects, and Alberta Environment regulates licensing. In 2009, there were 638 private water licenses for the irrigation of 47,646 acres of land in the SSRSB. [3]

2. Water Supply

Hydrologic terms used in this section are defined as follows (AMEC 2009):

- *Natural flow* (or discharge) is flow that is not noticeably affected by direct human activities such as reservoir operation, water withdrawals, diversions or releases. The flow may, however, be indirectly affected by human activities such as land-use changes.
- *Regulated flow* is flow that is noticeably affected by human activities.
- *Historic flow or recorded flow* is the discharge recorded at a hydrometric station. It may include a combination of regulated and natural flows.
- *Naturalized flow* is an estimate of natural flow at a site, calculated by adjusting historical flow to remove the effects of regulation.
- *Annual flow volume* is the total volume of flow for an entire year.
- *Summer flow volume* is of interest for irrigation as irrigation water demands occur primarily in summer. The summer period is defined as 1 May- 31 October
- *Summer low flow* is of interest for in stream flow needs and irrigators dependent on water supply directly from a water source with no upstream reservoir. It is the lowest 7-day mean discharge during the May-October period.

- *Winter low flow* is generally lower than summer low flow, and is of interest for in stream flow needs and year round water demands such as municipal, domestic, and industrial needs. It is the lowest 7-day mean discharge during the November-March period.

a. Hydrologic and Meteorological Characteristics

Elevations, topography, and landscape features influence the hydrologic and meteorological characteristics of a river basin. The South Saskatchewan River Basin is made up of four distinct sub-basins: the Oldman, Bow, Red Deer, and South Saskatchewan River. Table 2.1 in the appendix compares the hydrologic characteristics of the four sub-basins.

i. The South Saskatchewan River Sub Basin has a gross drainage area of 13,200 km^2. It has an effective drainage area of 6,600 km^2, 50% of the gross drainage area. The ratio of effective to gross drainage area is the smallest of the four sub-basins.

ii. Average annual precipitation in the SSRSB, at 278 mm, is the lowest of the four sub-basins.

iii. The median natural flow contribution from the SSRSB, at 3,662 dam^3, is by far the lowest of the four sub-basins. There are years where the estimated local inflow is a large negative value: the 10^{th} percentile local inflow is negative 122,400 dam^3. It is not unusual for the runoff contribution from a small sub-basin to be negative, but the magnitude of the negative flow has confounded hydrologists since the 1960s. Possible reasons for the negative flows include gauging errors, evaporation and seepage losses, channel and bank storage, return flow estimates, and gap filling for mission records, but the large and frequent negative flows remain unexplained. Alberta Environment's Hydrologic Modelling Committee concluded in 1978 that awareness of the anomaly is important and should be considered when modelling the basin. [8]

b. South Saskatchewan River

The South Saskatchewan River follows a natural flow regime with high flows during runoff events, rising to a June peak from mountain snowmelt, and low flows during winter. Flow in the river is essentially the sum of the flows in the Oldman River and Bow River. Flows will change from year to year partially due to differences in precipitation. [19] [43] The South Saskatchewan River is affected by development in the Bow and Oldman sub-basins, causing the regulation of roughly 50% of the flow within it. [8]

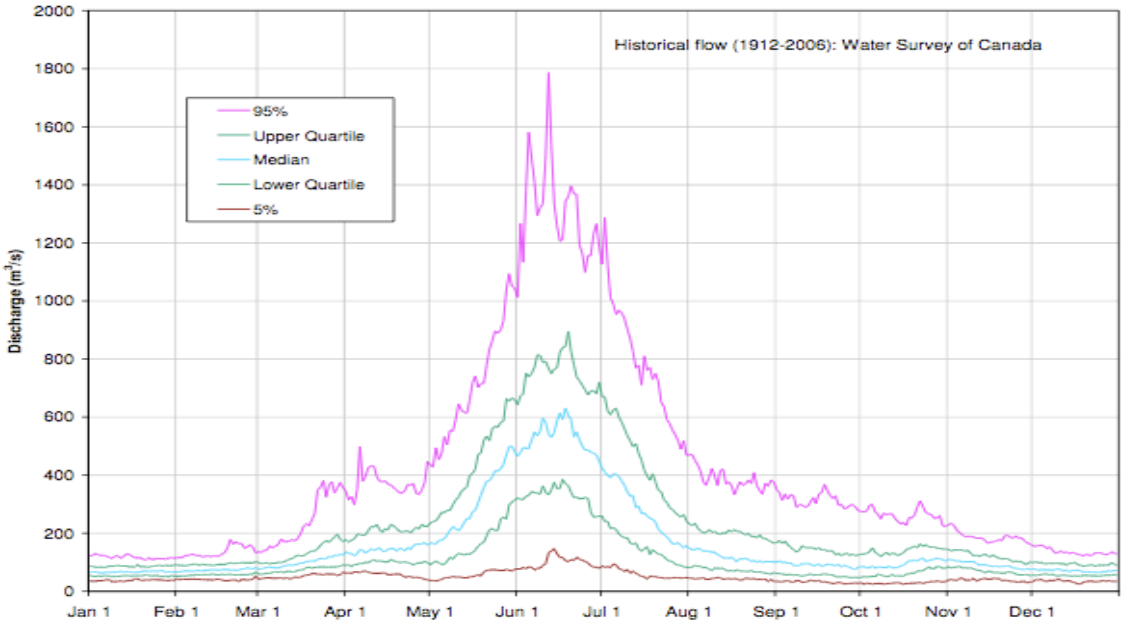
Table 2.2 in the appendix shows stream flow characteristics for the South Saskatchewan River at Medicine Hat between 1972 and 2001. Figure 2.1 in the

appendix shows annual historical and naturalized flow volumes for the South Saskatchewan River between 1912 and 2005.

The mean annual natural flow of the South Saskatchewan River at Medicine Hat is 7,002,000 dam^3. The mean recorded flow is substantially less, at 4,803,000 dam^3. Recorded flows are affected by the cumulative impacts of all projects in the Bow and Oldman River Basins, leading to the difference. On average, 80% of the annual natural flow and 68% of the annual recorded flow occurs during the summer months (Table 2.2). The lowest recorded volume, 1.7 million dam^3, occurred in 2001. The naturalized mean annual summer low flow was 99.9 m^3/s. Flow regulation and diversions reduced the mean and minimum 7-day summer low flows by 50% compared to the natural condition. The natural mean annual winter low flow was 23.2 m^3/s. Recorded 7-day winter low flows have increased considerably from naturalized flows, thanks in part to the influence of hydropower regulations in the upper Bow River Sub-basin. [8]

Figure 2.2 below shows a hydrograph of the South Saskatchewan River at Medicine Hat, using data from 1912 to 2006. The seasonal distribution of flow at Medicine Hat can be inferred from the hydrograph: typically, the river rises slightly in late-March and early-April due to snowmelt runoff on the plains, but the highest flows occur in June, with comparatively low flows from August through April.

Figure 2.2: Hydrograph of the South Saskatchewan River at Medicine Hat [8]



* Statistics correspond to data recorded from 1912 to 2006.

The Water Survey of Canada Real-time Hydrometric Database contains information on water level and stream flow an over 1700 locations in Canada, including the South Saskatchewan River at Medicine Hat. The database contains archived historical data and provides statistical analysis for flow rates on hundreds of Canadian rivers and streams. Alberta Environment also records river flows and levels for Alberta's river basins. The Alberta Environment website can be used to find data on flow rates and water levels for each basin in Alberta.

i. Hydrometric stations allow the measurement of discharge for a particular river or stream. Alberta Environment and the Water Survey of Canada operate many hydrometric stations throughout Alberta, allowing an accurate analysis of water supply in each basin and sub basin.

   A hydrometric station located in Medicine Hat monitors the South Saskatchewan River. The station, number 05AJ001, monitors the discharge of the river, allowing the calculation of the flow volume. As of 2010, it is the only gauge used on the South Saskatchewan River between the confluence of the Bow and Oldman rivers and the junction with the Red Deer River. The site has been used to measure the river since 1911. [13]

   Station number 05AK001, located on the South Saskatchewan River at highway 41, was used to gauge the discharge of the river starting in 1966 until its operation was discontinued in 1993. [13]

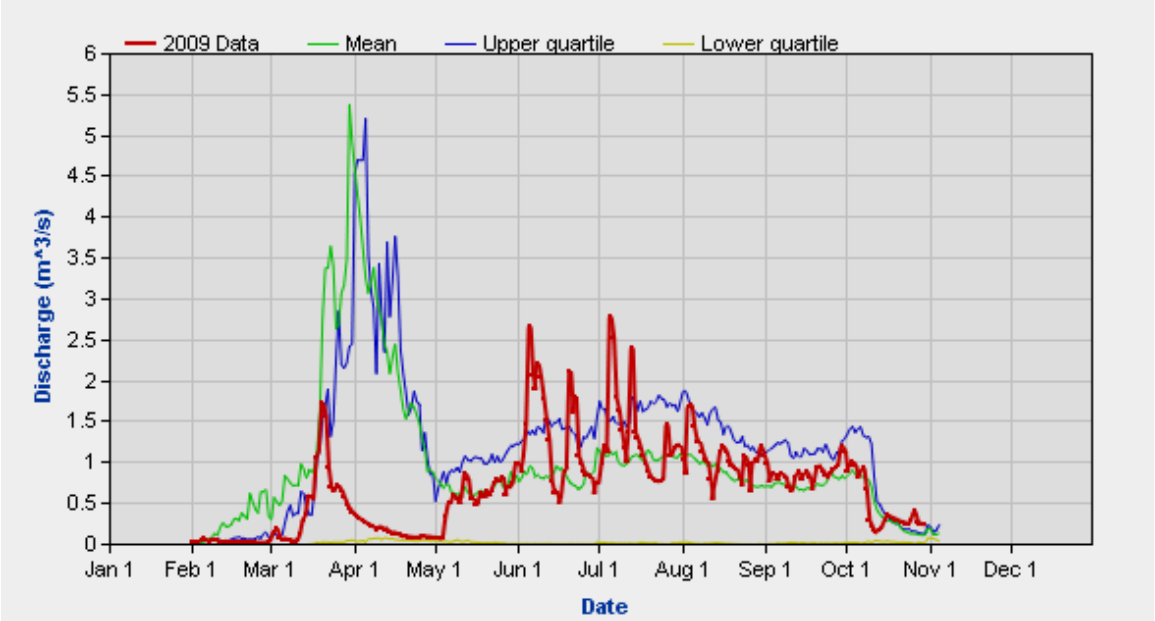
   Gauges on the Bow River, Oldman River, and Red Deer River, in conjunction with the gauge on the South Saskatchewan River at Medicine Hat, have been used to better understand the relationship between rivers of the different sub-basins. Inferences on water supply can be made by combining and comparing data from hydrometric stations. The use of more gauges on the main stem of the South Saskatchewan River in the SSRSB may allow a better understanding of hydrologic characteristics of the sub basin.

c. Tributaries in the South Saskatchewan River Sub-basin

Annual runoff produced by prairie streams tends to be highly variable and unreliable. Spring snowmelt drives plains runoff, with some contribution from spring and summer rains.

Figure 2.3 shows a hydrograph with historical data for Seven Persons Creek at Medicine Hat. Figure 2.4, 2.5 and 2.6 in the appendix show hydrographs for Ross Creek at Highway 41, Gros Ventre Creek near Dunmore, and Peigan Creek near Pakowki road, respectively.

Figure 2.3: Hydrograph of Seven Persons Creek at Medicine Hat (Water Survey Station 05AH005)
[13]



*Statistics correspond to data collected between 1910 and 2009.

Flows in the tributaries draining Cypress Hills are small, usually less than 3 m^3/s. Flows tend to be the greatest in March and April, when the spring melt clears the prairies of snow. Spikes in the hydrographs typically correspond to large amounts of precipitation as a result of storms. In dry years, the tributaries in the basin may have very little or no flow, showcasing the importance for stored water.

i. The Water Survey of Canada keeps information on gauging stations used on tributaries in the SSRSB. Historical data is available for gauging stations whose use has been discontinued, and real time data is available for active stations. Older gauging stations that have since been discontinued once recorded several of the tributaries in the SSRSB, such as Ross Creek, Bullshead Creek, and Seven Persons Creek. Newer hydrometric stations at different locations usually replace discontinued stations. Table 2.3 in the appendix lists the creeks monitored by Environment Canada as well as the station number of each hydrometric gauge as of 2010.

d. Irrigation Districts

The network of irrigation canals and pipelines spread across the SSRSB contribute to the water supply in the basin. Canada's largest irrigation district, the SMRID, supplies water to 2,300 water users in the Oldman and South Saskatchewan River Sub-basins. The district supplies 372,000 acres of land

across Southern Alberta: the Alberta Government capped it at this amount in 1991 following a review of irrigation districts in Alberta. The SMRID transfers water using 2,100 km of canal and pipeline. While irrigating 372,000 acres of land, the district also provides water to 14 separate cities, towns and villages, 10 water co-ops, 15 Hutterite colonies, and a number of industrial and municipal users, and provides recreational and wildlife opportunities on the various reservoirs spread throughout the area. [47]

The main canal of the SMRID is 283 km long, travelling from the start of the system to Medicine Hat. The canal has the capacity to carry 91 m^3/s at its origin. Capacity decreases along the system as deliveries are made to secondary canals, storage reservoirs, and the Raymond and Taber Irrigation Districts. The final stage of the canal, near Medicine Hat, has a capacity of 10 m^3/s. [46]

Approximately 166,000 acres of land in the SSRSB is supplied by water from the SMRID originating in the Oldman River Sub-basin. The Town of Bow Island, located in the SSRSB, uses water from the SMRID for domestic purposes. [7] [11]

e. Reservoirs

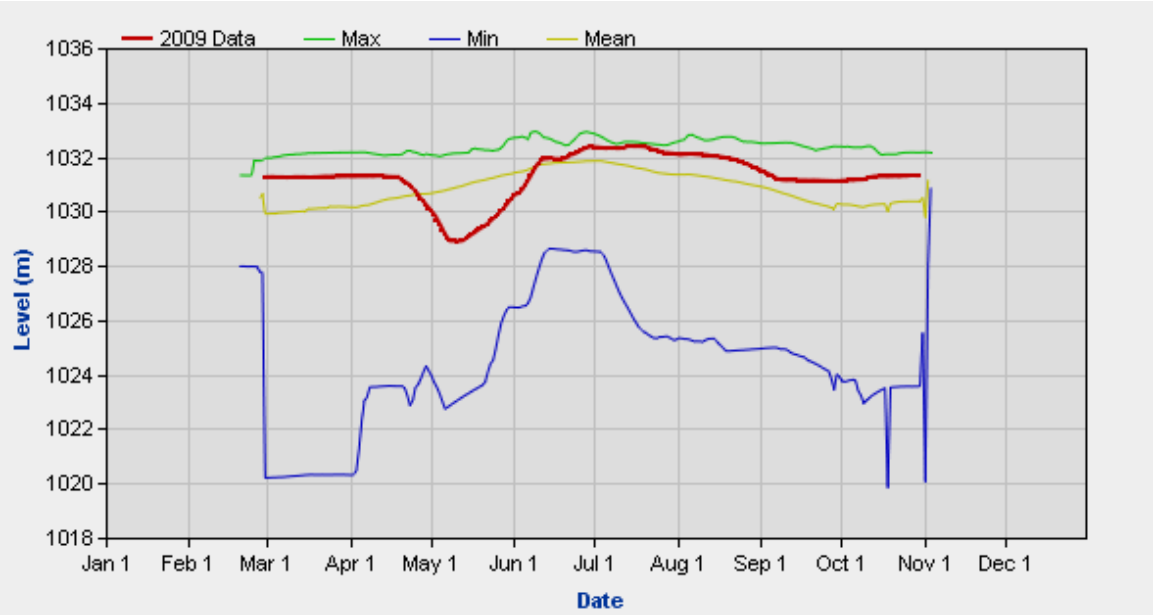
Without the extra water stored in reservoirs, prolonged periods of drought and dry years would seriously hamper agriculture in the region. However, stored water can be used in times of drought to mitigate the lack of natural water resources. As such, reservoirs are vital to the success of agriculture in the SSRSB. While providing water for irrigation, reservoirs can also supply water for municipal and industrial users. There are several reservoirs and lakes in the SSRSB, as described above in Report Section 1.c.

Table 2.4 in the appendix shows the full supply level (FSL) and capacity for reservoirs in the SSRSB monitored by Alberta Environment. The largest reservoirs are a part of the SMRID: Milk River Ridge Reservoir, Forty Mile Reservoir, Sauder Reservoir, and Murray Reservoir, which all have capacities in the tens of thousands of dam^3. Reservoirs that are not a part of the SMRID have a considerably smaller capacity: of these, only Elkwater Lake and Bullshead Reservoir have capacities exceeding 1,000 dam^3, with the rest having capacities under 1,000 dam^3.

A study of the Milk River Ridge Reservoir shows the variable nature of reservoirs in the SSRSB. Between mid-April and mid-October, large volumes of water pass through the reservoir to accommodate SMRID water needs. The mean residence time of water in the reservoir is historically only 41.3 days. Dry years force a higher demand for water, such as in 1988 where the water residence time was only 27 days. From 1977 to 1988, the average volume of water that passed through the reservoir was 688 100 dam^3, much greater than

the reservoir's capacity of 125 000 dam^3. [37] Figure 2.7 shows the water levels of the Milk River Ridge Reservoir between 1976 and 2009.

Figure 2.7: Water Levels for Milk River Ridge Reservoir from 1976 to 2009 (Water Survey Station Number 05AF030)
13



*Statistics correspond to data collected between 1976 and 2009.

Reservoirs tend to be kept at a consistent level despite the operation of irrigation districts and other users of water. Water pumped from an SMRID reservoir is replaced by excess water from earlier in the network. Dry periods and consecutive dry years can stress the system, forcing the use of reservoirs without adequate recharge of water from the irrigation network, leading to noticeably diminished water stores.

Water levels for Cypress Hills area reservoirs in the SSRSB can be found in the Alberta Environment Water Management Operation Reports for the SSRSB. Water levels for the SMRID reservoirs can be found in the Alberta Environment Water Management Operation Reports for the SMRID East Block. Water levels for the Milk River Ridge Reservoir are also available.

3. Water Allocation and Use

Terminology used in this section is defined as follows (AMEC 2009):

- *Water allocation* is the maximum amount of water a licensee is entitled to divert for uses set out in a license under the Water Act. It is an enforceable quantity reflecting the maximum annual amount a licensee intends to divert during the licensing period. It includes consumptive use, losses, and return flows.
- *Water consumption, losses and return flow* are estimates defined in a license. They reflect the intent of the applicant at the time the license application is made. Consumption is the amount of water used for the applicant's project. It is not available for re-use by others. Losses refer to water that is diverted and lost due to evaporation, seepage or other means that are not useful to the applicant. Return flow is water returned to the environment that is available for re-use by others. Typical return flows are treated wastewater from municipalities, irrigation operational surpluses or runoff from irrigated fields, and returns of industrial cooling waters.
- *Licensed Use* is the water use based on information provided in the license. It is equal to consumption plus losses, or allocation minus return flow (both calculations will give the same value). Licensed use is usually larger than actual use because the full allocation is not required in most years. Licensed use, however, can be less than actual use if return flows are less than the estimated licensed amounts, or losses are larger than the licensed amounts.
- *Actual use* is equal to the actual withdrawals minus return flows. It reflects the fact that a licensee may not withdraw the full entitlement, and return flow and losses may differ from the amounts recorded in the license.

a. Alberta Environment Water Management Plan

Alberta Environment adopted the current Water Management Plan in August 2006. The plan reflects a balance between protecting the aquatic environment and water allocation of rivers in the South Saskatchewan River Basin. It is meant to provide guidance to decision makers and act as a foundation for watershed management planning while balancing the needs of the environment and economy through effective water resource management. Recommendations and actions of the plan, some of which are described below, address several issues across all of the sub-basins involved in the South Saskatchewan River Basin. [18]

i. Alberta Environment, as of 2006, no longer accepts applications for new water allocations in the Bow, Oldman, and South Saskatchewan River Sub Basins. As a result of this recommendation, the SSRSB is effectively closed to new allocations in an effort to limit risk to water

users and the aquatic environment. However, water allocations may be obtained through existing water allocation transfers.

ii. Alberta Environment continues to manage the SSRB as a whole to meet the master Agreement on Apportionment requirements, dealing with the sharing of water on interprovincial streams.

iii. Water Conservation Objectives (WCOs) are set for the Bow, Oldman and South Saskatchewan River Sub Basins. WCOs are meant to offset the impact of water diversions by ensuring a minimum flow is achieved on the rivers at all times.

More information on the Water Management Plan can be found on the Alberta Environment website.

b. Water Allocation in Alberta

Alberta's Water Act is a legislative tool facilitating the conservation and management of water in Alberta. The Water Act regulates the diversion of water from surface and groundwater sources through a variety of methods including statutory rights for household purposes, registrations for traditional agricultural users, licenses, and certain diversions that do not require licenses such as firefighting.

Water licenses in Alberta identify the water source, location of the diversion site, volume, rate and timing of water to be diverted, priority of the "water right" established by the license, and any conditions the diversion must adhere to. Licenses can be issued for a temporary diversion up to a maximum of one year, or for longer time periods depending on the project type. Alberta Environment controls the allotment of water licenses through review of applications for new licenses and the renewal of older licenses. Activity in a water body without Alberta Environment approval or the diversion of water without a license is illegal in Alberta, with perpetrators liable to pay a monetary fee. [29]

Allocations are based on a First in Time, First in Right (FITFIR) system. Senior (older) water license holders are entitled to their allocation of water before more junior (newer) water license holders, regardless of purpose. In times of water shortage, newer licenses may be left without adequate water allocation in favour of keeping older licenses fulfilled. The Minister of Environment, under provisions in the Water Act, can address issues with the FITFIR system in an emergency. [31]

The closure of the South Saskatchewan River, Oldman River, and Bow River sub-basins has necessitated the transfer of existing licenses to accommodate new or alternate users. The transfer of licenses has opened a

"water market" in which water rights are bought and sold. This emerging market has become a source of controversy in the region; with supporters claiming the market encourages the efficient use of water and critics claiming the market will not properly account for social and environmental needs. [48]

More information on the Water Act can be found on the Alberta Environment website.

c. Instream Flow Needs

Instream Flow Needs (IFN) is the amount of water, flow rate, water level, or water quality that is required in a river or other body of water to sustain a healthy aquatic environment. Essentially, it is the minimum amount of water required to provide a high level of protection for the aquatic environment over the long term (i.e. over hundreds of years). Studies meant to obtain a value for the IFN of a body of water are usually concerned with four components: fish habitat, riparian vegetation (cottonwood forests), water quality, and channel maintenance. A guiding principal in determining the IFN is the variability in flows from season to season and year to year. In the South Saskatchewan River Basin, only the Red Deer River meets or exceeds the IFN. In the South Saskatchewan River and the SSRSB, there is a substantial gap between existing flows and IFNs. [18]

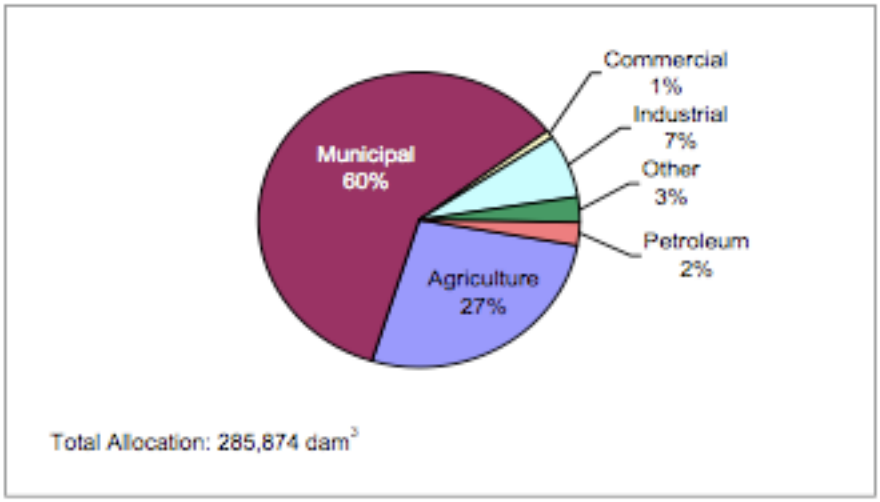
The determination of, and adherence to, IFN of rivers in Alberta has come under consideration in the management of water. As the notion of environmental stewardship develops throughout Alberta, IFN gives water management planers a target to reach to help maintain the health and diversity of aquatic environments.

Alberta Environment carried out an extensive report detailing the Instream Flow Needs for the South Saskatchewan River Basin in 2003. The full report on Instream Flow Needs can be found on Alberta Environment's website.

d. Water Allocations and Actual Use by Sector in the SSRSB

An overview of surface and groundwater water allocations in the SSRSB in 2005 is provided in Figure 3.1. The majority of allocations were for municipal purposes (60%), with agriculture accounting for 27%, 7% for industry, and less than 3% for each of the other major water use sectors: Commercial, Petroleum, and Other. Total allocations of water in the SSRSB in 2005 amounted to 285,874 dam^3.

Figure 3.1: Distribution of Active Water Allocations in the SSRSB, 2005 [7]



In 2005, existing allocations allowed a maximum of 281,971 dam^3 of water to be withdrawn for use in the SSRSB. These licenses assumed 205,316 dam^3 would be used and included a return flow allowance of 76,665 dam^3. 60% of water allocations were for the municipal sector, while municipal users were licensed to use 50% of all the water that can be consumed in the basin. Irrigation was the second most important water user, accounting for 22% of allocations and 28% of licensed consumption (Appendix, Table 3.1).

In terms of actual use, it is estimated that 66,112 dam^3 of water were used in 2005 (AMEC 2007). This is 32% of the water use allowed in existing licenses and registrations. The agricultural sector accounted for 41% of total water use, while industrial use accounted for 27% (Appendix, Table 3.1). Figure 3.2 shows how actual use compares to licensed allocations and use for each of the water use sectors.

Actual use is often unreported to Alberta Environment. Estimations reflecting assumptions on water use give an idea of actual water consumption, but the numbers for actual water use are not exact.

Figure 3.2: Water Allocations and Actual Use in the SSRSB, by Sector, in 2005 [7]

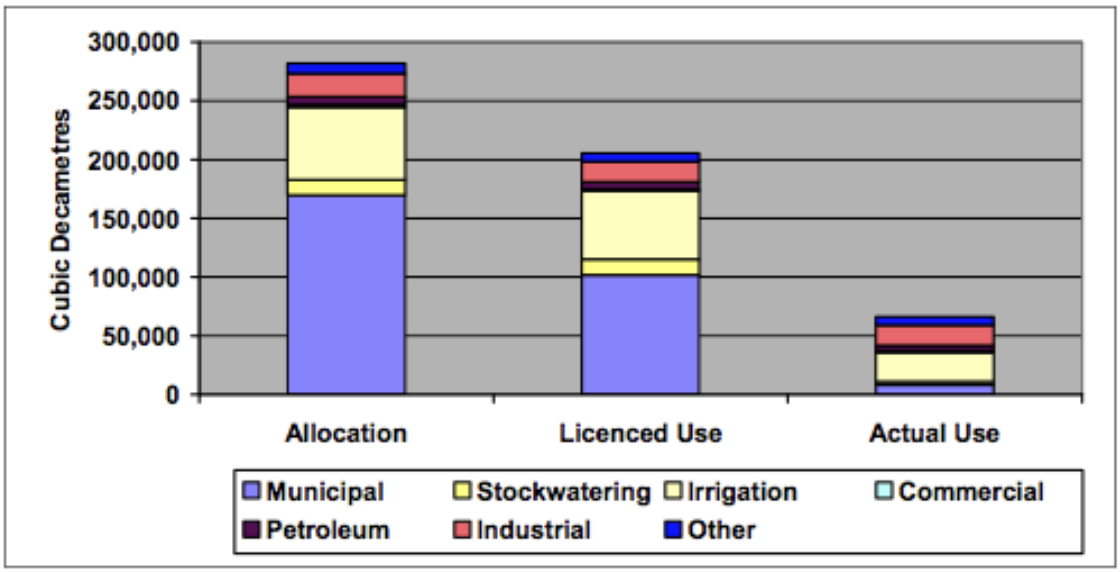


Figure 3.3, 3.4, and 3.5 in the appendix show the location surface water licenses, groundwater licenses, and registrations, respectively, in the SSRSB in 2005. Water allocations, licenses and actual use are broken down by sector below, using data from the Alberta Environment 2007 Report on Water Use.

i. Municipal Sector

A total of 167,503 dam^3 of surface water has been allocated for municipal purposes, representing 99% of municipal allocations. Ten surface water licenses allowing withdrawals of 165,871 dam^3 have been issued to urban municipalities. 2,111 dam^3 of groundwater are included in the municipal allocations, accounting for 1% of allocations. Nineteen groundwater licenses have been issued to urban users, allowing withdrawals of up to 1,982 dam^3 (Appendix, Table 3.2).

Other municipal licenses with allocations greater than 100 dam^3 are listed in Table 3.3 in the appendix. Among these licensees are the Department of National Defense and various water cooperatives.

Municipal licenses in the SSRSB in 2005 assumed that 101,772 dam^3 would be used (60% of the allocated amount) with a return flow allowance of 67,841 dam^3. Return flow allowances ranged between 35 and 40 percent for urban and rural municipalities using surface water. Groundwater users had return flow allowances ranging between 74 for urban users to less than one percent for rural users.

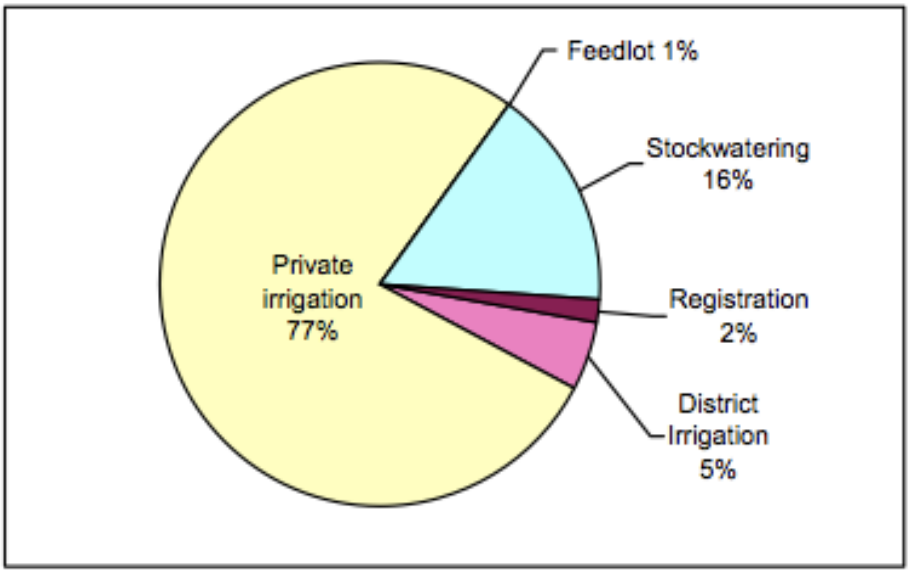
Actual municipal water use in 2005 was estimated to be 8,203 dam^3, amounting to 4.8% of the total allocation in the sector. Municipalities were estimated to have used 8% of their surface water licensed use, and 16% of their ground water licensed use (Appendix, Table 3.4). The estimates for actual water use suggest that the municipalities withdraw substantially less than the amount that they are entitled to. It should be noted that actual water use is estimated: only three municipalities, accounting for 96% of the total municipal allocations in the basin, reported their water diversions to Alberta Environment. These licensees reported water diversions of 7,910 dam^3, allowing an estimation of actual use in the basin to be set at 8,203 dam^3. [7]

ii. Agriculture Sector

In December 2005, 74,961 dam^3 of water was allocated to the agriculture sector in the SSRSB. This includes 2,277 registrations representing 1,230 dam^3 and 2,289 licenses representing 73,731 dam^3.[7] Water allocations to the agriculture sector accounts for 27% of all allocations in the SSRSB (Figure 3.1).

Figure 3.6 shows the distribution of water among the different agricultural uses in the SSRSB. Private irrigation accounts for 77% of allocations to the agriculture sector. District irrigation accounts for 5%, Stockwatering accounts for 16%, and feedlot and registrations together account for 3% of the total allocation. *

Figure 3.6: Water Allocations for Agriculture Activities in the SSRSB, 2005 [7]



1,619 registrations and 2,213 licenses allow withdrawals of 74,008 dam^3 of surface water, while 48 licenses and 8,372 registrations allowed withdrawals of 953 dam^3 of groundwater. [7]

I. Livestock watering is one of the two major uses of water in the agricultural sector of the SSRSB. 4,035 licenses and registrations allow the withdrawal of 13,297 dam^3. Registrations accounted for 1.6% of the allocation. None of the licenses or registrations for livestock watering have any allowances for return flow, thus the licensed water use is equal to the allocated amount. Additionally, farmers are able to obtain up to 1,250m^3 of water for household purposes as per regulations laid out in the Alberta Water Act. The number of these households is unknown. [7]

   Based on the livestock population in the SSRSB in 2001, the total amount of water required for livestock was estimated to be 1,945 dam^3, roughly 15% of the licensed allocation. This value does not take into account the loss of water due to evaporation and seepage. A more appropriate estimation of water use for livestock, when taking these factors into account, is 2,960 dam^3. Thus, actual use for livestock watering in 2005 was estimated to be 2,960 dam^3. [7]

   Cattle account for 90% of total water use. Pigs account for roughly 8%, while other types of livestock, like chickens, sheep, and horses, account for the remaining 2%. [7]

   Under a medium growth scenario, as outlined in the 2007 Alberta Environment Report on Water Use, water use for livestock operations is expected to rise to 3,757 dam^3 by the year 2025, up from the estimated 2,960 dam^3 used in 2005. [7]

II. Irrigation is the second major use of water in the agriculture sector. Both private and district irrigation occur in the South Saskatchewan River Sub Basin. Table 3.5 in the appendix lists the allocated and licensed use for irrigation in the SSRSB.

   For district irrigation in the SSRSB, the Ross Creek Irrigation District (RCID) is licensed to divert 3,701 dam^3 of water for 1,210 acres of land. In terms of actual use, the average annual diversion for the RCID is 1,500 dam^3, roughly 40% of its licensed allocation. In 2005, 95% of the

area irrigated under the RCID was used for forage crops. [1] The St. Mary River Irrigation District (SMRID) provides district irrigation for approximately 166,000 dam^3 of land in the SSRSB. [11] However, water used in the SMRID comes from the Oldman River Basin. Thus, information on SMRID water use was not included in the breakdown of water use, by sector, in the South Saskatchewan River Sub Basin.

Based on water allocations to private irrigators and annual irrigation requirements of 450mm (18 inches) it is estimated that water allocations in 2005 could sufficiently support 47,663 acres of land. There were 520 licenses allocating 57,963 dam^3 to private irrigators in 2005, representing 98% of the total allocation for irrigation. Neither Alberta Environment nor Alberta Agriculture has information on actual water use for private irrigators. However, by assuming private irrigators divert the same proportion of the licensed volume as district irrigators, a reasonable estimate of actual water use can be made. Using this method, in which private irrigators use 40% of the licensed volume, the actual diversion for private irrigation is 23,185 dam^3. [7]

Total allocations for irrigation amount to 61,663 dam^3. The SSRSB accounts for 8% of total private allocation and 19% of the private licenses issued in Alberta. Since applications for new surface water licenses are no longer accepted in the SSRSB, the ability to expand irrigated acres is limited. Water required for increased levels of irrigation will have to be accommodated within existing allocations or through the use of groundwater. Because of this, it is estimated that actual water use for irrigation will remain around 24,685 dam^3 by the year 2025. [7]

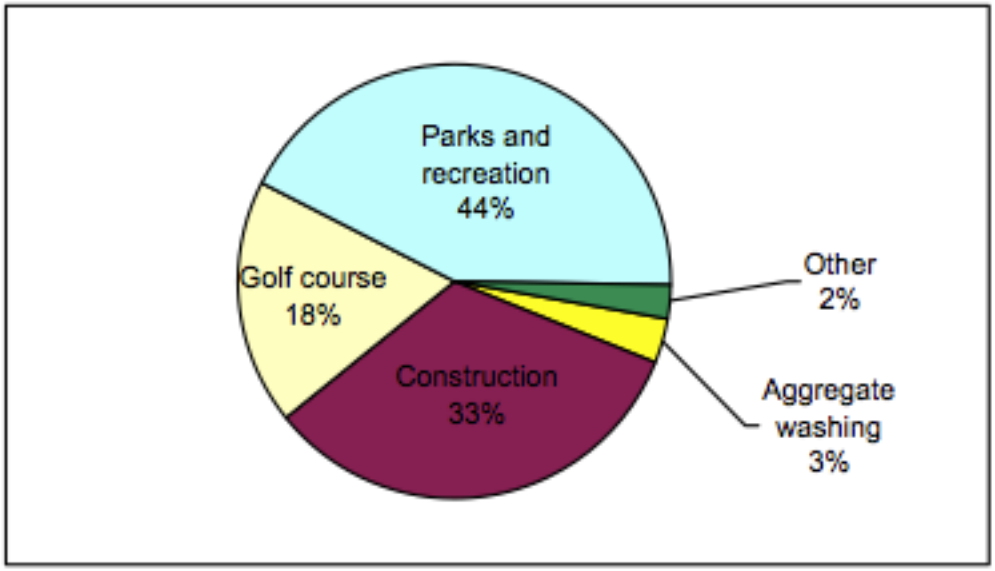
In summary, agricultural water use in 2005 was estimated to be 27,645 dam^3, 89% of which was for irrigation. Actual water use for irrigation (24,685 dam^3) was 8.3 times the amount of water used for livestock (2,960 dam^3). Growth in this sector is expected to come from livestock watering. Under a medium growth scenario, as outlined by Alberta Environment in the 2007 Report on Water Use, the agriculture sector is expected to use 28,442 dam^3 of water in 2025, a 2.8% increase from the 2005 amount. [7]

iii. Commercial Sector

14 licenses allowed the diversion of 2,034 dam^3 of water for commercial purposes, accounting for 0.7% of total allocation in the SSRSB. [7]

Figure 3.7 shows the distribution of allocations in the commercial sector. The three largest allocations - parks and recreation (44%), construction (36%), and golf courses (18%) - accounted for 95% of the total allocation in the sector.

Figure 3.7: Water Allocations for Commercial Activities in the SSRSB, 2005 [7]



Licenses issued for the commercial sector allowed withdrawals of 1,916 dam^3 of surface water (94% of total allocation). The largest allocation, parks and recreation accounted for 40% of the total surface water allocation. Licenses issued for the commercial sector allowed withdrawals of 119 dam^3 of groundwater (6% of total allocation). Parks and recreation held 70% of the allocation of groundwater. [7]

Table 3.6 lists the water allocations for commercial activities in the SSRSB in 2005. Parks and recreation held the largest allocation (869.6 dam^3); followed by construction (675.9 dam^3), golf courses (372.5 dam^3), aggregate washing (66.7 dam^3), and other (49.6 dam^3).

As of 2007, Alberta Environment's Water Use Reporting System (WURS) contained no information on actual water use in 2005 for any of the licensees in the commercial sector. However, by assuming licensees use all the water they are entitled to withdraw, actual use can be estimated. Actual use for major commercial activities in 2005 and forecasts for the year 2025, obtained through the methods described in

the Alberta Environment 2007 Report on Water Use, are included below. [7]

I. Parks and Recreation

Parks and recreation was estimated to use 287 dam^3 of water in 2005. Under a medium growth scenario, this activity is expected to use 336 dam^3 of water in 2025.

II. Golf Courses

Golf courses used 373 dam^3 of water in 2005. It is estimated that golf courses will use 1246 dam^3 of water in 2025, assuming a medium growth scenario.

In summary, the commercial sector was estimated to have used 1,451 dam^3. Assuming medium growth, it was estimated by Alberta Environment in the 2007 Report on Water Use that the sector will use 2,373 dam^3 of water by the year 2025. [7]

iv. Petroleum Sector

There were 6 active licenses allocating 6,881 dam^3 of water to the petroleum sector, accounting for 2% of the total allocations in the SSRSB. The vast majority has been allocated to gas and petrochemical plants. 99.8% of the licenses are for surface water (6,869 dam^3). [7]

6,879 dam^3 of water was allocated to gas and petroleum plants in 2005. Of this, four surface licenses accounted for 6,869 dam^3 while one groundwater license accounted for 10 dam^3. These licenses assumed that 89% of surface water and 100% of groundwater was to be consumed. It is estimated that 4,080 dam^3 of water was used by gas and petrochemical plants in 2005. It is assumed that future water use for gas and petrochemical plants will remain at current levels due to the restriction on new water allocations. [7]

One groundwater license for 1.2 dam^3 was issued for injection purposes, in which salt water is pumped into underground formations. Data suggested that 364 dam^3 was used for injection purposes, far greater than the 1.2 dam^3 allowed. This inconsistency is unexplained, and the source of this water is not known.

The petroleum sector had an actual use estimated at 4,443 dam^3. Future water forecasts for the sector are based on the assumption that water requirements for injection will decrease as production from existing oilfields declines and use by gas and petrochemical plants will

remain constant. Under these conditions, it is estimated that the sector will use 4,213 dam^3 in 2025.

v. Industrial Sector

In 2005, seven active licenses allocated 19,803 dam^3 of water to the industrial sector. These allocations accounted for 7% of total allocations in the basin. 95% of the allocation is for surface water, amounting to 18,894 dam^3. Figure 3.8 shows the distributions of allocations in the industrial sector.

Figure 3.8: Industrial Water Allocation by Use in the SSRSB, 2005 [7]

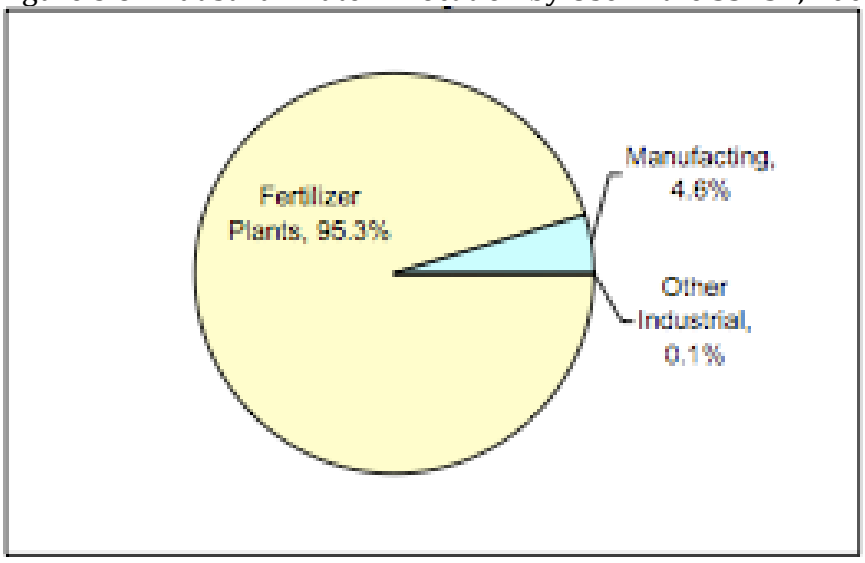


Table 3.7 shows the allocation and licensed use for industrial activities in the SSRSB in 2005. Fertilizer plants held 95% of allocations in the sector in 2005; amounting to 18,869 dam^3, with a return flow allowance of 1,727 dam^3. No information was available on actual water use by fertilizer plants, but the plants were assumed to use their full entitlement. Manufacturing activities held two licenses, allowing withdrawals of 909 dam^3 of groundwater. Licensees were assumed to use their full entitlement, amounting to 20% of the allocation or 181.8 dam^3. One license was issued for other industrial purposes, allowing withdrawals of 25 dam^3, and it was assumed that actual use for this purpose equaled this amount.

In summary, the industrial sector was dominated by water allocated to fertilizer plants. Licensees were assumed to use the full capacity of their licenses. Actual use was therefore calculated to be 17,348.5 dam^3.

Due to the restriction on new licenses in the SSRSB, the actual water use is expected to remain constant in the sector. [7]

vi. Other Sector

There were 21 licenses allocating 8,680 dam^3 of water to activities in the other sector, amounting to 3% of total allocations in the basin. All of the licenses were for surface water. The sector includes water management for flood control and lake stabilization, fish, wildlife, and habitat enhancement, and uses specified by a director with Alberta Environment. Figure 3.9 shows the distribution of water allocations in the other sector. [7]

Figure 3.9: Water Allocations in the Other Sector in the SSRSB, 2005 [7]

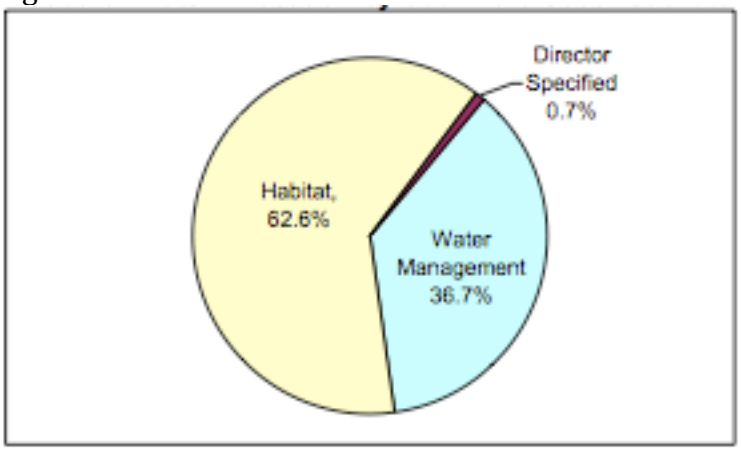


Table 3.8 summarizes the allocations and licensed use for activities in the other sector in 2005. 3,185 dam^3 of water was allocated to water management activities, with the assumption that 48% of the allocation would be used. It was assumed that the licensees were using their full entitlement, thus actual water use was calculated to be 1,525.8 dam^3. Fish, wildlife, and habitat enhancement held 5,435 dam^3 of allocations in the sector. Actual use was assumed to be 100% of the licensees' entitlement, or 5,434.7 dam^3. Director specified activities held allocations allowing 61 dam^3 of water to be withdrawn, and it was assumed that the licensees were using their full entitlement, or 61 dam^3.

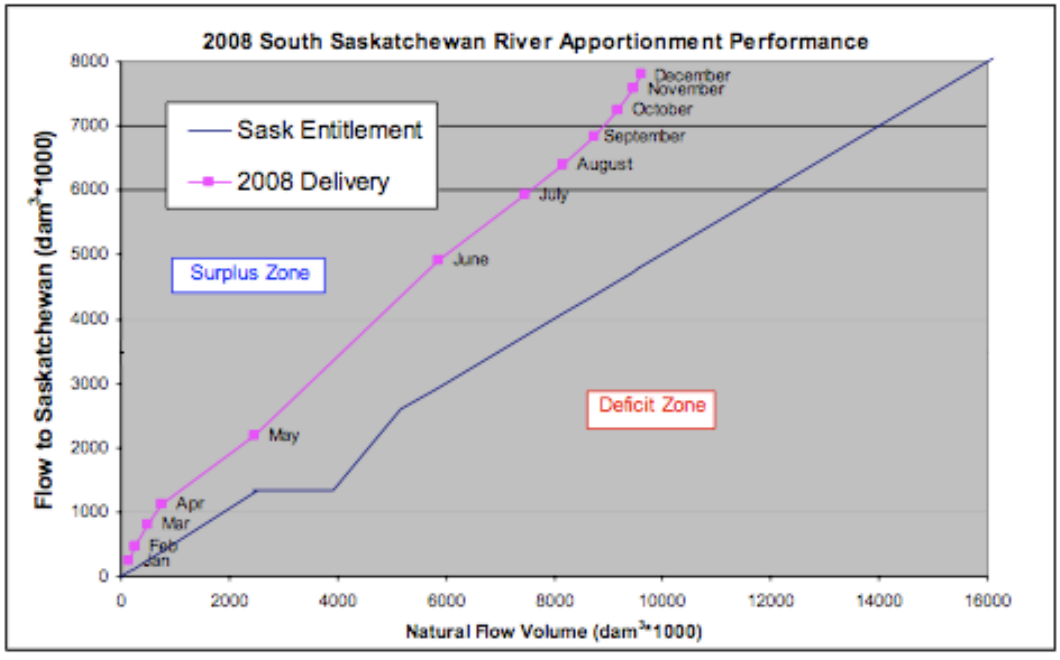
In summary, the other sector is dominated by water allocations for habitat enhancement, accounting for 63% of the water allocation and 77% of the licensed water use. Alberta Environment's 2007 Report on Water Use found an absence of information on the development of the sector, leading to the assumption that water use by activities in the other sector would remain constant over time.

e. Water Sharing with Saskatchewan

On October 30, 1969, the governments of Alberta, Saskatchewan, Manitoba, and Canada entered into the Master Agreement on Apportionment, which provided a formula for the sharing of waters of eastward flowing interprovincial streams. A major focus of this agreement is the South Saskatchewan River. Alberta is allowed to "divert, store or consume" from the river system each year a volume of water equal to one-half of the apportionable natural flow of the South Saskatchewan River at the Alberta-Saskatchewan border. In other words, Alberta is entitled to half of the water in the South Saskatchewan River. The remaining volume of water must be allowed to pass downstream into Saskatchewan. The exception to the general rule is that Alberta is entitled to divert, store, or consume 2.1 million acre-feet (2,590,000 dam^3) in any year, even if the natural flow of the river is less than 4.2 million acre-feet (5,180,600 dam^3). This exception allows Alberta to pass less than half of the apportionable flow to Saskatchewan. However, if Alberta wants to use more than half the apportionable flow, a flow rate of 1,500 cubic feet per second (42.48 m^3/s) must be maintained at the Saskatchewan border, unless the natural flow is less than 3,000 cubic feet per second (84.95 m^3/s), in which case half the natural flow must be passed. [18]

Figure 3.10 shows Alberta's annual deliveries to Saskatchewan versus the entitled amount in 2008. The total natural flow volume from the South Saskatchewan River Basin was 9,600,000 dam^3 in 2008. The recorded flow volume was 7,820,000 dam^3, 81% of the natural flow volume, and well in excess of the requirement of 50% under the Master Agreement on Apportionment. [34]

Figure 3.10: Alberta South Saskatchewan River Apportionment Performance [34]



Between 1975 and 1995, the South Saskatchewan River at the confluence with the Red Deer River had a mean annual flow of 8,399,000 dam^3. During this period, Alberta, on average, passed 75.5% of the apportionable flow to Saskatchewan, far exceeding the required 50%. This represents a mean annual surplus delivery of 2,246,000 dam^3 of water to Saskatchewan. During the driest years in the period, Alberta had surplus deliveries greater than 400,000 dam^3. [45]

Since the Master Agreement on Apportionment came into effect in 1969, Alberta has exceeded the minimum flow required under the agreement every year (Appendix, Figure 3.11 and 3.12). In 2001 the minimum flow was just met at 52%.

4. Flood and Drought Management Strategies

Alberta Environment (AENV) actively manages water resources in Alberta. The Water Management Operations – Operations Group, consisting of the Southern and Central/Northern Regional Teams, is responsible for operating and maintaining Alberta Environments water management infrastructure projects. This infrastructure includes major on-stream reservoirs, off-stream reservoirs, weirs, drainage ditches, lake stabilization, flood control, erosion control, major diversions, pump houses, check structures, turnouts, waste ways, and drain inlet works. Typically, this infrastructure is used to meet water users needs, recreational needs, flood and erosion control needs, Instream flow objectives, and apportionment requirements. AENV also operates these works during extreme events such as heavy flooding and droughts to minimize the impacts of these events. [32]

a. Flood Management

Heavy precipitation and snow melt can lead to flooding as streams reach and exceed their capacity to transport water. Dams and reservoirs allow some measure of control over flood waters, by partially storing and releasing water in a manner that both protects the integrity of dams while minimizing the impacts of downstream high flows on infrastructure and public safety. In terms of the SSRSB, flows in the South Saskatchewan River and in some of the tributaries involved with the SMRID irrigation network can be affected by the operation of dams and reservoirs in the Bow and Oldman River Sub Basins. [32]

Alberta Environment has an established advisory and warning system to alert residents of Alberta of flooding. There are three categories used in the warning system: high stream flow advisory, in which no major flooding is expected, flood watch, in which water levels may exceed a streams capacity and cause flooding, and flood warning, in which rising stream levels will result in flooding of areas adjacent to affected streams.

Advisories and warnings are updated frequently. [17] Current and archived advisories and warnings can be found on the Alberta Environment website.

Alberta Environment also operates a Geographical Information System (GIS) map of Alberta showing flood prone areas. The flood hazard map, which contains some information on the vulnerability of SSRSB streams to flooding, can be found on the Alberta Environment website.

June of 2010 saw heavy precipitation in the Cypress Hills region. Alberta Environment issued a high stream flow advisory on June 16th for all tributaries flowing out of the Cypress Hills region. After days of heavy precipitation, with up to 100mm in 24 hours, a flood warning was issued on June 18th for the tributaries draining the Cypress Hills. Irvine experienced heavy flooding as the flow in Ross Creek exceeded 200 m^3/s, considerably larger than the normal flow of less than 3 m^3/s. [27] Low lying areas of Medicine Hat experienced considerable flooding as the tributaries that wind through the City before joining with the South Saskatchewan River overflowed. Tributaries such as Ross Creek and Seven Persons Creek flooded adjacent land throughout much of the SSRSB. The warning was downgraded to a high stream flow advisory on June 22nd, and over the next few days the water level receded to pre-flood levels. [17]

Flooding can occur despite the best efforts of water managers. Flooding of the tributaries in the SSRSB in 2010 showed that even small streams could cause disastrous flooding under the right conditions. Preparedness can help to mitigate the effects of a major flood, as can adequate emergency planning.

b. Drought Management

Drought can be defined as a deficiency of moisture when compared to a normal or expected amount over an extended period of time. It can begin slowly and subtly, but historically it has proven to have as significant an impact as other, more dramatic disasters like flooding. Agriculture is usually the first industry to show the effects of drought through low crop yield and reservoir levels. Droughts persisting for more than two or three years can deplete groundwater supplies, lower water levels in streams, rivers, and lakes, and reduce runoff in major watersheds. Other effects of drought include soil erosion, increased amounts of fire and pests, increased unemployment, and net farm losses. [15]

The development of water storage sites across southern Alberta has helped to mitigate the effects of dry years. Reservoirs and effective water management have allowed the development of agriculture in the SSRSB. However, these projects have not eliminated the dangers accompanying drought. The drought spanning 2001 and 2002 in Canada severely affected

Alberta and Saskatchewan. The drought caused low river levels and no flow in some tributaries in Western Canada, and also caused a depletion of groundwater. Reservoirs in Southern Alberta had well below normal levels, and prairie dugouts dried out. The St. Mary's Reservoir was filled at only 29% capacity in August of 2000. The number of natural prairie ponds was the lowest on record in 2002, showing the sensitivity of wetlands in agriculture regions. Wind erosion increased, leading to massive dust storms across Alberta and Saskatchewan. In terms of agriculture, Alberta producers lost $413 million in 2001 and $1.33 billion in 2002 through the value of lost crop production. In response to low water supply, municipalities began to adopt water conservation and rationing. Restrictions on watering lawns, golf courses, and other non-essential uses across Canada helped to conserve more water. There was a water sharing agreement between senior water users (irrigation districts) in the SSRB and junior water users which helped mitigate the 2001 water shortage. The drought ceased in 2003, but not before leaving a lasting effect on the economy. [2]

Alberta Environment developed the 2010 Agriculture Drought Risk Management Plan (ADRMP) as a risk management approach to droughts in Alberta. The plan is meant to offer a more fiscally responsible method to combat drought than previous drought management policies while still reducing the impact of drought on producers. The ADRMP is supported by three approaches to action linked to the various levels of drought: drought preparedness, drought monitoring and reporting, and drought response. The plan aims to ensure that drought management planning and actions of governments are communicated to producers and are coordinated and effective, consistent over time and amongst departments, and that drought monitoring and reporting is effective and timely, supporting planning and action. [15] The full Agriculture Drought Risk Management Plan can be found on the Alberta Agriculture and Rural Development website.

Conclusion

Water quantity in the South Saskatchewan River Sub-Basin is a complicated topic spanning several topics of interest. Water flow in the South Saskatchewan River depends on developments in the Oldman River and Bow River and can vary considerably. Tributaries and the main stem of the South Saskatchewan River follow channels left over from glaciation thousands of years ago. Flow rates in tributaries vary considerably, with extremes including no flow and heavy flooding. Natural lakes are uncommon, and can turn into alkali flats in dry years. Reservoirs are used extensively to supply water for irrigation and other uses. Private and district irrigation allow agriculture to operate despite a naturally dry climate.

Environment Canada operates an extensive network of water monitoring stations across Canada. Several of these stations are located in the South Saskatchewan River Sub-Basin, allowing a look ?

Alberta Environment administrates water licensing. The South Saskatchewan River Sub-Basin is closed to new water allocations and licenses. A market for the transfer of existing allocations has developed in the years following the restriction on new allocations.

Sectors of water use include municipal, agricultural, commercial, petroleum, industrial, and other. Water use is considerably smaller than water allocation, indicating that licensees are not using their full entitlement of water. It should be noted that many licences have a smaller, licenced use amount, meaning they cannot consume 100% of their allocation. Alberta has consistently exceeded requirements in water sharing with Saskatchewan.

Alberta Environment is tasked with the responsibility of flood and drought management. Water management infrastructure is operated to minimize the effects of flooding, and an advisory and warning system is in place to help alert residents of floods. New legislation may help mitigate the effects of droughts in Alberta. Conservative use of stored water and limiting non-essential water use can assist in controlling the effects of an extended drought.

Recommendations

Difficulties in analyzing water use arise when actual water use is not reported. Water supply and use changes in response to many factors, and can vary considerably from year to year. Ensuring the accurate measurement and archival of hydrometric data, along with water use and other measures of water quantity, will allow a more in depth examination of water quantity in the South Saskatchewan River Sub-Basin.

With only one hydrometric water gauge on the South Saskatchewan River within the South Saskatchewan River Sub-Basin, it is difficult to understand how the flow of water changes as it courses through the river. More stations on the South Saskatchewan River may allow a better analysis of the hydrology of the South Saskatchewan River.

The cap on new water allocations, and the emerging water market may require more government legislature devoted to water ownership and transfer.

Appendix

Figure 1.2: River Basins in Southern Alberta [37]

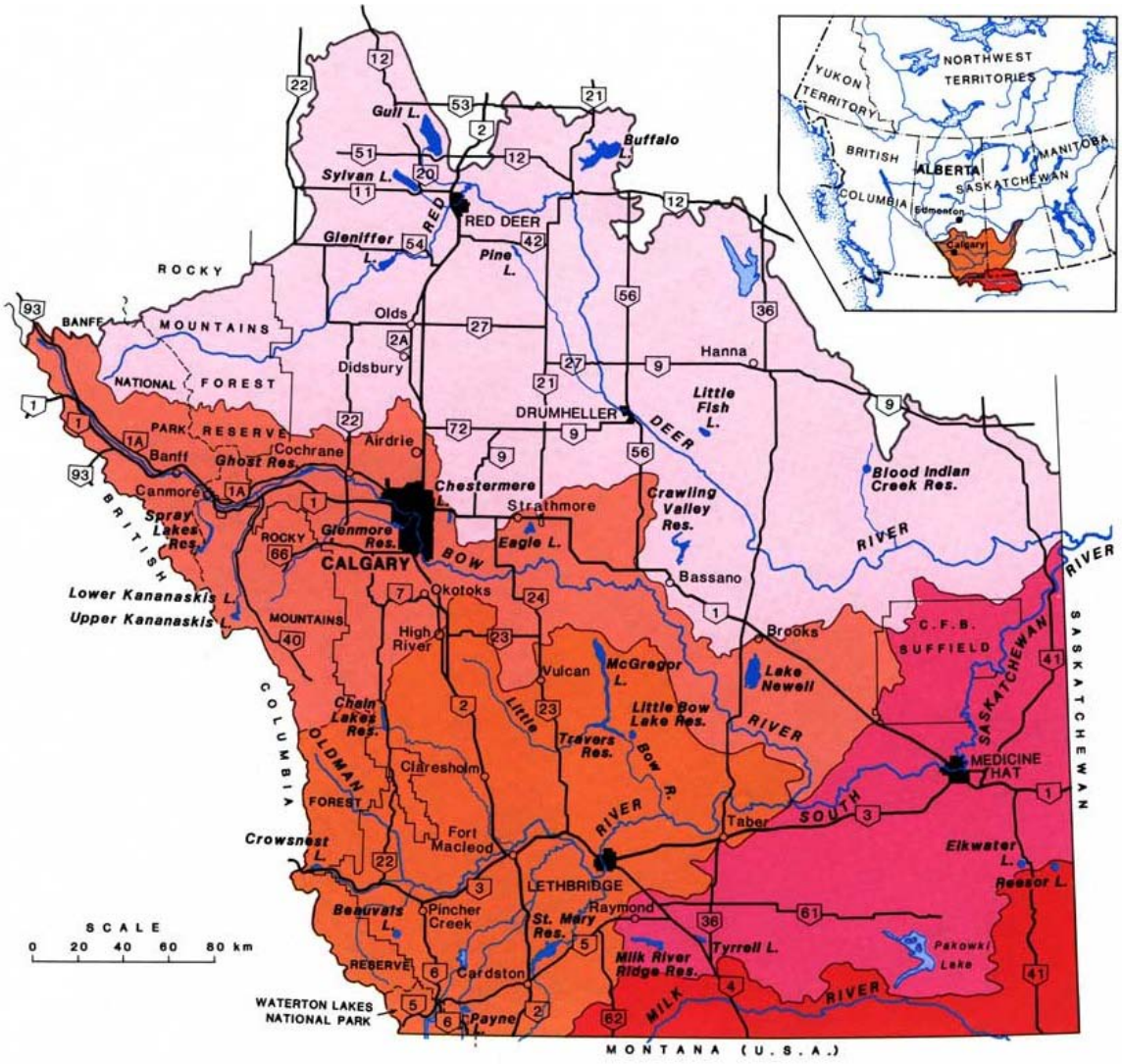
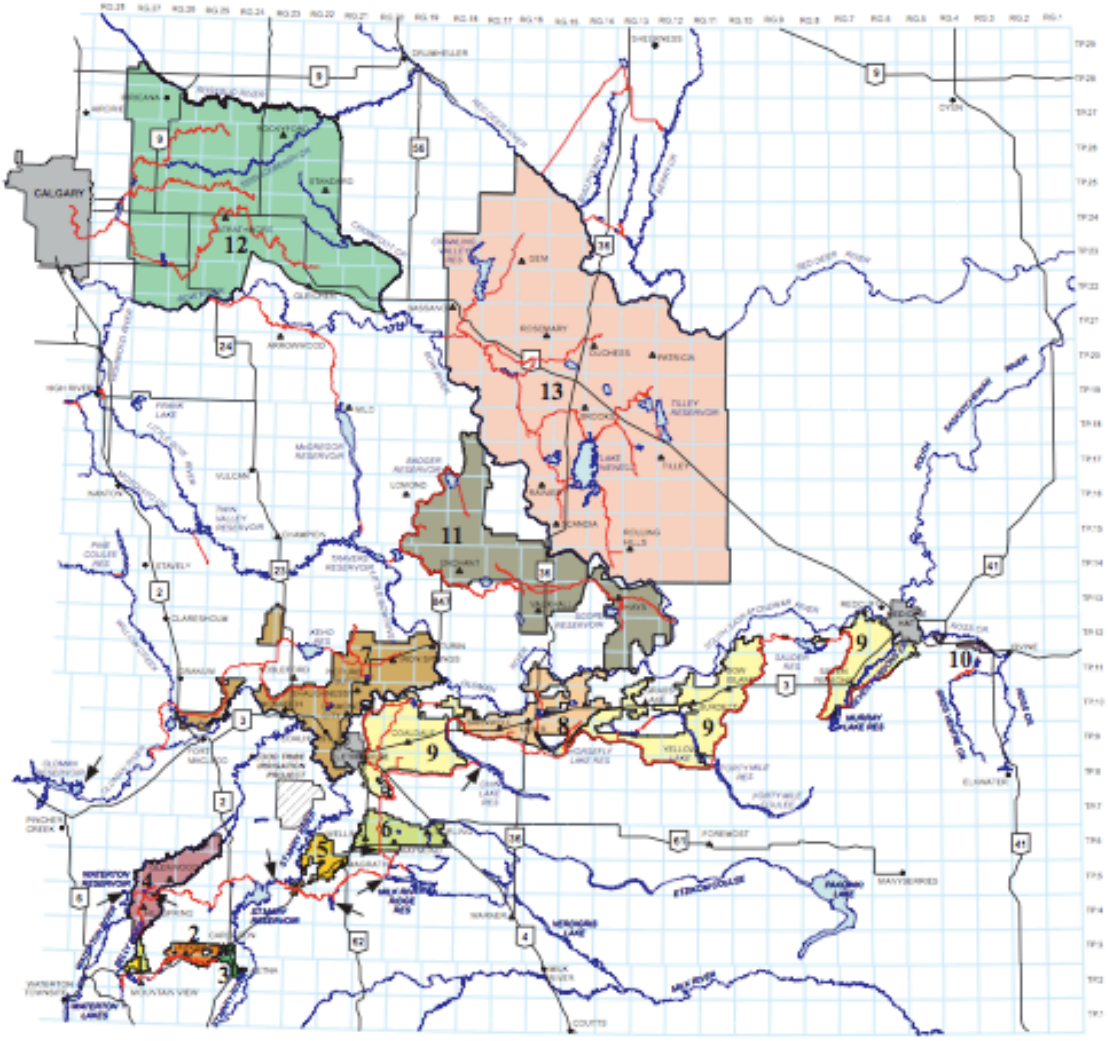


Figure 1.5: Alberta's Irrigation Districts [3]



There are 13 irrigation districts in southern Alberta providing water to 1,368,091 assessed acres of farmland. The infrastructure within these irrigation districts is comprised of approximately 7,975 kilometers of conveyance system, of which 339 kilometers are owned and operated by Alberta Environment.

Table 2.1: Sub-basin Hydrologic Characteristics [8]

Hydrologic Characteristic	Sub-basin				Total for South Sask. Basin
	Red Deer	Bow	Oldman	South Sask.	
Gross Drainage Area (km^2) [a]	46 800	25 300	27 500	13 200	112 800
Effective Drainage Area (km^2) [b]	32 400	19 200	20 900	6 600	79 100
EDA/GDA Ratio (%)	69%	76%	76%	50%	70%
Median Annual Temperature (˚C)	13.6	12.4	13.4	15.9	13.6
Median Annual Precipitation (mm)	393	538	488	278	435
Median Annual Natural Flow Volume (dam^3)	1 666 000	3 829 000	3 343 000	3 662	8 842 000
Median Runoff Yield over EDA (mm) [c]	51	199	160	0.6	112

[a] Gross drainage area is the entire area that may be expected to contribute to flow in a stream in a specific location under wet conditions. It is defined by the drainage divide between adjacent watersheds.
[b] Effective drainage area is the area judged to contribute to flow in a stream during a median flow year. It excludes poorly developed drainage areas that do not contribute to stream flow in median and low runoff years.
[c] Median Runoff Yield = Median Annual Natural Flow (dam^3) divided by Effective Drainage Area (km^2).

Table 2.2: Stream Flow Characteristics for the South Saskatchewan River at Medicine Hat, 1972-2001 [8]

	South Saskatchewan River at Medicine Hat	
	Naturalized	Recorded
Annual Volume		
Mean (dam^3)	7 002 000	4 803 000
Minimum (dam^3)	4 181 000	1 739 000
Summer Volume (May-Oct)		
Mean (dam^3)	5 595 000	3 270 000
Minimum (dam^3)	3 279 000	826 000
Summer Low Flow		
Mean annual 7-day (m^3/s)	99.9	49.1
Minimum annual 7-day (m^3/s)	29.2	16.9
Winter Low Flow (Nov-Mar)		
Mean annual 7-day (m^3/s)	23.2	34.8
Minimum 7-day (m^3/s)	5.30	13.4

Figure 2.1: Annual Historical and Naturalized Flow Volumes for the South Saskatchewan River at Medicine Hat, 1912-2005 [8]

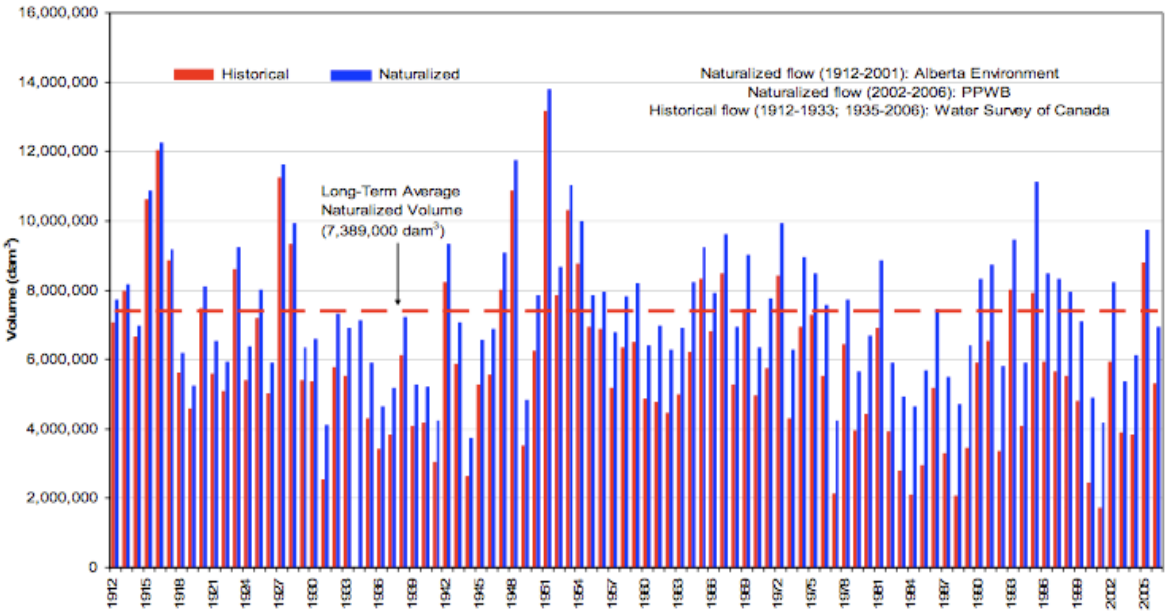
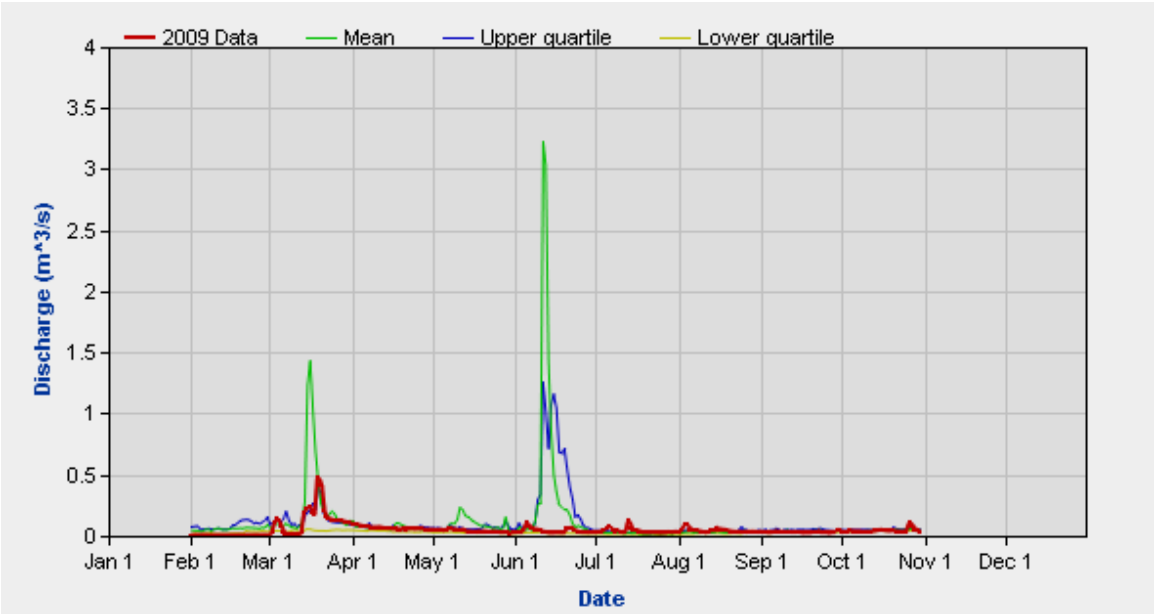
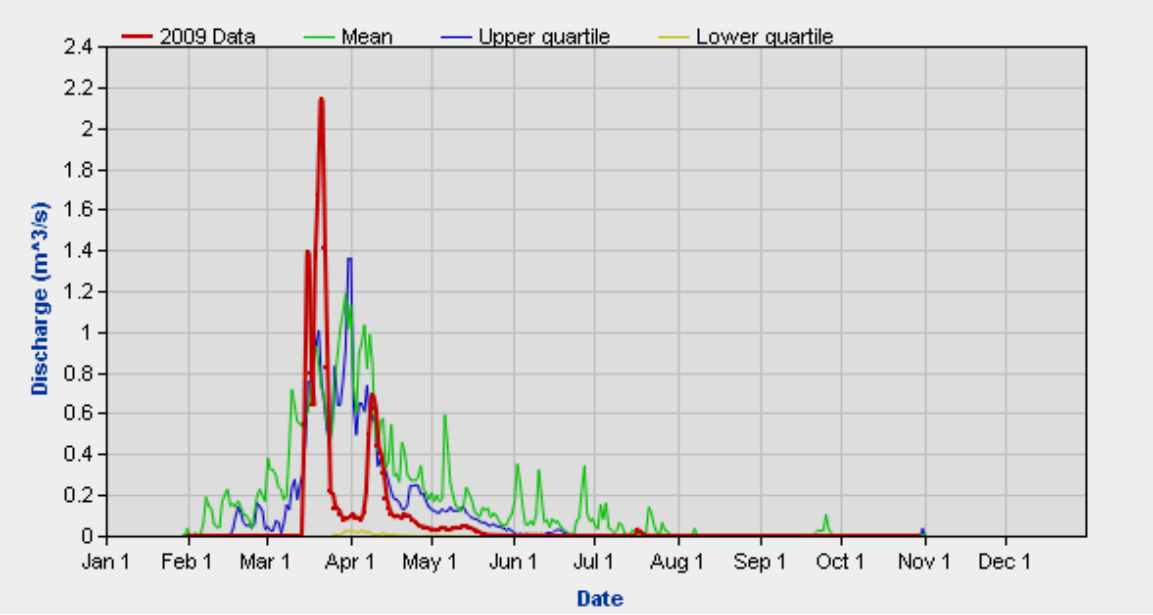


Figure 2.4: Hydrograph of Ross Creek at Highway 41 (Water Survey Station 05AH052)
13



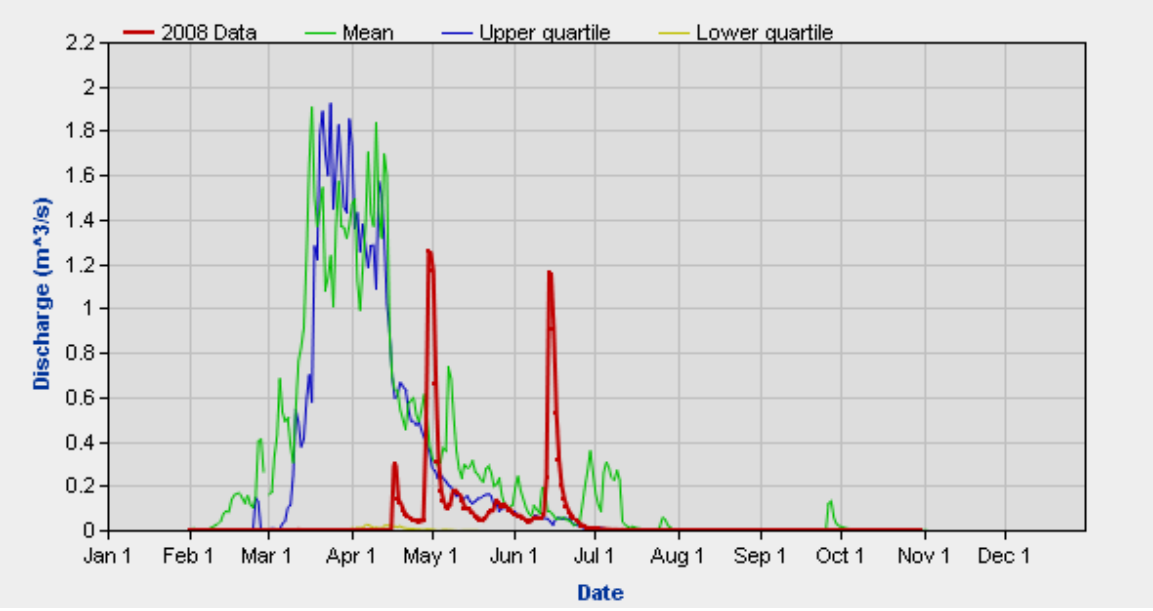
*Statistics correspond to data collected between 2000 and 2009.

Figure 2.5: Hydrograph of Gros Ventre Creek near Dunmore (Water Survey Station 05AH037) [13]



*Statistics correspond to data collected between 1921 and 2009.

Figure 2.6: Hydrograph of Peigan Creek near Pakowki Road (Water Survey Station 05AH041) [13]



*Statistics correspond to data collected between 1960 and 2008.

Table 2.3: Stations Monitored by Environment Canada for South Saskatchewan River Sub Basin Tributaries in 2010 [13]

Tributary	Location	Station Number
Boxelder Creek	Walsh	05AH001
Bullshead Creek	Black and White Trail	05AH053
East McAlpine Creek	Elkwater Lake	05AH043
Gros Ventre Creek	Dunmore	05AH037
Mackay Creek	Walsh	05AH002
Peigan Creek	Pakowki Road	05AH041
Ross Creek	Highway 41	05AH052
Sam lake Tributary	Schuler	05AH005
Seven Persons Creek	Medicine Hat	05AJ001

Table 2.4: Reservoirs Monitored by Alberta Environment in the South Saskatchewan River Sub Basin [22] [26]

Reservoir	Full Storage Level (m)	Capacity (dam^3)
Elkwater Reservoir	1,226.36	6,579
Spruce Coulee Reservoir	1,304.13	570
Bullshead Reservoir	1,074.496	1,846
Mackay Reservoir	1,186.323	714
McAlpine Reservoir	1,221.40	630
Cypress View Reservoir	979.619	410
Forty Mile Reservoir	813.00	86,440
Sauder Reservoir	804.00	37,780
Murray Reservoir	766.56	30,615
Milk River Ridge Reservoir	1,032.40	111,500

*Full storage level corresponds to the elevation of the reservoir.

Table 3.1: Summary of Allocations and Estimated Water Use in the SSRSB, 2005 [7]

Sector		Licensed Allocation and Use (dam³)				Estimated Water Use (dam³)		
		Allocation	Water Use	Return	Percent of Total Use	Use	Percent of Licensed Use	Percent of Total Use
Municipal		169,613	101,772	67,841	50%	8,203	8%	12%
Agricultural	Stockwatering	13,297	13,297	0	6%	2,960	22%	4%
	Irrigation	61,664	58,318	3,346	28%	24,685	42%	37%
Commercial		2,034	1,451	583	1%	1,451	100%	2%
Petroleum		6,881	6,108	772	3%	4,443	73%	7%
Industrial		19,803	17,349	2,454	8%	17,349	100%	26%
Other		8,680	7,021	1,659	3%	7,021	100%	11%
Total		**281,971**	**205,316**	**76,655**	**100%**	**66,112**	**32%**	**100%**

Figure 3.3: Surface Water Licenses in the SSRSB, 2005 [7]

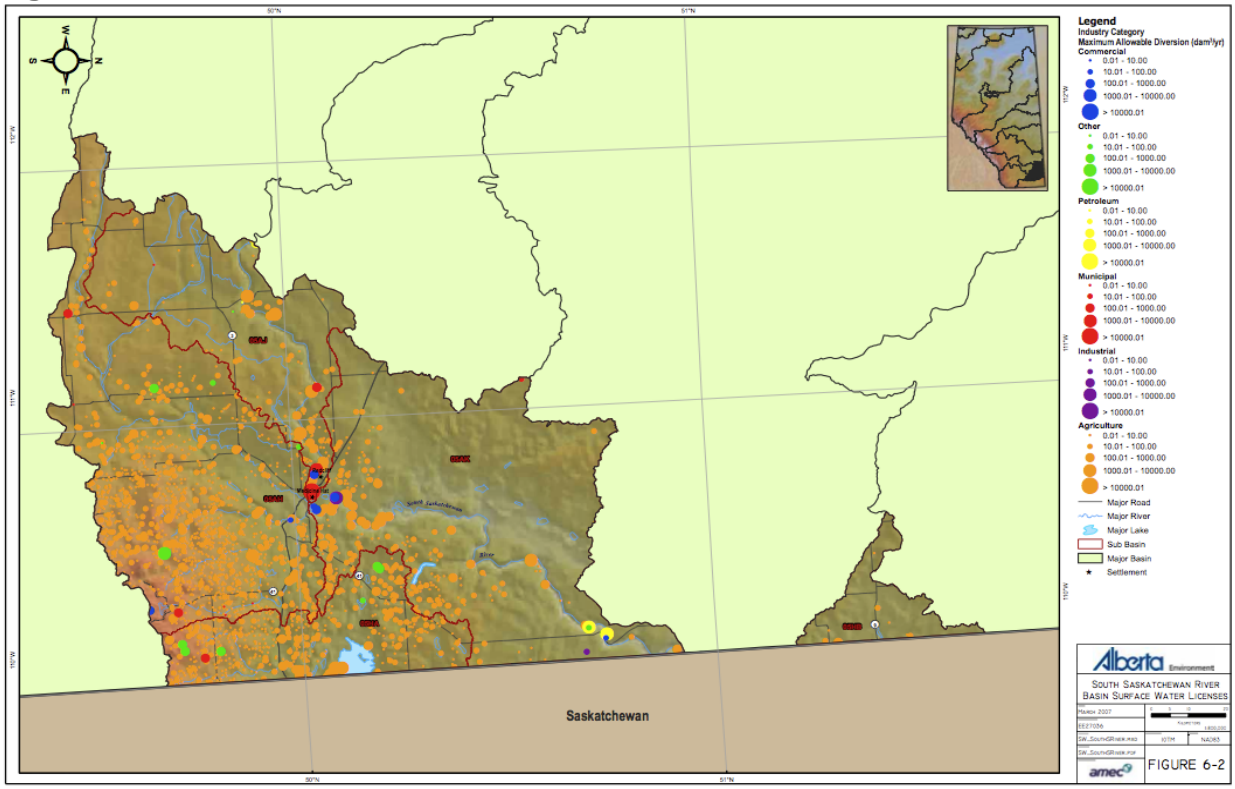


Figure 3.4: Groundwater Licenses in the SSRSB, 2005 [7]

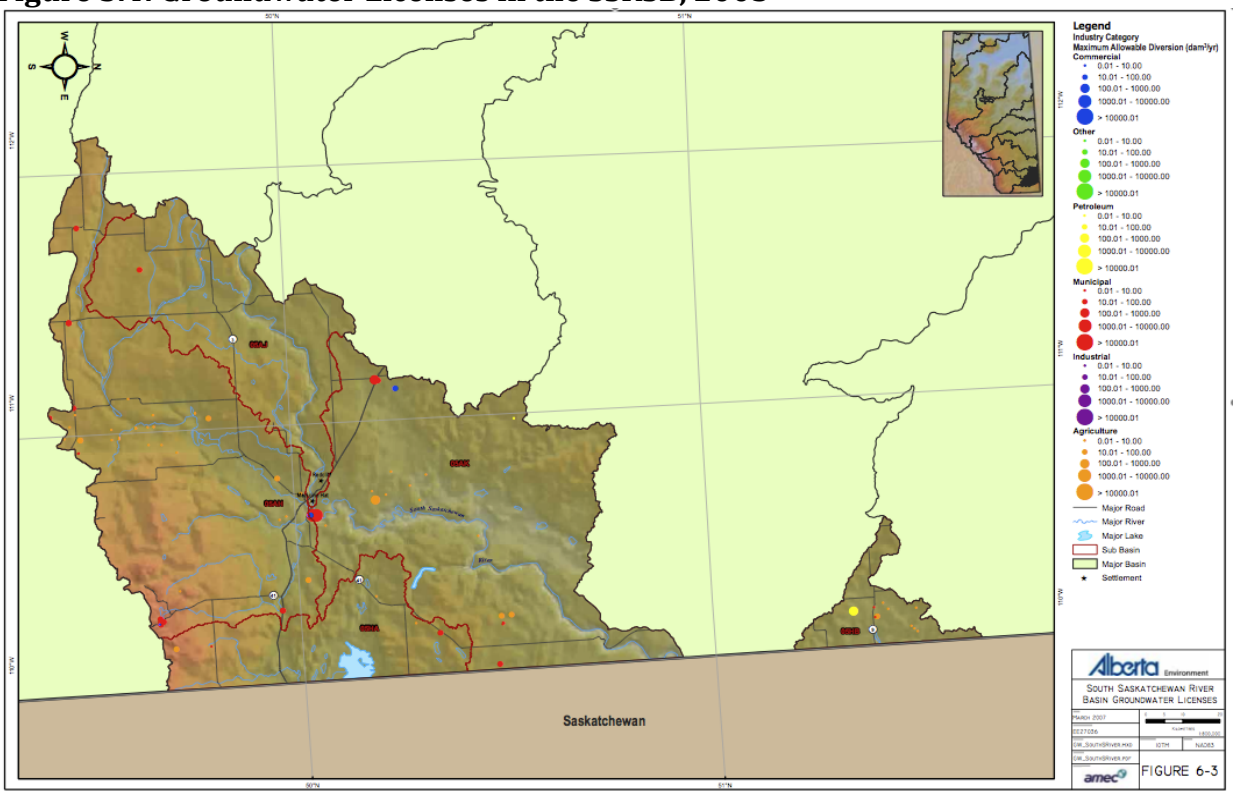


Figure 3.5: Surface and Groundwater Registrations in the SSRSB, 2005 [7]

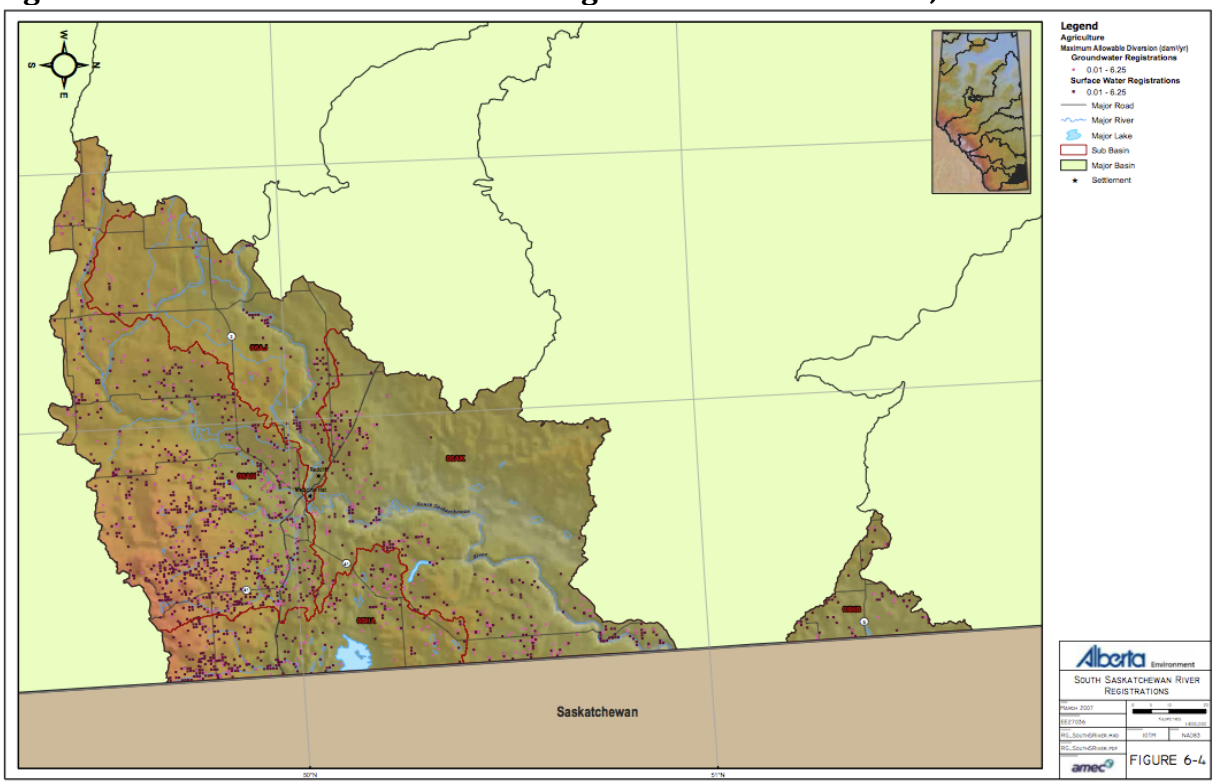


Table 3.2: Municipalities and Water Allocations in the SSRSB [7]

Municipality	2001 Population	2006 Population	2005 Allocation (dam^3)
City of Medicine Hat	51,249	56,977	162,820 *
Town of Redcliff	4,372	5,096	2,545
Town of Bow Island	1,704	1,790	678**
Village of Foremost	531	524	259
Cypress County	4,643	-	564
County of Forty Mile NO.8	1,929	-	-
M.D. of Taber	668	-	-
Special Areas (2,3,4)	218	-	-
County of Warner NO.5	117	-	-
M.D. of Acadia NO. 34	19	-	-
Total	**65,451**	**-**	**166,188**

* Medicine Hat has a larger allocation than cities of similar size because it operates its own power plant that draws water under the municipal license.
** Bow Island receives water from the Oldman Basin (678 dam^3).

Table 3.3: Other Municipal License Holders in the SSRSB [7]

Approval Holder	Water Source	Allocation (dam^3)
Department of National Defense	Groundwater	1,462
	Surface	704
Bullshead Water CO-OP LTD.	Surface	250
Water Operations Branch, Lethbridge	Surface	247
Hilda Water Pipeline CO-OP LTD.	Surface	183
ConocoPhillips Canada Resources CORP.	Surface	142
Cypress/Milk River District	Groundwater	120

Table 3.4: Estimated Municipal Water Use in the SSRSB in 2005 [7]

Municipal Use	Source	Allocations (dam^3)	Use (dam^3)
Urban	Surface	8,022	8,022
	Groundwater	96	96
	Subtotal	8,118	8,118
Rural	Surface	79	79
	Groundwater	6	6
	Subtotal	85	85
Total Use	Surface	8,101	8,101
	Groundwater	102	102
	Subtotal	8,203	8,203
Licensed Use	Surface	167,503	101,120
	Groundwater	2,111	652
	Subtotal	169,613	101,772
Percent of Licensed Use	Surface	4.8%	8.0%
	Groundwater	4.8%	15.7%
	Subtotal	**4.8%**	**8.1%**

Table 3.5: Irrigation Allocations and Use in the SSRSB, 2005 [7]

Activity	Source	Number of Licenses/ Registrations	Licensed Allocation and Use (dam^3)		
			Allocation	Water Use	Return
District Irrigation	Surface	1	3,700.5	3,453.8	246.7
	Groundwater	0	0.0	0.0	0.0
	Total	**1**	**3,700.5**	**3,453.8**	**246.7**
Private Irrigation	Surface	518	57,810.4	54,710.8	3,099.6
	Groundwater	2	153.0	153.0	0.0
	Total	**520**	**57,963.3**	**54,863.7**	**3,099.6**
Total	Surface	519	61,510.9	58,164.6	3,346.3
	Groundwater	3	153.0	153.0	0.0
	Total	**521**	**61,663.9**	**58,317.6**	**3,346.3**

Table 3.6: Water Allocations for Commercial Activities in the SSRSB, 2005 [7]

Activity	Source	Number of Licenses	Licensed Allocation and Use (dam^3)		
			Allocation	Water Use	Return
Aggregate Washing	Surface	2	66.7	66.7	0.0
	Groundwater	0	0.0	0.0	0.0
	Subtotal	**2**	**66.7**	**66.7**	**0.0**
Construction	Surface	1	675.9	675.9	0.0
	Groundwater	0	0.0	0.0	0.0
	Subtotal	**1**	**675.9**	**675.9**	**0.0**
Golf Course	Surface	3	372.5	372.5	0.0
	Groundwater	0	0.0	0.0	0.0
	Subtotal	**3**	**372.5**	**372.5**	**0.0**
Parks and Recreation	Surface	4	800.5	273.8	526.7
	Groundwater	3	69.1	12.8	56.2
	Subtotal	**7**	**869.6**	**286.7**	**582.9**
Other	Surface	0	0.0	0.0	0.0
	Groundwater	1	49.6	49.6	0.0
	Subtotal	**1**	**49.6**	**49.6**	**0.0**
Total	Surface	10	1,915.6	1,388.9	526.7
	Groundwater	4	118.6	62.4	56.2
	Total	**14**	**2,034.3**	**1,451.3**	**582.9**

Table 3.7: Licensed Allocations and Use for the Industrial Sector in the SSRSB, 2005 [7]

Water Use	Source	Number of Licenses	Licensed Allocation and Use (dam^3)		
			Allocation	Water Use	Return
Fertilizer Plants	Surface	4	18,868.9	17,142.0	1,726.9
	Groundwater	0	0.0	0.0	0.0
	Subtotal	4	18,868.9	17,142.0	1,726.9
Manufacturing	Surface	0	0.0	0.0	0.0
	Groundwater	2	909.1	181.8	727.3
	Subtotal	2	909.1	181.8	727.3
Other Industrial	Surface	1	24.7	24.7	0.0
	Groundwater	0	0.0	0.0	0.0
	Subtotal	1	24.7	24.7	0.0
Total	Surface	5	18,893.6	17,166.7	1,726.9
	Groundwater	2	909.1	181.8	727.3
	Total	**7**	**19,802.6**	**17,348.5**	**2,454.1**

Table 3.8: Licensed Allocations and Use for the Other Sector in the SSRSB, 2005 [7]

Water Use	Source	Number of Licenses	Licensed Allocation and Use (dam^3)		
			Allocation	Water Use	Return
Water Management	Surface	7	3,148.7	1,525.8	1,658.9
	Groundwater	0	0.0	0.0	0.0
	Subtotal	7	3,148.7	1,525.8	1,658.9
Habitat	Surface	13	5,434.7	5,434.7	0.0
	Groundwater	0	0	0	0.0
	Subtotal	13	5,434.7	5,434.7	0.0
Specified	Surface	1	60.5	60.5	0.0
	Groundwater	0	0	0	0.0
	Subtotal	1	60.5	60.5	0.0
Total	Surface	21	8,679.8	7,020.9	1,658.9
	Groundwater	0	0	0.0	0.0
	Subtotal	**21**	**8,679.8**	**7,020.9**	**1,658.9**

Figure 3.11: Alberta SSRB Annual Deliveries to Saskatchewan versus Entitlements [34]

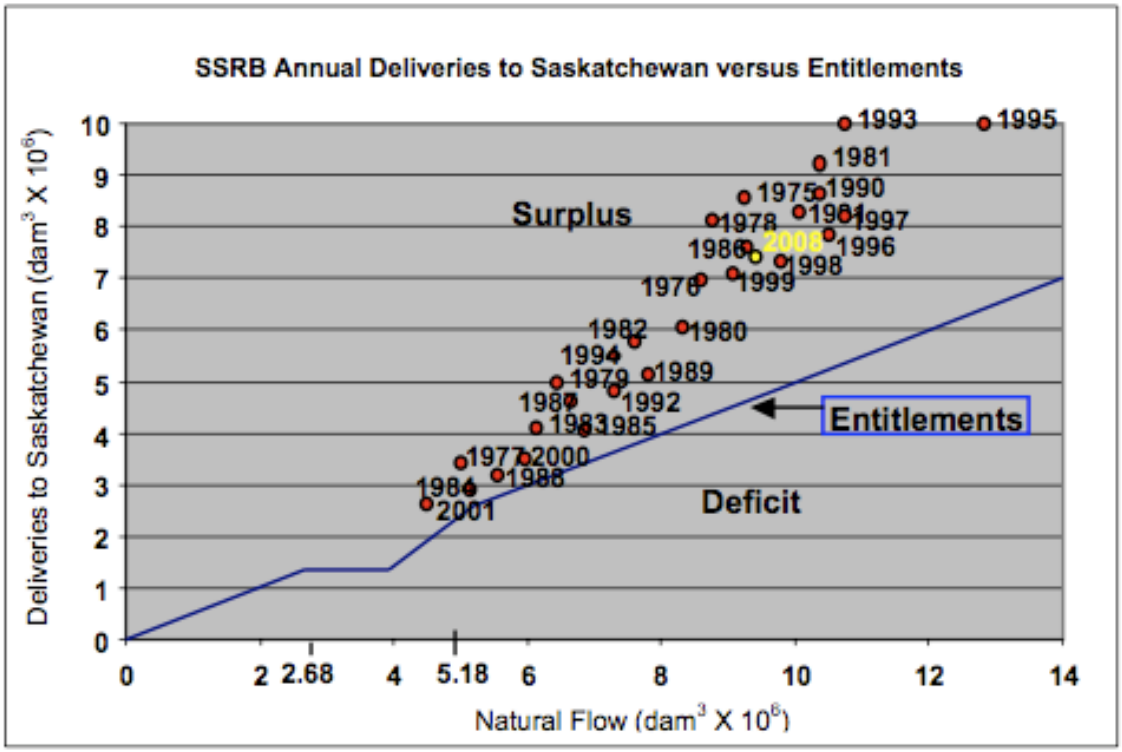
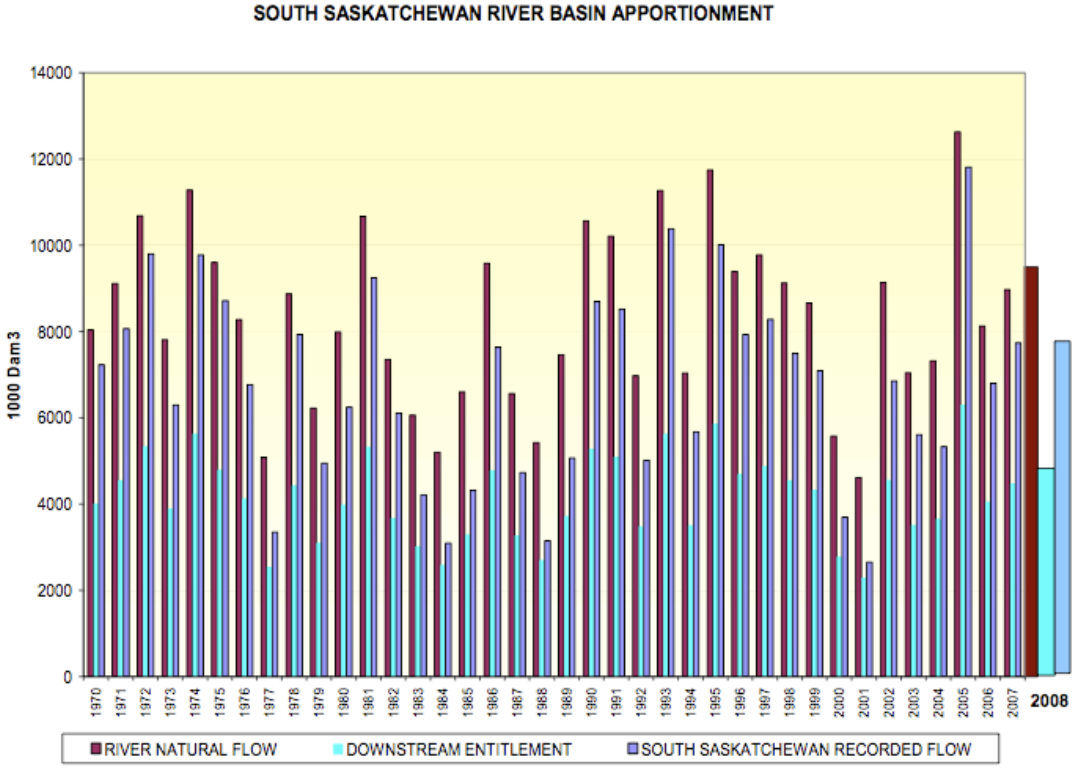


Figure 3.12: Alberta SSRB Apportionment Performance [34]



Glossary

Acre – measurement of area, equal to 4,046.87 square metres

Acre-foot – unit of volume, equal to the volume of one acre of surface area to the depth of one foot.

Cubic Decameter (dam^3) – unit of volume, equal to 1,000 cubic meters (m^3) or 1,000,000 litres.

Metres cubed per second (m^3/s) – Volume of water, measured in metres cubed, which flows past a point in one second.

Riparian – of, on, or relating to the banks of a natural course of water.

South Saskatchewan River Basin – major Canadian watershed. Drains much of Southern Alberta eastward via the Bow, Oldman, Red Deer, and South Saskatchewan Rivers.

South Saskatchewan River Sub-Basin (SSRSB) – component of the South Saskatchewan River Basin. Region begins at the confluence of the Bow and Oldman Rivers and drains the area east to Saskatchewan. The Red Deer River joins with the South Saskatchewan River near the Alberta – Saskatchewan border.

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The **South East Alberta Watershed Alliance (SEAWA)** was formed in 2007, incorporated as a non-profit society in 2008, and designated as the WPAC (Watershed Policy and Advisory Council) for the South Saskatchewan River sub-basin.

SEAWA Vision: *A healthy watershed that provides balance between social, environmental and economic benefits.*

SEAWA Mission: *South East Alberta Watershed Alliance brings together diverse partners to plan and facilitate the sustainable use of the South Saskatchewan River Watershed for present and future needs.*

SEAWA Members include interested individuals throughout the watershed along with our communities, ranchers, farmers, industries, companies, governments, conservation groups and educational institutions. We are proud to include the following among our founding members:

Government Sector: Alberta Government, City of Medicine Hat, Government of Canada, Cypress County, Palliser Health Region, Town of Redcliff, Town of Bow Island, and Special Areas Board.

Land Resource - Industry and Agriculture Sectors: St Mary River Irrigation District, Murray Lake Ranching, GG Bruins Farms, Short Grass Ranches, Canadian Fertilizers Limited, Redcliff Technology Enterprise Centre, Box Springs Business Park, and Canadian Centre for Unmanned Vehicles.

Academic, Research and Non-Governmental Organizations Sectors: Medicine Hat College, Alberta Research Institute, Red Deer River Watershed Alliance, and Hyperion Research.

Tourism and Conservation Sectors: Grasslands Naturalists, Canadian Badlands, and Medicine Hat Interpretive Program.

SEAWA Web-based State of the Watershed Report is managed by the *SEAWA State of the Watershed Committee (2010 members)*:

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