Present and Future Water Demand in Saskatchewan – A Summary by River Basins

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A report prepared for

SASKATCHEWAN WATERSHED AUTHORITY
MOOSE JAW

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Executive Summary

Water is being recognized as an increasingly valuable commodity. Necessary to life itself, water is needed for ecological functions, as well as for many social and economic activities. In some Saskatchewan River basins, current water supplies are being taxed, and further expansion of water availability may be required to meet the demand placed on it. Typically, such developments are very costly. As the future economic foundation in a basin increases, leading to growth in economic activities and to a resulting growth in population, competition for water will become even fiercer. Climate change may pose another threat to the region, partly because of reduced supplies and increased demand by some sectors. The development of sounder water management strategies may become a future necessity. Water management requires a working knowledge of what the future holds for various basins in the province. Included here are future water demand patterns and predictions of availability for the provincial basins.

An integrated assessment of both future water demand and availability of water has definite merit. This situation occurs because in particular cases water demand patterns can be affected by water availability. However, this study investigates only the water demand side of integrated water management. It was undertaken to estimate current (2010) water demand levels and forecast them for various Saskatchewan River basins by types of sectors for three future periods – Year 2020, 2040, and 2060.

Report Overview

Water demand in this study was taken as an equivalent quantity of water intake or of water withdrawn from a source (surface water bodies or groundwater aquifers). Although water demand is economically regulated by its price, this control acts along with other factors that affect behaviours of individuals or institutions. Since in this study such a demand function was not estimated, it was postulated that the quantities of water reported here reflect behaviour at a given time and a given price level for water; thus, the quantities are equivalent to water demand.

Methodology

In this study, total water demand was divided into two broad types: one, water demand resulting from socio-economic activities, called direct anthropogenic water demand, and two, consumption subject to natural and policy-related factors, called indirect anthropogenic water demand. The first type (direct anthropogenic) includes water needed by various economic sectors that produce goods and services. The second category (indirect anthropogenic) includes four kinds of water demand: evaporation, apportionment of water as subject to the trans-boundary agreements, the meeting of instream water flow needs, and the quantity demanded for environmental protection/preservation projects.

The direct anthropogenic water demand is a result of several types of economic and social activities. Some of these activities are related to the production of goods, while others needs consist of water for sustenance and related social activities. Total water demand for a given sector was estimated by using water demand coefficients and a scale of economic or social activity for a given purpose. Four economic sectors were identified within this type of demand: agriculture sector, mining/industrial sector, municipal/ domestic sector, and recreation sector.

In this study, current and future water demands (for the years 2020, 2040, and 2060) were estimated for three scenarios: Baseline Scenario, Climate Change Scenario, and Water Conservation Scenario. The Baseline Scenario assumed that trends based on past data will continue into the future, barring external shocks to the economic and social system. For the Climate Change Scenario, water demand was affected by changes in climate characteristics and occurrences of extreme events. Water demand coefficients for any water demand-related activity exposed to these conditions were adjusted for these future periods. Economic and social activities were maintained at the same level as in the Baseline Scenario. The third scenario assumed that the province has developed a water conservation policy and that measures have been adopted by various water use sectors to reduce water demand. As under the Climate Change Scenario, economic and social activities remained unchanged from the baseline scenario level.

All demand estimates were made using data already available either in public sources or obtained from Saskatchewan Watershed Authority (now called Water Security Agency) data bases. These data were taken at face value.

Water Demand Estimates under Baseline Scenario

Water demand in Saskatchewan for 2010 was estimated at 4,172 thousand dam^3, of which direct anthropogenic demands accounted for 930 thousand dam^3 (or 22.3% of the total water demand). By the year 2060, the basin will experience an increase of 82.1% in the total direct anthropogenic water demand (Table ES.1). As shown in Figure ES.1, total indirect anthropogenic water demand in the future was set as equal to the 2010 level, since all these demands are related to availability of water, which in the future would be affected by a set of natural factors and policy changes. Over the 2010-2060 period, this amount was estimated to be 3,242 thousand dam^3. By 2060, total water demand in Saskatchewan would increase to 4,936 thousand dam^3 – an increase of 18.3% of the 2010 level.

Total direct anthropogenic water demand in the basin was a sum of four types of socio-economic activities: (i) water required for agricultural production and related activities; (ii) water needed by industries and for mining; (iii) water demanded by people living in various communities in the basin, collectively called municipal and domestic water demands; and (iv) water needed for recreational and related human activities. These water demands are expected to increase over time. The agricultural sector is the main force behind the change, and within this sector, the increased amount of irrigated area is a significant determinant. This proportion is expected to increase in the future; by 2060, such agricultural activity would account for 34.1% of the total water demand. In total, direct anthropogenic water demand in the basin will increase to 1,694 thousand dam^3 in 2060, compared to the present level of only 930 thousand dam^3. As shown in Figure ES.2, much of this increase can be credited to agricultural water demand, and within that category, to irrigation. Industrial and mining water demands are also expected to increase, but not by a similar magnitude.

Table ES.1: Water Demand in Saskatchewan, under Baseline Scenario, 2010-2060

Sector	Amount of Water Demanded in dam^3			
	2010	**2020**	**2040**	**2060**
Agriculture	656,062	710,664	1,077,363	1,333,885
Industry/Mining	106,647	202,807	151,741	152,738
Municipal (Domestic)	166,916	171,578	186,570	206,530
Recreational	635	692	762	819
Total Direct Anthropogenic Water Demand	**930,260**	**1,085,741**	**1,416,436**	**1,693,972**
Indirect Anthropogenic Water Demands	3,241,696	3,241,696	3,241,696	3,241,696
Total Water Demand	**4,171,956**	**4,327,437**	**4,658,132**	**4,935,668**
% Increase in Direct Anthropogenic Water Demand Over 2010		16.7%	52.2%	82.1%
% Increase in Total Water Demand Over 2010		3.7%	11.7%	18.3%
Hydroelectric Power Generation Water Release	5,337,220	5,337,220	6,627,081	6,627,081

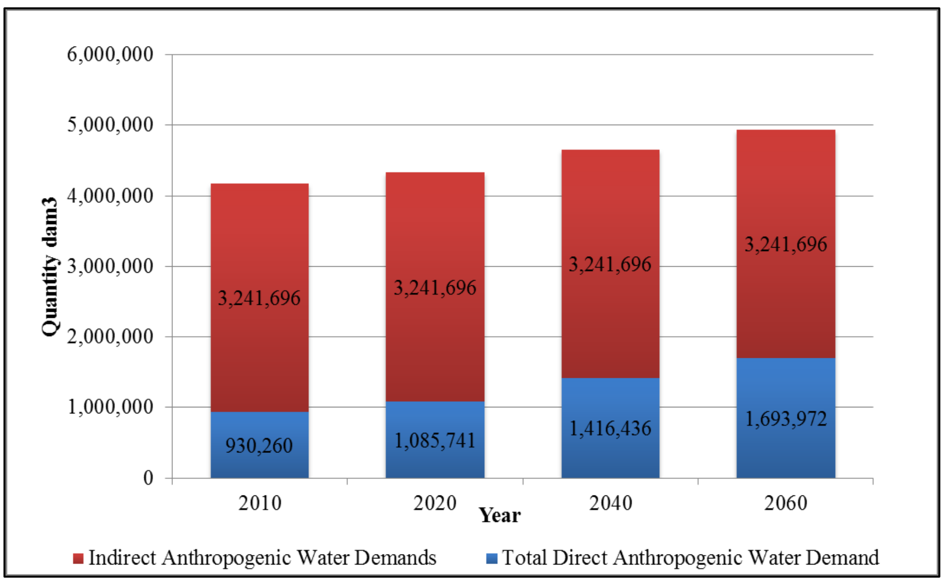


Figure ES.1: Distribution of Total Water Demand in Saskatchewan by Major Categories of Demand, Baseline Scenario, 2010 – 2060

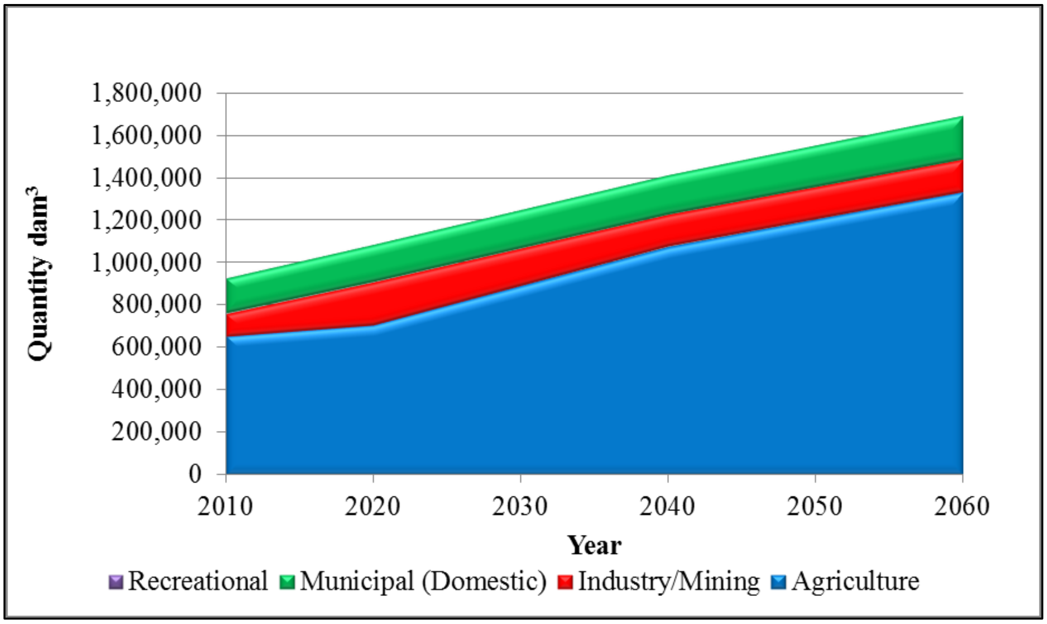
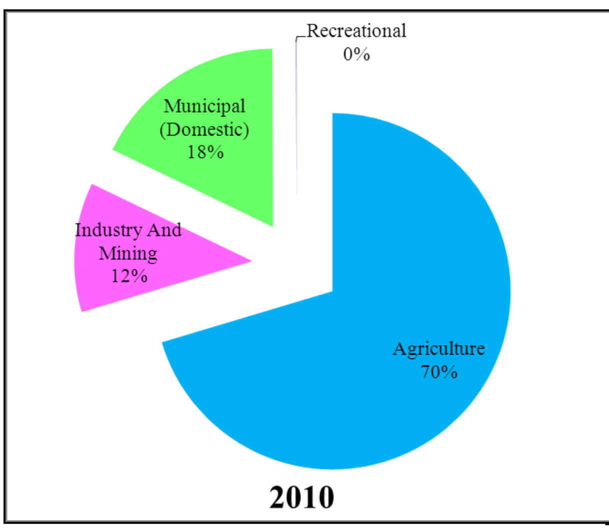


Figure ES.2: Trend in Direct Anthropogenic Water Demand by Type of Demand, Saskatchewan, Baseline Scenario, 2010 – 2060

As a result of varying trends over the 2010-2060 period, the composition of total direct anthropogenic water demand will change. As shown in Figure ES.3, agriculture will increase its share of the total to 80% as opposed to 70% in 2010. Industrial/mining, as well as Municipal/domestic water demand shares, will decline from the present 12% to 8% and from 18% to 12%, respectively.



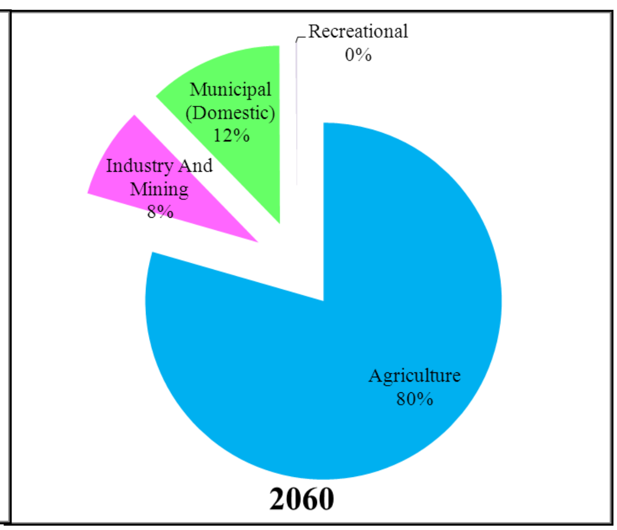


Figure ES.3: Distribution of Total Direct Anthropogenic Water Demand, by Type of Demand in the Saskatchewan River Basins, Baseline Scenario, 2010 and 2060

Water Demand Estimates under Climate Change Scenario

As noted above, in addition to the baseline forecasts of water demand, two other scenarios were used for making these forecasts. One of the scenarios was climate change, which can have an impact both on water supplies (availability) as well as on water demand. However, in this research, investigation was limited to water demand aspects. Even here, several difficulties were encountered in making these estimates. One such problem was a scarcity of information on the potential nature of climate change for the basin and its impact on water demand. Therefore, the basis for making such predictions is relatively weak; further research information needs to be generated in the context of Saskatchewan's (and more specifically, of each River Basin's) situation. The following results are based on our current knowledge.

The predicted effects of climate change on the direct anthropogenic and indirect anthropogenic water demand activities in the Saskatchewan River Basins are presented in Table ES.2. Direct anthropogenic water demand could increase in 2060 to 2,027 thousand dam^3, up by 20% from the baseline scenario level. Since indirect anthropogenic water demands are governed by natural changes in the water supply and by policy changes, these demands were made constant at their respective 2010 level, except for the evaporation losses. As a supply of water under climate change becomes available, these estimates may need to be revised.

Table ES.2: Water Demand under Climate Change Scenario in Saskatchewan River Basins, 2010 - 2060

Sector	Amount of Water Demanded in dam^3			
	2010	**2020**	**2040**	**2060**
Agriculture	656,062	710,664	1,240,763	1,658,493
Industry/Mining	106,647	202,807	147,573	148,596
Municipal (Domestic)	166,916	171,578	193,157	219,514
Recreational	635	692	781	859
Total Direct Anthropogenic Water Demand	**930,260**	**1,085,741**	**1,582,274**	**2,027,462**
Indirect Anthropogenic Water Demands	3,241,696	3,241,696	3,401,155	3,560,648
Total Water Demand	**4,178,706**	**4,334,188**	**4,990,615**	**5,595,128**
% Increase in Direct Anthropogenic Water Demand Over 2010		16.7%	70.1%	117.9%
% Increase in Total Water Demand Over 2010		3.7%	19.4%	33.9%
Hydroelectric Power Generation Water Release	5,337,220	5,337,220	6,627,081	6,627,081

Higher growing season temperatures will have a significant impact on the agricultural sector as both crops and livestock will require more water. The evaporation of water from water bodies, which is already a major indirect anthropogenic water demand, is one of the major increases that can be expected with climate change. For industrial and mining sectors, no evidence was found to suggest that climate change would affect the water demand.

Water Demand Estimates under a Water Conservation Scenario

The effect of water conservation measures on the water demand activities in Saskatchewan is presented in Table ES.3. Agricultural and industrial adoption of water conservation techniques and technologies has the greatest impact on the direct anthropogenic demand for water. However, the success of most water conservation measures is partially dependent on future legislation and regulations. Total water demand for direct anthropogenic purposes is estimated to be 1,456 thousand dam^3 by 2060 – an increase of approximately 56.6% over the 2010 level. Relative to a baseline scenario, water conservation could reduce anthropogenic water demand by 14% of the baseline estimate in 2060 (Table ES.4). Much of this decrease would likely occur through reductions in agricultural, industrial, and mining water demands.

Table ES.3: Water Demand under Water Conservation Scenario In Saskatchewan River Basins, 2010-2060

Sector	Amount of Water Demanded in dam^3			
	2010	**2020**	**2040**	**2060**
Agriculture	656,062	658,820	939,304	1,143,091
Industry/Mining	106,647	193,659	132,296	122,446
Municipal (Domestic)	166,916	168,943	178,395	190,216
Recreational	635	680	741	781
Total Direct Anthropogenic Water Demand	**930,260**	**1,022,102**	**1,250,736**	**1,456,534**
Indirect Anthropogenic Water Demand	3,241,696	3,241,696	3,241,696	3,241,696
Total Water Demand	**4,171,956**	**4,263,798**	**4,492,432**	**4,698,230**
% Increase in Direct Anthropogenic Water Demand Over 2010		9.9%	34.5%	56.6%
% Increase in Total Water Demand Over 2010		2.2%	7.7%	12.6%
Hydroelectric Power Generation Water Release	5,337,220	5,337,220	6,627,081	6,627,081

Table ES.4: Relative Change in Water Demand in Saskatchewan River Basins by Type of Demand under the Water Conservation Scenario Relative to Baseline, 2060

Type of Demand	Change (Decrease) in 2060 level % of 2010 Level
Agriculture	-14.3%
Industry/Mining	-20.1%
Municipal (Domestic and industrial)	-7.9%
Recreational	-4.6%

Total Direct Anthropogenic Water Demand	-14.0%

Water Demand by Source of Water

Most of the water for various types of demands is either obtained from surface water or groundwater. In some cases, groundwater is used to supplement any periodic shortfalls in surface water availability. Unfortunately, the existing data for total water demand by source of water is not very precise. Some exact information is available, but other estimates are based on assumptions. The estimated water demand by type is shown in Table ES.5. Based on these estimates, it appears likely that surface water demand will increase at a faster rate than that of groundwater. The proportion of surface water demand to total water demand increases from 86.5% in 2010 to 93.5% by 2060, as shown in Figure ES.4.

Table ES.5: Distribution of Total Direct Anthropogenic Within Basin Water Demand by Source of Water Saskatchewan River Basins, Baseline Scenario, 2010 - 2060

Particulars	2010	2020	2040	2060
Surface Water (dam^3)	804,612	963,987	1,304,074	1,584,467
Groundwater (dam^3)	125,648	121,754	112,362	109,505
Total Water Demand	**930,260**	**1,085,741**	**1,416,436**	**1,693,972**
Groundwater % of Total Demand	86.5%	88.8%	92.1%	93.5%

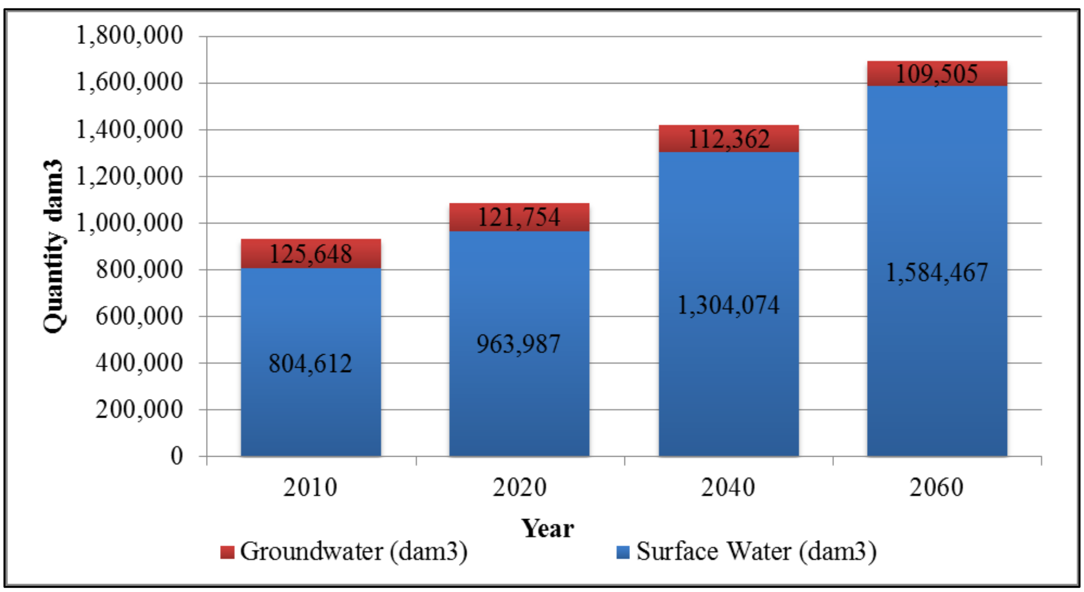


Figure ES.4: Proportion of Surface Water Demand to Total Direct Anthropogenic Water Demand, Saskatchewan River Basins, 2010 - 2060

Summary

Major increases in the water demand for various anthropogenic purposes are expected in Saskatchewan River Basins by 2060. These changes for the three scenarios over the 2010 - 2060 period are shown in Figure ES.5.

Under baseline assumptions, this increase may be as high as 80.1% of the 2010 level. Under climate change conditions, further increases would be expected, perhaps reaching 19.9% above the 2060 baseline water demand level. The adoption of water conservation measures by water-using sectors has the potential to reduce future water demand. Relative to the baseline scenario estimate, this reduction could be in the magnitude of 14%. However, the possible effectiveness of such measures depends very much on the policy measures undertaken by the provincial government and by other jurisdictions.

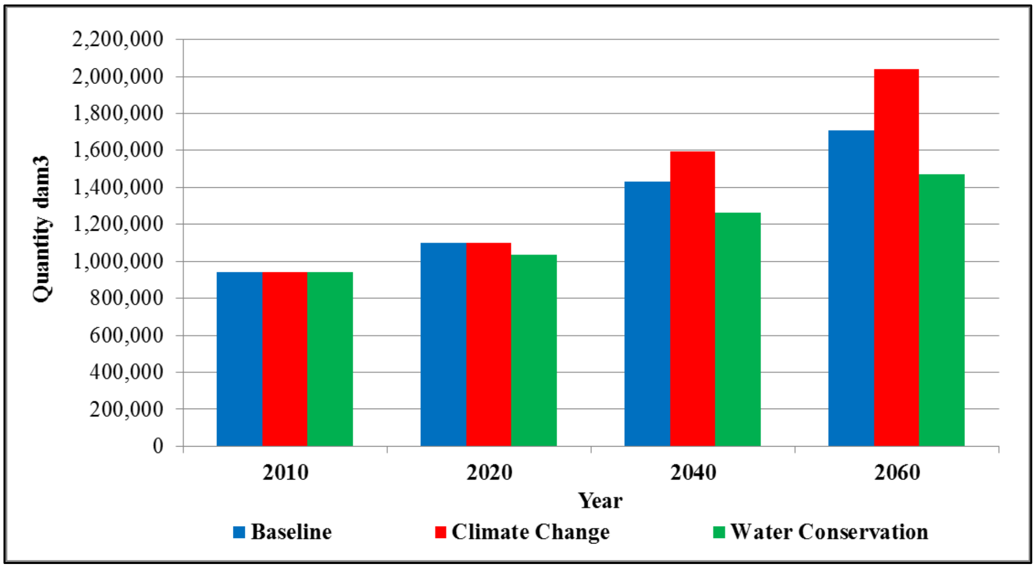


Figure ES.5: Direct Anthropogenic Water Demand under Alternate Study Scenarios in dam^3, Saskatchewan River Basins, 2020, 2040, and 2060

A need for water conservation measures, including the use of economic instruments, has been suggested by the National Roundtable on Economy and Environment. The Roundtable also states, "Recognizing that accurate water forecasting requires improving how we measure and report water-quantity data, governments and industry should work collaboratively to develop appropriate measurement and reporting requirements on a sector-by-sector basis" (NRTEE, 2012).

This study exhibits a few limitations, and there are several data deficiencies related to factors that affect water demand. Moreover, the impact of climate change on the basin's water demand is a relatively unstudied subject. Water conservation experience also suffers from a similar deficiency. Also, this study treated each river basin as a single entity, but significant variability in the water demand may exist within the basin. Identification of these water stress pockets needs to be done in conjunction with water supply information under alternative scenarios.

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List of Acronyms Used

AAFC	Agriculture and Agri-Food Canada
ARB	Assiniboine River Basin
BC	British Columbia
CFB	Canadian Forces Base
CHB	Cypress Hills (North Slope) Basin
CIBC	Canadian Imperial Bank of Commerce
CMHC	Canadian Mortgage and Housing Corporation
CPRC	Canadian Plains Research Center
ES	Executive Summary
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IBT	Interbasin Transfer
ICDC	Irrigation Crop Diversification Corporation
ICWE	International Conference on Water and the Environment
IPCC	Intergovernmental Panel on Climate Change
IPSCO	Interprovincial Steel and Pipe Corporation
LWB	Lake Winnipegosis Basin
MAA	Master Agreement for Apportionment
MG	Mega (Million) Watts
ML	Mega (Million) Liters
MRB	Missouri River Basin
NRTEE	National Roundtable on Environment and Economy
NRB	Northern (Four) River Basins

NS	Nova Scotia
NSRB	North Saskatchewan River Basin
OWLB	Old Wives Lake Basin
QRB	Qu'Appelle River Basin
PPWB	Prairie Provinces Water Board
SKRB	Saskatchewan River Basin
SIPA	Saskatchewan Irrigation Projects Association
SRB	Souris River Basin
SSRB	South Saskatchewan River Basin
SWA	Saskatchewan Watershed Authority
USGS	United States Geological Service

Chapter 1

Introduction

1.1 Background

Historically, human civilizations have flourished by situating themselves close to water ways. Access to water was an important ingredient for food security, human survival, growth of cities, and socio-economic activities. Fresh water thus plays a vital role in supporting our economic activity and in maintaining our culture. It is also an essential element in the broad functioning of economic activities and social activities in general. Although a common myth is that Canada is fortunate to have plentiful freshwater resources, in reality there is a mismatch. Most of the water is available in northern regions of the country where low or no population resides. The more heavily populated areas of southern Canada have a relatively low availability of water, and this situation creates an increased need for effective water management.

In Saskatchewan, the situation is very similar to that of Canada in its entirety. There are several large water bodies (lakes and rivers) in the northern part of the province. However, much of the economic activity is located in the southern part of the province, where water resources are almost fully utilized. Therefore, parts of southern Saskatchewan face high competition for available water.

As an important natural resource, water is used for various purposes. In some cases, water is withdrawn, used for socio-economic activities, recirculated, and then returned to the original water source. In other cases, although water is not removed from its natural water body, its presence facilitates several types of social-economic activities. In recent times, there has been increasing controversy and competition among various water use sectors as supplies are no longer meeting demands in some locations. This situation could be accentuated by future climate changes, since an increased need for water for irrigation could occur. Economic development activities would also assert the same type of pressure on existing water supplies.

One of the goals of the Saskatchewan Watershed Authority is “To Sustain Economic Growth – working to ensure a sustainable water supply, including allocation of surface and groundwater, delivering water conservation programming and operating and rehabilitating water management infrastructure” (SWA, 2012). This management involves a combination of both surface and groundwater resources in the province. However, groundwater is a buried treasure (Nowlan, 2005), and data and information on it remains very scarce (Rivera, 2005). In our province, surface water is more commonly used.

1.2 Water Management Issues

Water is a limited resource globally, but in semi-arid regions, such as in parts of Saskatchewan, this problem is even more acute. At the same time, society is getting more concerned about water quality and environmental issues in general; people are often particularly worried about issues related to water. In the past, the major concern in water management was water availability. To assist with this, many traditional steps have been taken, including additional storage of water, reducing variability of river flows, and redirecting and utilizing groundwater flows (Cohen et al., 2004). As sources for supply enhancement dwindle, water resource management is now leaning towards demand management.

In the past decades, policies have been focused on supply management, but the recent transition from water-supply management to water-demand management endeavours to strike a balance between supply and demand in order to ensure efficient use of water. Studies have shown that with the past and present trends in competition for water by various economic sectors in different locations, water demand will continue to increase as population increases and other alternative demands of water emerge. This study is relevant in the context of appropriate policy and planning on water supply and demand by policy makers. It is appropriate that these policies should be built on a better understanding of past and present trends of water consumption, climate change, population dynamics, migration, and changes in socioeconomic and demographic characteristics of water consumers. Researching these elements is important, for the development of appropriate policies and programs requires good information on the current level of water use by different users (Kulshreshtha, 1996). This study is therefore relevant for future planning and management of water supply systems in western Canada.

Demand management involves ways and means to reduce wasteful water use. These measures are needed, since in some regions available freshwater is inadequate for the local demand, and diverting it from other regions is replete with economic and political problems. Similarly in some areas, facilities to treat, distribute, and discharge water may not be adequate to meet expanding demand. In fact, a Saskatchewan Water Corporation survey was conducted in 1994; of the 597 communities responding to the survey, 172 indicated that water supply is a constraint to their future economic growth (Kulshreshtha, 1994). Miller et al. (2000) also suggest that rural water resources are certainly stressed in many ways that affect rural development; it is now, and will continue to be, limited by a wide variety of water issues.

Contamination of freshwater bodies is another problem in several parts of Saskatchewan. Run-off from farm land and nutrient loadings as a result of intensive agricultural practices lead to further water quality deterioration for specific demands that require purity. This difficulty further reduces water availability (both surface water and groundwater).

In addition to above issues, future water availability may also be affected by climate change. The Intergovernmental Panel on Climate Change (IPCC) has indicated that among the most important impacts of climate change will be its effect on the hydrologic cycle and on water management systems (Ayibotele, 1992). For the Canadian prairies, Byrne et al. (2010) state that "much of the western half of the continent is showing historical trends that suggest an increasing influence of the dry tropical climate``. Consequently we can expect negative impacts on all watersheds originating in the Rocky Mountains and on the western Prairies". Similar conclusions have been reported by Whitefield et al. (2004). At the same time, demand for water is expected to increase with climate change, presenting a situation of conflict among water using sectors. Resolving conflicts in water resources through proper demand management (use of appropriate economic, legal, and institutional mechanisms) has been proposed by the Dublin Statement in 1992 (See ICWE, 1992).

Demand management has been recognized as a manner in which future water management should be considered along with traditionally used supply enhancement. Water demand management, according to Brooks and Peters (1988), is defined as "any measure that reduces average or peak water withdrawals from surface or groundwater sources without increasing the extent to which wastewater is degraded". The starting point in this process is knowledge of current water demand. However, in order to develop sustainable water management, information on the future is equally important. As the NRTEE (2012) has indicated that the "Governments should develop new predictive tools such as water forecasting to improve their understanding of where and when water demands might increase. The information provided by forecasts will be important to inform water allocations and management strategies in the future".

For management of water, Saskatchewan is divided into five water management regions under the Saskatchewan Watershed Authority.[1] They manage water resources in 26 watersheds,[2] which are combined into 14 river basins.[3] Each of these river basins, being situated in different agro-climate zones, have different types of land use, population, and resulting water demand; they face different magnitudes of competition for water. Knowledge of how this completion would shape up in the future requires information on both aspects -- demand for water, as well as its availability. In this study, such information is prepared for the water demand aspect.

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[1] These regions correspond to five Saskatchewan Watershed Authority (SWA) regional offices – South-east, South-west, East-central, North-east, and North-west.

[2] A watershed is a region of land that drains into a given body of surface water, such as a lake, river, sea, or ocean. These bodies of water receive all run-offs from this area.

[3] A map of Saskatchewan water sheds and correspondence between watershed and river basins is shown in Appendix A.

1.3 Objectives and Scope of the Study

This study was designed to estimate water demand in various river basins of Saskatchewan. It includes results for all 14 river basins, but the four northern river basins (Kasba Lake Basin, Tazin River Basin, Lake Athabasca Basin, and Churchill River Basin) were combined into a single basin for the presentation of results on water demand. Water demand estimates are developed both for the current period (Year 2010) as well as for future time periods (Years 2020, 2040, and 2060). The estimation is done using a disaggregated approach to water demand. Various water demands were classified into consumptive and non-consumptive water. Within these types, individual water using activities were identified and estimates of water demand made. In addition, water demand patterns were also investigated under two sets of assumptions, called scenarios: (1) that climate change has occurred. This would have an effect on the requirements for various economic activities; and (2) that water users have adopted water conservation practices. These results compared to those calculated under the baseline scenario – scenario under which there is neither climate change nor any adoption of water conservation practices.

1.4 Organization of the Report

The rest of this report is divided into 10 chapters. Chapter 2 provides an overview of the Saskatchewan economy, its regional breakdown, and some socio-economic features relevant to water demand. This background information is followed in Chapter 3 by a brief discussion of the study methodology, including identification of water demand sectors and various activities, along with a summary of methods for estimating both future and current water demand in the basins. All current and future water demand estimates for the three study scenarios by various sectors are provided in specific chapters thereafter: Chapter 4 for agricultural water demand, Chapter 5 for industrial/mining water demand, Chapter 6 for municipal/domestic water demand, and Chapter 7 for recreational water demand. Chapter 8 includes water demand for indirect anthropogenic demands. A summary of all water demands is provided in Chapter 9.

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Chapter 2

Trends in Saskatchewan Economy

Water demand is influenced by many factors, including the economic activity of an area, the state of technology, and the social perception of water availability, as well as various levels of government policies and regulations that govern allocation and quality aspects of water use (PPWB, 1982). In this chapter, some of these factors are reviewed with a perspective limited to economic and social factors that affect water demand in the province.

2.1 Introduction

Saskatchewan is located in the prairie grass eco-region in the south; the boreal forest eco-region and the tundra ecozone[4] constitute the northern part of the province. This limits certain economic activities, such as agriculture to the southern part of the province.

Saskatchewan is a landlocked region, with Alberta to the west and Manitoba to the east. It is bounded by the international border with the United States of America at the 49th parallel, and by the Northwest Territories on the north at the 60th parallel. Its land base is 140.878 million acres, with a population estimated at 1.072 million as of April 1 2012.[5] The province had a stagnant population, which in recent years has started to show signs of growth (Figure 2.1).

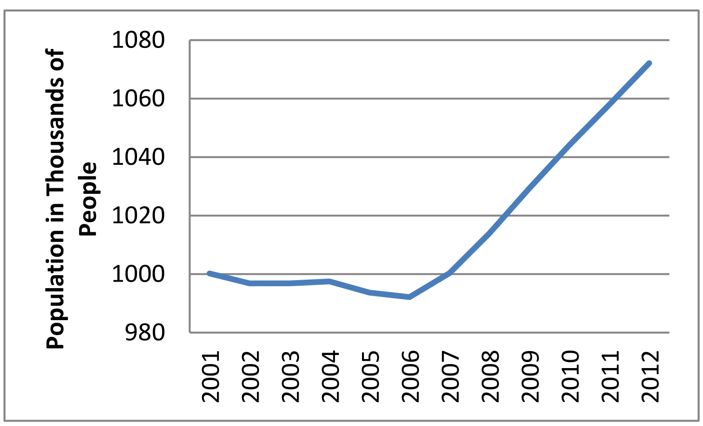

Figure 2.1: Population of Saskatchewan, 2001 – 2012

[4] An ecozone is defined as a spatial unit that describes particular biophysical features and underlying relationships, to illustrate the regional variety of physical environments (CPRC, 2005).

[5] Data obtained from Saskatchewan Bureau of Statistics (2012).

The population growth in recent years is reflected in the economic growth of the province. For example, Saskatchewan's real GDP grew by 4.2% in 2010, the second highest in Canada. Total GDP of Saskatchewan in 2007 was estimated at $48 billion, which is on a per capita basis $47,995. Even though Saskatchewan is being perceived as the granary province of the nation, the diversification of its economy resulted in the agricultural sector (along with forestry, fishing, and hunting sectors) accounting for only 6% of the GDP. Mining, oil and gas is one of the sectors that have constantly expanded over the last period, and it currently represents 25% of the provincial GDP. Table 2.1 presents the contribution to GDP of major industry groups in Saskatchewan, and Figure 2.2 depicts their respective shares. Primary industries constitute 39% of the total provincial GDP.

Table 2.1: Contribution of Major Industry Groups in Saskatchewan, 2007*

Sector	Gross Domestic product in Million Dollars
Agriculture, Forestry, Fishing, and Hunting	$2,841
Mining, Oil and gas Production	$11,845
Utilities	$1,093
Construction	$3,038
Manufacturing	$3,021
Wholesale Trade	$2,754
Retail Trade	$2,275
Transportation and Warehousing	$2,527
Finance, Insurance and Real Estate	$6,454
Business Services**	$2,474
Educational Services	$2,187
Health Services	$2,917
Accommodation and Food Services	$846
Other Services	$1,464
Public Administration	$2,366
Total Provincial Gross Domestic production in Market Prices**	$48,099

* Although 2008 data are available, there was a discrepancy in total gross domestic product for that year. It did not add up to the total shown by the Saskatchewan Bureau of Statistics. For this reason, 2007 data are presented.

** Includes: Information, Cultural, Professional, Scientific, Technical, Administrative and Support, Waste Management, and Remediation Services.

Source: Saskatchewan Bureau of Statistics (2012).

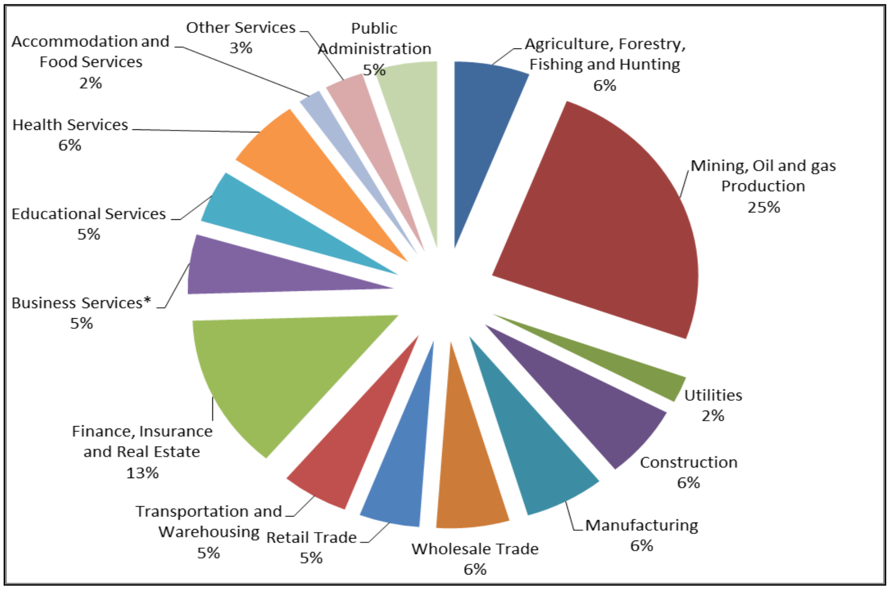

Figure 2.2: Contribution of Economic Sectors to Saskatchewan Gross Domestic Product, 2007

2.2 Location of the Study River Basins

All the water resources in Saskatchewan are divided into 14 river basins. They are shown in Figure 2.3. There is relatively a smaller level of economic activity in the northern part of the province. For this reason, four northern river basins were combined into a new aggregated river basin called the Northern River Basin. These basins are: Churchill River Basin, Athabasca River Basin, Kasba Lake Basin, and Tazin River Basin. For all estimation purposes, these four basins were treated as a single entity. The remaining ten basins were treated as a single region. Water demand estimated for all these basins have been presented in four reports.[6] This report is simply a summary of all these water demand estimates, aggregated to the provincial level. Details are provided by river basins for water demand by major economic sectors. More sub-sectoral details on the water demand are provided in other reports.[7]

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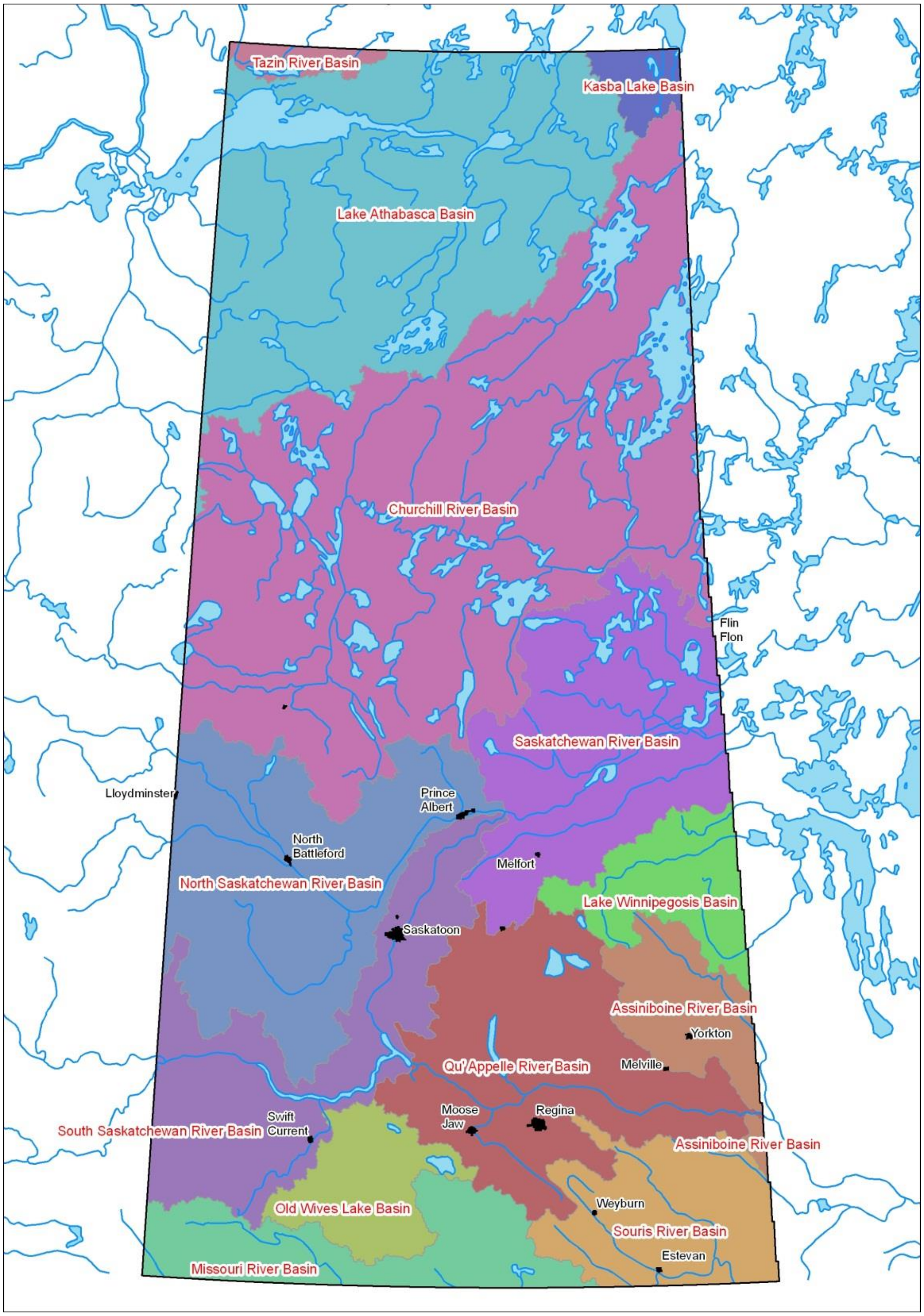
[6] It should be noted that each of these eleven basins have been examined in details in previous reports (see the above three reports plus Rest of Saskatchewan, see Kulshreshtha et al. (2012d).

[7] As noted above, these details are shown in Kulshreshtha et al. (2012a) for the Qu'Appelle River Basin, in Kulshreshtha et al. (2012b) for the South Saskatchewan River Basin, in Kulshreshtha et al. (2012c), and in Kulshreshtha et al. (2012d) for the remaining eight river basins.



Source: SWA (2012).

Figure 2.3: Map of Saskatchewan Showing Major River Basins

2.3 Physical Features of the River Basins

Saskatchewan contains a diverse geography, as both the Great Plains and Canadian Shield are the underlying basis for the location of the population and economic activity. The potash, uranium, and fossil fuel extraction sectors occupy areas of the province where deposits can be economically extracted. The Northern Basins comprise 44% of the area of Saskatchewan, as shown in Table 2.2, containing most of the evergreen and deciduous forest in the province (87% and 97% respectively). This area transitions from the Great Plains in the Southwest to the Canadian Shield where the Saskatchewan uranium industry is located. By contrast, most agricultural activity is located in the southern half of the province.

Table 2.2: Area of Saskatchewan River Basins

Basin	Acronym	Area of the Basin in Sq. km
Assiniboine	ARB	17,300
Cypress Hills	CHB	7,735
Lake Winnipegosis	LWB	18,711
Missouri	MRB	17,000
North Saskatchewan	NSRB	122,169
Northern Four	NRB	310,804
Old Wives	OWLB	22,500
Qu'Appelle	QRB	74,589
Saskatchewan	SKRB	54,129
Souris	SRB	20,400
South Saskatchewan	SSRB	27,265
Total[1]		**692,602**

[1] The above areas were obtained from various published sources and are based on some estimation on the part of the reporting agency. The total area adds up to 171.14 million acres, which is higher than 140.8 million acres reported by SAFRR (2003).

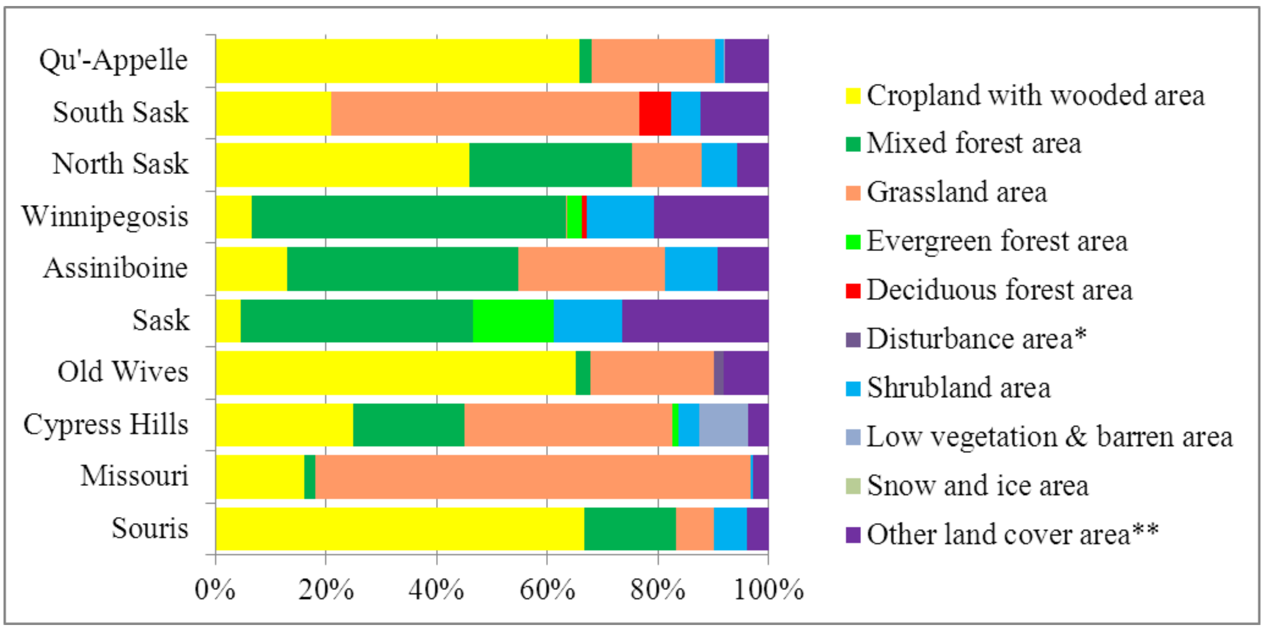
Land use of various river basins of Saskatchewan is shown in Table 2.3. Cropland is the dominant land cover in all southern basins, particularly in the Souris River Basin, Old Wives Lake Basin, North and South Saskatchewan River Basins, and Qu'Appelle River Basin. There is hardly any agriculture in the Northern Basins (0.1% of provincial total).

The types of crops grown are affected by the climate of the basin, for the semiarid southwest of the province transforms into the moist black soils of the north and eastern parts of the grain belt. Grassland is the second major land cover in the Missouri, Cypress Hills, Assiniboine, and South Saskatchewan Basins. As a result, cow-calf and mixed farming operations are typical in these basins. Figure 2.4 shows the land coverage in Saskatchewan by river basins.

Table 2.3: Land Cover by Type of Land Use in Saskatchewan River Basins, 2010

Land Cover	Souris	Missouri	Cypress Hills	Old Wives	Sask	Assini-boine	Winnipe-gosis	Northern	North Sask	South Sask	Qu'-Appelle
	Percent of Saskatchewan Total										
Total area	2.9%	2.4%	1.1%	3.2%	7.7%	2.5%	2.7%	44.4%	17.4%	5.0%	10.7%
Evergreen forest area	0.0%	0.0%	0.1%	0.0%	12.2%	0.0%	1.0%	86.7%	0.0%	0.0%	0.0%
Deciduous forest area	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	97.4%	0.0%	2.2%	0.0%
Mixed forest area	1.7%	0.4%	1.6%	0.3%	35.1%	11.2%	21.7%	2.8%	24.5%	0.0%	0.8%
Disturbance area*	0.0%	0.0%	0.0%	0.2%	0.0%	0.0%	0.0%	99.8%	0.0%	0.0%	0.0%
Shrubland area	0.6%	0.1%	0.3%	0.0%	10.4%	2.5%	4.7%	73.5%	5.3%	2.0%	0.6%
Grassland area	0.7%	16.6%	3.0%	2.5%	0.1%	7.1%	0.1%	29.8%	10.5%	21.2%	8.2%
Low vegetation & barren area	0.0%	0.0%	0.7%	0.0%	0.0%	0.0%	0.0%	99.1%	0.0%	0.0%	0.1%
Cropland with wooded area	6.8%	3.4%	2.0%	7.3%	3.9%	3.5%	2.5%	0.1%	38.1%	8.0%	24.3%
Snow and ice area	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%
Other land cover area**	0.4%	0.6%	0.3%	0.9%	22.1%	2.5%	7.9%	53.0%	4.7%	4.7%	2.9%

* "Disturbance" refers to forest disturbance, which can be caused by changes in forest structure or composition resulting from natural events such as fire, flood, or wind; mortality caused by insect or disease outbreaks; or human-caused events such as forest harvesting.



** This area includes water, settlements, low vegetation, and barren lands.

Figure 2.4: Land Cover in Saskatchewan by River Basins, 2010

2.4 Current Population Distribution

Saskatchewan's population[8] was 1,105,041 in 2010, and it increased by nearly 11.6% in comparison to 1995.[9] The total provincial population lives in a variety of communities. In this study, they were classified into several types of communities as shown in Figure 2.5. The first distinction was made between rural and urban population, each of which has several types of communities. Urban population included cities, towns, and bedroom communities near large urban centers. Similarly, the rural population included those living in villages, open non-farm areas, and on farms. In addition, First Nations' Reserves, resort villages, and institutions were identified as separate categories.

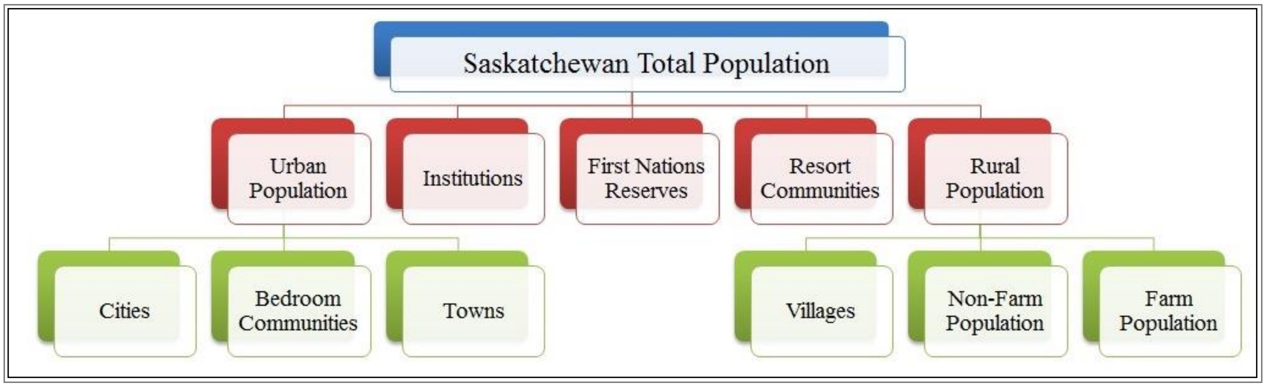


Figure 2.5: Classification of Saskatchewan Population by Type of Communities

Table 2.4 shows the population distribution by communities. The province has followed an urbanization trend, with large urban centers' increases and rural communities' declines. Currently more than half of Saskatchewan's population resides in cities. In fact, three quarters of the population lives in urban communities, such as cities, towns, and bedroom communities. Rural communities have decreased since 1995, currently accounting for 20% of the province's population. Inhabitants of the First Nations' Reserves account for only 5% of the population, even though their growth rate over the years was one of the highest. Figure 2.6 shows the distribution of Saskatchewan's population by community.

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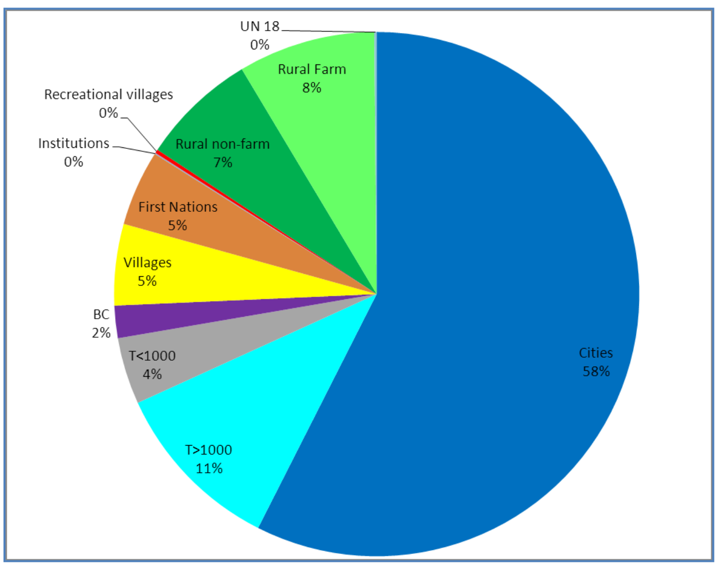
[8] This population is as reported by Statistics Canada. This estimate differs from that by the Saskatchewan Bureau of Statistics (2012), which reported a population of 1,072,082 people living in the province on April 1, 2012.

[9] This value is not strictly comparable, since the total population is for 1996 and not 1995.

Table 2.4: Saskatchewan Population by Type of Communities, 1995 and 2010

Water distribution System	Category	Population		2010 Change as % of 1995
		1995*	2010**	
Municipal	Cities	570,061	634,937	11.4%
	Sub-Total	**570,061**	**634,937**	**11.4%**
Domestic	Towns > 1000	111,418	118,598	6.4%
	Towns < 1000	42,138	45,428	7.8%
	Bed Room Communities	11,944	22,097	85.0%
	Sub-Total	**165,500**	**186,123**	**12.5%**
Rural	Villages	60,789	55,414	-8.8%
	Rural non-farm (Note 1)	183,902	78,865	--
	Rural farm		93,214	--
	Recreational / Resort Villages	413	2,500	505.3%
	Sub-Total	**245,104**	**229,993**	**-6.2%**
Others	First Nations	7,118	51,547	624.2%
	Institutions	701	800	14.1%
	Unorganized Division	1,753	1,641	-6.4%
	Sub-total	**9,572**	**53,988**	**464.0%**
Total Provincial Population		**990,237#**	**1,105,041**	**11.6%**

Note 1: For 1995, these populations were not available for individual categories.
* Source: SWA (2010a)
** Based on SWA (2011) and Statistics Canada (2012)
*** Excludes farm and rural non-farm population
# Refers to 1996 population reported by (SAFRR, 2003)



BC = Bedroom communities; T>1000 = Towns over 1000 people;
T<1000 = Town with less than 1000 people

Figure 2.6: Distribution of Saskatchewan Population by Type of Communities, 2010

Table 2.5 shows the population distribution by each river basin. In comparison to 1995, all basins recorded increases in terms of population. The most significant growth rates were encountered in the Northern River Basins (combined four basins), followed by Cypress Hills, North Saskatchewan, and Saskatchewan River Basins. Much of the growth in the Northern Basins can be attributed to the growth in First Nations' population in the province.

Table 2.5: Population of Saskatchewan River Basins for 1995 and 2010

Basin	**Population**			**2010* Change as % of 1995***
	1995*	**2010***	**2010****	
Qu'Appelle	270,863	293,593	328,285	8.4%
South Saskatchewan	270,697	284,642	309,629	5.2%
North Saskatchewan	112,722	155,231	197,384	37.7%
Souris	38,071	43,617	57,741	14.6%
Missouri	3,020	3,355	7,873	11.1%
Cypress Hills	4,006	5,530	9,205	38.0%
Old Wives	10,560	10,675	19,161	1.1%
Saskatchewan	25,440	34,327	48,294	34.9%
Assiniboine	36,000	42,510	54,505	18.1%
Lake Winnipegosis	6,411	8,212	14,685	28.1%
Northern	28,545	51,270	58,279	79.6%
Total	**806,335**	**932,962**	**1,105,041**	**15.7%**

* Excluding rural non-farm and rural farm population for comparison purposes, since this population could not be estimated.
****** Including rural non-farm and rural farm population

The distribution of Saskatchewan's population by river basins delimits three basin categories: **(1) Larger Basins**: North Saskatchewan, Qu'Appelle, and South Saskatchewan Watersheds, housing 18%, 30%, and 28% of the province's population as shown in Figure 2.4; **(2) Medium Size Basins:** Assiniboine, Churchill, Saskatchewan, and Souris River Basins; and **(3) Smaller Basins:** Athabasca, Cypress Hills North Slope, Kasba (no population records), Old Wives, Tazin (no population records), and Lake Winnipegosis Basin.

2.5 Major Economic Activities

A number of economic activities are pursued in Saskatchewan. Major goods- and services-producing economic activities in the basin are related to agricultural production, mining, and manufacturing, plus power generation. These activities are described further in this section.

2.5.1 Agriculture

Agriculture is one of the key goods-producing industries. Most of the land use in the province is agricultural, with approximately 32% of the land base devoted to such activities. As well, as large number of people depend on agriculture directly or indirectly on related industries.[10] In 2011, agriculture employed 39,500 workers directly and had a value of production of $120.9 billion.

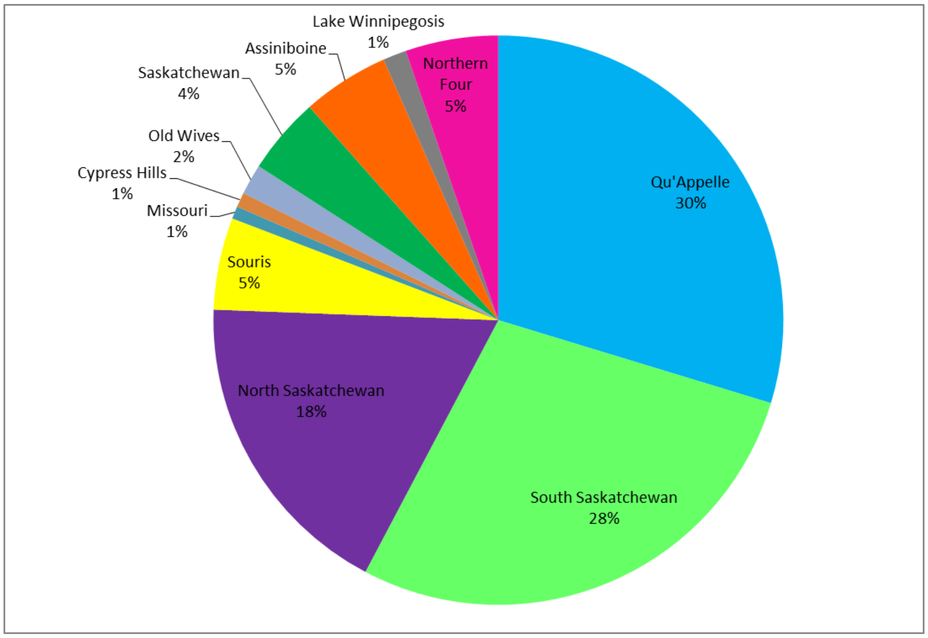


Figure 2.7: Distribution of Saskatchewan Population by River Basin, 2010

In Saskatchewan, currently (in 2010) there were 36,952 farms with an average size of 1,668 acres; a total of 61.5 million acres is occupied by farms (Table 2.6). A decline of nearly 17% was recorded over the 2006 levels in farm numbers, concomitant with an increase in the average farm size. Over the past half-century, there has been a consistent trend towards farm consolidation, resulting in a smaller number of farms (Figure 2.8). Over the last few decades, the provincial trend has been to shift agricultural production from small farms towards larger ones.

The total farm area is used for crop and livestock enterprises, as well as for other specialty enterprises (greenhouses and orchards). As shown in Figure 2.9, 65% of this area is devoted to

[10] For example, Kulshreshtha and Thompson (2005) observe that, although direct contribution of agriculture to total provincial gross domestic product was only 4.2%, total (direct, indirect and induced) impact was estimated at 16.6% of the total GDP. Similarly for employment, agriculture provided 11.6% of employment directly, but 26.9% through direct, indirect, and induced activities in the province. These data are based on averages of the 1998-2003 period.

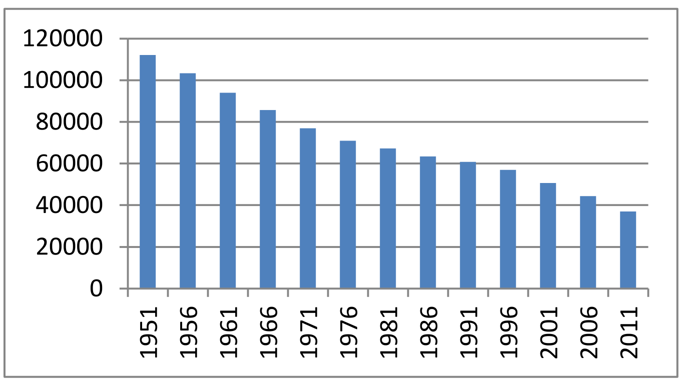
crops (called cropland), which includes some area for livestock forage. However, there is 8% of the total area devoted to seeded pastures. In addition, there is also 19% of the area for the native pastures. All these land uses are in support of livestock enterprises. The province has all types of livestock and poultry enterprises.

Table 2.6: Agricultural Activities in Saskatchewan River Basins, 2006 and 2010

Particulars	Value for 2010*
Number of Farms	36,952
Total Area of Farms (Acres)	61,529,240
Average Size of the farm (Acres)	1,668
Crop Production Activities	
Land in Crops (Acres)	36,324,490
Tame Hay or Seeded Pasture (Acres)	5,400,000
Natural Land for Pasture (Acres)	11,861,100
Other Land (Acres)	4,695,000
Irrigated Area (Acres)	342,064
% Zero Tillage	
Livestock Production Activities	
Cattle and Calves	3,016,000
Dairy (cows and Heifers)	44,000
Hogs	825,000
Sheep	114,500
Other Livestock	
Broilers	25,749,000
Eggs (# of Layers)	28,154,000
Turkeys	847,000

* Ministry of Agriculture census values 2011

Sources: Statistics Canada (2006); Statistics Canada (2009) and Saskatchewan Ministry of Agriculture (2011b)



Note: The LHD axis is no. of farms.

Figure 2.8: Number of Farms in Saskatchewan, 1951-2011

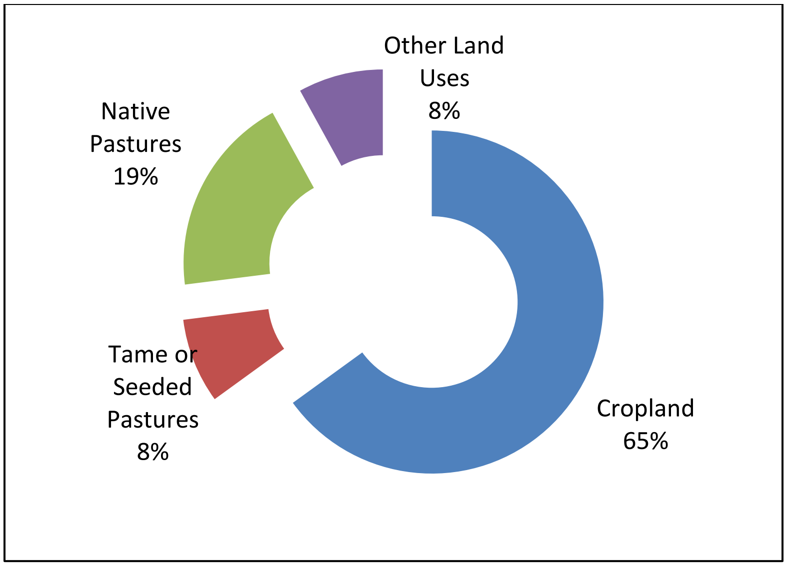


Figure 2.9: Land Use on Farms in Saskatchewan (All River Basins), 2010

In Saskatchewan, there are three river basins significant from the standpoint of agriculture: North Saskatchewan, Qu'Appelle, and South Saskatchewan River Basins. All together, they house 24,109 farms, representing 65% of the total; more than half (58%) of the provincial designated land base suitable for crops and related agricultural activities is located within these river basins.

2.5.2 Mining Activities

Saskatchewan is one of the significant national and international players in the mining sector. With abundant mineral resources, the province is one of the largest potash producer[11], and a leading uranium producer. The province also produces salt, coal, gold, silica sands, sodium sulphate, and other minerals. In 2011, the mining sector accounted for 13.4% of the provincial GDP. From mineral sale revenues, the province earned $21.8 billion in 2011, as shown in Table 2.7.

Uranium mining is a major activity in the Northern Basins, with four mines in production; the mine at Cigar Lake will be in production by 2020. Shown in Figure 2.10 (following Table 2.7 below) are the mining activities and their geographical distribution.

[11] According to Natural Resources Canada (2012), Canada has 46 percent of global potash reserves. A significant portion of these reserves are found in the Prairie Evaporite Deposit, which lies beneath the southern plains of Saskatchewan. Canada also produces 32 percent of the mineral's total global production, making it the world's largest potash producer and exporter. Most of these exports originate in Saskatchewan.

2.5.2.1 Potash Mining

The current production capacity of potash mines in Saskatchewan by mine location, water basin, and type of production process is presented in Table 2.8. Several operating mines have recently expanded capacity or are in the process of expanding production. Most of these mines, as shown later in Figure 2.11, are located in the Qu'Appelle and South Saskatchewan River Basins.

Table 2.7: Value of Mineral Sales by Type, Saskatchewan 2009-2011

Mineral Type	2009 (Mil $)	2010 (Mil $)	2011 (Mil $)
Uranium	1,260.4	x	x
Potash	3,067.0	5,582.5	6,853.0
Salt	27.8	28.6	30.3
Crude Oil	8,987.0	10,323.6	12,369.4
Natural Gas	745.3	638.5	491.1
Sand & Gravel	52.2	50.6	90.0
Others*	321.1	1,361.6	1,509.1
Total	**16,148.6**	**18,633.8**	**21,844.8**

X – Confidential

*Others includes Uranium in 2010 and 2011

Source: Saskatchewan Ministry of Energy and Resources (2011), NRCan (2011).

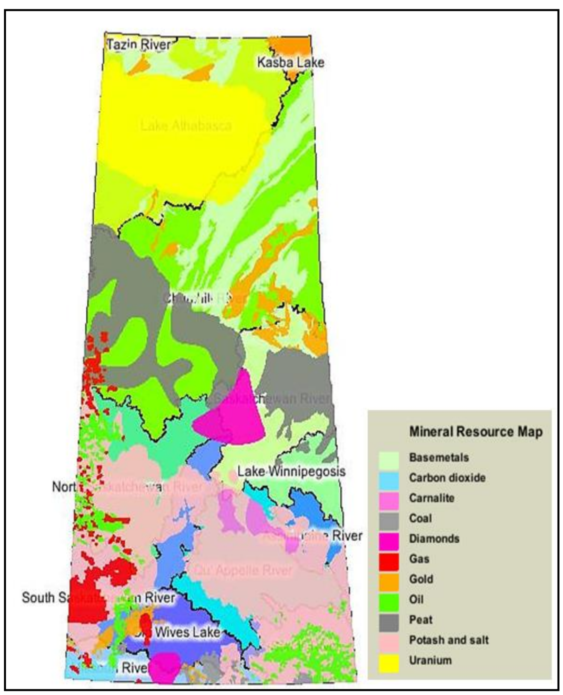
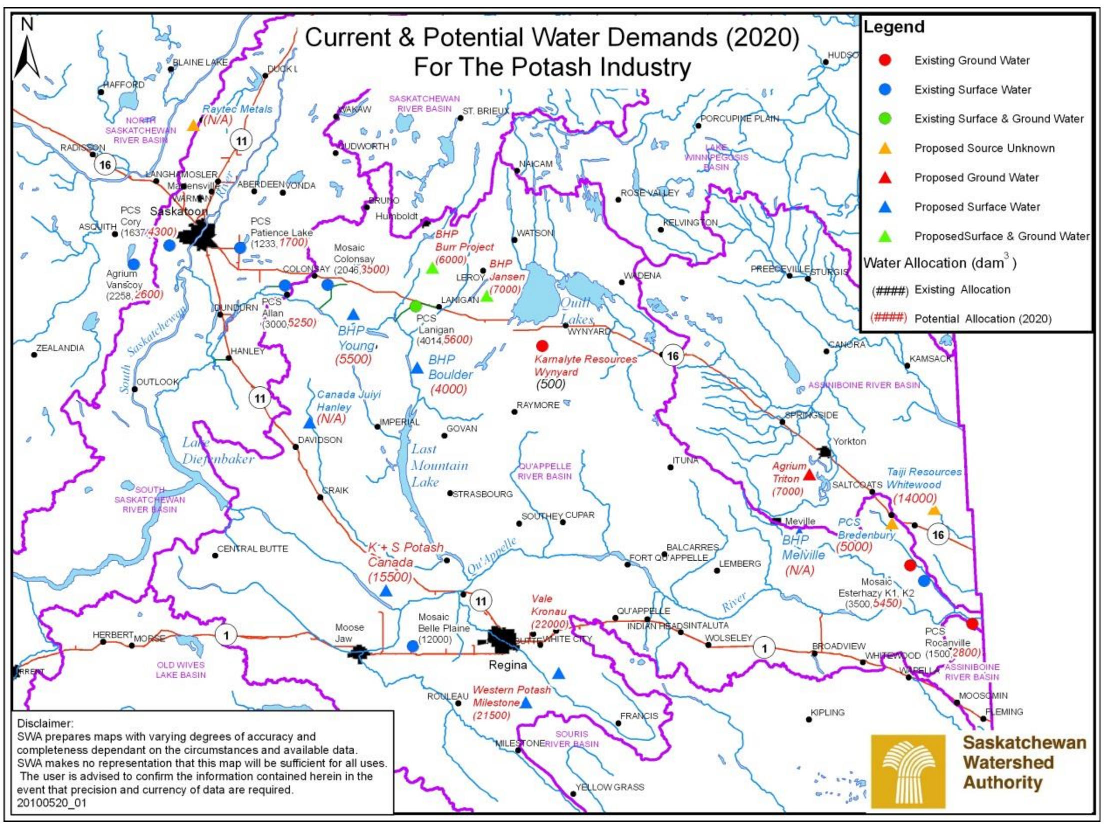


Figure 2.10: Saskatchewan Mineral Resource Map by River Basins

Table 2.8: Current Productive Capacity of Potash Mines

Corporation		River Basin	Technology Used	Current Capacity (,000 tonnes)
Potash Corp				
	Allan	South Sask	underground	1,900
	Lanigan	Qu'Appelle	underground	3,800
	Patience Lake	South Sask	solution	610
	Cory	South Sask	underground	2,000
	Rocanville	Assiniboine	underground	3,000
Agrium				
	Vanscoy	North Sask	underground	2,450
Mosaic				
	Esterhazy	Qu'Appelle	underground	5,300
	Belle Plain	Qu'Appelle	solution	2,900
	Colonsay	Qu'Appelle	underground	2,100
	Total			24,060

Source: CIBC 2008



Map courtesy of Saskatchewan Watershed Authority.

Figure 2.11: Map of Saskatchewan Selected River Basins Showing Location of Potash Mines

2.5.2.2 Oil and gas production

Saskatchewan is the second largest oil producer and the third largest natural gas producing province. With approximately 28,000 oil wells across the province producing 157.8 million barrels, Saskatchewan oil and gas sales totaled $12.8 billion in 2011. The provincial natural gas production was 6.2 billion m^3.

Oil and gas well drilling spans across most of the Saskatchewan River Basins. The Bakken formation is located in the southeast part of the province including the Assiniboine, Missouri, and Souris River Basins, with the latest being one of the most significant locations of oil production in the province. Currently, 64% of the horizontal and 39% of the vertical wells are located within this basin.

Other drilling activities are also taking place in the southwest, central and northwest parts of the province into the lower Shaunavon, Viking, Birdbear, and North Lloyd formations that are located within several river basins. Conventional technologies of vertical wells and water flooding, along with the new technology of horizontal well drilling and multi-stage frac are used to extract oil and natural gas from these formations. The advent of horizontal well technology and its successful application under Saskatchewan conditions has substantially increased the province’s oil and gas activity.

2.5.2.3 Metal Mining

Metal mining activities in Saskatchewan are located in the northern area of the province at Seebee. The gold mine is operated by Claude Resources, and the production in 2010 was approximately 14 tonnes.

In addition, the Saskatchewan River Basin has some exploratory mining activity. Exploration for diamonds in this basin has resulted in several proposed mines, with Shore Gold at Fort à la Corne developing a mine. It is assumed that similar types of mines will be developed over the forecast period of this water demand report, as average mine life falls into a 10-20 year range.

2.5.2.4 Non-Metal Mining

There are several non-metal mining activities in Saskatchewan. In the Qu’Appelle River Basin, salt from potash mine tailings at Belle Plaine and at Esterhazy are used in the production of various salt products.

Sifto Canada Ltd. operates a salt-producing mine at Unity, which is located in the North Saskatchewan River Basin, and there is a sodium sulphate mine in the Old Wives Lake Basin located at Chaplin.

2.5.2.5 Other Mining

Other mining activities in Saskatchewan include coal and diamond mining. Coal mining in the Missouri River Basin is mainly for supplying the needs of SaskPower's thermal power generation plant at Poplar River. The lignite coal production in this basin accounts for 30% of Saskatchewan production.

2.5.3 Forestry Water Demand

Although there are some forestry operations taking place in Saskatchewan, no separate record of water demand was found in the SWA database. For this reason, it was assumed that these operations obtain water from municipal systems. No estimates for this water demand sector were made.

2.5.4 Manufacturing Water Demand

In Saskatchewan, a large variety of manufactured goods are produced, most of which are exported both outside the province and the country. The food and beverage processing industry account for approximately 23% of total industrial goods sales, as shown in Table 2.9. Chemicals manufacturing generated $1,340 million in 2010. Chemical goods production in the province includes mostly fertilizers and herbicides, as well as chemicals for extracting and processing natural resources.

Table 2.9: Sales of Industrial Goods, Saskatchewan, 2010

Particulars	Annual Sales in Mill. $	Percentage of Total Sales
Chemical	1,340	12.3%
Food	2,468	22.6%
Machinery	1,158	10.6%
Fabricated Metal	598	5.5%
Wood Products	219	2.0%
Electrical Goods	184	1.7%
Non-metal Minerals	166	1.5%
Others	4,778	43.8%
Total	**10,911**	

Source: Saskatchewan Bureau of Statistics (2012b)

2.5.4.1 Current Manufacturing Activity

Manufacturing activities are located across Saskatchewan either in urban centres or in their close proximity. However, some manufacturers are also located outside these municipal water systems. A list of these manufacturers is provided in Table 2.10.

Table 2.10: Manufacturing Activity in Saskatchewan, by River Basin

River Basin	Type of Manufacturing	Product Produced	Location
AGRI-PROCESSING			
NSRB	North West Terminal Ltd	Ethanol	Unity
NSRB	Agrium Products Inc.	Ammonia	Vanscoy
NSRB	Husky Oil Ethanol	Ethanol	Lloydminster
NSRB	Prairie Malt	Malt	Biggar
SSRB	Cargill	Canola	Clavet
QRB	Pound-Maker Agventures Ltd.	Ethanol	Lanigan
QRB	Terra Grain Fuels Inc	Ethanol	Belle Plaine
QRB	YARA Inc (previously Saskferco)	Fertilizer	Belle Plaine
SRB	NorAmera BioEnergy Corporation	Ethanol	Weyburn
SKRB	Legumex Walker Inc.	Canola	Nipawin
REFINERIES			
NSRB	Canadian Crude Separators Inc.	Oil	Unity
NSRB	Husky Energy	Oil	Mervin
NSRB	Husky Oil Upgrader	Oil	Lloydminster
SSRB	Saskatchewan Ltd (Reynolds)	Oil	Lancer
QRB	Consumer Co-op Refineries	Gasoline	Regina
LIQUID NATURAL GAS STORAGE			
NSRB	BP Canada Energy Co.	Natural Gas	Kerrobert
NSRB	Trans Gas	Natural Gas	Landis
OTHER			
NSRB	Kohlruss Bros. Enterprises	Gravel	Lloydminster
NSRB	Nisbet Fire Control Centre	Fire Control	Prince Albert
NSRB	Wapawekka Lumber Ltd (CLOSED)	Lumber	Prince Albert
NSRB	Carrier Forest Products	Lumber	Prince Albert
NSRB	Prince Albert Forest Nursery	Nursery	Prince Albert
SSRB	AKZO (Chemical Man)	Chemicals	Saskatoon
SSRB	Allan Division	Chemicals	Allan
SSRB	ERCO Worldwide	Chemicals	Saskatoon
SSRB	United Chemical Company	Chemicals	Saskatoon
QRB	EVRAZ Inc (formerly IPSCO)	Steel products	Regina
QRB	Lilydale	Food	Wynyard
SRB		Cement	
ARB		Concrete	Yorkton
NRB	NorSask	Forest products	Meadow Lake

NSRB = North Saskatchewan River Basin; SSRB = South Saskatchewan River Basin; QRB = Qu'Appelle River Basin; SKRB = Saskatchewan River Basin; and ARB = Assiniboine River Basin

In the Qu'Appelle River Basin, three types of manufacturing activities exist where water is supplied from non-municipal sources. These include fuel (including ethanol) production and processing, fertilizer manufacture, steel milling, and food processing. Locations of these manufacturing firms and their production activities are shown in Table 2.10.

Other significant river basins for manufacturing activities are the South Saskatchewan and North Saskatchewan River Basins. In the South Saskatchewan River Basin, activities include a small size refinery, two agricultural processing plants, and four chemical plants that do not receive water from a given municipal water system.

The other significant river basin houses several manufacturing activities as well, such as a small refinery, the Heavy Oil Upgrader, enhanced oil recovery, three agricultural processing plants, and four forest products-related activities.

2.5.4.2 Induced Manufacturing Water Demand

In addition to expansion in existing industrial water demands, the basin may attract some other types of industrial water demands. These developments are hypothesized to be induced by either irrigation projects, or other related initiatives. SIPA (2008b) has suggested the following types of value-added building blocks for Saskatchewan, and they result from irrigation development:

- Beef livestock -- producing new heads of cattle and processing them in the province;
- Pork livestock -- producing and processing hogs;
- Dairy production coupled with additional dairy processing activity;
- Vegetable processing – particularly potato processing
- Energy – production of 20 million liters of ethanol annually

2.5.4.3 Power Generation Water Demand

Saskatchewan has an overall installed power generation capacity of 4,356 MW (Table 2.11). Most of the plants are owned and operated by SaskPower and span across the province. These plants are located in seven of the eleven river basins. The largest generation capacity is found in the Souris River Basin, followed by the South Saskatchewan River Basin, the North Saskatchewan River Basin, and the Missouri River Basin.

The power generation sector uses a mix of resources for production, but mainly coal (53.7%), natural gas (18.7%) and hydro (21.5%), as shown in Table 2.12. Water demand for hydroelectric power generation is non-consumptive in nature, as it is available to other users downstream. Wind energy- based power generation, as well as other types (such as solar) of power generation, does not require any water for generation of power. Water is needed primarily for coal and natural gas power generation.

Table 2.11: Power Generation Plants in Saskatchewan by Basin

River Basin and Generation Facility	Type of Fuel	Capacity in MW
Qu'Appelle Basin		
NRGreen Estlin Heat Recovery Project	Waste Heat	5
South Sask Basin		
Centennial Wind Power Facility	Wind	150
Cory Cogeneration Station	Natural Gas	228
Coteau Creek Hydroelectric Station	Water	186
Cypress Wind Power Facility	Wind	11
NRGreen Loreburn Heat Recovery Project	Waste Heat	5
Queen Elizabeth Power Station	Natural Gas	430
Success Power Station	Natural Gas	30
SunBridge Wind Power Project	Wind	11
North Sask Basin		
Ermine Power Station	Natural Gas	92
Landis Power Station	Natural Gas	79
Yellowhead Power Station	Natural Gas	138
NRGreen Kerrobert Heat Recovery Project	Waste Heat	5
Meridian Cogeneration Station	Natural Gas	210
North Battleford Energy Centre	Natural Gas	261
Northern Basins		
Charlot River Hydroelectric Station	Water	10
Island Falls Hydroelectric Station	Water	101
Meadow Lake Power Station	Natural Gas	44
Waterloo Hydroelectric Station	Water	8
Wellington Hydroelectric Station	Water	5
Souris River Basin		
Boundary Dam Power Station	Coal	828
Shand Power Station	Coal	276
NRGreen Alameda Heat Recovery Project	Waste Heat	5
Red Lilly Wind Project	Wind	27
Assiniboine River Basin		
Spy Hill Generating Facility	Natural Gas	86
Missouri River Basin		
Poplar River Power Station	Coal	582
Saskatchewan River Basin		
E.B. Campbell Hydroelectric Station	Water	288
Nipawin Hydroelectric Station	Water	255
Total Province of Saskatchewan		4,356

Table 2.12: Electrical Energy Generation in Saskatchewan by Type of Fuel Used, 2011

Supply	Sale of Electric Power in GWh	Percentage of Total Supply
Coal	11,614	53.7%
Gas	4,032	18.7%
Hydro	4,641	21.5%
Wind	682	3.2%
Imports	502	2.3%
Other	140	0.6%
Total Supply	**21,611**	**100.0%**

In the future, an estimated new capacity for Saskatchewan of 1,609 MW will be needed by 2020; by 2033, 2,159 MW will be required, along with replacement of or reinvestment in, the existing capacity to 2060 (SaskPower, 2011). Several different generation and conservation options could be used to meet the expected demand, given the cost structure of each option and the requirements to meet base and peak load demands. Since a large percentage of the population and economic activity is centered on Saskatoon and Regina, a generation capacity to meet electricity demands from within and outside these basins will likely be considered.

The replacement of major generation units and construction of new generating stations will likely be located within the basins near existing transmission lines. It is also likely that to 2020, the current generating capacity -- if replaced -- will be equipped with similar technology. At 2040 and certainly 2060, other generating options will be available that have different water demands or requirements than the incumbent technology.

The increased capacity, as forecast by SaskPower, is allocated to power generation by wind, co-generation, hydro, natural gas, waste heat, solar, BioMass, and nuclear. Commitments to reduce GHG emissions from fossil fuels, primarily coal, by using carbon capture and storage technology will reduce net electricity output while increasing water demand as extra cooling is required.

2.5.5 Communities' Water Demand

The population of Saskatchewan was estimated at 1,112,217 for 2010 and is expected to increase by approximately 32% by 2060, reaching a total of 1,465,726 people. As shown in Figure 2.12, an urbanization trend of the province's population over the forecast period can be noticed. Currently, almost 74% of Saskatchewan's population resides in urban centers, 21% in rural communities, and nearly 5% of the population is represented by First Nations' people living on reserves. By 2060, the distribution of Saskatchewan's population is expected to slightly change.

Urban population is projected to represent 79% of the total population, therefore increasing its share by 5%.

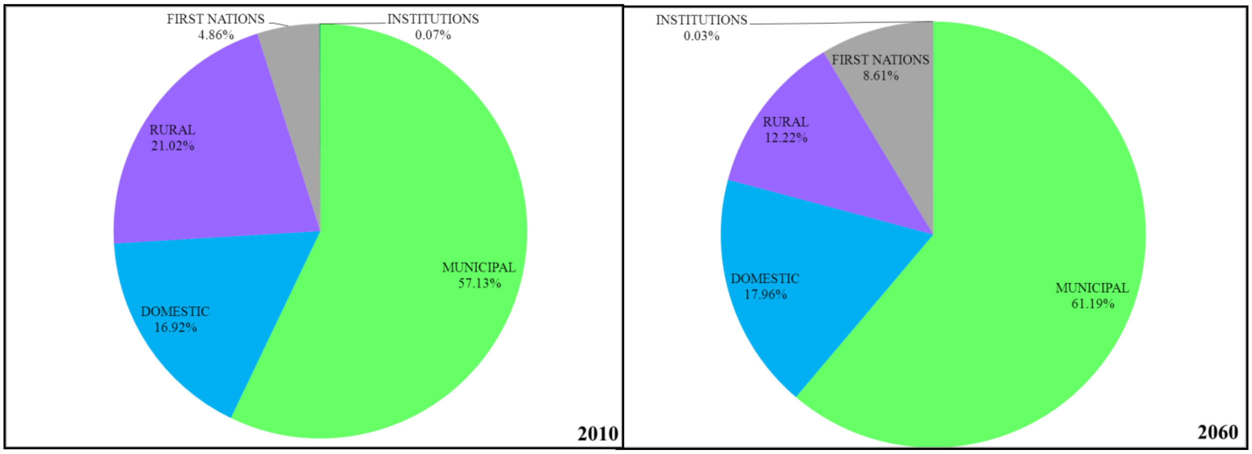


Figure 2.12: Distribution of Saskatchewan Population by Type of Communities, 2010-2060

Rural communities are predicted to reduce their share by approximately 9% by 2060, whereas First Nations' communities are expected to increase by nearly 5%. As shown in Table 2.13, all communities, except for the rural ones, are expected to expand over the projected period. First Nations' and bedroom communities' (around City of Saskatoon and Regina) populations are predicted to record the highest growth rates, 133.3% and 178.7% respectively.

Table 2.13: Population Projection for Saskatchewan River Basins Communities, by River Basin for 2010-2060

Basin	Population				2060 Population as
	2010	2020	2040	2060	
Assiniboine	56,782	57,806	61,028	66,552	17.2%
Lake Athabasca	2,187	3,000	4,628	6,256	186.1%
Churchill	54,451	59,193	79,214	100,206	84.0%
Cypress Hills (North Slope)	9,205	9,049	8,906	9,312	1.2%
Missouri	7,873	7,127	5,683	5,089	-35.4%
North Saskatchewan	197,384	205,778	236,111	269,669	36.6%
Old Wives Lake	19,161	17,608	14,836	13,575	-29.2%
Qu'Appelle	336,020	342,884	367,640	396,603	18.0%
Saskatchewan	48,294	50,050	53,894	59,926	24.1%
Souris	59,515	59,873	61,115	64,630	8.6%
South Saskatchewan	307,473	332,763	390,743	459,821	49.5%
Lake Winnipegosis	13,872	13,597	13,368	14,087	1.5%
Total Saskatchewan	**1,112,217**	**1,158,728**	**1,297,166**	**1,465,726**	**31.8%**

Present rural communities comprise 233,811 people and are foreseen to lower to 179,127 by 2060, a decrease in population of approximately 23%.

In relative terms, the urban population category indicates an overall growth of approximately 41% by 2060 in comparison to the reference year, but in absolute terms, this population category is expected to see the highest growth. Currently, the urban centers are inhabited by 823,565 people and by 2060, are foreseen to house more than a million people. Within this category, most of the population is concentrated in large cities such as Regina and Saskatoon. The city of Saskatoon has the largest population in the province, and in the future is expected to record the highest growth rates, as shown in Figure 2.13.

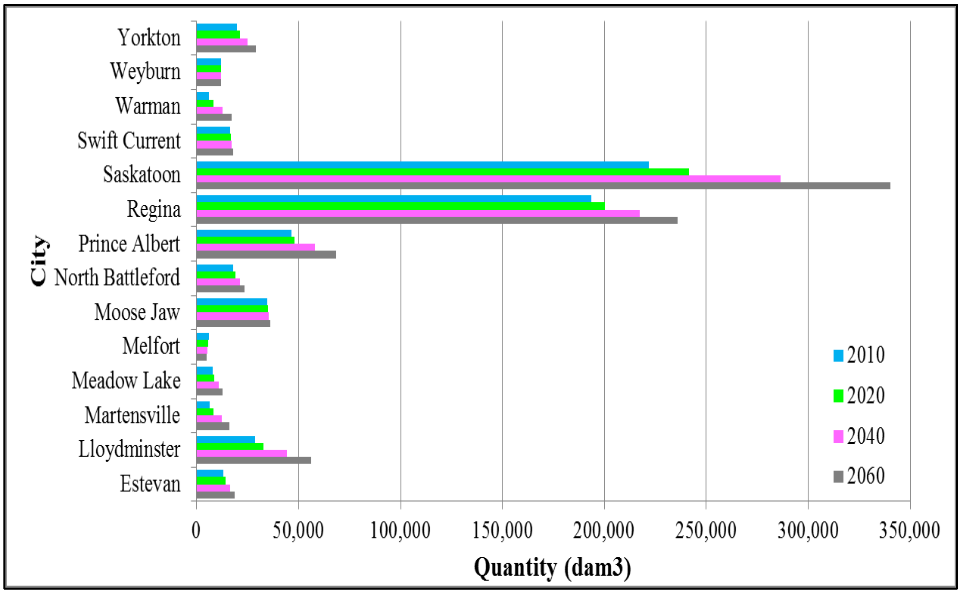
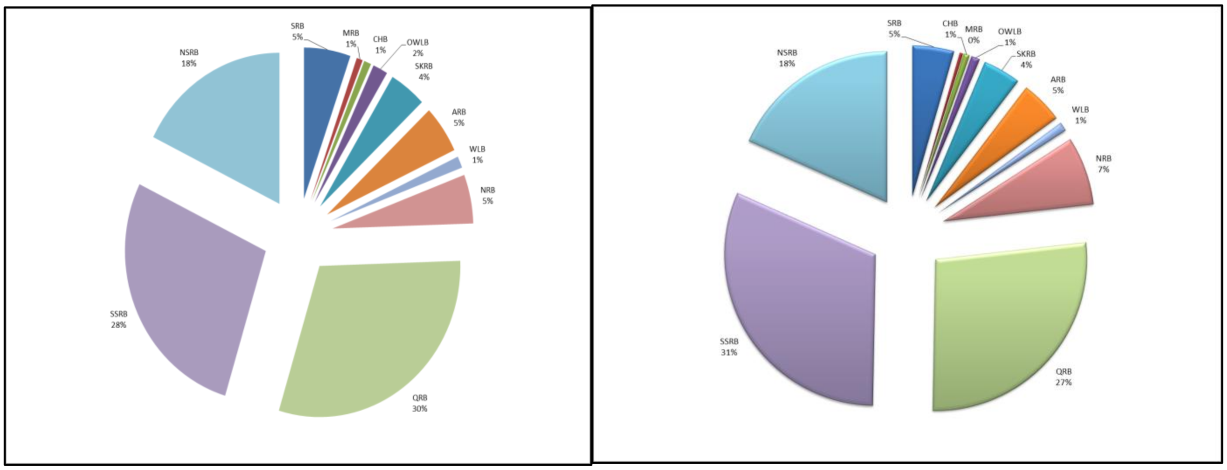


Figure 2.13: Distribution of Saskatchewan Municipal Population by City, 2010-2060

The distribution of Saskatchewan's population by river basins suggests major growth rates are expected to occur in the Lake Athabasca Basin, the South Saskatchewan River Basin, and the North Saskatchewan River Basin. In absolute population, 76% of the provincial population is located in the Qu'Appelle, the South Saskatchewan, and the North Saskatchewan River Basins. As seen in Figure 2.14, Qu'Appelle River Basin is currently the largest watershed in terms of population, inhabited by 30% of the province's population, followed by South Saskatchewan River Basin, with 28% and North Saskatchewan River Basin, with 18%. The ranking of the basins is expected to change by 2060. The North Saskatchewan River Basin will preserve its share of the population and remain third, whereas the most populated watershed by 2060 is expected to be South Saskatchewan, which is foreseen to house 31% of Saskatchewan's population.



2010 **2060**

Figure 2.14: Distribution of Saskatchewan Population by River Basin, 2010-2060

Two public institutions are located in Saskatchewan -- more exactly in the Qu'Appelle River Basin -- the Canadian Forces training base at Moose Jaw CFB 15 Wing and the Regina Correctional Centre.

As Saskatchewan's urban population continues to expand, increased rates in water demand are foreseen, concomitant with declines in water usage by rural communities.

2.5.6 Recreation and Tourism

Saskatchewan has large water resources for water-based recreational activities; many of them are visited by local people and those from outside the provincial borders. Saskatchewan houses two national parks: Prince Albert and Grasslands National Parks, 34 provincial parks, 100 regional parks, and a large number of recreational sites. Several dams and impoundments have been built to create reservoirs that allow recreational activities. In addition, local municipalities maintain recreational facilities for local residents.

Most of the recreational sites are located in the southern half of the province, especially in North Saskatchewan, Qu'Appelle and South Saskatchewan River Basins. These sites also tend to be those visited more frequently by visitors. In the semi-arid climate of southern Saskatchewan, value of water-based recreations is higher than other types of recreational activities.

2.6 Indirect Anthropogenic Water Demands

In addition to the above socio-economic activities, there are a number of other water demands that can be identified. Although some of these are related to policies or agreements in place, most of them are not directly related to, or required to, undertake various human activities. These demands include environmental, apportionment, and for evaporation water demands. Some of these demands have been equated to the amount of water lost, as is the case with evaporation losses of water. The definition of water loss in this study is taken to be synonymous with water not available to other water users.

2.6.1 Environmental and Instream Flows

One of the major water demands is for environmental purposes. There are two major environmental demands of water in Saskatchewan basins. The first one is for maintenance of wetlands, and the second one is for maintenance of minimum flows in the streams.

Water diverted for environmental purposes, such as lake stabilization and habitat restoration, represents a significant demand in the province. Ducks Unlimited has several duck habitat projects in the province. According to SIPA (2008a), Ducks Unlimited has a total of fifty two large wetland segments in the province, consisting of 5,674 acres. They operate 34 wetland structures and have 17 wetlands with fixed crest structures.

In terms of instream flows, there are two rivers that are subject to regulations. The Alberta government has instituted a conservation flow rate of $42.5 m^3/s$ on the South Saskatchewan River, which is the same rate as under the Master Agreement for normal stream flow conditions (R. Halliday and Associates, 2009). The Saskatchewan government is also committed to a normal flow rate of $42.5\ m^3/s$ released from the Gardiner Dam.

The Qu'Appelle River System provides habitat for a variety of fish and wildlife species. The Qu'Appelle Dam may be operated to maintain instream flows for fish and wildlife production. In order to meet the minimum flow needs, the requirement would be 4,946 dam^3 of water, according to SWA (2007). In the other river basins, no evidence was found to support minimum flow requirements.

2.6.2 Apportionment

The term "Apportionment Flow" is defined as flow that is subject to apportionment. Typically, this flow is equal to natural flow because natural flow at the boundary is subject to apportionment (PPWB, 1997). The Prairie Provinces Water Board was established in 1948 to ensure water resources in the three Prairie Provinces are shared fairly. To this effect, the provinces of Alberta, Saskatchewan, and Manitoba and the Government of Canada created the Prairie Province Water Board. In 1969, the four governments changed how the Prairie Provinces

Water Board operated by signing the Master Agreement on Apportionment (MAA). This agreement established an intergovernmental framework to manage transboundary waters. The purpose of the MAA is to apportion or share water equitably among the Prairie Provinces and to protect interprovincial surface water quality and groundwater aquifers. Under the Master Agreement on Apportionment among the three Prairie Provinces, typically half of natural amount of water arising in an upstream province has to be released on to the downstream province. The data from the Prairie Provinces Water Board indicates that on average the natural flow of the rivers has been sufficient to meet the required flow to downstream jurisdictions.

2.6.3 Evaporation and Percolation Water Loses

One of the major water demands in any basin is water lost through evaporation and percolation from rivers and large surface water bodies. Although some of the water percolates underground, since that becomes a part of the groundwater resource, it is not regarded as lost (or used). Evaporation losses are related to temperature change and other climatic factors such as cloud cover, precipitation, and wind speed. There are many surface water bodies in the province, and each of these would result in some evaporative water losses. Evaporation losses are higher in southern Saskatchewan than in the north, as shown in Figure 2.15.

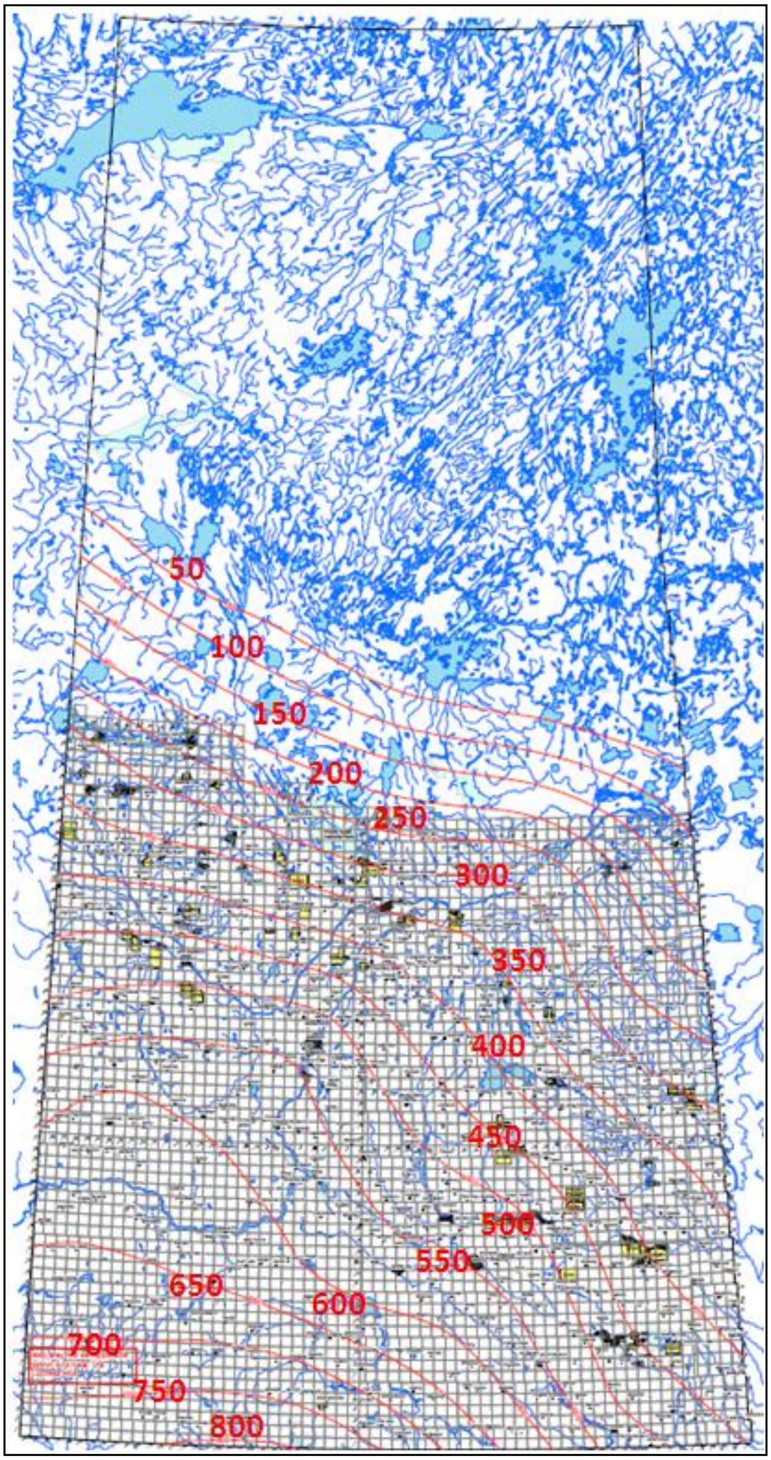
2.7 Trend in Factors Affecting Water Demand

Increase in the area under irrigation and livestock populations are the main forces influencing the demand for water for the agricultural sector in Saskatchewan. Specifically, the proposed West Side Irrigation Project and Qu'Appelle Valley South Project would account for most of the change in water demand to 2060 if fully implemented. The demand for water in the livestock sector is contingent on the beef cattle sector; specifically, the cow-calf operations and expansion of the feedlot industry.

The expansion of existing potash mines and development of new potash mines, especially solution mines, will have the biggest impact on water demand in the mining sector. Because of the nature of the potash extraction process, the water once used is unfit for other users. Also, for some mines to be developed, significant amounts of water will have to be transferred from adjacent basins to fill the demand.

Industrial/manufacturing water demands will generally follow the growth in the economy, as demand for the products grows within Canada and for export.

Oil and gas will see continued heightened activity as horizontal drilling technology is used in this sector. However, as the exploration matures, less drilling activity will take place, producing a concurrent decline in water demand to 2060.



Source: Map provided by Saskartchewan Watershed Authority

Figure 2.15: Mean Annual Net Evaporation for Small Lakes and Reservoirs, Saskatchewan

Moreover, the replacement of existing generation capacity and expansion of generation capacity will both affect the demand for water to 2060. Thermal generation of electricity using coal or natural gas will have the largest impact on water demand for this sector. The decision as to the replacement or refurbishment of the plants, combined with decisions on carbon capture and storage, will affect the 2060 demand for water from this sector. As alternative generation options become economical, the need for thermal generation will be reduced. Wind, solar, run of the river, and heat recovery options have no or little impact on other demands for water. The major hydroelectric generation options in the province have been exploited; leaving small dams and run of the river generation options.

Chapter 3

Study Methodology

This chapter provides a review of methods used for estimation of water demand for the 2010 and future time periods – 2020, 2040, and 2060. Although the methodology of estimation has been presented in other river basin reports,[12] only an overview is presented in this report. All estimations were based on either available secondary data or data received from the Saskatchewan Watershed Authority.

3.1 Overview of Methodology

Since this report is a summary of four previous reports, the description of methodology is a condensed form of that already provided in these reports. Salient features of the methodology are provided here. For details, readers are advised to refer to consult the four earlier reports.

3.1.1 Nomenclature of Water Use/Demand

In integrated water management, and particularly in water demand management, demand and water demand levels are very common terms. There are several terms that are used to describe or approximate water demand, sometimes synonymously. These other measures include water demand, water intake, water withdrawn, water requirements, and water needs, among others. These designations are described in Table 3.1. Water demand is the amount of water withdrawn (bought) by a given user (consumer) at a given price for water and other factors affecting its use. Water use is the quantity needed for a given task or for the production of a given quantity of some product or crop (Wikipedia, 2011). This concept differs from the concept of "water footprint".[13] According to the USGS (1990), water use is defined as follows:

> One, in a restricted senses, the term refers to water that is actually used for a specific purpose, such as domestic use, irrigation, or industrial processing. … the quantity of water use for a specific use is the combination of self-supplied withdrawals and public-supply deliveries. Two, More broadly, water use pertains to human's interaction with and influence on the hydrologic cycle, and

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[12] The reports include those for the Qu'Appelle River Basin (Kulshreshtha et al. 2012a), the South Saskatchewan River Basin (Kulshreshtha et al. 2012b), and the North Saskatchewan River Basin (Kulshreshtha et al. 2012c).

[13] The water footprint of an individual, community, or business is defined as the total volume of freshwater used to produce the goods and services consumed by the individual or community or produced by the business. Water use is measured in water volume consumed (evaporated) and/or polluted per unit of time. The water footprint is a geographically explicit indicator, not only showing volumes of water use and pollution, but also the locations (Wikipedia, 2011).

includes elements such as water withdrawal, delivery, consumptive use, wastewater release, reclaimed wastewater, return flow, and instream use.

Water intake or water withdrawn are terms used for total water released from a source, and are typically measured quantities. These releases are done in response to water requirements downstream from the source of release of water. Water requirements and/or needs are calculated on the basis of either actual observations or some technical/regulatory basis. Water demand is an economic concept and unless water users pay a price for the water and adjust their water demand in reaction to price, water demand is a very distinct concept compared to the others. Estimation of water demand requires micro-level (water user level) data under a regime of different price levels. Water use is an approximation to water demand at a point in time given the price (cost) of water to the user and other factors that affect water demand decisions. Thus, if one assumes a static situation, at a given point in time, water use can be considered a close approximation to water demand. However, in this study, water demand represents a proxy for water use, needs, and amount withdrawn by a given anthropogenic activity in question.

Table 3.1: Nomenclature Related to Water Demand

WATER INTAKE: Refers to the actual or measured amount of water withdrawn to sustain a given economic activity, requirement, or need.

WATER WITHDRAWN: Conceptually similar to water intake. This could be measured or unmeasured.

WATER REQUIREMENTS: This is the quantity of water needed to sustain or to maintain an activity. It is different from water intake only if a part of the requirement is satisfied from a source not usually measured. For example, water requirements of a crop can be satisfied by rainfall, snowmelt, and water withdrawn from surface or groundwater (including that for irrigation).

WATER NEEDS: Amount of water that is based on some agronomic or technical requirement of the economic or natural activity in question. Conceptually it is very similar to water requirements.

WATER USE: Amount of water that is utilized in finishing a given economic, social, or natural activity involving water. It may be a result of economic or social conditions, or may be affected by natural factors.

WATER DEMAND: An economic concept wherein the amount of water utilized for a given anthropogenic activity is dependent on its cost to the user, along with the state of other factors affecting this decision.

Total water demand in a region can be classified into several categories of demands, depending on the criterion used. One such criterion is the purpose of water demand. Using this criterion, total water demand can be divided into two categories:

1. Direct anthropogenic water demand: Where water demand is induced by economic (including social) activities, and thus could be directly related to humans.
2. Indirect anthropogenic water demand: Where water is either indirectly related to human activity (for example, construction of reservoirs resulting in evaporation of water, or apportionment water demand determined by policy decisions) or determined by natural phenomena.

Another criterion commonly used for disaggregating water is whether some or all water is lost (and is not available to other users at that point of demand or downstream). In some water demand categories, some or all water is lost during the process. These demands are called consumptive demands. In contrast, in other demands no water is lost.[14] These demands are called non-consumptive demands.

These two criteria can be applied together. Thus, direct anthropogenic water demands can be consumptive or non-consumptive. Similar examples can be found for indirect anthropogenic water demands. Thus, in the context of Saskatchewan water demand, total water demand can be divided into four categories, as shown in Table 3.2.

Conceptually, in Saskatchewan, there can be twelve sectors of water demands: eight direct anthropogenic and four indirect anthropogenic. Four of these direct anthropogenic water demand sectors are consumptive in nature, while the other four are non-consumptive water demands. Indirect anthropogenic water demand sectors have two non-consumptive and two consumptive water demands. It should be noted that not all basins have all these sectors. As well, in this study, not all water demands could be estimated on account of information/data availability and gaps.

Major direct anthropogenic consumptive water demand sectors include water demanded for agricultural activities, industrial and mining production, as well as municipal and domestic purposes (including power generation, both thermal electric power generation and hydroelectric power generation). Non-consumptive water demands may include recreational, hunting (waterfowl), transportation, and power generation (hydroelectric) related water demands. There are two sectors that could have both consumptive and non-consumptive water demands. For example, recreational activities-related water demand can be both consumptive for maintenance

[14] However, water returned in some uses may not be in the same location. For example, water use for hydro power generation is released at a different location downstream.

of facilities used by recreationalists, and non-consumptive for water-related activities (swimming, aesthetics, boating, waterfowl hunting). Similarly in the power generation subsector, thermal power generation is consumptive in nature, whereas hydroelectric power generation is non-consumptive in nature.

Table 3.2: Types of Water Demand in Saskatchewan

<table>
<tr><th>Consumptive Water Demand Sectors</th><th>Non-consumptive Water Demand Sectors</th></tr>
<tr><td colspan="2">Direct Anthropogenic Water Demands</td></tr>
<tr><td>(1) Agricultural water demand: Further subdivided into five activities:
• Irrigation water demand
• Crop production related water demand
• Stock watering
• Nurseries and greenhouse water demand
• Aquaculture related water demand</td><td>(1) Recreational activities related water demand</td></tr>
<tr><td rowspan="3">(2) Industrial and Mining related water demand
• Industrial (manufacturing) related water demand, including Intensive livestock operations, Biofuel processing, and other agricultural processing (Not served by a municipal system)
• Mining water demand for metal and non-metal mining, and for oil and gas production
• Power generation (Thermal electric power) water demand</td><td>(2) Hunting water demand (Waterfowl)</td></tr>
<tr><td>(3) Transportation related water demand</td></tr>
<tr><td rowspan="3">(4) Hydroelectric power generation</td></tr>
<tr><td>(3) Municipal and domestic water demand, which can be further divided into the following types:
• Municipal water demand to include residential, manufacturing, commercial, and other water demands
• Non-municipal domestic water demand
• Farm domestic water demand
• Other domestic water demand</td></tr>
<tr><td>(4) Recreational Related Facilities water demand</td></tr>
<tr><td colspan="2">Indirect Anthropogenic Water Demands</td></tr>
<tr><td>(5) Evaporation water demand</td><td>(5) Instream water demand</td></tr>
<tr><td>(6) Apportionment water demand</td><td>(6) Environmental water Demand</td></tr>
</table>

In terms of water demand, one should also make a distinction between water demand (intake or withdrawn) and water consumption. Some of the water demands have a return flow, making water consumption smaller than total water intake. Total water intake less return flow is equivalent to water consumption. This return flow varies for various water demands. Although most of these water users withdraw water from surface water bodies, a limited quantity of domestic, farm related, mining, and industrial water demand is obtained from groundwater sources.

In addition to water demands for socio-economic activities within the basin, four types of water demands, called indirect anthropogenic demands, are relevant. Most important among these are evaporation water demand and apportionment water demand. The first one is associated with large water bodies (such as lakes, reservoirs, and even rivers and streams). The second water demand is directed by regulations and agreements. Non-consumptive indirect anthropogenic water demands include instream water needs, and water diverted to environmental projects.

3.1.2 Water Demand Estimation Overview

For some sectors, water demand could not be estimated in this study. These included recreational non-consumptive water demand, waterfowl hunting related water demand, and transportation related water demand. However, given that these demands are non-consumptive in nature; total water demand in a given basin is not affected. Total water demand in a basin was then a sum of the remaining nine types of water demands.

3.1.2.1 Direct Anthropogenic Consumptive Water Demands

The anthropogenic consumptive water demand was a sum of water demanded by four sectors: (1) Agricultural and related production sector; (2) Industry/Mining sector, including power generation; (3) Municipal and domestic sector; and (4) Recreation sector.

<u>Agricultural Water Demand</u>: This water demand included a variety of water demands, mainly for irrigation, water demanded by dryland farmers for crop production, livestock water demand, and other related demands for food and fish production. Food production water demand was from greenhouses and nurseries. Fish production water demand was from aquaculture operations. However, primary information on these operations was very poor. For this reason, estimated amounts were obtained from another study.[15] On account of lack of time series data on production and actual demand, total water demand was estimated at a selected point in time.[16] It was estimated simply as a product of scale (physical measure such as area or size of activity) and

[15] Further details on this methodology are provided in Section 3.3.4 and 3.3.5 of this chapter.

[16] As noted in Chapter 1, four points of water use estimates were selected: Current (2010) and Future (2020, 2040, and 2060).

an estimated water demand coefficient. The latter was estimated using specific water demand details based on data collected by SWA or obtained from industry sources.

Industrial and Mining Water Demand: Total water demand for industrial and mining included four types of demand sectors: (1) Mining sector, which included potash mining, oil and gas production, uranium mining, and other non-metal mining; (2) Manufacturing sector, which included all agri-processing and non-agricultural processing not receiving water from a municipal water distribution system; (3) Induced Agri-Processing operations, which included all economic activities stemming from irrigation development in the basin; and (4) power generation, which included thermal electric power generation. In all cases, water demand estimates resulted from scale of production multiplied by respective water demand coefficient. The water demand coefficients for these demands were estimated by using specific water demand details based on data collected by SWA or obtained from industry sources.

Municipal and Domestic Water Demand: This water demand was estimated by disaggregating all communities and related institutions into several categories. All communities within each basin were arranged in a hierarchical order in terms of services provided. First of all, they were divided into two broader categories: Those served by a municipal water system, those not served by such a system. The former included urban jurisdictions. It therefore included a combination of water demands – residential, manufacturing, commercial, and other service industries, public water demands, and other water demands. Available data did not permit a breakdown of this total water demand.[17] For this reason, in this study, this breakdown was not attempted. Large industrial users that did not receive water through a municipal system are included as the Industrial and Mining water demand category of water demand.

Recreation water demand was a sum of two components: Water demanded by residents in the resorts or recreation communities, and water demanded for maintenance of parks and other recreational sites used for recreational activities.

3.1.2.2 Direct Anthropogenic Non-Consumptive Water Demands

Power generation in the province consists of two types of operations: (1) thermal electric power, and (2) hydroelectric power. The first type of power generation is consumptive in nature and is accounted for under the Industrial and Mining water demand. The hydroelectric power generation is the method included in this category. However, since it is a non-consumptive

[17] Information of this breakdown may be available at the municipal water utility level. Although this information could be collected from surveying each of these institutions, this was considered beyond the resources of this study. Such work is left for future research in this area.

activity, water released for such power generation was estimated but not added to the total water demand in the basin.

3.1.2.3 Indirect Anthropogenic Consumptive Water Demands

This category of water demand included two activities that consume water: That for evaporation from water bodies, and water released for apportionment demand. Evaporation water demand was of two types: (1) that from natural lakes and other large water bodies, and (2) that from man-made reservoirs constructed for the purpose of irrigation or hydroelectric power generation.

Apportionment water demand is dictated by regulatory and other policies governing the sharing of water among provincial and international water ways. Generally speaking, a part of the total water in a basin is passed on to the next province (if the river crosses a provincial boundary) or to the USA (if the river crosses the international boundary).

3.1.2.4 Indirect Anthropogenic Non-Consumptive Water Demands

The last category of water demand included two specific sources of water demand: Water required for maintaining the minimum flow requirement of rivers and other water bodies, and water released for projects serving environmental goals of the society. Water demand for these purposes was estimated if it was a recurring demand. If these purposes are served by a one-time demand, these were excluded from total water demand estimates.

Total water demand was a sum of the above two types of consumptive water demands. In this estimation, special attention was paid to interbasin transfers (IBT). These transfers are a result of a complex set of pipelines operated by the Saskatchewan Water Corporation and other jurisdictions (private and public) that cross basin boundaries.

3.1.3 Stages in Water Demand Estimation

In this study, water demand estimation required several major stages. Four stages are noteworthy: (1) Review of literature; (2) Developing correspondence between administrative regions and river basins; (3) Estimation of physical scale of operations that demand water, and (4) Estimation of water demand coefficient for a given water demand. The first two stages are described in this section, while the other two are described in Section 3.2.4.

3.1.3.1 Review of Literature

Study methodology for a particular water demand was designed following a review of the literature. A more detailed review of this literature is provided in Kulshreshtha et al. (2012a). However, a number of observations based on this review are provided here. These included the following:

- There have not been many Canadian studies for various types of water demands.
- Different types of methodologies are needed for different types of water demands. Choice of a particular approach depends, to a certain extent, on the scenario for the consideration, but also largely on data availability.
- Given the number of studies that have adopted various methodologies and the inherent limitations of each approach, the multivariate regression analysis approach and that employing water demand coefficients for forecasting water demand are the most common.
- The latter approach is more common where time series data are limited or not available.

3.1.3.2 Correspondence between Administrative Boundaries and the River Basins

As noted earlier in this report, total water in a river basin required two types of information -- basin level physical activity driving water demand, and a water demand coefficient for that particular activity. In Canada, much of the secondary data are collected by administrative boundaries. Examples of these include rural municipalities, census divisions, census agriculture regions, towns, villages, and First Nations' Reservations, among others. In order to use these data for river basin level activity, some conversion is needed. This was accomplished by developing a table showing the relationship between the various river basins and these administrative regions. The criterion for developing correspondence was the area within each administrative region that was within the river basin. It provided no challenge for those administrative regions that were wholly within the river basin. For those that were partially within the river basin, an overlay of the river basin map and the administrative boundaries map was used. Proportions were based on a visual estimate of the area within the basin. The resulting tables for each basin are shown as appendices.[18] These appendices include tables showing correspondence between river basins and for census division, census agricultural district, and rural municipality.

3.1.4 Methodology for Estimation for Anthropogenic Water Demands

Having developed a conceptual estimation methodology based on the review of literature, and a correspondence between river basins and administrative regions, the research team completed two tasks for estimation. These tasks included estimation of the physical level of related activity for a given water demand, and estimation of the respective water demand coefficient. These steps

[18] These appendices are provided in Kulshtreshtha et al. (2012a) for the Qu'Appelle River Basin, in Kulshreshtha et al. (2012b) for the South Saskatchewan River Basin, in Kulshreshtha et al. (2012c), and in Kulshreshtha et al. (2012d) for the remaining eight river basins.

for the direct anthropogenic water uses are described in this section, while those for the indirect anthropogenic water demands are explained in Section 3.3.5.

To a large extent, water demand coefficients were based on industry based information for a single time period. Where data were available, methodology was modified. Details on the methodology adopted for various types of water demands are provided in this section.

3.1.4.1 Agricultural Water Demand

Agricultural water demand, in this study, was estimated in a disaggregated manner. Total agricultural water demand was divided into the following five types: (1) Irrigation water demand; (2) Stock watering; (3) Crop production related water demand; (4) Nurseries and greenhouse water demand; and (5) Aquaculture related water demand. The methodology followed for each of these demands is described below.

Total irrigation water demand was a product of irrigated area and the average quantity of water used per unit of irrigated area. Since irrigation is a supplementary demand of water, precipitation and temperature (which is measured through the use of evapotranspiration) play an important role in determining the amount of water needed for a given crop. Since evapotranspiration varies from year to year, irrigation water demand also has year to year variability. Furthermore, in some basins, irrigation is provided through irrigation districts, as well as by private producers (private irrigators) having direct access to water. Private irrigators develop their own systems of water withdrawal from the local water body and its delivery to the farm gate. Both of these issues were taken into account in estimating irrigation water demand for the basin. More details on this methodology are provided in the reports for individual basins.

For the dryland crop production, water is primarily used for herbicide application. Although some water could also be used for cleaning farm machinery on these farms, the amounts are small, and very little information is available. For this reason, this water demand included only that for herbicide application. This water demand was estimated using the crop mix in each Saskatchewan basin, while taking into account differences in tillage practices and in summerfallow practices.

Livestock water demand was estimated using the water requirements approach. Since water requirements for different types of livestock are dissimilar, a disaggregated approach was undertaken. This approach required information on the livestock inventory by type of livestock, which was obtained from Statistics Canada (2006 and 2011a) and from Agriculture Statistics of the Saskatchewan Ministry of Agriculture (2011a). These data included beef cattle, dairy, hogs and sheep for 2010 and were available at the Crop District (Census Agriculture Region) level. Other livestock populations were obtained at the crop district level from Statistics Canada (2006). These data included livestock raised on intensive livestock operations in Saskatchewan. These data were obtained from SaskPork (2011) for hog operations, Saskatchewan Ministry of Agriculture (2008) for feedlot cattle and dairy operations, and from Saskatchewan Turkey

Producers Marketing Board (2011) for turkey producing operations. The categories of hog, feedlot cattle, turkey, and dairy production within a crop district were adjusted for the given river basin where the production took place.

The location of cattle feedlots in Saskatchewan, along with the stated capacity range of each feedlot, was obtained from Saskatchewan Ministry of Agriculture (2008). These data were used to estimate feedlot capacity within a river basin. To estimate the number of cattle fed in the feedlots in a year, those with a stated capacity of 10,000 head or greater were multiplied by a factor of 1.44 (indicative of number of times these feedlots are filled) while those feedlots with less than 10,000 head capacity were assumed to be filled once. The mid-range of the production capacity was used for feedlots occupied by less than 10,000 animals.

According to Statistics Canada (2010), there were 145 greenhouses and 35 nurseries in Saskatchewan in 2010, with 476 hectares of field area and 26 hectares of container area operated by nurseries in 2010. Average months of operation of greenhouses have gone from 5.6 months in 2007 to 6.1 months in 2010 -- an increase of 9.1% while the area of greenhouses in Saskatchewan has decreased from 235,254 m^2 in 2007 to 187,626 m^2 in 2010 -- a decline of 20% (Statistics Canada, 2010). Bedding plants and potted plants are the main products produced along with the production of vegetables in approximately 12,000 of 187,626 m^2 of greenhouse area in Saskatchewan. Saskatchewan crop district level data from Statistics Canada (2006) were used to estimate greenhouse areas in each of the basins. Again, for a lack of better proxy, relative area of the crop district within a given basin was used to allocate provincial greenhouse area to the basin. Water demand for greenhouse and nursery activities was estimated by using area in production and type of product. Water demand coefficients were obtained from Beaulieu et al. (2001) whose calculations include water demand for spraying as well as for cleanup.

In general, there is a lack of information on aquaculture in the province and its various river basins. However, R. Halliday and Associates (2009) have estimated this water demand. These estimates were borrowed in this study.

3.1.4.2 Industrial / Mining Water Demand

Industrial water demand in this study included all goods producing industries (excluding agriculture), as well as power generation industries. This water demand included both mining operations and manufacturing. Manufacturing activities in the province are located either in communities with municipal water systems, or outside such centers. Since municipal/domestic water demand would include the first type of manufacturing water demand, only the second type of water demand requires further estimation. In this type of water demand, power generation was added as a separate type of water demand. These are described briefly below.

(1) For potash mining water demand, estimation was done on a mine by mine basis. Estimated water demand coefficients were developed for each mine. Differences in the

technology used in the milling process of the mines, along with the type of end product produced, were taken into account for estimation of their water demand level.

(2) For oil and gas production, wells drilled and producing oil were the basis for water demand estimation. The nature of technology used for such processes was the deciding factor for the water demand estimation.

(3) Estimation of water demand for non-metal mining was done using a disaggregated plant-specific level of water demand.

(4) Water demand for manufacturing is related to several factors -- type of manufacturing, source of water, annual production level. Their water demand coefficients were estimated by taking into account these factors.

3.1.4.3 Municipal/domestic Water Demand

All the basin population resides in various types of communities – cities, towns and villages, or on farms and non-farm unincorporated settlements. Some of these communities have a municipal water system, while others do not.

Total water demand was estimated as a sum of six types of water demands: (i) Municipal water demand – for cities and other jurisdictions where a municipal water system is in place; (ii) Domestic water demand – for towns and other larger urban centers other than cities; (iii) Rural water demand – for villages; (iv) Institutional water demand; (v) First Nations' Reservations water demand; and (vi) Other domestic water demands — to include farm and rural non-farm water demand.

Total municipal/domestic level water demand was a product of per capita water demand and population of that given community. Data on water demand and population of various types of communities were obtained from the Saskatchewan Watershed Authority (2010 and 2011a).

The methodology for the estimation of municipal/domestic water demand was designed by estimating populations for various communities and their respective water demand on a per capita basis. Data for the period 1995 to 2009 were obtained from SWA. Trend analysis was undertaken using these time series data. Three types of trends were estimated: (1) Simple linear trend; (2) Non-linear trend using a quadratic model; and (3) Semi-log function with dependent variable in log form. In the case of per capita water demand, in addition to the trend variable, the population of the community was also used. The hypothesis was that as community increases in size, its per capita water demand may decline since some of the common (public) water uses will be shared by more people.

If the trend analysis did not result in a statistically significant result, an average from the past five years was used. For most communities, 2010 population was estimated using past trends.

Where the estimated 2010 population was lower than the actual 2009 population, the 2010 population was revised accordingly;

The 2009 actual population was increased by the proportional change in forecasted 2010 over 2009 populations. These analyses were undertaken for each of the six types of water demands listed above.

In addition to the community level water demand, institutions were also included. These institutions are not supplied water from a given municipal water distribution system.

3.1.4.4 Tourism and Recreational Water Demand

Tourism and recreational water demand is a result of two types of water demands: non-consumptive water demand in surface water bodies, and consumptive water demand through permanent residents at these recreational sites. The first type of water demand, on account of being non-consumptive in nature, was excluded from the total water demand. The second type of water demand was estimated as a sum of two separate (but related) sets of activities: (1) For maintenance of recreational facility; and (2) water demand by residents of recreational communities and resorts. The first water demand was hypothesized to be unrelated to the number of visitors. To estimate this water demand, a time trend in total water demand was estimated. Depending on the results, current and future water demand levels were estimated.[19] For point (2), water demand in recreation communities was estimated by using a similar approach as that employed to calculate municipal/domestic water demand.

3.1.5 Method of Estimation for Indirect Anthropogenic Water Demands

This water demand is not directly related to human activity, although society has some influence on the generation of these water demands. Generally speaking, these demands result from a combination of policy decisions and indirect contributions of humans, along with some natural processes. As noted above, this was a total of four water demands, which are described below.

3.1.5.1 Net Evaporation Loss Estimation

The level of evaporative loses of water was based on the evaporation rate per unit of area and the area of the water body within a given river basin. The area of the body of water and water depth to a great extent determine the differences in the amount of evaporation loss among surface water bodies. Shallow water bodies warm up faster in the spring relative to deeper lakes, while deeper bodies of water are generally ice-free for longer periods into the fall. Streams generally

[19] Results were treated in a similar manner as were those for communities. If the time trend was statistically significant, a forecast using estimated regression coefficients was made. If the trend was not significant, a five-year average was used as the level of water for the current and future time periods.

breakup earlier and remain ice-free longer than surface water bodies because of their current flow. In southern Saskatchewan, the average annual evaporation is greater than the available annual precipitation. As a result, very little precipitation makes its way to stream flows.

Evaporation generally takes place from large-surfaced water bodies. According to the Atlas of Canada (see Natural Resources Canada, 2011), estimates of the mean annual lake evaporation in Saskatchewan varies from less than 50 mm in the northern part of the province to 800 mm in the extreme southern part.

3.1.5.2 Net Environmental Water Demand

This type of water demand was identified as that required to maintain/preserve some environmental goals of the society. Included in this demand are activities such as wetland preservation, preservation of marshes, and other similar environmental sites. One must note that some of the activities also attract visitors from the basin and beyond. However, in this study, this water demand was classified as that for environmental purposes. Water demand for these various projects is highly variable as spring runoff and water flows are the main sources of recharge. For this reason, it is assumed that after the initial intake to fill the wetlands, a very small quantity of water is needed. Unless some evidence was found on the level of annual intake, this water demand was assumed to be zero.

3.1.5.3 Apportionment Water Demand

This water demand is related to policy measures decided by the provincial and federal governments (and in some cases, by international bodies). This type of water demand was developed to share surface water availability fairly between two jurisdictions (provinces or countries). The term “Apportionment Flow” is defined as flow that is subject to apportionment. Typically this flow is equal to natural flow because natural flow at the boundary is subject to apportionment (PPWB, 1997). The administration of this water demand is done by the Prairie Provinces Water Board, which was established in 1948 to ensure water resources in the three Prairie Provinces are shared fairly. To this effect, the Provinces of Alberta, Saskatchewan, and Manitoba and the Government of Canada created the Prairie Province Water Board. In 1969, the four governments changed how the Prairie Provinces Water Board operated by signing the Master Agreement on Apportionment (MAA). This Agreement established an intergovernmental framework to manage transboundary waters. This water demand applies only to those basins where rivers cross a provincial boundary or international boundary.

Similar to the MAA for the Canadian Prairie Provinces, there are agreements between Governments of Canada and the USA for apportionment for the rivers that cross international boundaries.

3.1.5.4 Instream Flow Needs

Various river and their tributaries are habitats for a variety of fish and wildlife species. For this reason, there may be recommended winter and summer base flows to maintain these habitats. Since these values differ from location to location, each basin is treated on its own accord. Similar to the environmental water demand, this water demand was therefore treated in a similar manner. If evidence was found to have a stream flow for this purpose, it was included as a water demand. In cases where such evidence was not available, this water demand was assumed to be zero.

3.1.6 Return Flow and Water Consumption Estimation

The methodology in Section 3.3.5 provides estimates of gross water demand – equivalent to water intake or water withdrawal. To estimate water consumption, one needs to take into account water returned to the original source. The latter is called return flow. The return flow is generally associated with District Irrigation projects, industries, and communities with a water and sewer system. Kulshreshtha et al. (1988) estimated these return flows as follows:

District Irrigation = 25% of the water intake

Urban Communities = 68% of the water intake

For manufacturing industries, Statistics Canada (2008a) has estimated the water used for Saskatchewan for 2005 and its discharge (return flow). Results are shown in Table 3.3. According to these estimates, almost 80% of the total water intake by manufacturing establishments is returned to the source. However, this ratio would differ from product to product. Unfortunately, such detailed information is lacking. Therefore, in this study, the same ratio of water intake to discharges/returned was used for various types of manufacturing.

Table 3.3: Water Use Parameters in Manufacturing Industries, 2005

Water Use Parameter	Total Amount in 2005 (dam^3)	Percent of Total Water Intake
Water demand / intake	60,100	100.0
Water recirculation	6,400	10.6
Water retained in the processed goods or lost	5,700	11.9
Water discharge	48,000	79.9

Source: Statistics Canada (2008a)

Water consumption for a given manufacturing water demand activity (or sector) was simply the total amount of water intake minus return flow. These water demand levels are shown in Table

3.4. The lowest proportion of water resulting as consumption is from urban (municipal systems) water demand, followed by irrigation and manufacturing.

Table 3.4: Water Consumption Levels for Various Direct Anthropogenic Water Demands

Water Demand Activity Group	Anthropogenic Activity	Total Water Consumption as % of
Agricultural Water Demand	District Irrigation	75.0%
	Other Irrigation	100.0%
Industrial Water Demand	Potash Production	100.0%
	Oil and Gas Production	100.0%
	Manufacturing	20.1%
Municipal/domestic Water Demand	Municipalities	32.0%
	Other communities	100.0%
	Institutions*	32.0%
Recreation and Non-Direct Anthropogenic water demands		100.0%

* Assumed not to be drawing their water needs from a municipal system.

3.2 Water Demand Estimation Methodology for Future Water Demand

Future water demand in a given basin is somewhat of an extension of the past pattern of water demand, although some future changes may also play important roles in altering or determining these water demand levels.

Since current water is directly related to level of economic activities and/or population, future water demand was also hypothesized to be governed by these factors in a virtually similar manner. The only exception to this probable circumstance would result from a significant change in the water demand coefficients for various activities. Two factors that can affect water demand coefficients in the future are:

(1) Onset of climate change by 2030 or in the period thereafter, and
(2) Adoption of water conservation measures by water users.

Although the water conservation policy of the province and other regulations may also determine the rate of change in these levels, a lack of information led to assuming no major deviation in the existing policy. Conservation policies, however, do have an influence on the water demand coefficients. Based on a review of the literature, such effects were incorporated. Water demand levels in the future can also be altered by the state of water availability, leading to more water conservation or to curtailing of certain types of economic activities.[20]

3.2.1 Factors Affecting Future Water Demand Levels

Future water demand in any region is a culmination of four types of changes or factors: Economic activities, population and its distribution; water demand patterns and history (including conservation); and changes in the bio-physical system (such as climate change). A rising level of population in a given river basin would affect the level of water demanded for various economic, sustenance, and social activities. Population is also a factor in determining the level of economic activities in the basin, and both elements are often very highly correlated.

The estimation of future water demand for various sectors has not been a very popular area of study except for municipal and/or domestic water demands. A complete review of these studies is provided in Kulshreshtha et al. (2012a). Although the review of the literature was helpful in identifying a suitable forecasting methodology, on account of the nature of data available, the methods developed were similar to those used for the current water demand. This methodology is described below for each of the four direct anthropogenic water demands and for the non-direct anthropogenic water demands.

3.2.1.1 Future Water Demand for Agriculture

Future water demand for agricultural purposes was estimated for each of the five types of demand. These are described in this section.

Future Irrigation Water Demand

For irrigation, the methodology for projecting water demand was similar in essence as that followed for current water demand. Two factors that required further attention were possible expansion of irrigated areas in the future and changes in the water demand coefficients. The projected irrigated area in the basin was multiplied by the appropriate crop water demand coefficient. The expansion of irrigation was based on known irrigation schemes.

For estimating water demand coefficients for irrigation, assumptions were made. It was assumed that future irrigation would be served by using pivot irrigation systems. As noted above, a distinction between district and private irrigation was maintained. The

[20] Investigation of implications of water supply on water use patterns is not attempted in this study, and therefore, is left for future studies.

future irrigation water requirements for crops were estimated by using 2008 crop requirement data combined with an estimate of the growing season precipitation plus seedbed moisture.

Future Dryland Crop Production Activities Related Water Demand

Estimation of the basin area under various crops for 2020 was based on the AAFC (2011) Medium Term Outlook for 2017. Crop area for the major grains and oilseeds of wheat, durum, canola, flax, and specialty crops of canary seed, chick peas, field peas, lentils, mustard, and sunflower were forecasted in this study. The percentage change in area seeded to a crop from 2010 to 2020 was applied to the area seeded at the water basin level in 2009 to arrive at the estimated 2020 seeded area. It should be noted that estimates for 2040 and 2060 have to consider relative net returns given the yield and price of a commodity that will determine the area seeded. The relative net returns will be affected mainly by the crop response to the climate conditions in 2040 or 2060 given the expenditure on developing new varieties. However, very little information is available on these aspects of crop choice by producers.

In addition to crop mix, a number of other factors can change water demand for pesticide spraying in the basin. The majority of crop production in western Canada is small grains with cereal grains, pulses, and oilseeds comprising the majority of the seeded area. The major trend in crop production in Saskatchewan over the past 20 years has been the increased demand of zero tillage (Statistics Canada, 2006). Associated with this trend has been the dramatic reduction in summerfallow and the greater diversity of crops grown.

The water demand for spraying on a per acre basis was calculated as follows: (i) A per pass rate of 50 litres per acre plus a 1% factor for cleanout was used; (ii) This was multiplied by the number of passes under different tillage systems; and (iii) The above was multiplied by the number of acres in zero tillage or minimum tillage plus the area in Chem fallow or Chem-Till Fallow.

Future Livestock Water Demand

The estimation of livestock production for 2020 was based on AAFC (2011) Medium Term Outlook for 2017. Inventories of animals within the dairy, poultry, sheep, hog and beef sectors, and laying hens for egg production were forecasted. Productivity growth rates for the various sectors are important in estimating the activity levels for each one in 2040 and 2060. The continued industrialization of the production process for dairy, hog, poultry, and egg operations has implications for the number of animals needed to produce a given quantity of output. Mapping of the genome will allow for greater accuracy in selection for desirable traits and in enhancement of traits related to productivity. Intensive livestock operations at present are able to implement these new technologies and to capture the increased productivity gains. Forecasts were based accordingly on due consideration of these factors.

The type of livestock, their age, climate, feed, and location on farm (indoors/outdoors) affect the uptake of water. Water needs are generally associated with the rate of water loss, which translates into temperature being a main factor. Generally, temperature has a greater effect on the water requirements of smaller animals than on those of larger animals. A grazing animal's water intake is affected by the type of pasture and the time of year as affected by the weather and moisture content of the forage.

Future Greenhouse and Nursery Water Demand

For nurseries and greenhouses, the water needs (or requirements) per plant were estimated and multiplied by the total number of plants per nursery. This result was calculated for all the nurseries in the region, depending on the size. If industry specific information was available, future area was estimated. In the absence of any information, past trends were used as a guide.

Future Water Demanded for Aquaculture

Information on aquaculture, as indicated above, is very poor. As a result, secondary information obtained from R. Halliday and Associates (2009) was used. The future level of water demand was assumed to remain at the current level.

3.2.1.2 Forecasting of Industrial / Mining Water Demand

Methods used for forecasting water demand for mining and manufacturing industries in the basin was based on a projection of new mines and manufacturing industries that might be developed in the basin. An attempt was also made to project future levels of economic activity for the current establishments.

In addition, new industrial activity as a result of irrigation development in the basin was also included. These developments were called induced economic activities and several types of value-added production were considered: Beef livestock -- producing new heads of cattle and processing them in the province; Pork livestock -- producing and processing hogs; Dairy production coupled with additional dairy processing activity; Vegetable processing – particularly potato processing; Slaughtering and meat processing; and Energy – production of ethanol.

3.2.1.3 Forecasting of Municipal/domestic Water Demand

Forecasts for municipal/domestic water demand are typically done by using past trends in factors that have been shown to influence past water demand. Information on regulations, pricing, cost of supply, and public education was not available for estimating future water demand in the basin. As a crude approximation, future water demand was first approximated by change in number of water users (measured as population). Total water demand was simply a product of projected population (2020, 2040, and 2060) for a given type of community and their respective water demand coefficient for a given point in time. An estimation of per capita water demand was based on regression analysis of trend in a given type of community in a given river basin. Data on water demand and population were collected from the Saskatchewan Watershed Authority for the period 1995 to 2009 by type of community and for some institutions (2010a).

3.2.1.4 Recreational Water Demand

For the recreation communities (or resorts), future water demand for recreational communities was based on their trend in population and per capita water demand. For the maintenance of recreation facilities, a trend analysis in past water demand was undertaken.

3.2.1.5 Indirect Anthropogenic Water Demands

Four water demands that were included in this category are: Environmental purposes, Instream needs, evaporation losses from surface water bodies, and Apportionment purposes.

Environmental water demand: This water demand was based on future plans for environmental projects in a given river basin. This estimate was subject to availability of information.

Future instream flow needs: This water demand was assumed to be the same as the current requirements, if known. Where such information was not available, this demand was assumed to be zero.

Evaporation water demand: This water demand was assumed to remain at the same level as the current evaporation water demand.

A**pportionment water demand**: This water demand was applied to those rivers that cross provincial or international boundaries. Since this water demand is dependent on water supply, it was assumed to be at the average of recent past periods. If no information was available, it was assumed to be zero.

3.3 Study Scenarios

Water demand for each river basin was estimated under three study scenarios: (i) baseline scenario, (ii) climate change scenario, and (iii) water conservation scenario. The methodology followed for estimating water demand under these scenarios is described in this section.

3.3.1 Baseline Scenario

A baseline scenario is generally used as a reference for comparison against alternative futures or scenarios. Under this scenario, economic and social systems are assumed to be the same as those described in the previous two sections. No major shocks or policies are envisaged. Water demand under the baseline scenario reflects the past trends and future plans under current economic conditions.

3.3.2 Climate Change Scenario

Climate change is highly relevant in any forecast of water demand in the future. The essential question is: "Can Canadians (and those in a given river basin) manage a change in water resources that they put on their crops, run through their turbines, and pipe into their homes" (paraphrased from Waggoner, 1990). Human-induced climate change is caused by the emissions of carbon dioxide and other greenhouse gases (GHGs) that have accumulated in the atmosphere over the last century or so. There is enough scientific evidence now that makes climate change serious and compelling (Stern, 2007).

The major changes identified by various IPCC reports (Easterling et al. 2007) include the following points: change in average temperature, change in the average precipitation, distribution of precipitation and its form (more in the form of rain and less as snow), occurrence of extreme events, and rise in sea level. According to Lemmen and Warren (2004), these changes would have significant effects on water resources, such as (1) changes in annual stream flow, possible large declines in summer rainfall, leading to shortage of supply; (2) increased likelihood of severe drought, increased aridity in semiarid zones; and (3) increases or decreases in irrigation demand and water availability. These changes would lead to many concerns, and notable among these are (1) implications for agriculture, hydroelectric power generation, ecosystems and water apportionment; (2) losses in agricultural production, accompanied by changes in land use; (3) uncertain impacts on farm sector incomes, groundwater, stream flow, and water quality. The same study also noted that climate change may simultaneously affect water demand. In addition to population growth and wealth distribution, climate change may increase demand for water because of higher temperatures and drier conditions.

A review of literature was undertaken to assess the impact of climate change on water demand. Unfortunately, no such study was found for Saskatchewan or even for Western Canada. Therefore, the review was extended to North America, Europe, and other parts of the world. However, although information to make adjustments in water demand was still less than satisfactory, this review suggested many implications of climate change on water resources. The impact on the water demand may come through direct impact of climate characteristics, but also through indirect linkages. Two important indirect linkages may be through water quality and water availability.

In this study, two major effects resulting from climate change were included: (1) change in average temperature (and resulting evapotranspiration) and (2) increased frequency of extreme events. Two types of extreme events are expected in the future: extreme dry events, called droughts (single period, back-to-back droughts, and longer multi-period droughts), and extreme wet events (high rainfall and/or intense rainfall in a short period of time), resulting in floods in some regions.

Changes in water demand level in a given river basin were based on demand-specific changes as suggested in the literature or by expert opinions. For example, agricultural water demand was based on moisture deficit. Similarly, for livestock water demand, studies that have addressed this issue were consulted. Water demand for mining was adjusted using expert opinion, where available. Municipal and domestic water demands were adjusted through results from available studies.

Another aspect of climate change is the frequency of extreme events – droughts and excessive rains. Based on the past yield records, it appears that during the last 50 years, there have been four major droughts – 1961, 1988, 2001, and 2002 (Wheaton et al., 2005). Recent droughts and excessive moisture events can be considered harbingers of the extremes likely to occur. A precise forecast of droughts, though, is extremely complex, so some arbitrary decisions were made.[21] It was assumed that drought frequency by 2020 would remain unchanged (from the current 8%). As noted above, by 2090 drought frequency is expected to triple. A straight line projection was used to estimate the future frequency of droughts. The estimated frequency was 13% by 2040 and about 18% by 2060.

With respect to floods, no Canadian study was found that has predicted these events for any climate change conditions; however, Drakup and Kendall (1990) state that large-scale spring ravine flooding would be expected to decrease from an expected increase in winter runoff and a decreased snowmelt and spring runoff. However, this effect could not be incorporated.

3.3.3 Water Conservation Scenario

Provincially, through the Saskatchewan Watershed Authority and locally, through municipalities, efforts have been made to make the water users aware of water shortages, and to convince them to adopt water conservation practices. This has been accomplished through several types of measures, including switching to lower water use appliances (i.e. rebates for low flush toilets). Programs of various types to educate the public on the demand of water have been and are being used. The urgency or force of the approach seems to depend on immediate supply side problems,

[21] This aspect of climate change requires some input from people whose expertise is climatology and climate change.

such as drought or plant shutdown, among others. These factors influence the adoption of water conservation and thereby affect water demand. However, to predict these changes is somewhat problematic without a comprehensive study of attitudes of the people and their willingness to adopt water conservation measures.

Much of the literature on water conservation is reported for the domestic water demand. A review of these initiatives is provided by CMHC (Undated). Nonetheless, water conservation experiences with other water uses have not been prolific in the literature. According to the Policy Research Initiative (2005), water recycling is an important characteristic of the industrial response to a price change (a popular water conservation measure). Water cost, though, seldom accounts for more than one percent of the total cost of production of many industrial firms. Few studies have been done on the interaction of water price and the price of inputs other than water (Renzetti, 2002). Studies of the cost structure of various types of industrial water users in Saskatchewan are needed to evaluate the efficacy of water conservation policies.

For agricultural water demand, empirical studies have shown that irrigation water demand is relatively unresponsive to price changes, as a given crop requires a certain amount of water in a given setting (Policy Research Initiative, 2005). It has been argued that the demand for irrigation water would remain inelastic until water costs rise substantially (Bazzani et al., 2004).

In light of a large degree of uncertainty in the impact of water conservation programs and the rate of adoption, the approach used was to select the conservation potential for each type of water demand. These results are shown in Table 3.5. Municipal water demand has been shown to be reduced up to 17% of the current level. However, in this study, we used a reduction of 2.5% for the near future and predicted its rising to 12.5% for 2060. Non-municipal water demand can also be reduced through adoption of water conservation measures. However, the magnitude of reduction was assumed to be smaller than that for the municipal systems. Industrial and institutional water demand was treated in ways similar to the municipal water demand. Water conservation in agriculture (particularly in irrigation) was effected through adoption of water saving irrigation systems.

The results of water demand for the current and future time periods under the three study scenarios are presented in the following chapters.

Table 3.5: Reduction in Water Demand, by Type of Demand, Resulting from Adoption of Water Conservation Practices

Type of Demand	Maximum Potential	Maximum Population Adopting measures	Maximum Reduction in Water Demand	Savings in Water Demand (Relative to Baseline Scenario) by		
				2020	2040	2060
Municipal Domestic (Community Water Demand)*	43%	40%	17.2%	2.5%	7.5%	12.5%
Non-Municipal Domestic Water	--	--	--	0.58%	1.16%	2.90%
Commercial, Industry and Institutional Water Demand***				2.5%	7.5%	12.5%
Recreational Water				N.C.	N.C.	N.C.
Irrigation Water Demand	Estimated using efficiency improvements in water delivery system for a given crop mix					

* Based on the experience of Kelowna, B.C.
** Based on the experience of New Glasgow, NS
*** Assumed to the level of water conservation for the municipal water demand
N.C. = No Change

Chapter 4

Agriculture Water Demand

As noted in Chapter 3, agricultural water demand was a sum of five individual water demands. These are water demands for irrigation, spraying of herbicides, livestock water (stockwater), greenhouses and nurseries water, and aquaculture. Results for each of these demands for individual basins have been presented in basin reports.[22] Total water demand for the province, distributed by river basins (where appropriate), is provided in this chapter.

4.1 Irrigation Water Demand

In Saskatchewan, through the development of the South Saskatchewan Irrigation Project, including the creation of Lake Diefenbaker, there is a large irrigation potential. In fact, even in other areas of the province, further expansion of up to 1.5 million acres has been estimated (Abrahamson and Ireland, 1985). In a more realistic manner, SIPA (2008b) estimated that 885,583 acres of land can be developed in the province.

In this study, irrigation expansion followed guidance from the projection, but developed more realistic expansion plans for each basin in consultation with industry experts. Currently, there are 347,849 acres of irrigation in the province with 36% in irrigation districts and the remainder in private irrigation (Table 4.1). Irrigation expansion is expected to increase the area under irrigation to 849,903 acres by 2060 as "fill in" in the current irrigation districts and with the irrigation expansion of Qu'Appelle South and the Westside Irrigation Project. Much of the newer irrigation would deliver water using pivots, which is the most efficient manner of delivering water to the crops. As shown in Table 4.1, the area served by pivots in the province would increase from 142 thousand dam^3 currently to 644 thousand dam^3 by 2060 – an increase of three and one-half times the current level. As shown in Figure 4.1, all other types of irrigation delivery systems would remain at the current level. An important consideration in the choice of irrigation system is the water use efficiency and cost of adoption. As water availability becomes tighter, there is added pressure for converting the surface irrigation systems to sprinkler irrigation systems. However, a thorough projection of how these systems change was not attempted in this study.

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[22] In this chapter and subsequent ones, readers are referred to Kulshreshtha et al. (2012a) for details on the Qu'Appelle River Basin; Kulshreshtha et al. (2012b) for details on the South Saskatchewan River Basin; Kulshreshtha et al. (2012c) for the North Saskatchewan River Basin, and to Kulshreshtha et al. (2012d) for the other eight selected river basins.

Table 4.1: Irrigated Area in Saskatchewan by Type of System, 2010 to 2060

Irrigation System	Irrigated Area in Acres			
	2010	2020	2040	2060
Wheelmove	30,586	30,586	30,586	30,586
Pivot	142,054	179,644	453,501	644,107
Linear	1,302	1,302	1,302	1,302
Misc. Sprinklers	22,536	22,536	22,536	22,536
Surface	54,185	54,185	54,185	54,185
200mm Backflood	46,124	46,124	46,124	46,124
Misc. Back Flood	47,747	47,747	47,747	47,747
Remainder	3,314	3,314	3,314	3,314
Total	**347,849**	**385,440**	**659,296**	**849,903**

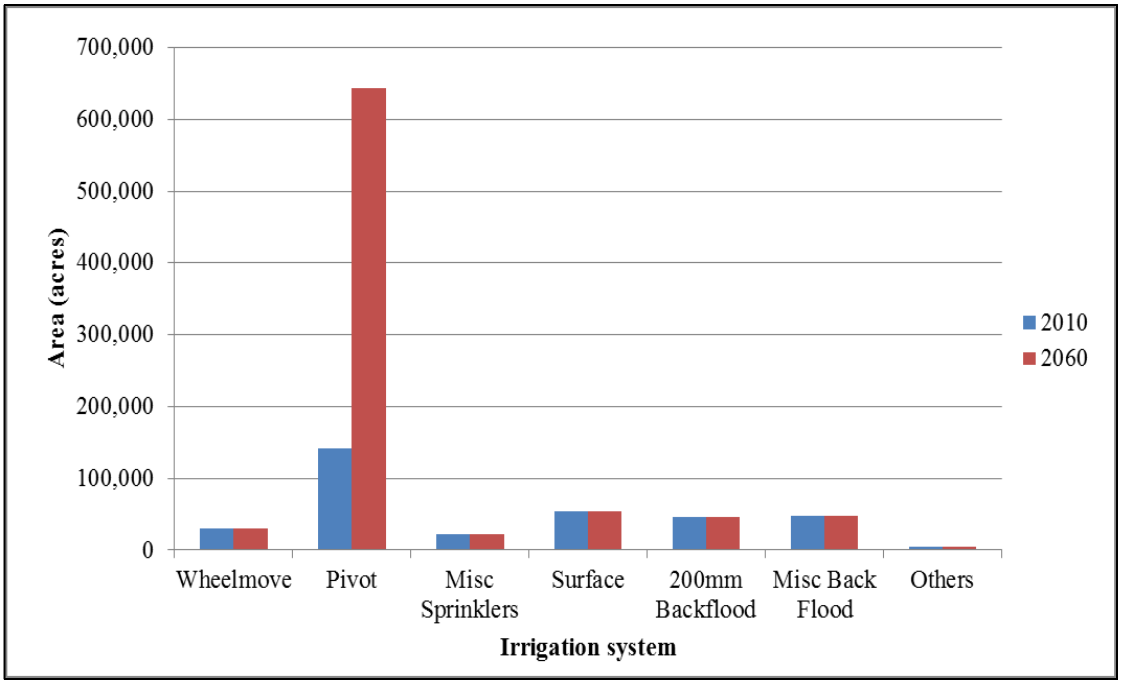

Figure 4.1: Distribution of Irrigated Area by Irrigation System, 2010 and 2060

Using the above set of irrigated area measurements, provincial water demand estimates for the Baseline, Climate Change, and Conservation Scenarios were made. These are presented in Table 4.2 to 4.4 for the three scenarios, respectively.

Under the baseline scenario, irrigation demand is estimated at 609 thousand dam^3 of water. If by 2060 both the Westside and the Qu'Appelle South irrigation projects go ahead and reach the full adoption, irrigation water demand in the province would be slightly more than double the current level – 1.28 million dam^3 (Table 4.2). A comparison of 2010 and 2060 levels of irrigation water demand by river basins is shown in Figure 4.2. As evident from this figure, the share of the South Saskatchewan River Basin for the provincial irrigation water demand will increase from 38% currently to 57% by 2060.

Table 4.2: Estimated Irrigation Water Demand by River Basins, Saskatchewan, under Baseline Scenario, 2010 - 2060

River Basin	Amount of Water Demand in dam^3				% Change in 2060 over 2010
	2010	2020	2040	2060	
Assiniboine	3,419	3,436	3,474	3,518	2.9%
Cypress Hills	41,348	41,598	42,160	42,815	3.5%
Lake Winnipegosis	3,236	3,236	3,236	3,236	0.0%
Missouri	114,816	115,010	115,445	115,953	1.0%
North Saskatchewan	39,344	40,677	49,576	70,782	79.9%
Northern	6,383	6,383	6,383	6,383	0.0%
Old Wives	101,108	101,802	103,361	105,178	4.0%
Qu'Appelle	54,856	56,553	154,367	194,965	255.4%
Saskatchewan	2,727	2,734	2,749	2,766	1.4%
Souris	11,442	11,516	11,682	11,876	3.8%
South Saskatchewan	231,295	278,636	533,962	723,787	212.9%
Total Irrigation Water	**609,972**	**661,579**	**1,026,394**	**1,281,258**	110.1%

Table 4.3: Estimated Irrigation Water Demand by River Basins, Saskatchewan, under Climate Change Scenario, 2010 - 2060

River Basin	Amount of Water demand in dam^3			
	2010	2020	2040	2060
Assiniboine	3,419	3,436	4,052	4,433
Cypress Hills	41,348	41,598	48,686	53,175
Lake Winnipegosis	3,236	3,236	3,814	4,138
Missouri	114,816	115,010	127,904	135,499
North Saskatchewan	39,344	40,667	57,987	89,639
Northern	6,383	6,383	7,492	8,115
Old Wives	101,108	101,802	114,091	122,386
Qu'Appelle	54,856	56,553	180,769	247,158
Saskatchewan	2,727	2,734	3,216	3,501
Souris	11,442	11,516	13,323	14,485
South Saskatchewan	231,295	278,636	626,558	919,459
Total Irrigation Water Demand	**609,972**	**661,579**	**1,187,891**	**1,601,989**
% Change over the Baseline Scenario	0.0%	0.0%	15.7%	25.0%

Table 4.4: Estimated Irrigation Water Demand by River Basins, Saskatchewan, under Water Conservation Scenario, 2010 - 2060

Basin	**2010**	**2020**	**2040**	**2060**
Assiniboine	3,419	3,144	2,935	2,807
Cypress Hills	41,348	38,188	35,858	34,439
Lake Winnipegosis	3,236	2,919	2,658	2,451
Missouri	114,816	104,677	96,572	90,289
North Saskatchewan	39,344	36,206	42,594	59,894
Northern	6,383	5,760	5,249	4,830
Old Wives	101,108	93,813	88,562	85,620
Qu'Appelle	54,856	52,425	135,250	169,262
Saskatchewan	2,727	2,498	2,316	2,176
Souris	11,442	10,542	9,876	9,488
South Saskatchewan	231,295	259,561	468,334	631,966
Total Irrigation Water Demand	**609,972**	**609,734**	**890,203**	**1,093,220**
% Change over the Baseline Scenario	0.0%	-7.8%	-13.3%	-14.7%

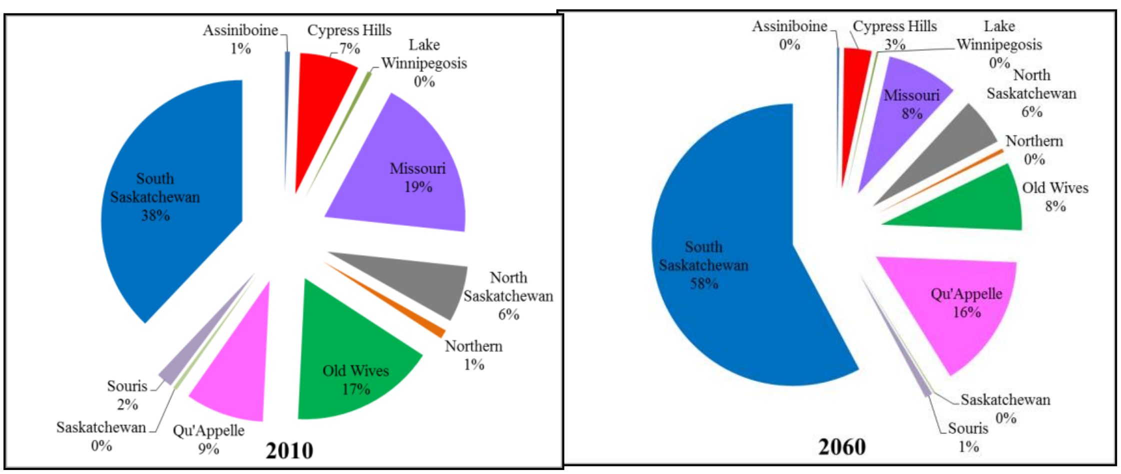

Figure 4.2: Distribution of Irrigation water Demand by River Basins, 2010 and 2060

Relatively speaking, the largest increase in the irrigation water demand would be observed for the Qu'Appelle River Basin (an increase by 255%) and in the South Saskatchewan River Basin (an increase of 213% of the current level). The South Saskatchewan River Basin will continue to have the highest amount of irrigation activity with the development of the Westside Irrigation Project.

Under climate change, as expected, all basins would see an increase in the irrigation water demand. For the province as a whole, this total irrigation water demand was estimated to be 25% higher than that under the baseline scenario in 2060.

Under water conservation, some relief in the relative increase in irrigation water demand may be observed. Under the study's set of assumptions, by 2060, 14.7% of the provincial irrigation water demand may be reduced relative the baseline scenario level. Trends in the water demand for the province under the three scenarios is presented in Figure 4.3.

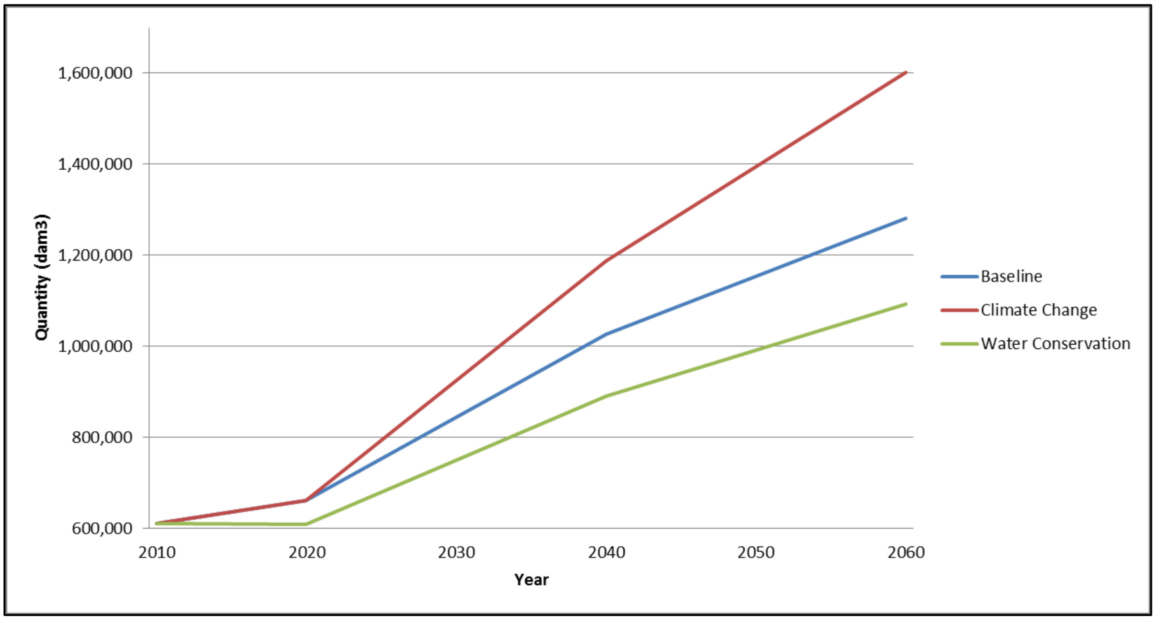

Figure 4.3: Saskatchewan provincial Water Demand for Irrigation under Study Scenarios, 2010-2060

4.2 Dryland Agricultural Water Demand

The estimated provincial water demand for the application of pesticides to annual crops and for chemical fallow is presented in Table 4.5. The area of cropland, crop type, sprayer cleanup, and farming technology were factors used in estimating the amount of water demand in 2010. Under the baseline scenario, this water demand was estimated at 1,492 dam^3 of which 100% is consumed. In the above estimation, it was assumed that 80% of the water demand is taken from surface water bodies.

Climate change will have a marginal impact as more pests and greater use of zero tillage over the baseline scenario are anticipated elements. Technology changes in the application of pesticides and removal of pests in crops by mechanical means could significantly affect water demand by

2060. Estimates of water demand by basins for the three scenarios are presented in Tables 4.6 to 4.8. The amount of area in annual crops, zero tillage adoption, and summerfallow are the main differences among the basins.

Table 4.5: Estimated Provincial Water Demand and Consumption for Dryland Farming, Saskatchewan, 2010 - 2060

Particulars	Amount of Water Demand in dam^3			
	2010	2020	2040	2060
Baseline Scenario				
Water Demand	1,492	1,470	1,452	1,452
Consumption	1,492	1,470	1,452	1,452
Surface Water	1,194	1,176	1,162	1,162
Climate Change Scenario				
Water Demand	1,492	1,503	1,521	1,579
Consumption	1,492	1,503	1,521	1,579
Surface Water	1,194	1,203	1,217	1,263
Conservation Scenario				
Water Demand	1,492	1,470	1,307	726
Consumption	1,492	1,470	1,307	726
Surface Water	1,194	1,176	1,046	581

Table 4.6: Estimated Provincial Water Demand for Dryland Farming, Saskatchewan, under Baseline Scenario, 2010 - 2060

	Amount of Water Demand in dam^3			
Basin	**2010**	**2020**	**2040**	**2060**
Assiniboine	88	90	89	89
Cypress Hills	45	40	38	38
Lake Winnipegosis	43	46	45	45
Missouri	73	66	65	65
North Saskatchewan	296	289	286	286
Northern	33	33	33	33
Old Wives	116	109	107	107
Qu'Appelle	350	353	348	348
Saskatchewan	86	89	89	89
Souris	155	155	153	153
South Saskatchewan	209	201	199	199
Total Water Demand for Dryland Farming	1,492	1,470	1,452	1,452

Table 4.7: Estimated Provincial Water Demand for Dryland Farming, Saskatchewan, Under Climate Change Scenario, 2010 - 2060

River Basin	Amount of Water Demand in dam^3			
	2010	2020	2040	2060
Assiniboine	88	92	93	96
Cypress Hills	45	41	41	43
Lake Winnipegosis	43	47	47	49
Missouri	73	68	69	72
North Saskatchewan	296	296	300	312
Northern	33	34	34	35
Old Wives	116	111	113	117
Qu'Appelle	350	360	363	377
Saskatchewan	86	91	92	96
Souris	155	158	160	166
South Saskatchewan	209	206	209	217
Total Water Demand for Dryland Farming	1,492	1,503	1,521	1,579
% Change from Baseline Scenario	0.0%	2.3%	4.7%	8.7%

Table 4.8: Estimated Provincial Water Demand for Dryland Farming, Saskatchewan, under Water Conservation Scenario, 2010 - 2060

Basin	2010	2020	2040	2060
Assiniboine	88	90	80	45
Cypress Hills	45	40	35	19
Lake Winnipegosis	43	46	41	23
Missouri	73	66	58	32
North Saskatchewan	296	289	257	143
Northern	33	33	30	16
Old Wives	116	109	96	53
Qu'Appelle	350	353	314	174
Saskatchewan	86	89	80	44
Souris	155	155	138	76
South Saskatchewan	209	201	179	99
Total Water Demand for Dryland Farming	1,492	1,470	1,307	726
% Change from Baseline Scenario	0.0%	0.0%	-10.0%	-50.0%

Under the baseline scenario, water demand for dryland farms (mainly for spraying of the herbicide) would decrease slightly by 2060. This lessening occurs on account of assumptions made about adoption of zero tillage by Saskatchewan farmers, and about areas under summerfallow. However, this decrease is only 2.7% of the 2010 level (Table 4.6). In terms of basin distribution, the largest water demand for this purpose is estimated for the Qu'Appelle River Basin, followed by the North Saskatchewan River Basin. A distribution of the total dryland farming water demand by river basins is shown in Figure 4.4.

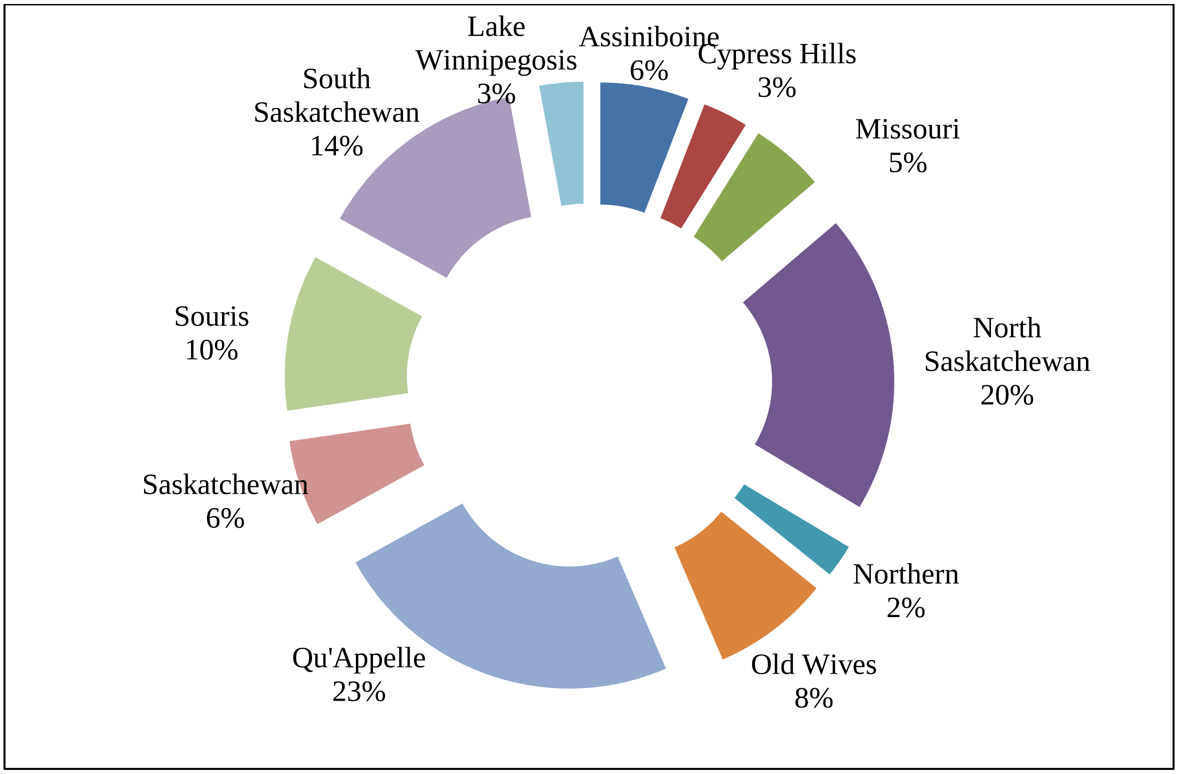

Figure 4.4: Distribution of Dryland Farming Water Demand for Saskatchewan by River Basins, 2010

Under the climate change scenario, the amount of water demand would likely increase. This increase for the province as a whole was estimated at 8.7% over and above the baseline scenario level for the year 2060 (Table 4.7). Under the water conservation scenario, water demand for spraying purposes could be reduced by as much as 50% of the level shown under the baseline scenario. Probable reasons for this include technological developments for the removal of weeds by robotic equipment, which may be adopted first by market garden farmers, then by organic farmers, and finally by commercial growers over the 2040 to 2060 period. Fungicides and insecticides, along with some herbicides, will still require water for application. A trend in this water demand under the three scenarios is plotted in Figure 4.5.

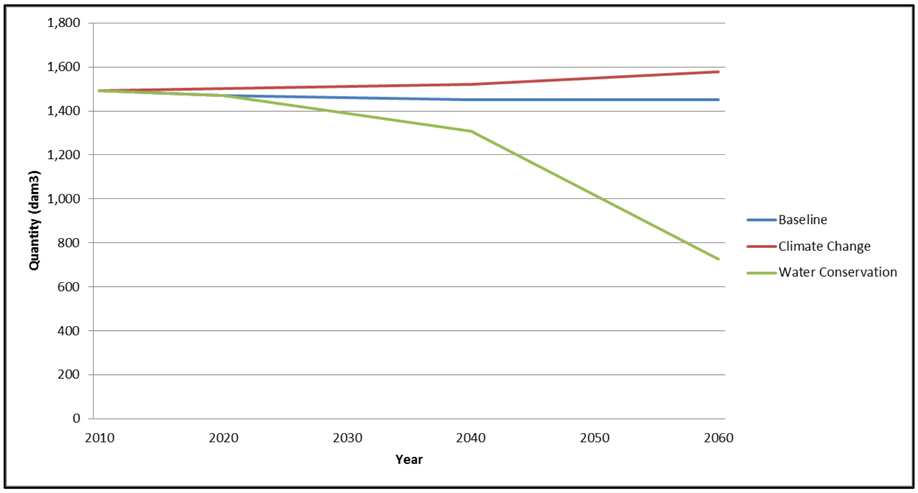

Figure 4.5: Trend in Water Demand for Dryland Farming under Study Scenarios, Saskatchewan, 2010-2060

4.3 Livestock Water Demand

After the irrigation water demand, livestock water demand is the second highest within the agriculture sector. The total water used for this purpose in 2010 was estimated at 43.6 thousand dam^3 (Table 4.9). The estimated provincial water demand for livestock, consumption, and percentage of surface water for the livestock sector is also presented in Table 4.9.

Table 4.9: Provincial Livestock Water Demand and Consumption

Particulars	Unit	Amount in (dam^3)			
		2010	2020	2040	2060
	Baseline Scenario				
Water Demand	dam^3	43,591	46,604	48,477	50,106
Water Consumption	dam^3	43,591	46,604	48,477	50,106
Share of Surface Water to Total Water Demand	%	42.7%	42.6%	42.4%	42.3%
	Climate Change Scenario				
Water Demand	dam^3	43,591	46,604	50,312	53,856
Water Consumption	dam^3	43,591	46,604	50,312	53,856
Share of Surface Water to Total Water Demand	%	42.7%	42.6%	42.2%	42.1%
	Conservation Scenario				
Water Demand	dam^3	43,591	46,604	46,754	48,076
Water Consumption	dam^3	43,591	46,604	46,754	48,076
Share of Surface Water to Total Water Demand	%	42.7%	42.6%	42.5%	42.6%

The dairy and beef cattle sectors account for 79% of the total demand of water for the livestock sector with the poultry and egg, along with the hog sectors, accounting for 8% each. Climate change will have an impact on water demand as livestock will consume more water and require more water for cooling in confinement livestock operations. Opportunities for the conservation of water exist primarily in improved drinking water equipment.

The estimates of the water demand by river basins for the three scenarios are presented in Tables 4.10 to 4.12 for the three study scenarios. The size of the beef cattle herd within each basin is, to a large extent, the main difference in water demand among basins. Under the baseline scenario, the total amount of water demand in the province is estimated at 43.6 thousand dam^3, which would increase to 50 thousand dam^3 by 2060 – which is an increase of almost 15%. Within the province, the higher amount of water demanded for livestock is in the Qu'Appelle River Basin, followed by the North Saskatchewan River Basin, as evident from Figure 4.6.

Table 4.10: Estimated Livestock Water Demand for Saskatchewan by Basins under the Baseline Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	2020	2040	2060
Assiniboine	3,160	3,410	3,587	3,746
Cypress Hills	1,483	1,581	1,633	1,683
Lake Winnipegosis	1,335	1,423	1,485	1,543
Missouri	2,943	3,133	3,243	3,350
North Saskatchewan	8,524	9,086	9,420	9,691
Northern	1,381	1,468	1,510	1,544
Old Wives	3,800	4,052	4,194	4,326
Qu'Appelle	9,266	9,956	10,409	10,799
Saskatchewan	1,998	2,130	2,217	2,296
Souris	4,326	4,608	4,762	4,896
South Saskatchewan	5,376	5,757	6,017	6,233
Total Livestock Water Demand	43,591	46,604	48,477	50,106

Under the climate change scenario, the water demand for livestock purposes increases. This increase is primarily the result of higher water requirements for various types of livestock under warmer temperatures. By 2060, one would expect this water demand to increase to 53.9 thousand dam^3, which is an increase of 7.5% over the baseline level.

Under a water conservation scenario, some reduction in this water demand is plausible. By 2060, total provincial water demand may be as low as 48 thousand dam^3, which is a reduction of 4%

over the baseline scenario level. A comparison of livestock water demand under various study scenarios is shown in Figure 4.7.

Table 4.11: Estimated Livestock Water Demand for Saskatchewan by Basins under the Climate Change Scenario, 2010-2060

Basin	2010	2020	2040	2060
Assiniboine	3,160	3,410	3,749	4,071
Cypress Hills	1,483	1,581	1,689	1,800
Lake Winnipegosis	1,335	1,423	1,553	1,675
Missouri	2,943	3,133	3,368	3,600
North Saskatchewan	8,524	9,086	9,740	10,359
Northern	1,381	1,468	1,553	1,636
Old Wives	3,800	4,052	4,344	4,631
Qu'Appelle	9,266	9,956	10,834	11,660
Saskatchewan	1,998	2,130	2,308	2,478
Souris	4,326	4,608	4,920	5,227
South Saskatchewan	5,376	5,757	6,255	6,720
Total Livestock Water Demand	43,591	46,604	50,312	53,856
% Change over the Baseline Scenario	0.0%	0.0%	3.8%	7.5%

Table 4.12: Estimated Livestock Water Demand for Saskatchewan by Basins under the Water Conservation Scenario, 2010-2060

Basin	2010	2020	2040	2060
Assiniboine	3,160	3,410	3,448	3,573
Cypress Hills	1,483	1,581	1,578	1,625
Lake Winnipegosis	1,335	1,423	1,428	1,476
Missouri	2,943	3,133	3,131	3,232
North Saskatchewan	8,524	9,086	9,104	9,318
Northern	1,381	1,468	1,465	1,497
Old Wives	3,800	4,052	4,052	4,176
Qu'Appelle	9,266	9,956	10,009	10,304
Saskatchewan	1,998	2,130	2,137	2,203
Souris	4,326	4,608	4,612	4,739
South Saskatchewan	5,376	5,757	5,791	5,934
Total Livestock Water Demand	43,591	46,604	46,754	48,076
% Change over the Baseline Scenario	0.0%	0.0%	-3.6%	-4.1%

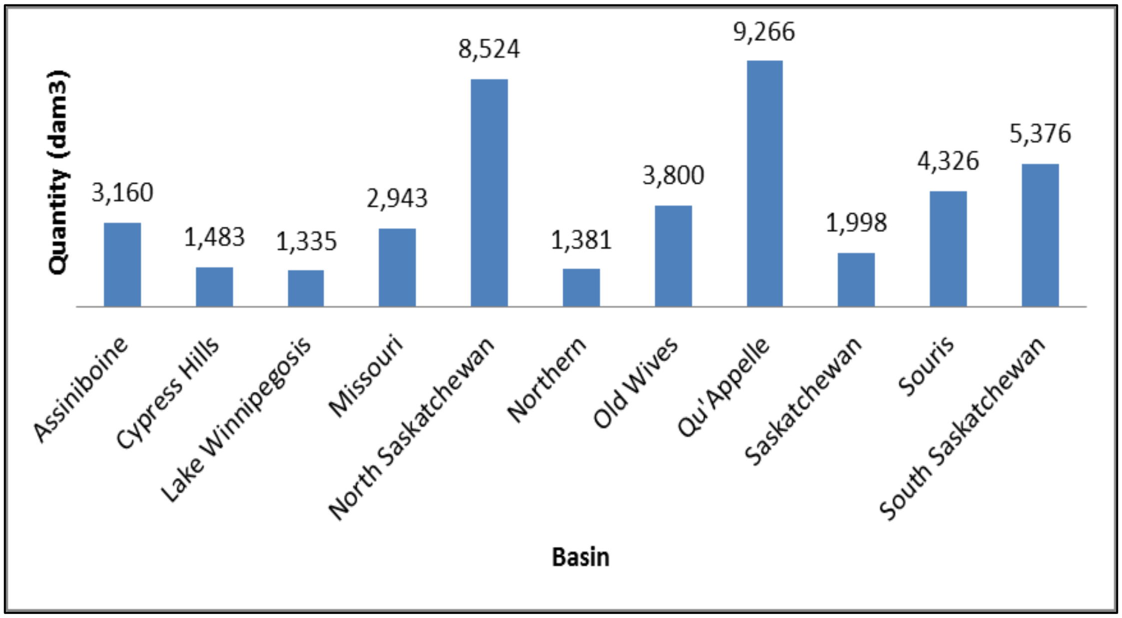

Figure 4.6: Level of Water Demand for Livestock by River Basins, 2010

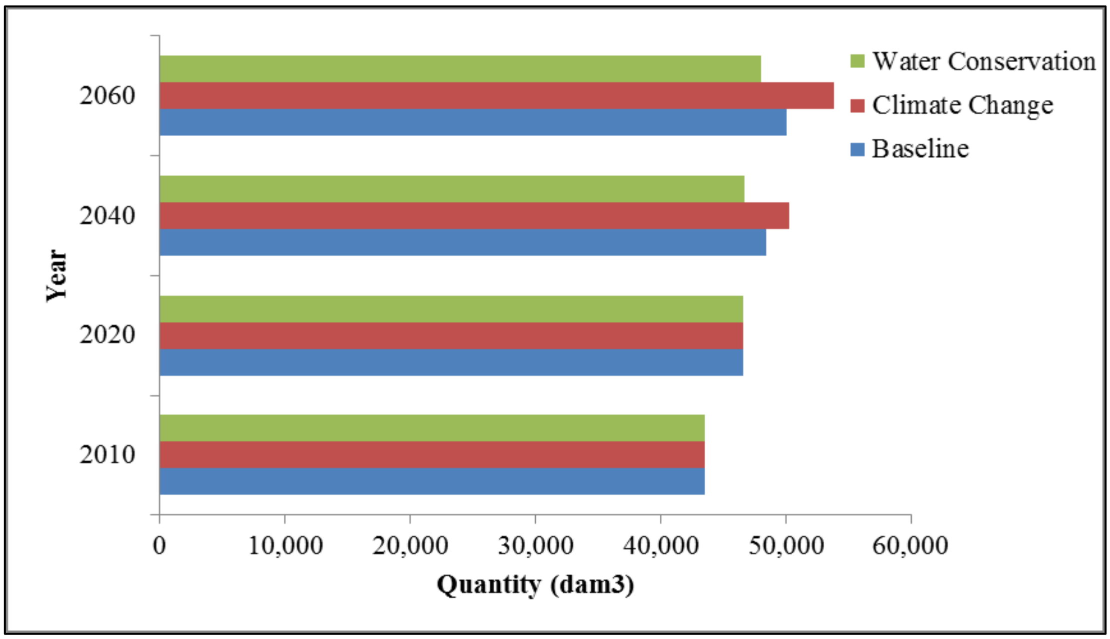

Figure 4.7: Water Demand for Livestock Purposes under Study Scenarios, 2010-2060

4.4 Greenhouse and Nurseries Water Demand

Water demand in the greenhouse and nurseries sector is presented in Table 4.13 for Saskatchewan as a whole. No effect of climate change or water conservation on this demand was estimated because of a lack of information. There is only a limited amount of data available as to production practices and types of products produced in Saskatchewan by this sector. Furthermore, some of these operations are under climate controlled conditions, and may not be affected by climate change. Similarly, although some water conservation measures could be implemented, a lack of knowledge of such measures precluded the estimation of this water demand in this study.

Table 4.13: Water Demand and Consumption for Greenhouse and Nurseries Sector, Saskatchewan, 2010-2060

Particulars	Water Demand in dam^3			
	2010	2020	2040	2060
Water Demand	559	565	593	623
Consumption	559	565	593	623
Surface Water % of Intake	112	113	119	125

Total water demand by the greenhouses and nurseries sector was estimated at 559 dam^3 in 2010, which may increase to 623 dam^3 by 2060. This will mark an increase of 11.4% over the 2010 level. The distribution of the total provincial water demand for this purpose by river basins is shown in Table 4.14. Furthermore, the size of the greenhouse market in a basin is directly linked to the size of the urban population within the basin, as access to a close market is necessary. Therefore the Qu'Appelle, South Saskatchewan, and North Saskatchewan basins have the highest water demand for this sector. This distribution is shown in Figure 4.8.

Table 4.14: Estimated Greenhouse and Nurseries Sector Water Demand, Saskatchewan by River Basins, 2010-2060

River Basin	Water Demand in dam^3			
	2010	2020	2040	2060
Assiniboine	24	24	26	27
Cypress Hills	12	12	13	13
Lake Winnipegosis	16	16	17	17
Missouri	12	13	13	14
North Saskatchewan	152	153	161	169
Northern	16	16	17	18
Old Wives	12	12	13	13
Qu'Appelle	117	119	124	131
Saskatchewan	50	50	53	55
Souris	28	29	30	31
South Saskatchewan	120	121	127	134
Total	559	565	593	623

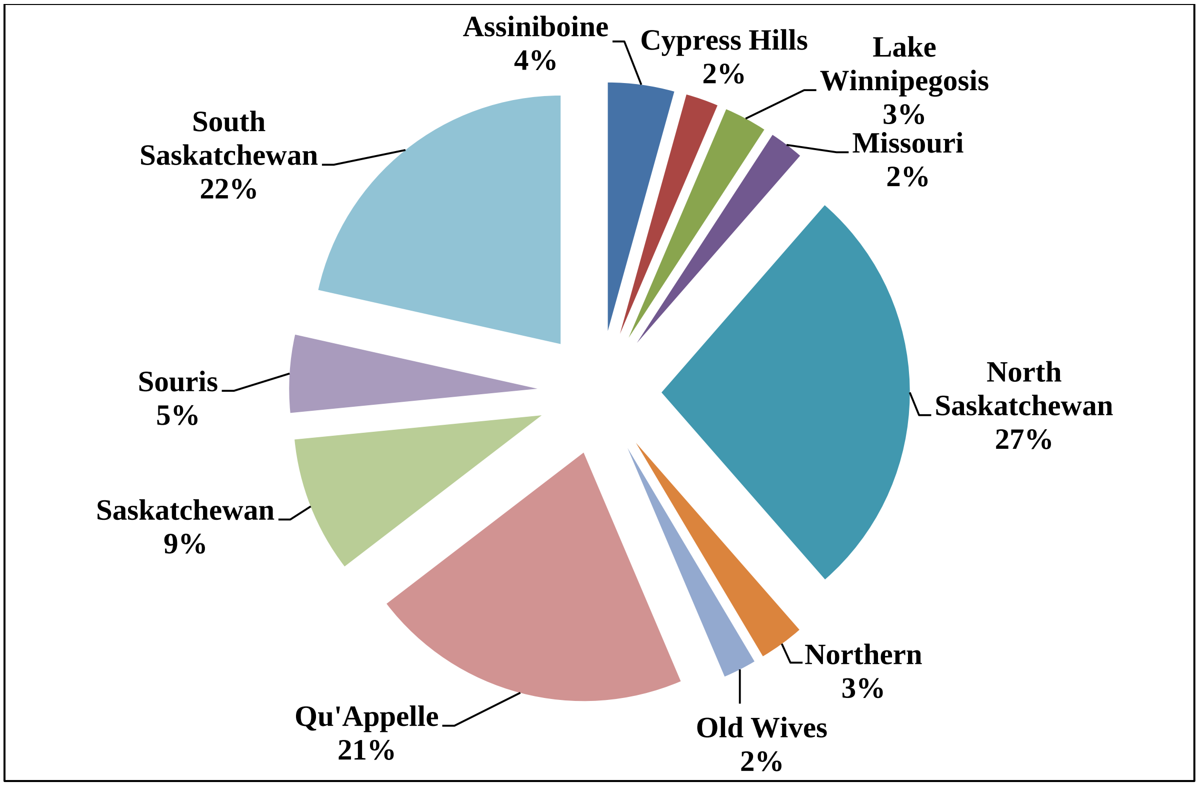

Figure 4.8: Distribution of Provincial Water Demand by the Greenhouses and Nurseries Sector by River Basins, 2010

4.5 Aquaculture Water Demand

Data on aquaculture operations as to number, production, and location was unavailable, and were therefore obtained from secondary sources (from R. Halliday and Associates, 2009). This study reported that 447 dam^3 of water were demanded in the aquaculture sector, of which 140 dam^3 are surface water.

Much of this water demand for aquaculture activities is in the South Saskatchewan River Basin, followed by the Qu'Appelle River Basin. Other basins that have some aquaculture activity include the North Saskatchewan River Basin, Northern Basin,[23] and Saskatchewan River Basin (Table 4.15). Other basins were not reported to have any aquaculture related water demand. Also, the effect of climate change and water conservation on the demand of water for aquaculture was not estimated due to lack of information.

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[23] As noted earlier, this basin is an aggregate of four northern basins – Churchill River Basin, Lake Athabasca Basin, Kasba River Basin, and Tazin River Basin.

Table 4.15: Estimated Aquaculture Water Demand in Saskatchewan by River Basins, 2010-2060

Basin	**2010**	**2020**	**2040**	**2060**
Assiniboine	0	0	0	0
Cypress Hills	0	0	0	0
Lake Winnipegosis	0	0	0	0
Missouri	0	0	0	0
North Saskatchewan	16	16	16	16
Northern	9	9	9	9
Old Wives	0	0	0	0
Qu'Appelle	111	111	111	111
Saskatchewan	12	12	12	12
Souris	0	0	0	0
South Saskatchewan	299	299	299	299
Total	447	447	447	447

Source: R. Halliday & Associates (2009).

4.6 Total Agricultural Water Demand

The five demands of water by agriculture sector are now aggregated to show total agricultural water demand in Saskatchewan. Results are shown in Table 4.16. The total water demand by the agriculture sector under baseline conditions would increase from 656 thousand dam^3 to 1.33 million dam^3 – an increase of 103% over the 2010 level. Much of this increase in irrigation would be as a result of infill irrigation projects, and of other new projects developed within the Lake Diefenbaker Development Area, and as a result of diversion from Lake Diefenbaker to the Qu'Appelle River Basin. Irrigation water demand dominated the total agricultural water demand in the province, as shown in Figure 4.9. Irrigation water demand accounts for 93% of the total and is the only major demand among all agricultural water demands. Total water demands by the agricultural sector would increase over a period of time and under the climate change scenario, as evident in Figure 4.10. However, the adoption of water conservation practices may bring forth some reduction in water demand by 2060.

4.7 Water Intake by Source

Surface water is the primary source for agriculture mainly because irrigation water demand gets an estimated 95% of its water from surface sources. Water demanded for livestock is a significant user of groundwater especially over the winter months for cattle operations. The estimates for surface water demand by basin for each scenario are presented in Tables 4.17 for the baseline scenario, in Table 4.18 for the climate change scenario, and in Table 4.19 for the water conservation scenario.

Table 4.16: Total Agriculture water Demand in Saskatchewan by Type of Demand and Study Scenarios, 2010-2060

Type of Agricultural Water Demand	Total Water Demand in dam^3			
	2010	**2020**	**2040**	**2060**
	Baseline Scenario			
Irrigation	609,972	661,579	1,026,394	1,281,258
Dryland Demand	1,492	1,470	1,452	1,452
Livestock	43,591	46,604	48,477	50,106
Greenhouses	559	565	593	623
Aquaculture	447	447	447	447
Total Agriculture Water Demand	**656,062**	**710,664**	**1,077,363**	**1,333,885**
	Climate Change Scenario			
Irrigation	609,972	661,579	1,187,891	1,601,989
Dryland Demand	1,492	1,503	1,521	1,579
Livestock	43,591	46,604	50,312	53,856
Greenhouses	559	565	593	623
Aquaculture	447	447	447	447
Total Agriculture Water Demand	**656,062**	**710,697**	**1,240,763**	**1,658,493**
	Water Conservation Scenario			
Irrigation	609,972	609,734	890,203	1,093,220
Dryland Demand	1,492	1,470	1,307	726
Livestock	43,591	46,604	46,754	48,076
Greenhouses	559	565	593	623
Aquaculture	447	447	447	447
Total Agriculture Water Demand	**656,062**	**658,820**	**939,304**	**1,143,091**

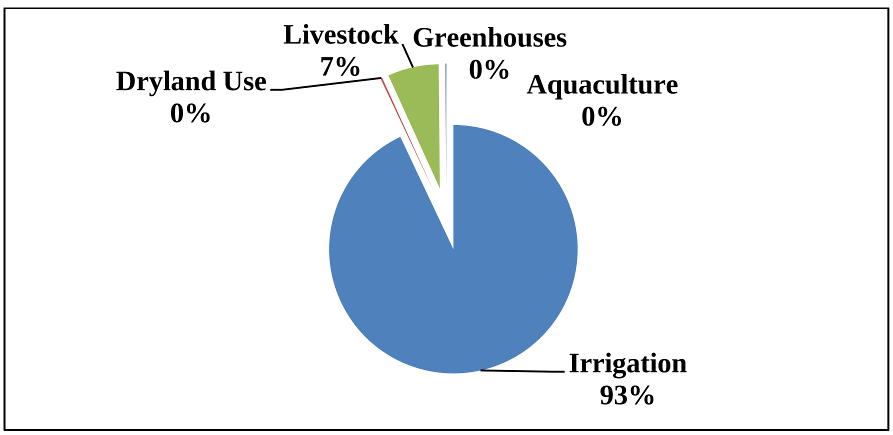

Figure 4.9: Distribution of Total Agricultural Water Demand in Saskatchewan by Type of Demand, 2010 Baseline Scenario

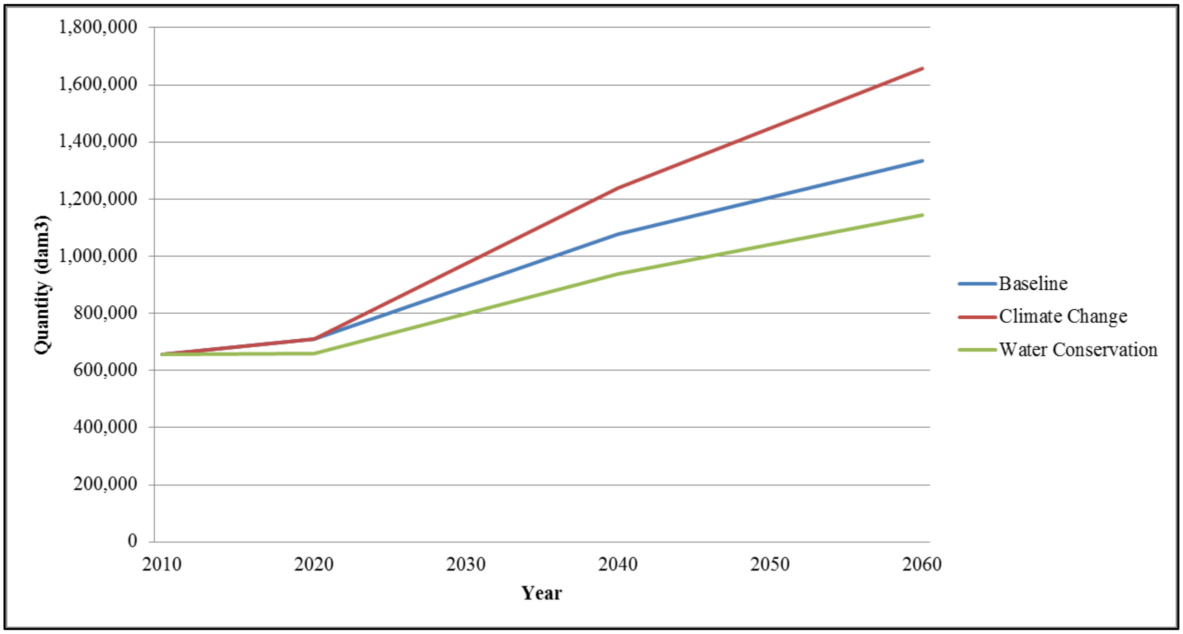

Figure 4.10: Trend in Total Agricultural Water Demand in Saskatchewan under Study Scenarios, 2010-2060

Table 4.17: Estimated Baseline Surface Water Demand by Basin (dam^3)

River Basin	**Total Water Demand in dam^3**			
	2010	**2020**	**2040**	**2060**
Assiniboine	4,573	4,685	4,786	4,893
Cypress Hills	40,007	40,299	40,883	41,561
Lake Winnipegosis	3,619	3,654	3,676	3,698
Missouri	110,430	110,707	111,189	111,744
North Saskatchewan	41,410	42,967	51,990	73,307
Northern	6,785	6,828	6,848	6,865
Old Wives	97,868	98,675	100,296	102,172
Qu'Appelle	56,154	58,108	156,075	196,822
Saskatchewan	3,496	3,559	3,606	3,655
Souris	13,066	13,276	13,513	13,770
South Saskatchewan	222,134	269,590	524,991	714,892
Total Surface Water Demand by Agriculture	599,542	652,347	1,017,853	1,273,378

Table 4.18: Estimated Climate Change Scenario Surface Water Demand by Basin (dam^3)

River Basin	Total Water Demand in dam^3			
	2010	2020	2040	2060
Assiniboine	4,573	4,686	5,424	5,934
Cypress Hills	40,007	40,300	47,435	51,976
Lake Winnipegosis	3,619	3,655	4,277	4,648
Missouri	110,430	110,708	123,699	131,398
North Saskatchewan	41,410	41,639	60,538	92,454
Northern	6,785	6,828	7,979	8,645
Old Wives	97,868	98,677	111,091	119,518
Qu'Appelle	56,154	58,114	182,637	249,352
Saskatchewan	3,496	3,560	4,109	4,465
Souris	13,066	13,279	15,231	16,543
South Saskatchewan	222,134	269,594	617,673	910,745
Total Surface Water Demand by Agriculture	599,542	651,040	1,180,092	1,595,677
% Change over the Baseline Scenario Level	0.0%	-0.2%	15.9%	25.3%

Table 4.19: Estimated Conservation Scenario Surface Water Demand by Basin (dam^3)

River Basin	Total Water Demand in dam^3			
	2010	2020	2040	2060
Assiniboine	4,573	4,393	4,190	4,091
Cypress Hills	40,007	36,889	34,553	33,145
Lake Winnipegosis	3,619	3,337	3,075	2,873
Missouri	110,430	100,375	92,264	86,005
North Saskatchewan	41,410	38,496	44,857	62,169
Northern	6,785	6,205	5,690	5,276
Old Wives	97,868	90,686	85,427	82,507
Qu'Appelle	56,154	53,981	136,782	170,820
Saskatchewan	3,496	3,323	3,136	2,998
Souris	13,066	12,302	11,625	11,249
South Saskatchewan	222,134	250,515	459,270	622,908
Total Surface Water Demand by Agriculture	599,542	600,502	880,870	1,084,040
% Change over the Baseline Scenario Level	0.0%	-7.9%	-13.5%	-14.9%

Water basins with the higher amounts of irrigation have the highest proportion of surface water uses in Saskatchewan. These basins include the South Saskatchewan River Basin, Qu'Appelle River Basin, Old Wives Lake Basin, and Missouri River Basin. The amounts of surface and groundwater in Saskatchewan for agriculture are shown in Figure 4.11. As irrigation expansion takes place, the importance of groundwater demand by agriculture decreases. In 2010, 8.6% of agricultural water demand was from groundwater sources, which decreases to 4.5% by 2060 under the baseline scenario.

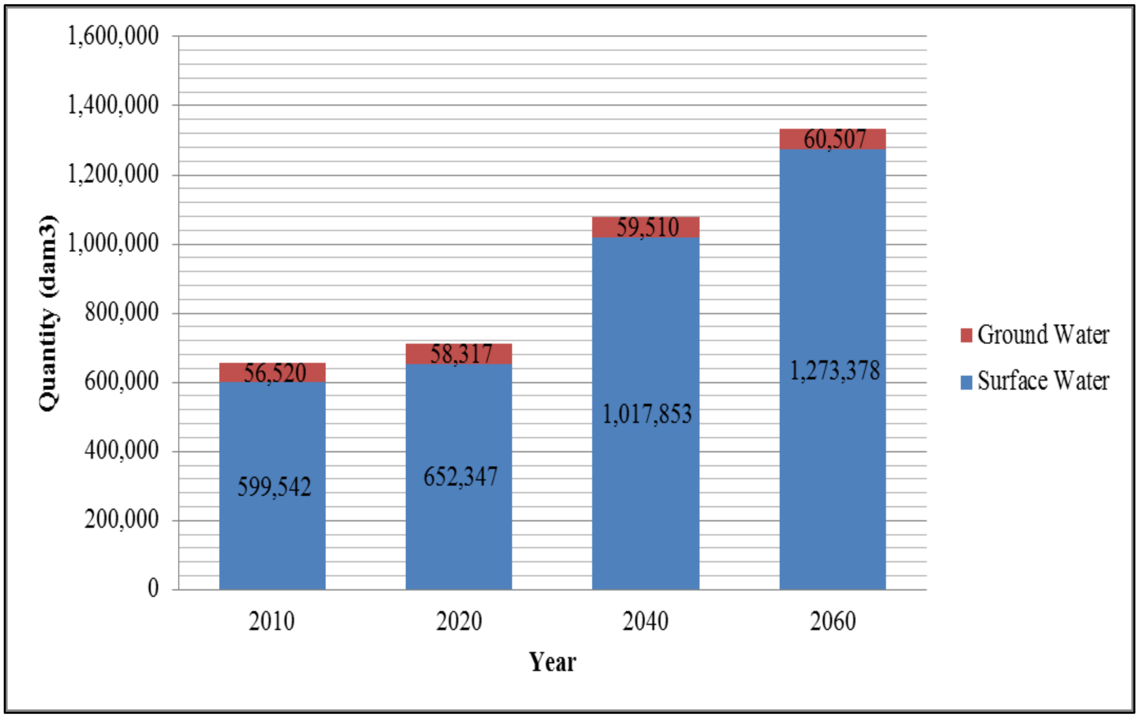

Figure 4.11: Amount of Surface and Groundwater Demanded by Agriculture Sector, Baseline Scenario, 2010-2060

Under climate change, the demand for surface water also increases. As shown in Table 4.18, surface water demand by agriculture increases by 25.3% above the baseline scenario level. Much of this increase happens as a result of irrigation expansion, which requires more water during this scenario, and most of this water is withdrawn from surface water bodies. Under the water conservation scenario, there is slight relief in terms of water withdrawn from surface water bodies -- now, the total amount of surface water demand is 15% lower than that seen under the baseline scenario.

4.8 Water Consumption

Agriculture is a major consumer of water in Saskatchewan as livestock, greenhouse, and dryland activities have no return flow, while district irrigation was estimated at 25% return flow. Specific estimates of water consumption for irrigation demand by study scenarios are presented in Table 4.20.

Table 4.20: Provincial Irrigation Water Demand and Consumption, by Study Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	2020	2040	2060
Baseline Scenario				
Water Demand	609,972	661,578	1,026,394	1,281,257
Return Flow	152,493	165,395	256,598	320,314
Consumption	457,479	496,184	769,795	960,943
Climate Change Scenario				
Water Demand	609,972	660,245	1,187,891	1,601,989
Return Flow	152,493	165,061	296,973	400,497
Consumption	457,479	495,184	890,918	1,201,491
Water Conservation Scenario				
Water Demand	609,972	609,734	890,203	1,093,220
Return Flow	152,493	152,433	222,551	273,305
Consumption	457,479	457,300	667,652	819,915

Although currently irrigation consumes about 475 thousand dam^3 of water, by 2060, this amount would increase to almost one million dam^3. Under climate change this amount would be even higher than this level at 1.2 million dam^3.

When all the agricultural water demands are combined, the level of water consumption increases, as shown in Table 4.21. Water consumption by agriculture under the baseline scenario is estimated at one million dam^3 under the baseline scenario, and 1.26 million dam^3 under the climate change scenario. Under the water conservation scenario, since less water is withdrawn, the level of consumption is only 870 thousand dam^3. Details on each river basin are presented in Table 4.22.

Table 4.21: Estimated Provincial Agricultural Water Consumption under Study Scenarios, 2010-2060

Study Scenario	Total Water Demand in dam^3			
	2010	2020	2040	2060
Baseline	503,568	545,269	820,763	1,013,570
Climate Change	503,568	544,302	943,789	1,257,995
Water Conservation	503,568	506,385	716,752	869,785

Table 4.22: Estimated Water Consumption by Agriculture Sector, by River Basin, Baseline Scenario, 2010-2060

	Total Water Consumption in dam^3			
Basin	**2010**	**2020**	**2040**	**2060**
Assiniboine	5,836	6,101	6,307	6,500
Cypress Hills	32,551	32,831	33,304	33,846
Lake Winnipegosis	3,821	3,912	3,974	4,033
Missouri	89,140	89,469	89,905	90,393
North Saskatchewan	38,495	40,052	47,065	63,248
Northern	6,226	6,313	6,356	6,391
Old Wives	79,759	80,524	81,834	83,329
Qu'Appelle	50,985	52,952	126,768	157,612
Saskatchewan	4,190	4,332	4,432	4,526
Souris	13,090	13,428	13,706	13,987
South Saskatchewan	179,476	215,355	407,114	549,705
Total	503,568	545,269	820,763	1,013,570

In all scenarios, the extent of irrigation activity within a basin is the main factor that determines the amount of water consumed within a basin. The distribution of total water consumed by agriculture in each river basin is shown in Figure 4.12.

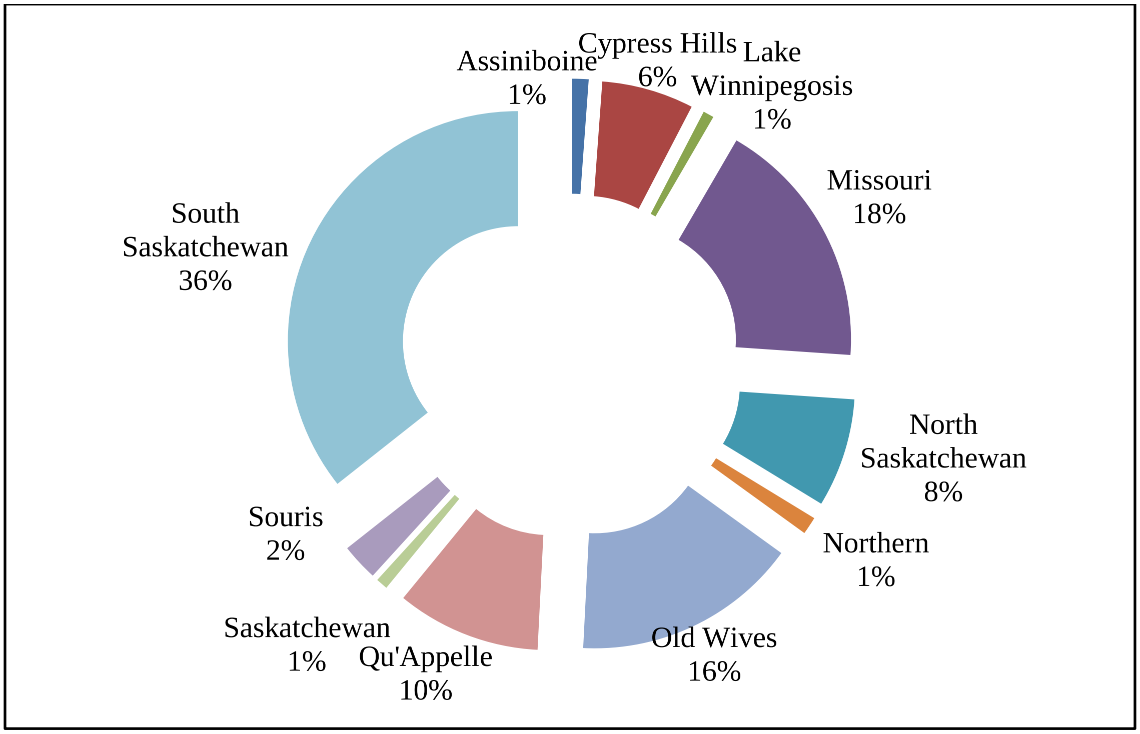

Figure 4.12: Distribution of Water Consumption by Saskatchewan Agriculture Sector by River Basins, Baseline Scenario, 2010

Water consumption estimates under the climate change scenario and water conservation scenario are shown in Tables 4.23 and 4.24, respectively. Agricultural water consumption under climate change increases to 1.26 million dam^3, as against only one million dam^3 under the baseline scenario. Under the water conservation scenario, water that was consumed is reduced to 870 thousand dam^3.

Table 4.23: Estimated Water Consumption by Agriculture Sector by River Basin, Climate Change Scenario, 2010-2060

Basin	**Total Water Consumption in dam^3**			
	2010	**2020**	**2040**	**2060**
Assiniboine	5,836	6,103	6,907	7,519
Cypress Hills	32,551	32,832	38,257	41,736
Lake Winnipegosis	3,821	3,913	4,477	4,845
Missouri	89,140	89,471	99,378	105,310
North Saskatchewan	38,495	39,058	53,707	78,085
Northern	6,226	6,314	7,232	7,785
Old Wives	79,759	80,527	90,037	96,551
Qu'Appelle	50,985	52,959	147,008	197,646
Saskatchewan	4,190	4,333	4,877	5,266
Souris	13,090	13,432	15,101	16,288
South Saskatchewan	179,476	215,360	476,809	696,964
Total	503,568	544,302	943,789	1,257,995

Table 4.24: Estimated Water Consumption by Agriculture Sector by River Basin, Water Conservation Scenario, 2010-2060

	Total Water Consumption in dam^3			
Basin	**2010**	**2020**	**2040**	**2060**
Assiniboine	5,836	5,882	5,755	5,749
Cypress Hills	32,551	30,274	28,519	27,487
Lake Winnipegosis	3,821	3,674	3,479	3,354
Missouri	89,140	81,720	75,631	70,995
North Saskatchewan	38,495	36,698	41,484	54,566
Northern	6,226	5,846	5,458	5,163
Old Wives	79,759	74,533	70,582	68,457
Qu'Appelle	50,985	49,856	111,994	137,665
Saskatchewan	4,190	4,155	4,018	3,946
Souris	13,090	12,698	12,187	11,962
South Saskatchewan	179,476	201,049	357,646	480,441
Total	503,568	506,385	716,752	869,785

4.9 Summary

Agriculture is a major water user of water in many river basins of Saskatchewan. The irrigation water demand presently accounts for 93% of the total amount of water demanded for the production of agricultural commodities in Saskatchewan. The projected expansion of irrigation to 2060 will only increase this percentage. Surface water is the main source for water demand in agriculture currently accounting for 91% of the water demand. Climate change could affect the demand for water from agricultural operations by increasing water demand to 124% of the 2060 baseline projections. While water conservation options, if implemented, would reduce water demand to 85% of the 2060 baseline projection, agricultural water demand would remain a significant water demand sector. In addition, a large proportion of the water demand is consumed, either by crops or livestock, resulting in 76% of the total water demand being lost by not being returned to the original water body.

Chapter 5

Industrial / Mining Water Demand

Saskatchewan is a rich province in terms of potash mines, uranium, and oil and gas. In addition, there is significant number of agri-processing establishments. Water demand for these activities is reported in this chapter by various river basins of Saskatchewan. Four types of activities are included here: (1) Mining water demand; (2) Manufacturing water demand; (3) Power Generation water demand, and (4) Irrigation Induced Industrial Activity related water demand. Each of these activities is described in this order in this chapter.

5.1 Mining Water Demand

As noted in Chapter 2 of this report, Saskatchewan has several types of mining activities. Major activities that demand water are potash production, oil and gas production, uranium mines, salt production, and other metal and non-metal mines.

5.1.1 Water Demand for Potash Production

The water demand estimates for the potash sector for the Baseline and Conservation scenarios are presented in Tables 5.1 and 5.2. On account of the nature of the production process and demand of water, climate change is not expected to affect water demand levels. Future water demand was estimated as a result of current production capacity plus new mines that might be in operation by 2060. These operations will increase water demand in 2060 to 126.7 thousand dam^3, some 5.7 times over the 2010 estimated levels. The adoption of conservation measures could reduce the water demand to 101 thousand dam^3 – a reduction of 25 thousand dam^3 by 2060 (Table 5.2).

Table 5.1: Saskatchewan Potash Water Demand Estimates by Source of Water under Baseline Scenario, 2010-2060

Particulars	Source of Water	Amount of Water in dam^3			
		2010	2020	2040	2060
Existing Mines	Surface	18,696	51,892	51,892	54,857
	Ground	3,363	3,457	3,457	3,457
New Mines	Surface	0	42,103	44,867	53,081
	Ground	0	1,544	9,836	9,836
	S/G*	-	5,476	5,476	5,476
Total	Surface	18,696	93,995	96,759	107,939
	Ground	3,363	5,001	13,293	13,293
	S/G	-	5,476	5,476	5,476
Total Potash Mining Water		**22,059**	**104,472**	**115,528**	**126,708**

* Source not clear. Could be either surface or groundwater, or a combination of the two.

Table 5.2: Saskatchewan Potash Water Demand Estimates by Source of Water under Water Conservation Scenario, 2010-2060

Particulars	Source of Water	Amount of Water Demand in dam^3		
		2020	2040	2060
Existing Mines	Surface	50,064	46,143	44,683
	Ground	3,381	3,208	3,025
New Mines	Surface	40,066	38,342	41,180
	Ground	1,467	8,361	7,377
	S/G	5,394	5,120	4,792
Total	Surface	90,131	84,485	85,863
	Ground	4,847	11,569	10,402
	S/G	5,394	5,120	4,792
Total Potash Mining Water Demand		**100,372**	**101,174**	**101,057**

Much of the water currently demanded for potash production comes from surface water bodies. Many of the mines are now supplied with water from the South Saskatchewan River Basin, either directly or through transferring water to other basins (such as the Saskatoon South-East Water Supply canal supplying water to mines located in the Qu'Appelle River Basin). In the future, as shown in Figure 5.1, water demand would come both from surface and groundwater sources. Various new mines being proposed and /or developed may withdraw groundwater or a combination of surface and groundwater.

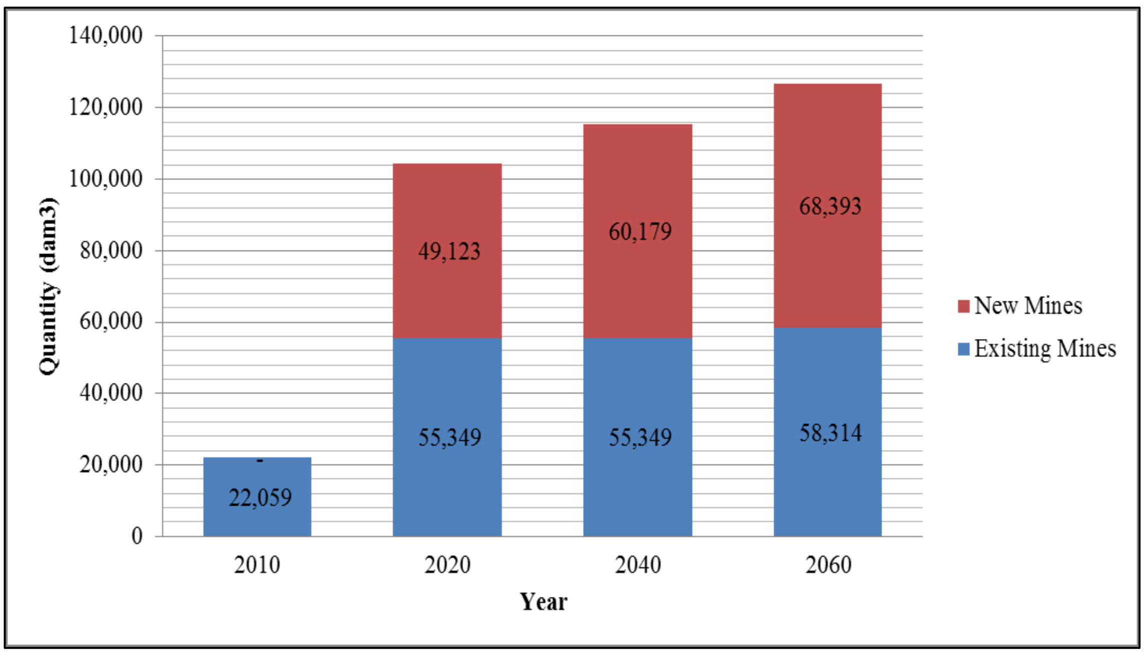

Figure 5.1: Water Demand for Potash Mines, Saskatchewan, Existing and New Mines, Baseline Scenario, 2010-2060

The estimated total water demand by Saskatchewan for potash production under two study scenarios is plotted in Figure 5.2. As noted earlier, no effect of climate change on water demand for the potash industry was assumed.

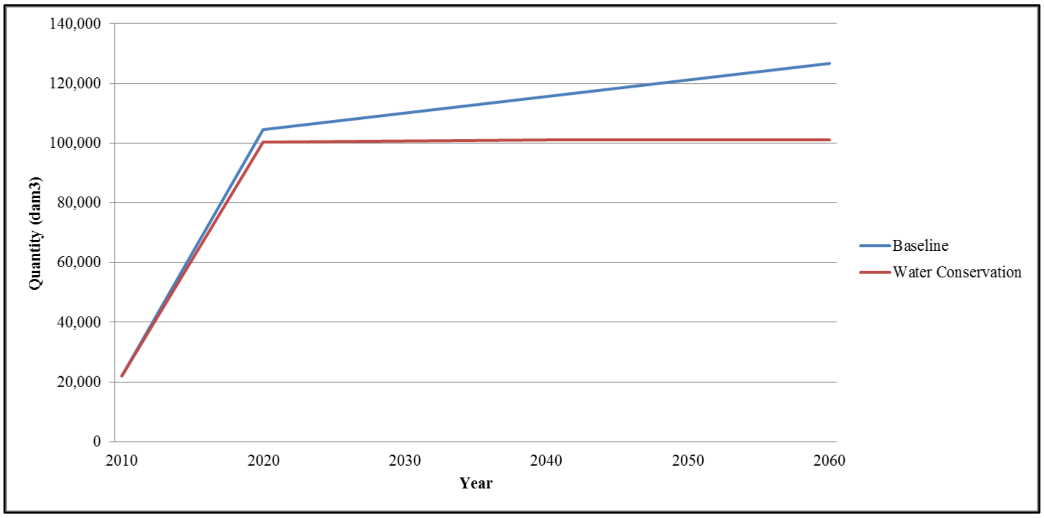

Figure 5.2: Water Demand for Potash Mining, Baseline and Water Conservation Scenarios, Saskatchewan, 2010-2060

Water demand for the province by river basins is shown in Tables 5.3 for the baseline scenario and in Table 5.4 for the water conservation scenario. Most of the province's potash production is located in the Qu'Appelle River Basin. However, the amount of water demanded for its purposes is provided by within basin water bodies, as well as through interbasin transfers (IBT) from the South Saskatchewan River Basin.

Table 5.3: Saskatchewan Water Demand for Potash Production under Baseline Scenario by River Basins, 2010-2060

River Basin	Amount of Water demand in dam^3			
	2010	**2020**	**2040**	**2060**
Assiniboine RB	1,017	6,493	6,493	6,493
South Saskatchewan RB (Transferred to North Saskatchewan RB)	1663	3220	3220	3220
South Saskatchewan RB (Within Basin production)	3,298	10,071	10,071	13,037
South Saskatchewan RB (Transferred to Qu'Appelle R B)	2,082	9,209	9,209	17,423
Qu'Appelle RB (Within Basin Water)	13,999	75,479	86,535	86,535
Other River Basins	0	0	0	0
Total Potash Mining Water Demand	**22,059**	**104,472**	**115,528**	**126,708**

Table 5.4: Saskatchewan Water Demand for Potash Production under Water Conservation Scenario, by River Basins, 2010-2060

River Basin	Amount of Water demand in dam^3		
	2020	**2040**	**2060**
Assiniboine RB	6,395	6,071	5,681
South Saskatchewan RB (Transferred to North Saskatchewan RB)	3172	3011	2817
South Saskatchewan RB (Within Basin production)	9,920	9,417	11,407
South Saskatchewan RB (Transferred to Qu'Appelle RB)	8,979	8,518	15,245
Qu'Appelle RB	71,906	74,157	65,907
Other River Basins	0	0	0
Total Potash Mining Water Demand Total	**100,372**	**101,174**	**101,057**

The South Saskatchewan River Basin, through IBT, provides water to both the Qu'Appelle and the North Saskatchewan River Basins. As shown in Figure 5.3 (left panel), 17% of the total water demanded for potash production in Saskatchewan is transferred from the South Saskatchewan River Basin. The Qu'Appelle River Basin remains to be a major potash producing basin now, and its share in the future increases in the future (Figure 5.3, right panel). Still. The pattern of water demand remains the same under a water conservation scenario, except that the amounts are lower than those under the baseline scenario (Table 5.4).

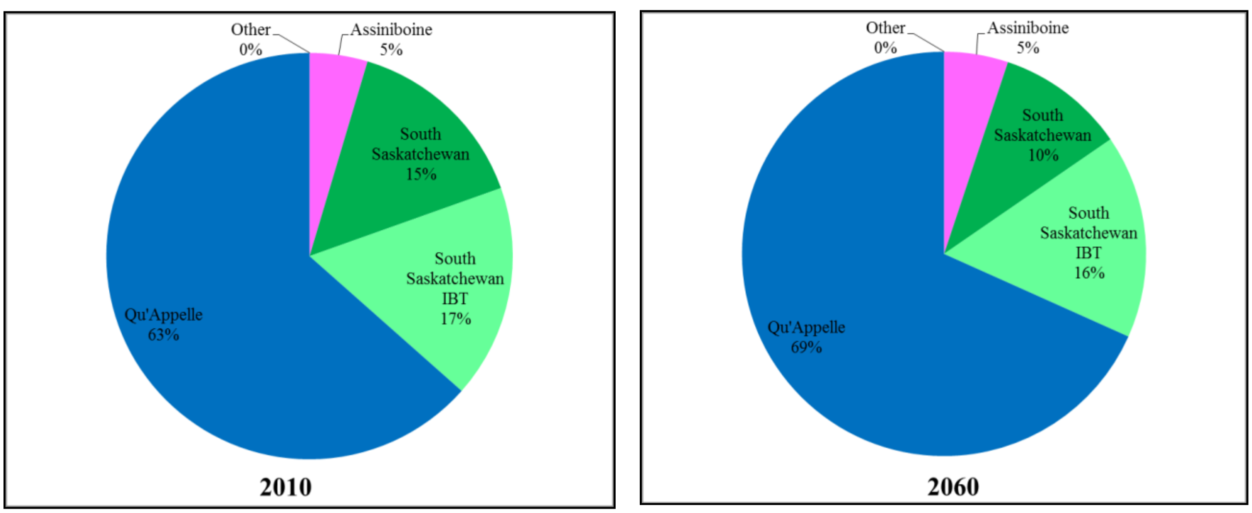

Figure 5.3: Distribution of Potash Mining Water Demand by River Basins, Saskatchewan, Baseline Scenario, 2010 and 2060

5.1.2 Oil and gas Water Demand

Oil and gas production-related water demand is relatively smaller than that for potash production, and is forecasted to be lower in the future. This effect occurs on account of dwindling resources as drilling for wells becomes uneconomic in the future. The total water demand for this purpose is estimated to be 9,588 dam^3 at present, which will reduce to 1,931 dam^3 by 2060. Distribution of this water demand by river basins is provided in Table 5.5 for the baseline scenario. The major activity in this sector is located in the Souris River Basin, followed by Northern River Basins, and by the North Saskatchewan River Basin (Figure 5.4). All the water demanded in the oil and gas sector is considered to be consumed, as it is rendered unsuitable for other uses.

Table 5.5: Water Demand for Oil & Gas Sector, Saskatchewan by River Basins, under Baseline Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
Assiniboine	692	930	558	140
Northern Basins	1,028	1,380	828	207
Cypress Hills	242	325	195	49
Missouri	881	1,183	710	178
North Saskatchewan	933	1,253	752	188
Old Wives	50	68	41	10
Qu'Appelle	341	458	275	69
Souris	5,215	7,002	4,201	1,050
South Saskatchewan	205	275	165	41
Total Oil and Gas Production Water Demand	**9,588**	**12,873**	**7,724**	**1,931**

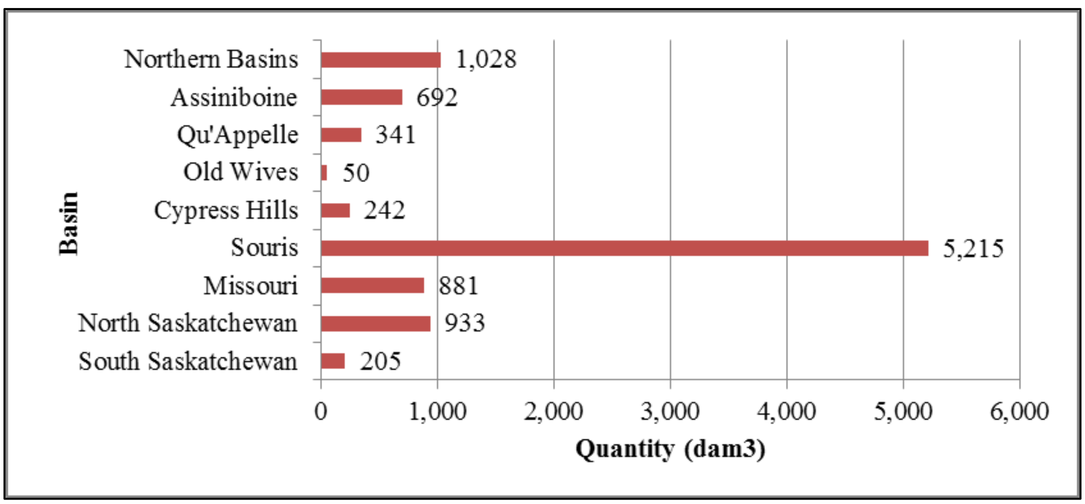

Figure 5.4: Level of Water Demand for the Oil and gas Production by River Basins, Baseline Scenario, 2010

Because of the nature of the operations, oil and gas production-related water demand was assumed to be unaffected by climate change. Therefore, water demand for this scenario would remain at the same level as the baseline scenario. Under the water conservation scenario, water demand level would be lower, as shown in Table 5.6. In 2060, this water demand may be only 1,641 dam^3, as against 1,931 dam^3 under the baseline scenario – a decrease by 15% of the baseline level.

Table 5.6: Water Demand for Oil & Gas Sector, Saskatchewan by River Basins, under Water Conservation Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
South Saskatchewan	205	234	140	35
North Saskatchewan	933	1,065	639	160
Missouri	881	1,006	604	151
Souris	5,215	5,952	3,571	893
Cypress Hills	242	276	166	41
Old Wives	50	57	34	9
Qu'Appelle	341	389	233	58
Assiniboine	692	790	474	119
Northern Basins	1,028	1,173	704	176
Total	**9,588**	**10,942**	**6,565**	**1,641**

5.1.3 Uranium Water Demand

Uranium mining is a major activity in the Northern Basins, with four mines in production and the mine at Cigar Lake intended to be in production by 2020. Given that uranium or other mines typically have a productive life of 15 to 25 years, it is assumed for the purposes of estimating water demand that mines of similar production will be brought on line over the 2020 to 2060 period. Current uranium mines are presented in Table 5.7.

Table 5.7: Uranium Mining Activity in Saskatchewan, 2011

Corporation	Location	Source of Water	Production in Tonnes of U_3O_8
Rabbit Lake	Rabbit Lake	Surface	1,769.5
Cluff Lake	Athabasca	Closed	Closed
McArthur River	Key Lake	Surface	9,029.0
Key Lake	Key Lake	Ground	
Cigar lake	Athabasca Basin	Surface	Not in Production
McClean Lake	McClean lake	Surface	1,388.0

The uranium industry is located in the Northern Basins, and the water demand for the three scenarios is presented in Table 5.8. It was assumed that all water once used would be unavailable for other uses, resulting in all water withdrawn being consumed. Relative to 2010, the water demand for uranium production is expected to decline slightly (Figure 5.5). Under the baseline scenario, water demand in 2060 would be 17.7% lower than that seen in 2010. Similarly, under the climate change scenario, water demand in 2060 would increase by 4% in 2060 over the 2010 level. Under this scenario, 2060 water demand would be 14.4% lower than that under the baseline scenario.

Table 5.8: Water Demand for the Uranium Sector by Scenario (dam^3)

Scenario	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
Baseline	4,445	3,515	3,585	3,657
Climate Change	4,445	3,515	3,657	3,803
Water Conservation	4,445	3,445	3,514	3,584

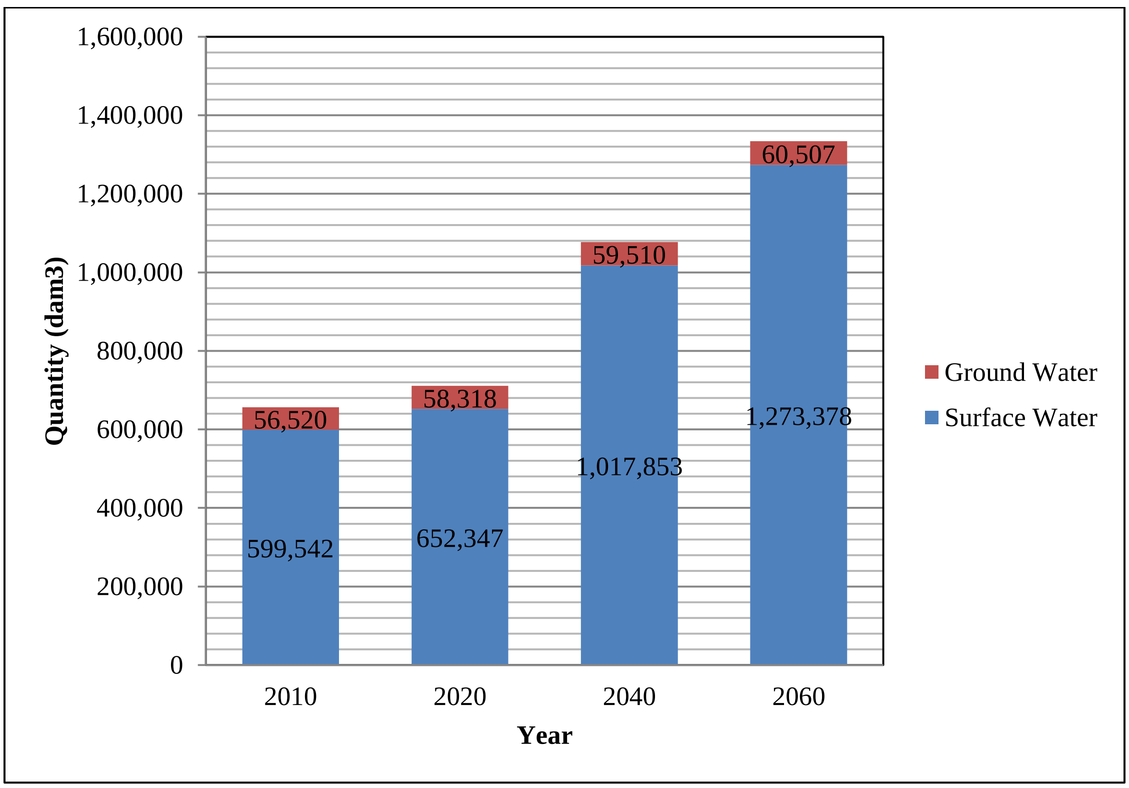

Figure 5.5: Water Demand for Uranium Production in Saskatchewan, by Study Scenarios, 2010-2060

5.1.4 Other Fuel (Coal) Mining Water Demand

In addition to oil and gas production, a large quantity of coal is mined in Saskatchewan. Much of this coal finds its way to power generation. In fact, most of the coal mining production is supplied to electrical power generation plants of Shand, Boundary, and Poplar River. Estimates of the baseline scenario water demand for this activity are presented in Table 5.9. The future of coal as a fuel for electricity generation is in question as GHG reduction targets will need to be met. No effect of climate change on the production process for coal extraction is estimated, while conservation estimates of water demand are presented in Table 5.10. Water conservation may bring some relief in water demand levels, but the magnitude is rather small (reduction of 1.8%).

Table 5.9: Water Demand for the Coal Mining Activity in Saskatchewan by River Basins, Baseline Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
Missouri	56	56	56	56
Souris	222	222	222	222
Total Water Demand	**278**	**278**	**278**	**278**
Consumption	**63**	**63**	**63**	**63**

Table 5.10: Water Demand for the Coal Mining Activity in Saskatchewan by River Basins, Water Baseline Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
Missouri	56	55	55	55
Souris	222	218	218	218
Total Water	**278**	**273**	**273**	**273**
Consumption	**63**	**61**	**61**	**61**

5.1.5 Metal Mining Water Demand

Gold mines in the Northern Basins and a diamond mine in the Saskatchewan Basin are the two metal mining activities in Saskatchewan. Their water demand was combined and is presented in Tables 5.11 to 5.13 for the baseline, climate change, and water conservation scenarios, respectively. It was assumed that water, once used, was unavailable for other water use sectors. Therefore, all water is assumed to be consumed. For metal mining, the water demand levels do not change significantly from one scenario to the other.

Table 5.11: Metal Mining Water Demand in Saskatchewan by River Basins, Baseline Scenario, 2010-2060

River Basin	Amount of Water in dam³			
	2010	2020	2040	2060
Northern	14	14	15	15
Saskatchewan	0.1	0.1	0.1	0.1
Total*	**14**	**15**	**15**	**15**

* Total may not add precisely due to rounding.

Table 5.12: Metal Mining Water Demand in Saskatchewan by River Basins, Climate Change Scenario, 2010-2060

River Basin	Amount of Water in dam³			
	2010	2020	2040	2060
Northern	14	14	15	16
Saskatchewan	0.1	0.1	0.1	0.1
Total	**14**	**15**	**15**	**16**

Table 5.13: Metal Mining Water Demand in Saskatchewan by River Basins, Water Conservation Scenario, 2010-2060

River Basin	Amount of Water in dam³			
	2010	2020	2040	2060
Northern	14	14	14	15
Saskatchewan	0.1	0.1	0.1	0.1
Total	**14**	**14**	**15**	**15**

5.1.6 Non-Metal Mining Water Demand

In addition to non-metal mining, Saskatchewan produces a number of non-metal mine products. Two products that fit in this category are salt and sodium sulphate. Salt mines in the province are located in the North Saskatchewan and Qu'Appelle River Basins. There is a single sodium sulphate mine located in the Old Wives Lake Basin.

Estimates of water demand for the baseline and water conservation scenarios are presented in Tables 5.14, and 5.15, respectively. No evidence on the impact of climate change on this water demand was found, and thus it is assumed to have no impact. Like other mining water demands, since no water is available for other uses, total water intake is assumed to be consumed.

Table 5.14: Non-Metal Mining Water Demand in Saskatchewan by River Basins, Baseline Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
North Saskatchewan	291	320	352	291
Old Wives	5,356	5,464	5,573	5,356
Qu'Appelle	31	34	37	31
Total	**5,678**	**5,817**	**5,962**	**5,678**

Table 5.15: Non-Metal Mining Water Demand in Saskatchewan by River Basins, Water Conservation Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
North Saskatchewan	283	291	320	283
Old Wives	5,251	5,356	5,464	5,251
Qu'Appelle	30	31	34	30
Total	**5,564**	**5,678**	**5,817**	**5,564**

Total water demand for the non –metal mines in Saskatchewan was estimated at 5,678 dam^3 per year. Of this total, Old Wives Lake Basin has the highest share (94% of the total). Since no specific time trends were noticeable, and no major new additional changes were expected during the study period, the 2060 period water is virtually the same as the present water demand.

Under a water conservation scenario, there is a possibility of reducing some water demand. In 2060, under this scenario, water demand could be about 2% lower that estimated under the baseline scenario.

5.1.7 Summary of Mining Water Demand

In this section, results are presented for all mining water demands. Water demand presented in the above sections was added together to yield the displayed results. The results are shown in Table 5.16 for the baseline scenario. Over the study period, this water demand is expected to increase by 322% of the 2010 level. Much of this increase will result from new potash mines that will start operations during this period. Climate change, as shown in Table 5.16, would have a minimal impact on this water demand, partly as a result of the nature of operations in this sector. Water conservation measures, if adopted, would result in lower demand, as shown in Figure 5.6. In 2060, these measures may reduce total mining water demand for the province by about 18.9% of the baseline level.

Table 5.16: Summary of Water Demand Estimates for the Saskatchewan Mining Sector by Study Scenario, 2010-2060

Scenario	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
Baseline	32,361	113,958	125,224	136,620
Climate Change	32,361	113,958	125,296	136,767
Water Conservation	32,361	109,668	110,676	110,771

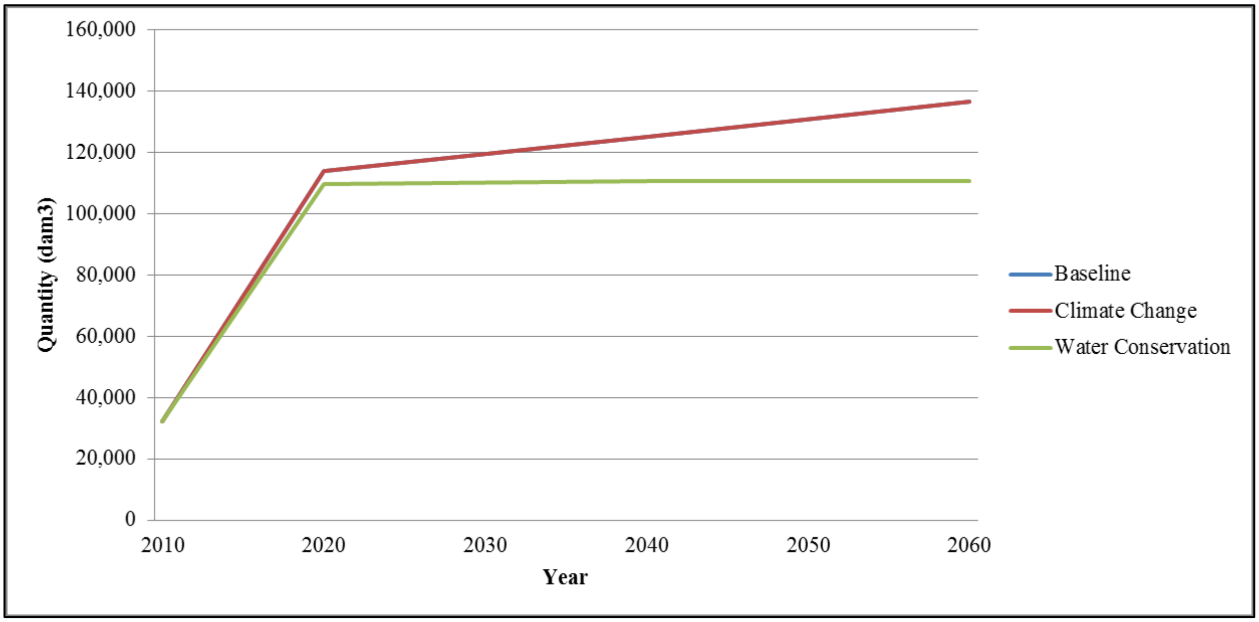

Figure 5.6: Saskatchewan Mining Water demand (and Consumption) under Study Scenarios, 2010-2060

From the nature of most mining activities, the water once used in the mining process is unavailable for other uses. Thus, all water demand levels shown in Table 5.17 are lost and therefore equal to water consumption by the mining sector.

5.2 Water Demand by Manufacturing Sector

Several types of manufacturing activities are present in various river basins of Saskatchewan. Many of these establishments are located within large urban areas, and they obtain their water requirements from a municipal water distribution system. These were excluded from the estimation of water demand in this study[24]. However, there are several establishments that are

[24] Water demand for these manufacturing industries in included under the municipal water demand.

outside such systems and are included here. These can be divided into two types of establishments: (1) those related to agriculture through their input requirements and (2) those that produce non-agricultural goods. These industries include biofuel firms, associated with or outside of food production[25] activities, as well as other types of food processing (such as meat processes or canola processing). A variety of non-agricultural manufacturing firms also exist in Saskatchewan, but many of these activities are associated with a municipal water distribution system. Those that are served through their own licenses issued by the Saskatchewan Watershed Authority for water withdrawal were analyzed in this section. The main non-agricultural manufacturing activities include establishments such as the co-operative oil refinery and the Yara fertilizer plant, among others. However, since for some of these firms separate[26] water demand estimates are not available, water demand was combined for both types of all manufacturing industries. Estimates for the water demand by manufacturing industries in various river basins of for the baseline, climate change, and conservation scenarios are presented in Tables 5.17 to 5.19, respectively. Please note that these water demands are exclusive of those required for the irrigation-induced manufacturing establishments.

Table 5.17: Water Demand by Manufacturing Industries under Baseline Scenario, Saskatchewan by River Basins, 2010-2060

River Basin	Amount of Water Demand in dam^3			
	2010	**2020**	**2040**	**2060**
Assiniboine	4	4	4	4
Cypress Hills	0	0	0	0
Lake Winnipegosis	0	0	0	0
Missouri	0	0	0	0
North Saskatchewan*	7,200	7,344	7,490	7,640
Northern Four	644	657	670	683
Old Wives	0	0	0	0
Qu'Appelle	7,445	7,811	8,517	9,263
Saskatchewan	327	334	340	347
Souris	319	307	291	272
South Saskatchewan	2,525	2,590	2,658	2,727
Total Province of Saskatchewan	**18,464**	**19,047**	**19,970**	**20,936**

* In addition, 6,752 dam^3 of water is received from the province of Alberta for industries located in this basin

[25] This refers to biofuel plants that have an associated livestock feedlot. One such plant is located at Lanigan, SK.

[26] Refers to agri-processing and non-agriculture processing parts of the same company.

Table 5.18: Water Demand by Manufacturing Industries under Climate Change Scenario, Saskatchewan by River Basins, 2010-2060

River Basin	Amount of Water Demand in dam^3			
	2010	2020	2040	2060
Assiniboine	4	4	4	4
Cypress Hills	0	0	0	0
Lake Winnipegosis	0	0	0	0
Missouri	0	0	0	0
North Saskatchewan	7,200	7,344	7,642	7,948
Northern	644	657	383	711
Old Wives	0	0	0	0
Qu'Appelle	7,445	7,811	8,688	9,448
Saskatchewan	327	334	347	361
Souris	319	307	297	283
South Saskatchewan	2,525	2,590	2,711	2,836
Total Province of Saskatchewan	**18,464**	**19,047**	**20,072**	**21,591**

Table 5.19: Water Demand by Manufacturing Industries under Water Conservation Scenario, Saskatchewan by River Basins, 2010-2060

River Basin	Amount of Water Demand in dam^3			
	2010	2020	2040	2060
Assiniboine	4	4	4	4
Cypress Hills	0	0	0	0
Lake Winnipegosis	0	0	0	0
Missouri	0	0	0	0
North Saskatchewan	7,200	7,184	7,307	7,428
Northern	644	644	657	670
Old Wives	0	0	0	0
Qu'Appelle	7,445	7,655	8,347	9,077
Saskatchewan	327	327	334	333
Souris	319	301	286	267
South Saskatchewan	2,525	2,538	2,604	2,672
Total Province of Saskatchewan	**18,464**	**18,653**	**19,539**	**20,451**

5.3 Power Generation Water Demand

5.3.1 Overview of Power Generation Sector

All power generation in the province takes place under the jurisdiction of the Saskatchewan Power Corporation (hereafter called SaskPower). This agency provides electrical power through its own generation as well as through imports. Currently, SaskPower has a total generation capacity of 4,356 MW. Two river basins where this capacity is located are the Souris River basin (capacity of 1,136 MW as shown in Table 5.22) and the South Saskatchewan River Basin (with a capacity of 1,151 MW).[27] These two basins, as shown in Figure 5.7, have half of the provincial electrical power generation capacity.

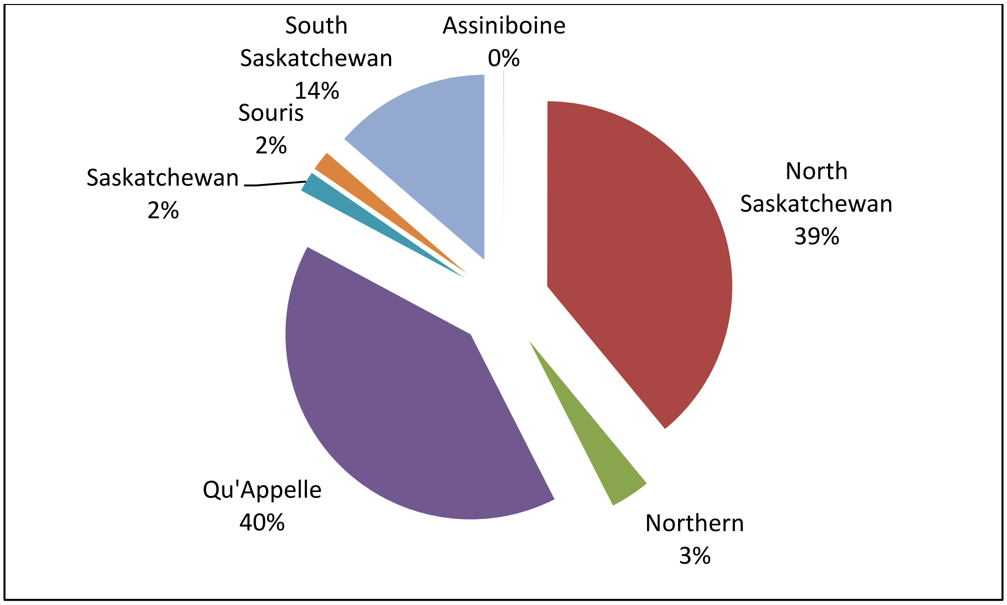

Figure 5.7: Distribution of Manufacturing Water Demand in Saskatchewan by River Basins, under Baseline Scenario, 2010

Total water consumption for manufacturing industries under the baseline scenario was estimated at 18.5 thousand dam^3. Almost 40% of this water demand was in the Qu'Appelle and the North Saskatchewan River Basins (partly as a result of a large biofuel plant at Lloydminster, and many industries around the cities of Regina and Moose Jaw). This water demand is drawn from Saskatchewan sources. In addition, some water used in this basin is supplied by the Province of Alberta. The South Saskatchewan River Basins have the next largest water demand for

[27] A list of current electricity generation plants by basin was presented in Chapter 2 of this report.

agricultural processing activities. These two river basins, as shown in Figure 5.7, claim 14% of the total provincial manufacturing water demand in 2010.

5.2.3 Summary of Industrial Water Demand

The water demand estimates for agri-processing industries and non-agricultural manufacturing industries are combined to obtain water demand for the manufacturing sector in Saskatchewan. Results are shown in Table 5.20. Under climate change, the province would witness an increase of total water demand. In 2060, this level would increase from 20.9 thousand dam^3 under the baseline scenario to 21.6 thousand dam^3 – an increase of 3.3% of the baseline level. Although through adoption of water conservation measures, some of this increase could be reduced, the water demand level may decrease to 20.5 thousand dam^3 by this period, which is a decrease of about 2% of the baseline level of water demand. For the three scenarios, results are graphically presented in Figure 5.8. As shown here, a higher demand is expected under climate change relative to the baseline scenario.

Table 5.20: Water Demand Estimates by the Manufacturing Sector, Saskatchewan by Scenarios, 2010-2060

Scenario	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
Baseline	18,464	19,047	19,970	20,936
Climate Change	18,464	19,047	20,072	21,591
Water	18,464	19,047	19,970	20,936

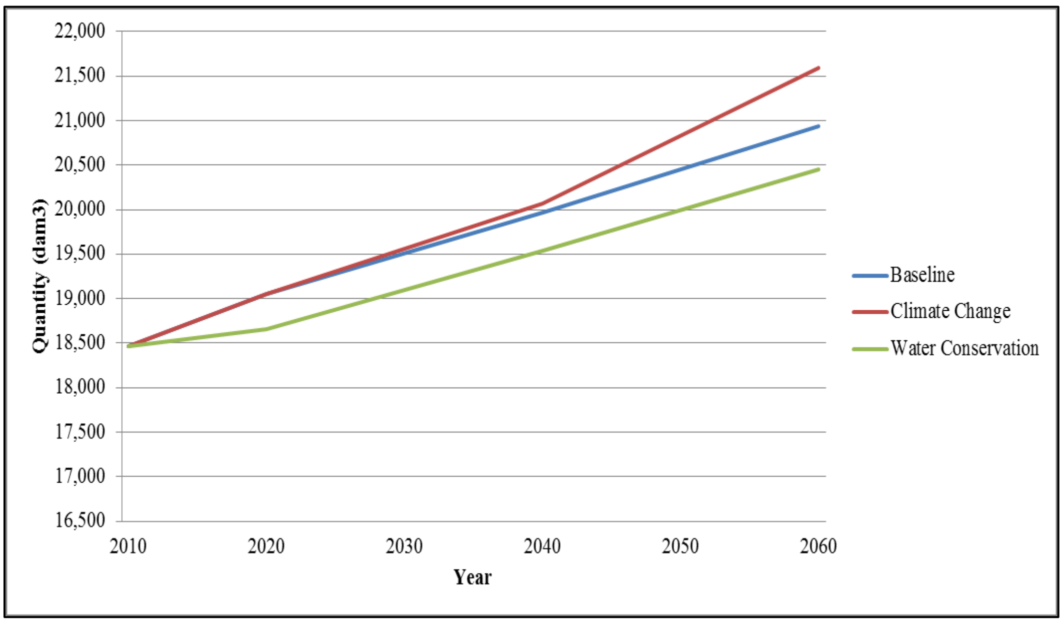

Figure 5.8: Pattern of Manufacturing Water Demand in Saskatchewan by Study Scenario, 2010-2060

A portion of the water intake is returned to the original or alternative source. As noted earlier, water consumption is the difference between water intake and water returned. In the case of North Saskatchewan River Basin, water intake is both from the within basin surface and groundwater, as well as from the province of Alberta. Since the location of water return from these industries is not clear, all water returned was assumed to be in the basin. As a result of this assumption, total water consumption in the province exceeds the level of water intake, as shown in Table 5.21. Water consumption by this sector was estimated for the three study scenario, and the results are presented in Table 5.21. Consumption levels represent about 78% of total water demand in 2010. In the future, this level is expected to be reduced to 73% or less.

Table 5.21: Water Consumption Estimates by the Manufacturing Sector, Saskatchewan by Scenarios, 2010-2060

Scenario	Water Consumption in dam^3			
	2010	**2020**	**2040**	**2060**
Baseline	19,683	19,022	19,713	20,435
Climate Change	19,683	19,053	20,175	21,180
Water Conservation	19,683	18,567	19,220	19,898

5.3 Power Generation Water Demand

5.3.1 Overview of Power Generation Sector

All power generation in the province takes place under the jurisdiction of the Saskatchewan Power Corporation (hereafter called SaskPower). This agency provides electrical power through its own generation as well as through imports. Currently, SaskPower has a total generation capacity of 4,356 MW. Two river basins where this capacity is located are the Souris River basin (capacity of 1,136 MW as shown in Table 5.22) and the South Saskatchewan River Basin (with a capacity of 1,151 MW).[28] These two basins, as shown in Figure 5.9, have half of the provincial electrical power generation capacity.

An estimated new capacity for Saskatchewan of 1,609 MW will be needed by 2020, and by 2033 it will increase to 2,159 MW along with replacement of, or reinvestment in, existing capacity to 2060 (SaskPower 2011). Various different generation and conservation options will be used to meet the expected power demand given the cost structure of each option and the requirements to meet base and peak load demand. Since a large percentage of the population and economic activity is centered on Saskatoon and Regina, generation capacity to meet these electricity

[28] A list of current electricity generation plants by basin was presented in Chapter 2 of this report.

demands from within and outside various basins will be considered. The replacement of major generation units and the construction of new generating stations would likely be located within the basins near existing transmission lines. It is also likely that to 2020 the current generating capacity, if replaced, will be using a similar technology. By 2040 and certainly by 2060, other generating options will be available that have different water requirements than the current technology in demand.

Table 5.22: Capacity of Power Generation Plants in Saskatchewan by River Basin, 2010

River Basin	Fuel Type	Generation Capacity in MW
Qu'Appelle Basin	Waste Heat	5
South Saskatchewan River Basin	Wind, Natural Gas, Water, Waste Heat	1,051
North Saskatchewan River Basin	Natural Gas, Waste Heat	785
Northern River Basins	Water, Natural Gas	168
Souris River Basin	Coal, Waste Heat	1,136
Assiniboine River Basin	Natural Gas	86
Missouri River Basin	Coal	582
Saskatchewan River Basin	Water	543
Provincial Total Generation Capacity		**4,356**

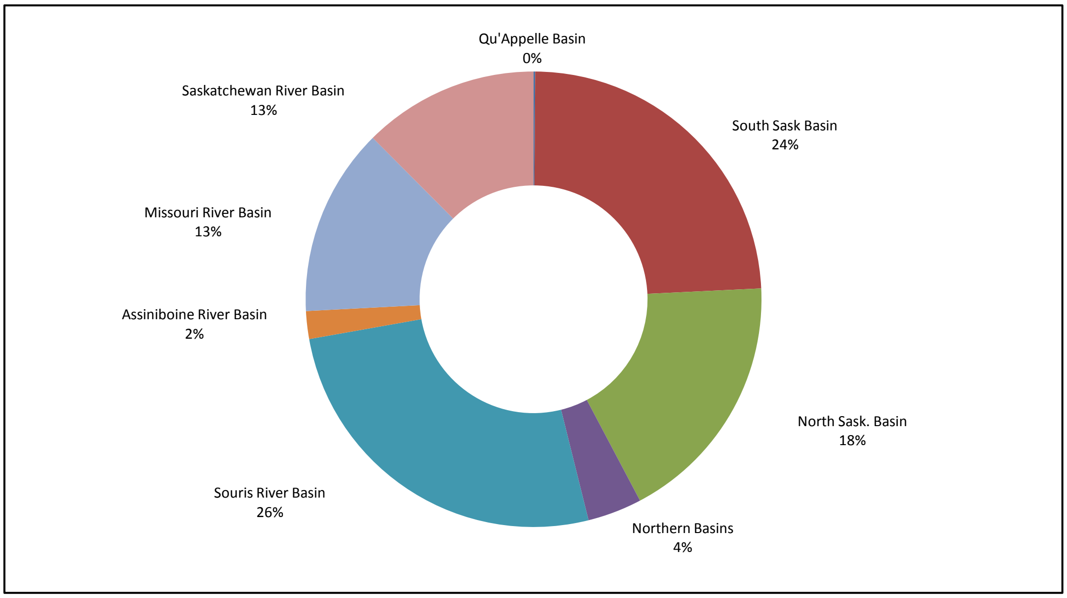

Figure 5.8: Distribution of Power Generation Capacity in Saskatchewan, by River Basin, 2010

Current and future estimates of electricity generation by source are presented in Table 5.23. As noted, SaskPower presently has a generation capacity of 4,356 MW. Given trends in power consumption, this capacity would have to be increased by 2060 to 7,646 MW. As shown in Figure 5.10 (Top Panel), power is produced mainly from coal (39%), natural gas (27%), and hydro (20%).

Table 5.23: Current and Estimated Future Provincial Generation Capacity, Saskatchewan, by Type of Fuel, 2010-2060

Type of Process / Fuel Type	Generation Capacity in MW			
	2010	2020	2040	2060
Hydro	853	853	1,195	1,195
Natural Gas	1,160	1,667	2,107	2,682
Wind	199	398	796	1,732
Solar	-	1	265	323
Heat Recovery + Biomass	20	40	353	431
Co Gen	438	876	706	861
Coal	1,686	1,686	843	422
Total Generation Capacity	**4,356**	**5,521**	**6,264**	**7,647**

The increased capacity, as forecasted by SaskPower, is allocated to power generation by renewable sources -- wind, co-generation, hydro, natural gas, waste heat, solar, biomass, and nuclear. By this period, these sources would claim 44% of the total provincial power generation capacity (Figure 5.10, Bottom Panel). Such alternatives would be made to reduce GHG emissions from fossil fuels, primarily coal, by using carbon capture and storage technology. This effort would reduce net electricity output from these sources and increase their demand through the extra cooling that will be required. Over the 2010-2060 period, coal generation would see, relatively speaking, reduction, replaced by renewable power generation facilities (Figure 5.11).

5.3.2 Non-consumptive (Hydroelectric) Water Needs/Demand for Power Generation

SaskPower presently operates seven hydroelectric power dams in the province, with three dams accounting for most of the capacity. These dams include Couteau Creek, in the South Saskatchewan River Basin, Campbell Hydroelectric Station (33.8% of total provincial hydro power capacity), and Nipawin Hydroelectric Station, both in the Saskatchewan River Basin. Their share of the total provincial hydroelectric power generation capacity is estimated at 21.8% for the Couteau Creek station, 33.8% for the Campbell Hydroelectric Station, and 29.9% for the Nipawin Hydroelectric Station.

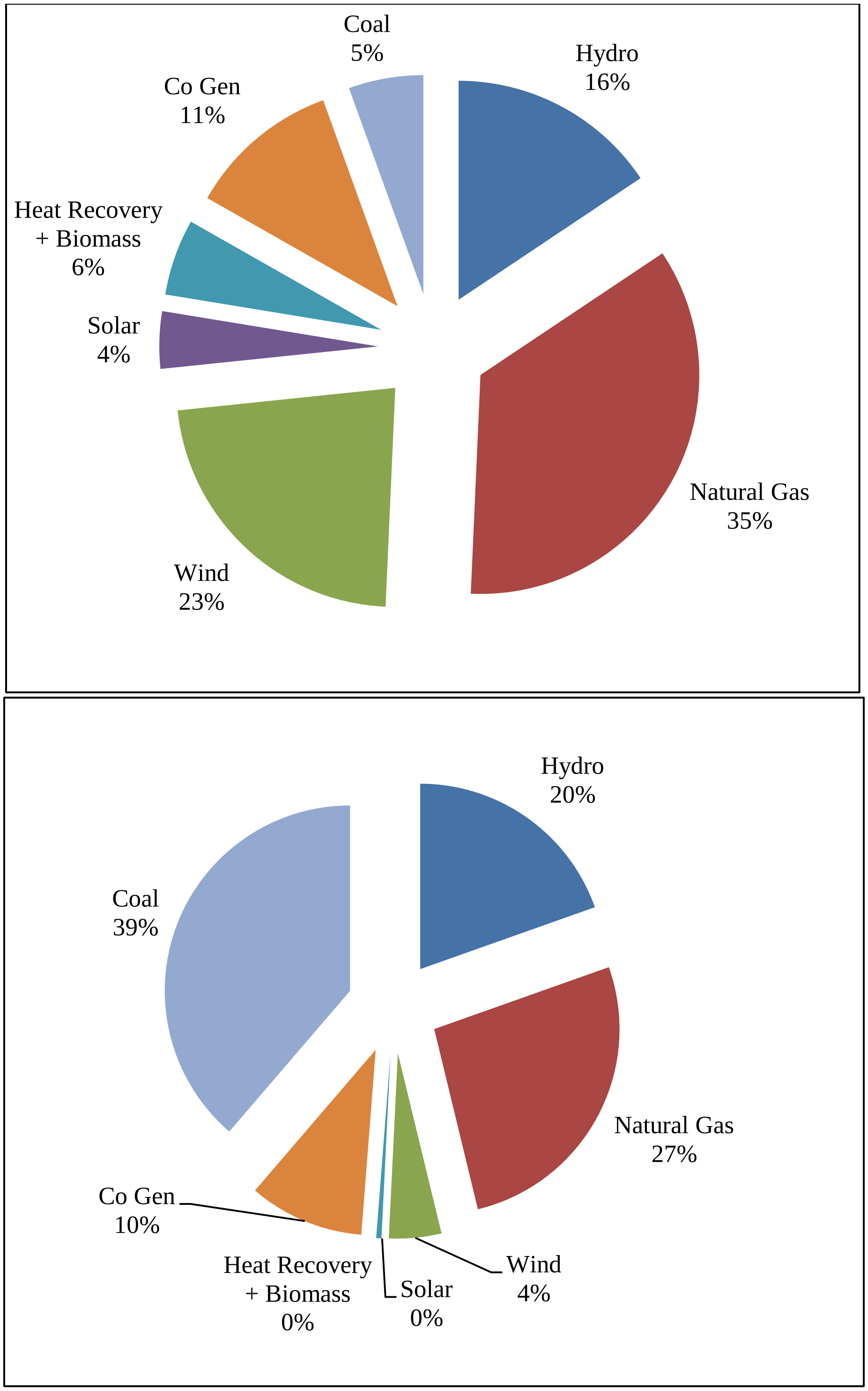

Figure 5.9: Distribution of Power Generation Capacity in Saskatchewan, 2010 (Top Panel) and 2060 (Bottom Panel)

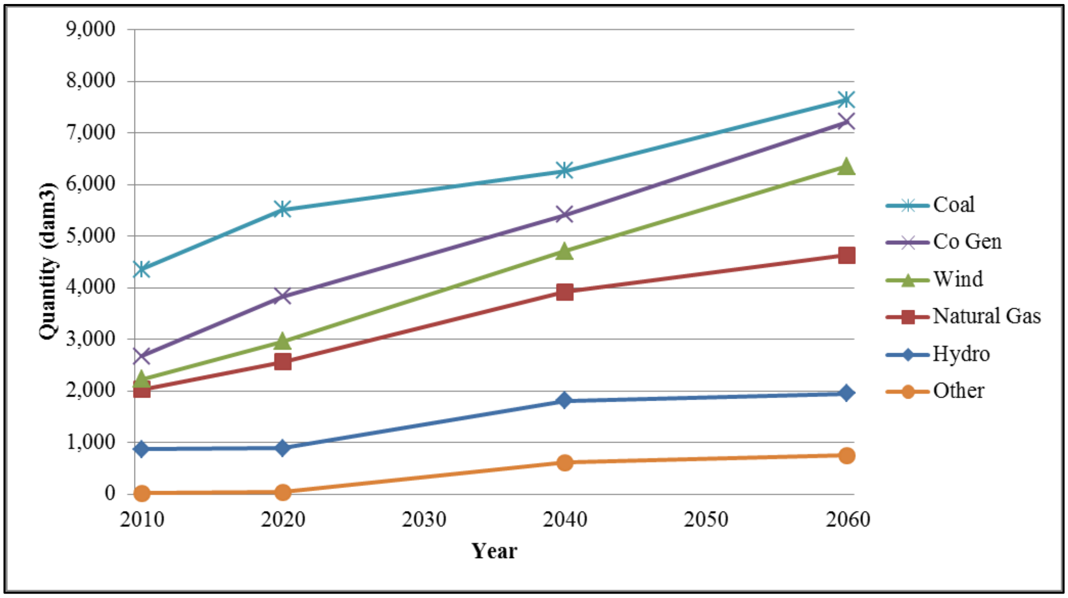

Figure 5.10: Development of Power Generation Capacity in Saskatchewan by Type of Process/Fuel Type, 2010-2060

Additional capacity is being considered in the form of run of the river generation with possible development by 2040.[29] SaskPower has identified hydropower development on the Saskatchewan River and its north and south branches, the Churchill River, and the Fond du Lac River (SaskPower, 2011). Possible hydropower generation in Northern Saskatchewan has been identified at 27 sites. Of these, 13 sites have a potential installed capacity of 10 MW; seven have a potential installed capacity between 2 MW and 10 MW; 10 have a potential installed capacity less than 2 MW (SaskPower, 2011). The Qu'Appelle South irrigation project could be a source of hydroelectric generation for the flow into Buffalo Pound from the proposed canal. These generating plants would be small in terms of electricity production.

The water released or to be released for hydroelectric power generation to 2060 is presented in Table 5.24. In 2010, 5.3 million dam^3 of water was released for this purpose. Since it is a non-consumptive water demand, theoretically water is available for other users downstream from the power station. However, in some river basins (such as Saskatchewan River Basin or the Northern River Basins) such demands are limited. By 2060, it is estimated that the amount of water to be released could rise to 6.6 million dam^3 – an increase by 40% of the release in 2010. As shown in Figure 5.12, some of this increase may be a result of new generation capacity in the North Saskatchewan River Basin.

[29] It is unclear whether climate change has been taken into account in these forecasts.

Table 5.24: Release of Water for Hydroelectric Power Generation, Saskatchewan, by River Basins, All Scenarios, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	2020	2040	2060
Sask Basin	2,570,400	2,570,400	2,807,085	2,807,085
Northern Basin	1,106,728	1,106,728	1,713,643	1,713,643
North Saskatchewan	-	-	446,261	446,261
SSRB	1,660,092	1,660,092	1,660,092	1,660,092
Province	**5,337,220**	**5,337,220**	**6,627,081**	**6,627,081**

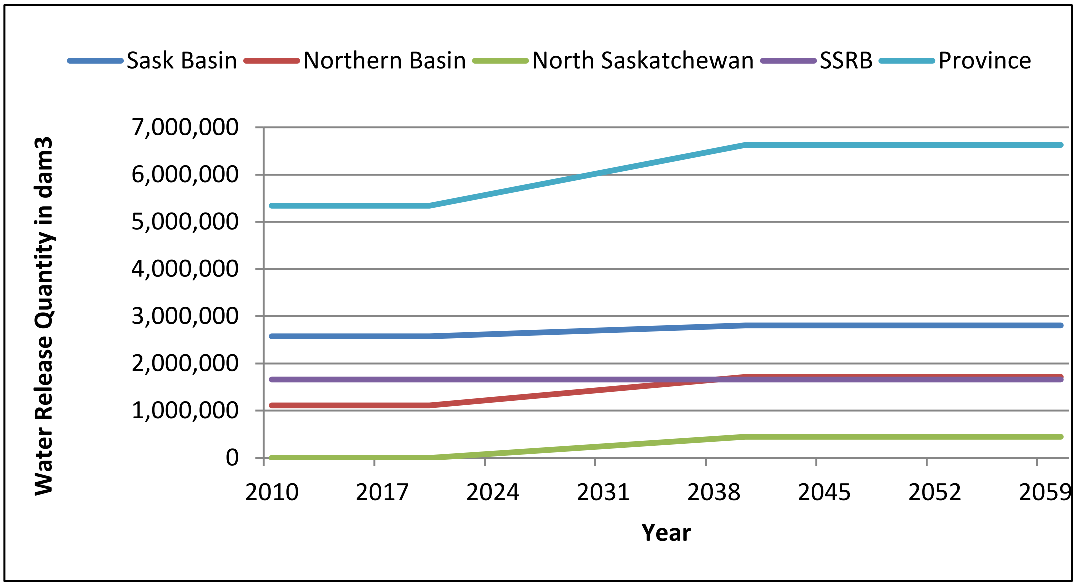

Figure 5.11: Water Release Requirements for Hydroelectric Power, Saskatchewan, 2010-2060

Climate change could impact the amount of water available to be released for hydroelectric power generation, resulting from lower water levels. This condition may result in a lower amount of power that may be generated. Water conservation, though, could occur through an increased efficiency of generators as old generators are replaced at the end of their economic lives. However, such effects would be marginal, given the volume of water demanded to generate hydroelectricity (Zulkoski, 2012).

5.3.3 Thermal Electric Water Demand

Thermal electric power generation using coal will continue until these plants are replaced. As shown in Table 5.25, this demand could continue until 2040, when other renewable energy sources can reduce the need for coal-fired plants. The shift away from coal to natural gas and other generation options, combined with meeting GHG commitments, will start to affect the water demand by 2040 and do so more significantly by 2060. Increases in natural gas demand from co-generation plants and from standalone facilities will more than double the water demand created from this type of generation by 2060.

Table 5.25: Provincial Water Demand for Thermal Electric Generation by Fuel Type, under Baseline Scenario, 2010-2060

Process Type	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
Coal	38,250	38,250	30,707	15,354
Natural Gas	4,126	6,112	8,210	10,164
Total Water Demand	**42,376**	**44,362**	**38,917**	**25,518**

Under the climate change and water conservation scenarios, significant changes in water demand level are not expected. These results, as shown in Tables 5.26 and 5.27, respectively, suggest smaller changes in total water demand for thermal electric power generation. In fact, as shown in Figure 5.13, water demand levels are estimated to be similar under these scenarios. Climate change could affect water demand in that greater quantities of water would be needed to achieve the same level of cooling. However, this necessity may be offset as newer technology is employed. A shift from water cooling towers to air cooled production could have a dramatic effect on water consumption by 2060, as water cooled systems demand 1,011 liters of water per MWh in contrast to only 21 litres per MWh for air cooled systems (Zulkoski, 2012). The potential adoption of such advanced technology is an implicit assumption in these projections.

Table 5.26: Provincial Water Demand for Thermal Electric Generation by Fuel Type, under Climate Change Scenario, 2010-2060

Process Type	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
Coal	38,250	38,250	31,321	15,968
Natural Gas	4,126	6,112	8,374	10,571
Total Water	**42,376**	**44,362**	**39,696**	**26,538**

Table 5.27: Provincial Water Demand for Thermal Electric Generation by Fuel Type, under Water Conservation Scenario, 2010-2060

Process Type	Amount of Water in dam^3			
	2010	**2020**	**2040**	**2060**
Coal	38,250	36,337	27,636	13,051
Natural Gas	4,126	5,795	6,908	7,461
Total Water	**42,376**	**42,132**	**34,544**	**20,511**

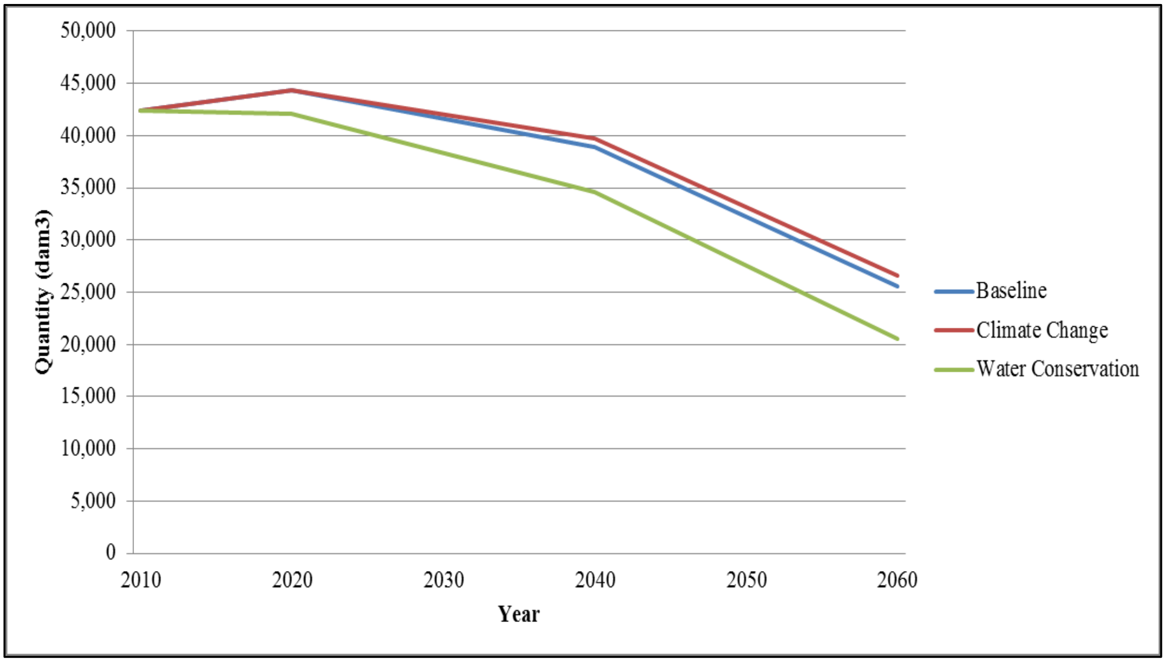

Figure 5.12: Thermal Electric Power Generation Water Demand in Saskatchewan, by Study Scenarios, 2010-2060

As thermal power generation water demand changes over time, it would affect different river basins in different ways. This distribution is shown in Table 5.28 for the baseline scenario. Water demand for this purpose in the basins where coal fired plants are located (such as the Missouri River Basin and the Souris River Basin) would decline by 2060. In contrast, new operations using natural gas in the North Saskatchewan and South Saskatchewan River Basins would increase water demand in these basins (Figure 5.14). The estimated water demand levels for thermal electric power generation by river basins under climate change and water conservation scenarios are shown in Tables 5.29 and 5.30, respectively. Distribution of water demand by river basins remains very similar to that shown under the baseline scenario.

Table 5.28: Saskatchewan Water Demand for Thermal Electric Generation by River Basins, under Baseline Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	2020	2040	2060
Assiniboine	103	148	187	239
Missouri	15,086	15,086	7,543	3,771
Northern	53	76	96	122
North Saskatchewan	2,115	2,933	4,032	5,026
Souris	23,164	23,164	23,164	11,582
South Saskatchewan	1,855	2,954	3,894	4,777
Total Water Demand	42,376	44,362	38,917	25,518

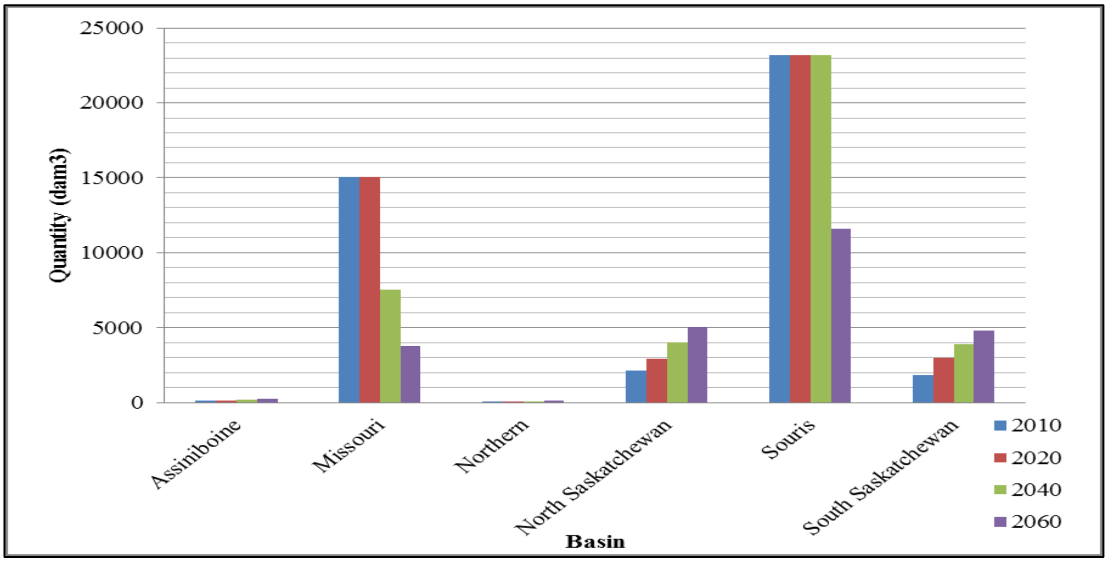

Figure 5.13: Distribution of Thermal Electric Power Water Demand in Saskatchewan, by River Basins, 2010-2060

Table 5.299: Saskatchewan Water Demand for Thermal Electric Generation by River Basins, under Climate Change Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	2020	2040	2060
Assiniboine	103	148	191	248
Missouri	15,086	15,086	7,694	3,922
Northern	53	76	98	127
North Saskatchewan	2,115	2,933	4,113	5,227
Souris	23,164	23,164	23,628	12,045
South Saskatchewan	1,855	2,954	3,972	4,968
Total	42,376	44,362	39,696	26,538

Table 5.30: Saskatchewan Water Demand for Thermal Electric Generation by River Basins, under Water Conservation Scenario, 2010-2060

River Basin	Amount of Water in dam^3			
	2010	2020	2040	2060
Assiniboine	103	133	112	72
Missouri	15,086	14,331	6,789	3,206
Northern	53	68	58	37
North Saskatchewan	2,115	2,787	3,427	3,770
Souris	23,164	22,006	20,848	9,845
South Saskatchewan	1,855	2,807	3,310	3,583
Total	42,376	42,132	34,544	20,511

In summary, projections for the demand of water by the electrical generation sector are dependent on alternative generation options being used to meet increased electricity demand and in the replacement of electricity generated by coal at 2060. The technologies of wind, solar, and heat recovery require no water to generate electricity and from water conservation point of view, would be preferred. However, the relative cost of production of these renewable power sources would determine the magnitude of their demand, and thus, the future water demand level for power generation.

5.4 Irrigation Induced Economic Activity

5.4.1 Type of Induced Economic Activities

In addition to expansion in existing industrial water demands, the basin may attract some other types of industrial water demands. These developments are hypothesized to be induced by either irrigation projects, or other related initiatives. Recently, SIPA (2008b) has suggested the following types of value-added building blocks for Saskatchewan resulting from irrigation development: Beef livestock -- producing new heads of cattle and processing them in the province;

- Beef livestock -- producing new heads of cattle and processing them in the province;
- Pork livestock -- producing and processing hogs;
- Dairy production coupled with additional dairy processing activity;
- Vegetable processing – particularly potato processing
- Energy – production of ethanol

For the various Saskatchewan river basins, hog and dairy production were excluded from these developments, partly because the basins have not shown a big increase in hogs or in dairy (since dairy is subject to quotas for further expansion). Potato processing was also not included since the crop mix as proposed for the irrigation did not include specialty crops (such as potatoes). In this section, three types of developments are envisaged in the basin: (i) more feedlots resulting from irrigated forage, (ii) higher ethanol production resulting from higher production of grains (and perhaps corn), and (iii) additional agri-processing firms due to irrigated livestock products.

<u>Feedlot Development:</u> To estimate the level of expansion of <u>intensive livestock operations</u> permitted by increased irrigation in the various basins, the area required for feed production, bedding and manure disposal needed to be considered. The magnitude of this area will determine the number of enterprises that could effectively operate. Production of silage using irrigation for dairy or cattle feedlots are the main enterprises that would be attracted to an irrigation district. Transportation costs for the bulk low density products of silage, straw and manure limit the range over which these products can be economically transported.

The number of head and type of feeding (background, finishing or both) will determine the amount of irrigated area needed for silage production and amount of water needed for the livestock. The background feeder cattle typically require 1.18 tonnes of silage over a 128 day feeding period while finishing cattle will require 0.27 tonnes over a 143 day period (ICDC, undated). Barley and corn are the main crops grown for silage with average yield for silage of 14.5 and 21.7 tonnes per acre, respectively (ICDC, 2011). The economic hauling distance of silage and manure are the two key factors in the overall profitability of an intensive livestock operation. The amount of land needed is also dependent on the rotational constraints of crops grown and the amount of manure that can be applied.

A base unit of production of 10,000 head capacity feedlot at a 1.45 refill rate for a feeder calf to finishing operation would require yearly 1,445 acres of barley or 967 corn acres or a combination thereof to meet the silage requirement. If the rotational constraints are every 2nd year then 2,891 and 1,934 acres for barley or corn rotation, respectively, are needed. Therefore, up to 20 quarter sections would be needed for a barley based feedlot and up to 14 for a corn based feedlot.

Daily manure production in a feedlot is approximately 25.9 kilograms per animal (Saskatchewan Ministry of Agriculture 2011b). Therefore, on a yearly basis approximately 6,000 acres are needed for manure application given an application rate of 22.7 tonnes per acre. Since manure can only be applied every 3rd year, 18,000 acres need to be available for manure application within an economic hauling distance. Therefore, the constraint that would limit the number of intensive livestock operations within an irrigation district is the requirement of an adequate amount of area to dispose of the manure within the economic hauling distance. Technological developments such as biodigesters[30] enable greater economic hauling distances relative to raw manure as a higher valued end product is created. The drawback is that it adds to the capital cost of starting a feedlot combined with the capital cost of irrigation.

<u>Ethanol and Biodiesel</u>: To assess the future <u>ethanol and biodiesel</u> market in various basins in the province, a number of factors need to be considered. New fuel efficiency standards for vehicles that will come into effect over the 2013-15 period will affect the demand for transportation fuels by 2020. Ethanol and biodiesel will have to be competitive with petroleum motor fuels and other alternative sources of energy to increase their respective market shares above the government mandated levels. Biodiesel is price competitive with diesel if produced from sample grade canola or flax (Nagy and Furtan, 2006). New crops, such as Camelina, may provide a feedstock

[30] A biodigester is a technology that converts animal and organic wastes into biogas and nutrient-rich liquid fertilizer. The biogas can be piped to a simple gas cooking range and used as fuel, while the fertilizer can be put back on crops to increase yields. Biogas can also be converted into electricity.

for biodiesel manufacture that is competitive with petroleum diesel. The market in Saskatchewan of about 40 ML is small compared to the cost competitive plant sizes of 250 ML. In addition, two biodiesel plants of this size are already proposed for Alberta. Beyond the expansion plans of Milligan BioTech (20 ML by 2020) there would be no major growth for this biodiesel in Saskatchewan. Cellulosic ethanol plants using biomass are the next generation of ethanol manufacture that could have growth potential in Saskatchewan. However, the relatively small size of cellulosic operations compared to grain ethanol plants due to the limited economical range of feedstock transportation requires a reliable cheap source of biomass in order to be competitive.

The transportation fuel market in Saskatchewan could reasonably be expected to be in the 2,000 to 3,000 ML range for both gasoline and diesel markets by 2020, given the growth in the economy and regulations on vehicle fuel consumption. Therefore, the mandated biofuel requirements for ethanol will be easily met from Saskatchewan production. Export markets in British Columbia, Alberta and northern tier States are the growth areas for Saskatchewan ethanol production.

Irrigated area in the proposed QSP could be used for the production of feedstocks for the ethanol industry either for a grain based or a biomass-based plant. Currently, Terra Grain Fuels at Belle Plaine contracts for high starch wheat to be used in the ethanol production. The improvement in the yield of grain corn that matures with less than 2400 heat units combined with increased temperatures and a longer growing season from climate change could result in irrigated area being devoted to grain corn. Competitive grain corn yields relative to other crops, combined with a market for corn stover[31] residue, could make this a profitable crop in comparison to other cropping alternatives.

A biomass ethanol plant with a capacity of 30,000 tonnes using corn stover as the primary feedstock at a yield of 1.6 tonnes per acre would require 18,525 acres of corn per year. If the rotation followed is corn in one in four years, the area requirement would be 74,100 acres. The QSP could accommodate at least one 30,000 tonne corn stover biomass plant or a larger facility if other biomass feedstocks were used.

Agri-Processing Development: Associated with the feedlots may be an increase in the slaughtering and meat processing industry. On account of the late start of irrigation, no change is

[31] Stover is the leaves and stalks of corn (maize), sorghum or soybean plants that are left in a field after harvest. Corn stover is the major feedstock being used for generating ethanol through fermentation.

expected by 2020. For 2040, it is assumed that there would be two large and two small slaughtering and meat processing plants in place. By 2060, with the increased irrigated area, there would be a likelihood of five large and three small such plants. It was assumed that by 2040, there can be for a total capacity of 30,000 head of cattle. By 2060, there could be 5 large and 3 small plants, with a total capacity of 65,000 head of cattle.

5.4.2 Water Demand Implication of Future Beef Feedlots and Ethanol Production

Irrigated crop area for livestock production would be the competing agricultural activity for the biomass produced in the irrigation district. The economic hauling distance of the biomass, whether for the livestock feedlot or the ethanol plant is a key factor in the profitability of either operation. The crop mix on the irrigated land in the Qu'Appelle South Project would be influenced by the establishment of either a 10,000 head livestock feedlot or a 30,000 tonne ethanol plant or both. A shift from cereal crop production to silage for livestock or grain for ethanol would change the demand for water. Barley or corn silage crops have different water use requirements and different water demands than those for the production of grain from small cereal grains or corn crops (see Kulshreshtha et al. 2012a).

Increased production of barley silage or grain corn relative to the base crop mix would have the biggest effect on water demand (demand) for irrigation. An increase in the area seeded to grain corn to meet the biomass requirements for a 30,000 tonne ethanol plant in the Qu'Appelle South Project would increase the water demand for irrigation by 1,230 dam^3. This amount was estimated as the extra amount of water needed to grow grain corn when substituting small grains in the crop mix. Likewise an increase in area seeded to barley silage to accommodate four beef feedlots would reduce the water demand by 2,727 dam^3 from the base scenario.

It is conceivable that ethanol production may be linked with feedlots. This would mean that water would also be needed for livestock watering. An ethanol plant-linked 10,000 animal capacity feedlot would require 184.9 dam^3 of water. With 4 feedlots in the basin, the total amount of water needed would be 739.6 dam^3. Depending on the type of production process used, water consumption in a biomass ethanol production could be 33.7, 22.3 or 7.2 liters per litre of ethanol for current technology, advanced technology or gasification, respectively (Wu et al. 2009). Therefore, a 30,000 tonne ethanol plant would require 364 dam^3, 241 dam^3 or 78 dam^3 if the technology used was the current technology, advanced technology or gasification, respectively. The water demand coefficient for the agri-processing plants was based on a review of the literature[32]. For North Carolina (United States of America) plants, a coefficient of 567 to 1703 litres of water per animal slaughtered was reported. Using a mid-value of this interval, it is

[32] We are very thankful to Ms. Dolores Funk for providing information on water requirements for various types of uses based on a review of literature.

assumed that 1135 litres of water per animal (equivalent to 0.001135 dam^3) would be required by these operations.

The net effect of the irrigation projects in various basins with the addition of livestock feedlot operations (each with a capacity of 10,000 head) and a few biomass ethanol plants (using advanced technology) would be a reduction in total water demand for these induced activities.

5.4.3 Water Demand for Induced Economic Activities

Total water demand with the introduction of feedlots would result in a net decrease for the province as a whole. Under the baseline scenario, this would translate into a reduction of about 53 thousand dam^3 of water in 2040 and 2060 (Table 5.31). In 2060, under climate change and water conservation scenarios, water demand for this purpose was estimated at a reduction of 51 and 48 thousand dam^3, respectively (Tables 5.32 and 5.33).

Table 5.31: Induced Economic Activities' Water Demand in Saskatchewan by Type of Development, under Baseline Scenario, 2040 - 2060

Industry	Water Demand in dam^3			
	2010	2020	2040	2060
Biomass Ethanol	0	0	10,297	10,297
Agricultural Processing	0	0	34	74
Feedlots	0	0	-62,998	-62,998
Total	**0**	**0**	**-52,666**	**-52,627**

Distribution of the induced activities' water demand by river basins is shown in Table 5.34 to 5.36 for the baseline, climate change and water conservation scenarios. With the large expansion of irrigation activity in the South Saskatchewan River Basin, much of the impact is felt in this basin, although slightly lower impacts are observed for the North Saskatchewan and the Qu'Appelle River Basins as well. The rest of the river basins in the province do not have district irrigation and therefore, development of such industries is not likely.

Table 5.32: Induced Economic Activities' Water Demand in Saskatchewan by Type of Development, under Climate Change Scenario, 2040 - 2060

Industry	Water Demand in dam^3			
	2010	2020	2040	2060
Biomass Ethanol	0	0	10,297	8,826
Agricultural Processing	0	0	34	74
Feedlots	0	0	-62,821	-60,112
Total	**0**	**0**	**-52,490**	**-51,212**

Table 5.33: Induced Economic Activities' Water Demand in Saskatchewan by Type of Development, under Water Conservation Scenario, 2040 - 2060

Industry	Water Demand in dam^3			
	2010	2020	2040	2060
Biomass Ethanol	0	0	10,091	9,889
Agricultural Processing	0	0	33	72
Feedlots	0	0	-60,798	-58,672
Total	**0**	**0**	**-50,673**	**-48,711**

Table 5.34: Induced Economic Activities' Water Demand in Saskatchewan by River Basins, under Baseline Scenario, 2040 - 2060

River Basin	Water Demand in dam^3			
	2010	2020	2040	2060
Qu'Appelle	0	0	-482	-442
South Saskatchewan	0	0	-51,113	-51,113
North Saskatchewan	0	0	-1,071	-1,071
Total	**0**	**0**	**-52,666**	**-52,627**

Table 5.35: Induced Economic Activities' Water Demand in Saskatchewan by River Basins, under Climate Change Scenario, 2040 - 2060

River Basin	Water Demand in dam^3			
	2010	2020	2040	2060
Qu'Appelle	0	0	-458	-391
South Saskatchewan	0	0	-50,973	-50,820
North Saskatchewan	0	0	-1,065	-1,058
Total	**0**	**0**	**-52,490**	**-51,212**

Table 5.36: Induced Economic Activities' Water Demand in Saskatchewan by River Basins, under Water Conservation Scenario, 2040 - 2060

River Basin	Water Demand in dam^3			
	2010	2020	2040	2060
Qu'Appelle	0	0	-537	-551
South Saskatchewan	0	0	-49,127	-47,212
North Saskatchewan	0	0	-1,007	-947
Total	**0**	**0**	**-50,673**	**-48,711**

5.5 Water Source Industrial / Mining Water Demand

Sources of water for various types of industrial/mining activities are shown in Table 5.37 and 5.38. The oil and gas production is entirely dependent on groundwater, whereas the power generation uses only surface water. Other types of activities demand a combination of surface and groundwater.

Table 5.37: Industrial and Mining Water Demand in Saskatchewan by Sector, under Baseline Scenario, 2010-2060

Sector	Source of Water	Water Demand in dam^3			
		2010	2020	2040	2060
Potash	Surface Water	18,696	99,471	102,235	113,415
	Groundwater	3,363	5,001	13,293	13,293
Oil & Gas	Surface Water	0	0	0	0
	Groundwater	9,587	12,873	7,724	1,931
Manufacturing	Surface Water	16,887	17,024	17,266	17,519
	Groundwater	8,328	8,775	9,457	10,168
Power Generation	Surface Water	42,376	44,361	38,916	25,518
	Groundwater	0	0	0	0
Other	Surface Water	7,628	9,343	9,542	9,312
	Groundwater	2,787	282	298	316
Induced	Surface Water	0	0	-52,184	-52,184
	Groundwater	0	0	-482	-443
Total	**Surface Water**	**85,588**	**170,198**	**115,775**	**113,579**
	Groundwater	**24,066**	**26,931**	**30,290**	**25,265**
	Surface Water % of Total Water	**78.1%**	**86.3%**	**79.3%**	**81.8%**

Table 5.38: Industrial and Mining Water Demand in Saskatchewan by River Basins, under Climate Change Scenario, 2010-2060

Sector	Source of Water	Water Demand in dam^3			
		2010	2020	2040	2060
Qu'Appelle	Surface Water	17,916	82,150	85,022	85,138
	Groundwater	5,979	8,098	16,327	16,791
South Saskatchewan	Surface Water	7,650	15,587	23,949	27,865
	Groundwater	233	304	195	72
North Saskatchewan	Surface Water	13,735	16,174	16,278	17,352
	Groundwater	5,215	5,622	5,219	4,757
Souris	Surface Water	23,370	23,371	23,371	11,709
	Groundwater	5,550	7,325	4,507	1,337
Missouri	Surface Water	15,142	15,142	7,599	3,800
	Groundwater	881	1,183	710	178
Cypress Hills	Surface Water	-	-	-	-
	Groundwater	242	325	195	49
Old Wives Lake	Surface Water	5,191	5,295	5,401	5,509
	Groundwater	111	129	103	74
Saskatchewan	Surface Water	327	334	340	347
	Groundwater	0	0	0	0
Assiniboine	Surface Water	103	5,624	5,663	5,715
	Groundwater	1,713	1,950	1,578	1,160
Northern	Surface Water	2,154	3,785	3,882	3,660
	Groundwater	4,142	1,996	1,456	848
Total	**Surface Water**	**85,588**	**167,460**	**171,505**	**161,095**
	Groundwater	**24,066**	**26,931**	**30,290**	**25,265**
	Surface Water % of Total	**78.1%**	**86.1%**	**85.0%**	**86.4%**

5.6 Summary of Industrial / Mining Water Demand

In Table 5.39, a summary of total water demand for the industrial/mining sector is presented. Total water demand is estimated at 103 thousand dam^3. This water demand would peak around 2020 at 190 thousand dam^3, since after that period induced activities may decrease the total water demand. By 2060, the water demand would be only 132 thousand dam^3.

Table 5.39: Total Water Demand for the Industrial / Mining Sector in Saskatchewan, under Baseline Scenario, 2010-2060

Sector	Water Demand in dam^3			
	2,010	**2,020**	**2,040**	**2,060**
Potash	22,059	104,472	115,528	126,708
Oil & Gas	9,587	12,873	7,724	1,931
Manufacturing	18,464	19,047	19,970	20,936
Power Generation	42,376	44,361	38,916	25,518
Other Mining	10,415	9,625	9,840	9,628
Induced	0	0	-52,666	-52,627
Total Water Demand	102,901	190,378	139,312	132,094

Chapter 6

Municipal/Domestic Water Demand

6.1 Introduction

Total water demand for municipal/domestic purposes was estimated in a disaggregated manner. Total population of a river basin was divided into various types of communities – cities, Towns, Bedroom Communities, Villages, Resorts or Recreational Villages, and First Nations Reserves, as listed in Chapter 2. Municipal water demand typically includes other demands besides the residential water demand. In addition, any institutions not served by the municipal water distribution systems were also included. Two public of these institutions are located in the Qu'Appelle River Basin -- the Canadian Forces training base at Moose Jaw CFB 15 Wing, and the Regina Correctional Centre. Total water demand was simply a product of per capita water demand and the population for the given type of community.

This rest of this chapter is divided into nine sections: Section 2 describes the municipal water demand for cities and similar communities, followed in Section 3 by estimated domestic water demand for towns. Rural water demand is described in Section 4, that for the First Nations in Section 5, and that for the public institutions in Section 6. Section 7 covers other water demands which include rural non-farm and farm water demands. Next Sections 8 and 9 describe sources of water and estimated consumption levels. The last section provides a summary of total municipal/domestic water demand in the province.

The methodology for the estimation of municipal/domestic water demand was designed by estimating populations for various communities and their respective water demand on a per capita basis using regression analysis. For details on estimation methodology see Section 3.6 in Kulshreshtha et al (2012a).

6.2 Municipal Water Demand

The province of Saskatchewan houses 15 cities, among which Regina and Saskatoon are the most populated urban centers. Currently the municipal water demand is 106,651 dam^3, but it is estimated to increase to 141,000 dam^3 by 2060, an increase of approximately 32% (Table 6.1). As shown in Figure 6.4, in Saskatchewan the municipal water demand represents 64% of the total municipal/domestic water demand, a share that is expected to increase by 4% by 2060. Much of this is a result of the rapid rate of urbanization that has been occurring in

Saskatchewan[33]. Municipal water demand in the province is mostly supplied through basin water resources. However, there are exceptions. In the Qu'Appelle River Basin, water demand for the city of Humboldt originates in the South Saskatchewan River basin[34]. This transfer is called "interbasin transfer – IBT" and is shown as a separate entry in Table 6.1.

Table 6.1: Estimated Municipal (Cities') Water Demand for Saskatchewan by River Basins under the Baseline Scenario, 2010- 2060

Basin	Cities	Total Water Demand (dam^3)				Change by 2060 as % of 2010
		2010	2020	2040	2060	
Assiniboine	Yorkton	2,406	2,603	3,049	3,571	48.4%
North Saskatchewan	Lloydminster	4,337	4,621	5,471	6,032	39.1%
North Saskatchewan	North Battleford	2,141	2,273	2,536	2,799	30.7%
North Saskatchewan	Prince Albert	6,879	7,106	8,598	10,090	46.7%
Northern Four	Meadow Lake	861	976	1,205	1,435	66.7%
Qu'Appelle	Moose Jaw	6,215	6,266	6,370	6,476	4.2%
Qu'Appelle	Regina	27,624	27,306	26,541	25,796	-6.6%
Saskatchewan	Melfort	692	667	629	594	-14.2%
Souris	Estevan	2,427	2,642	3,072	3,502	44.3%
Souris	Weyburn	1,907	1,915	1,930	1,946	2.0%
South Saskatchewan	Martensville	550	720	1,061	1,402	154.9%
South Saskatchewan	Saskatoon	46,601	50,768	60,253	71,509	53.4%
South Saskatchewan	Swift Current	2,795	2,852	2,971	3,094	10.7%
South Saskatchewan	Warman	536	765	1,272	1,841	243.5%
Interbasin Transfers						
Qu'Appelle	Humboldt*	680	721	812	913	34.3%
Total Municipal Water Demand		**106,651**	**112,201**	**125,770**	**141,000**	**32.2%**

* City of Humboldt is located in the Qu'Appelle River Basin but water is supplied by South Saskatchewan River Basin.

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[33] According to estimates provided by SAFRR (2003), in 1951 the rural population was 69.6% of the total provincial population (thus urban population was only 30.4%). By 2010, as shown in Table 2.4, urban population has increased to 79.2% of the total provincial population.

[34] In addition, according to SWA, in recent years approximately 115,000 dam3 of water has been released annually through the Qu'Appelle River Dam to meet various municipal and other water demands in the Qu'Appelle River Basin.

Different river basins in the province have different levels of urbanization. This is depicted in Figure 6.2. Most urbanized basins in the province are the South Saskatchewan River Basin, followed by the Qu'Appelle River Basin. These basins house the two largest cities in the province – Saskatoon in the South Saskatchewan River Basin, and the city of Regina in the Qu'Appelle River Basin. In 2010 Saskatoon demanded 46,601 dam^3. The second largest river basin in terms of municipal water demand is the Qu'Appelle River Basin. The city of Regina is the most significant consumer within this basin, with a current consumption of 27,624 dam^3.

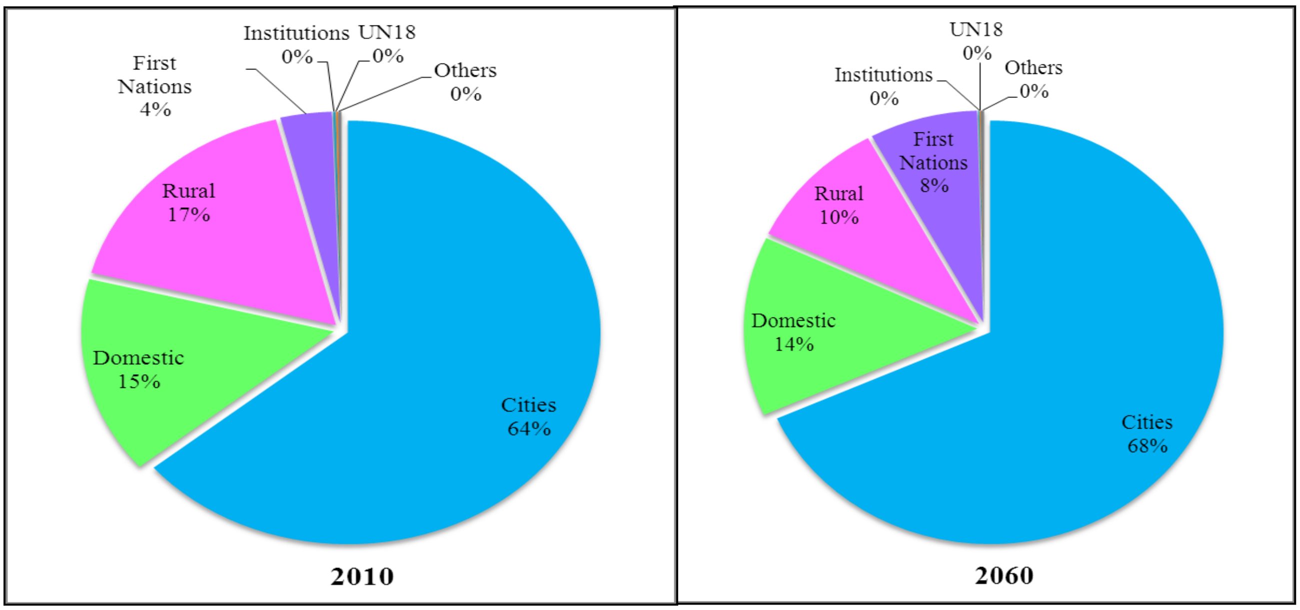

Figure 6.1: Saskatchewan Total Municipal/Domestic Water Demand by Community Type, 2010-2060

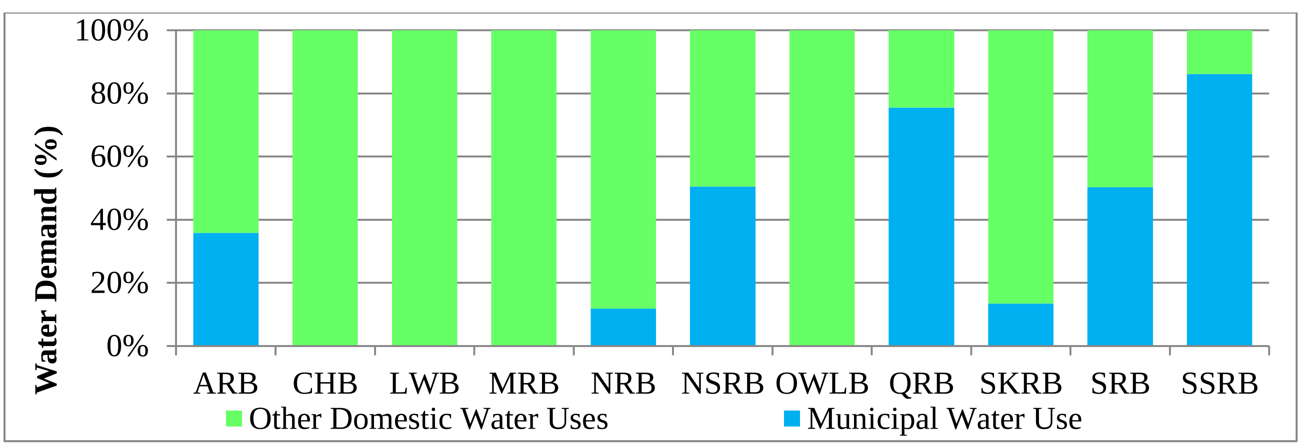

Figure 6.2: Municipal Water Demand share of Total Municipal/Domestic Water Demand by River Basins for Saskatchewan, 2010

The North Saskatchewan and the Saskatchewan River Basins are also somewhat urbanized, but not at the level of the South Saskatchewan and the Qu'Appelle River Basins. Four of Saskatchewan's River Basins have no municipal water consumption: Cypress Hills North Slope Basin, Lake Winnipegosis Basin, Missouri River Basin and Old Wives Lake Basin.

6.2.1 Municipal Water Demand under Baseline Scenario

Municipal water demand was estimated for the all the fifteen cities located in Saskatchewan. Total water demand for these communities was estimated as a product of population and water demand coefficients, shown in Appendix B, Table B.1. It should be noted that for large urban centers, this water demand includes that for manufacturing, commercial, firefighting, street cleaning and other public demands.

Municipal water demand per capita coefficients indicate a significant variation from one community to another. The values range from 87 m^3 (Martensville) for smaller urban communities and increase to 210 m^3 (Saskatoon), for larger cities, as shown in Figure 6.3. A higher water demand per capita coefficient could be indicative of manufacturing activity within the city, and perhaps a more active economy. Adoption of water conservation measures may also be a factor in the coefficients. However, these aspects of water were not investigated in this study, and require further research for better understanding.

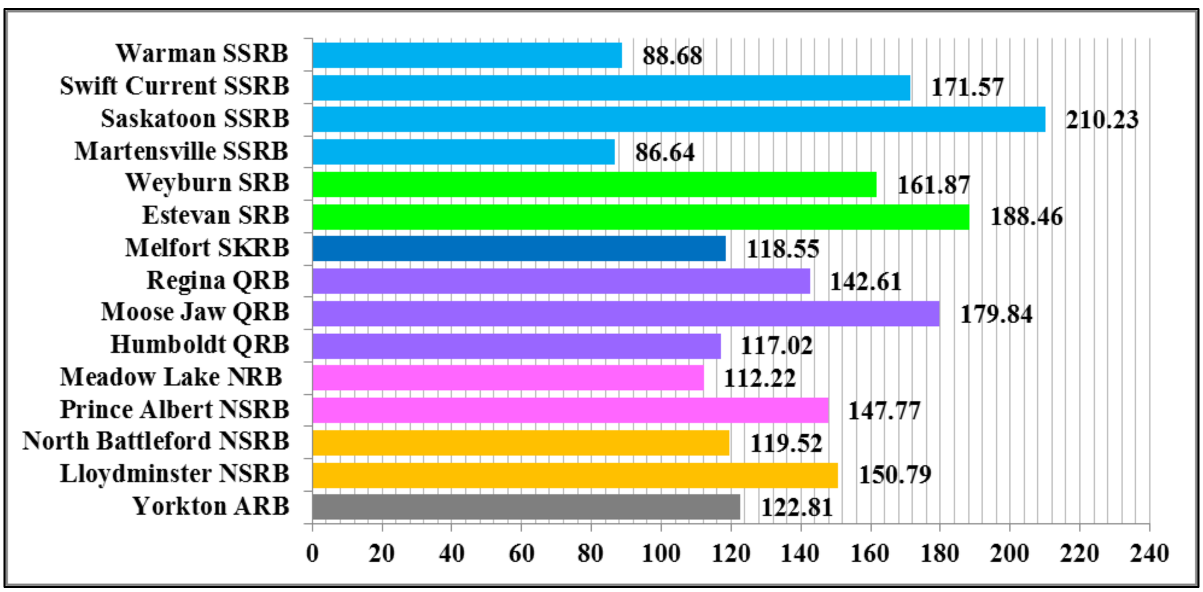

Figure 6.3: Municipal Water Demand per Capita Coefficients for Saskatchewan by River Basins, 2010

Total municipal water demand in the province is expected to increase from 106,651 dam^3 in 2010 to 141,000 dam^3 in 2060 – an increase of approximately 32% (Table 6.1). Saskatoon water demand has a significant share in this increase. It is expected that the city water demand will rise from current levels of 46,601 dam^3 to 71,509 dam^3 by 2060 -- increase of 53%. Regina's water demand is expected to slightly decrease by nearly 7%, from the present 27,624 dam^3 to 25,796 dam^3 by 2060. Water conservation practices followed by Regina's residents are assumed to be the reason for this decline. Smaller urban centers, like Martensville and Warman, are expected to record high growth rates, but in absolute figures their growth remains modest.

Figure 6.4 shows the distribution of total municipal water demand by cities and by river basins. Urban centers in South Saskatchewan River Basin are currently the largest municipal water consumers in the province and are expected to further increase their consumption by 2060. Qu'Appelle River Basin and North Saskatchewan River Basin are expected exhibit modest growth. The rest of the basins are expected to maintain the same relatively small shares in the total municipal water demand.

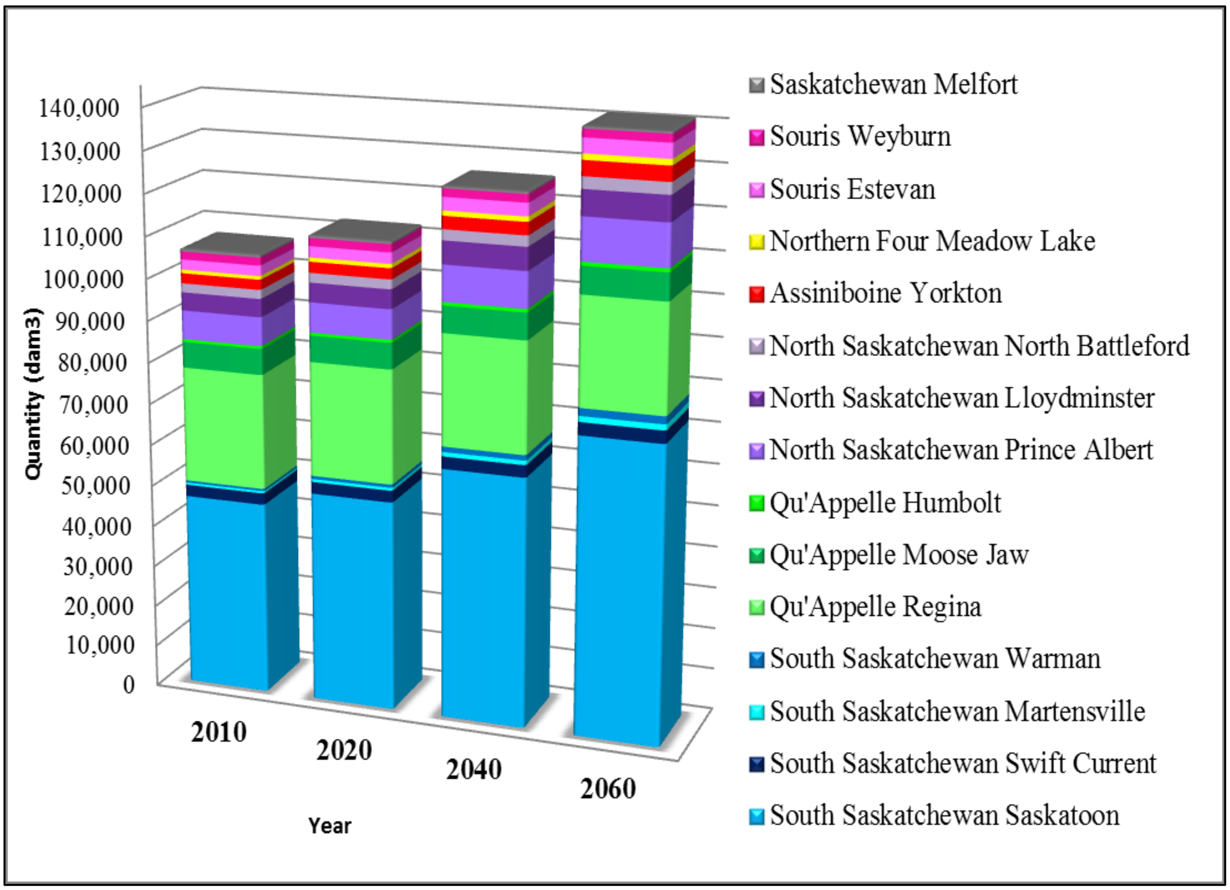

Figure 6.4: Distribution of Saskatchewan Total Municipal Water Demand by City and River Basins, 2010-2060

6.2.2 Municipal Water Demand under Climate Change Scenario

Under this scenario, similar to the baseline scenario, total water demand for municipal purposes was a product of the adjusted water demand coefficient and the population as used for the baseline scenario.

This scenario incorporates the adjusted values of the per capita water demand coefficients for climate change. In order to estimate the effect two aspects were considered: (i) Temperature and precipitation change; and (ii) Frequency of dry extreme events.

To estimate the impact of extreme events on domestic water demand in Saskatchewan, per capita domestic water demand data for 1995-2009 were used. It was assumed that the 2001 and 2002 droughts would impact the level of water demand in a positive manner. These events were introduced through a binary variable (which took a value of 1 if the year has an occurrence of drought, and 0 other wise). The other two variables – trend and size of the community, were retained for this analysis. The effects of climate change on the water demand per capita are shown in Appendix B Table B.1.

In developing the climate change scenario it was assumed that there will be no major impacts on the domestic water demand by 2020. Assuming that the average temperature in the basin under climate change may be similar to the Great Lakes region, a 2.4% increase in domestic water demand was assumed by 2040. For 2060, an increase of 5% of the baseline scenario's level of water demand was assumed. Population predictions for all three time periods were assumed to be the same as the baseline scenario. Total municipal water demand in the basin under climate change is expected to be higher than that for the baseline scenario. These estimates are presented in Table 6.2. Relative to 2010, water demand for this purpose in Saskatchewan will increase by almost 40% by 2060. This is primarily a result of higher temperatures and the increased frequency of extreme events. Total municipal water demand under this scenario is expected to be 148,919 dam^3 by 2060. Climate change could bring forth an increase of nearly 6% over the baseline scenario in municipal water demand by 2060.

6.2.3 Municipal Water Demand under Water Conservation Scenario

The estimation of municipal water demand under a water conservation scenario, for Saskatchewan's River Basins was similar to that followed for the climate change scenario. For the municipal water demand, a mid-value of water conservation potential of 25% and an adoption rate of 1% per annum, were assumed. The reference year was 2010 and the relative savings in water demand by 2020 were 2.5%, 7.5% for 2040 and 12.5% by 2060.

The effect of water conservation was brought into calculations for 2020 and onwards. Table B.3, Appendix B, shows the adjusted coefficients' values for the water demand per capita for cities located in different river basins.

Estimated municipal water demand for this scenario is shown in Table 6.3. Employing a conservational scenario is expected to produce a reduction in municipal water demand. Total water demand in 2060 is expected to be 118,386 dam^3, which is nearly 10% lower than under the baseline scenario.

Table 6.2: Estimated Municipal (Cities) Water Demand for Saskatchewan by River Basins under Climate Change Scenario, 2010- 2060

Basin	Cities	Total Water Demand (dam^3)				Change by 2060 as % of 2010
		2010	2020	2040	2060	
Assiniboine	Yorkton	2,406	2,603	3,122	3,749	55.8%
North Saskatchewan	Lloydminster	4,337	4,621	6,199	7,305	68.4%
North Saskatchewan	North Battleford	2,141	2,273	2,597	2,939	37.3%
North Saskatchewan	Prince Albert	6,879	7,106	8,804	10,595	54.0%
Northern Four	Meadow Lake	861	976	1,234	1,507	75.0%
Qu'Appelle	Moose Jaw	6,215	6,266	6,523	6,799	9.4%
Qu'Appelle	Regina	27,624	27,306	27,178	27,086	-1.9%
Saskatchewan	Melfort	692	667	644	623	-10.0%
Souris	Estevan	2,427	2,642	3,145	3,677	51.5%
Souris	Weyburn	1,907	1,915	1,977	2,043	7.1%
South Saskatchewan	Martensville	550	720	1,086	1,472	167.6%
South Saskatchewan	Saskatoon	46,601	50,768	61,699	75,085	61.1%
South Saskatchewan	Swift Current	2,795	2,852	3,042	3,249	16.2%
South Saskatchewan	Warman	536	765	1,290	1,877	250.2%
Interbasin Transfers						
Qu'Appelle	Humboldt	680	721	812	913	34.3%
Total Municipal Water Demand		**106,651**	**112,201**	**129,352**	**148,919**	**39.6%**
Change % over Baseline Scenario		100.0%	100.0%	102.8%	105.6%	

6.2.4 Summary of Municipal Water Demand

A summary of total municipal water demand for the 2010 - 2060 period under the three study scenarios is presented in Table 6.4. Under climate change in 2060 the basin will experience a 5.6% increase in municipal/domestic water demand, whereas under the water conservation scenario, a reduction of 10.1% is possible.

Table 6.3: Estimated Municipal (Cities) Water Demand for Saskatchewan by River Basins under Water Conservation Scenario, 2010- 2060

Basin	Cities	Total Water Demand (dam^3)				Change by 2060 as % of 2010
		2010	2020	2040	2060	
Assiniboine	Yorkton	2,406	2,538	2,820	3,124	29.8%
North Saskatchewan	Lloydminster	4,337	4,505	5,060	5,278	21.7%
North Saskatchewan	North Battleford	2,141	2,216	2,346	2,449	14.4%
North Saskatchewan	Prince Albert	6,879	6,928	7,953	8,829	28.3%
Northern Four	Meadow Lake	861	952	1,115	1,255	45.8%
Qu'Appelle	Moose Jaw	6,215	6,110	5,892	5,666	-8.8%
Qu'Appelle	Regina	27,624	27,306	26,541	25,796	-6.6%
Saskatchewan	Melfort	692	650	582	519	-25.0%
Souris	Estevan	2,427	2,576	2,841	3,064	26.2%
Souris	Weyburn	1,907	1,867	1,785	1,703	-10.7%
South Saskatchewan	Martensville	550	702	981	1,226	122.9%
South Saskatchewan	Saskatoon	46,601	49,499	55,734	62,571	34.3%
South Saskatchewan	Swift Current	2,795	2,781	2,748	2,707	-3.1%
South Saskatchewan	Warman	536	746	1,176	1,611	200.6%
Interbasin Transfers						
Qu'Appelle	Humboldt	680	721	812	913	34.3%
Total Municipal Water Demand		**106,651**	**110,097**	**118,386**	**126,711**	
Change % over Baseline Scenario		100.0%	98.1%	94.1%	89.9%	

Table 6.4: Summary of Municipal Water Demand in Saskatchewan, Study Scenarios, 2010 – 2060

Scenarios	Total Domestic Water Demand in dam^3				2060 level % of Baseline
	2010	2020	2040	2060	
Baseline	106,651	112,201	125,770	141,000	100.0%
Climate Change	106,651	112,201	129,352	148,919	105.6%
Water Conservation	106,651	110,097	118,386	126,711	89.9%

6.3 Domestic Water Demand

In Saskatchewan nearly 15% of the water is now demanded by relatively smaller communities, smaller than cities. It is expected that in the future this share in the total provincial water demand will decrease by 1%. Under this category of water demand, three types of communities are included: (1) Bedroom Communities, (2) Larger Towns, with a population over 1000 and (3) Smaller Towns, population under 1000. Their water demand is described in Sections 6.3.1 to 6.3.3.

6.3.1 Bedroom Communities Water Demand

In Saskatchewan, there are several bedroom communities and all of them span around the two larger urban centers of Regina and Saskatoon. These communities are located in Qu'Appelle River Basin and South Saskatchewan River Basin, respectively. From the standpoint of share in the total water demand, these communities account for only 1.1%, but are expected to double their share by 2060, accounting for 2.5% of the total water demand. Bedroom communities have one of the highest growth rates in Saskatchewan's water demand. Population increases in these communities is the major factor affecting future water demand, development that is further triggered by the expansion of large urban centers.

6.3.1.1 Bedroom Communities Water Demand under Baseline Scenario

Under a baseline scenario the water demand of bedroom communities is expected to almost triple by 2060, increasing from their present 1,865 dam^3 to 5,260 dam^3. Table B.4 shows the water demand coefficients; Table 6.5 demonstrates estimates for the water demand for bedroom communities. Regina's bedroom communities are expected to increase their water demand from their current 1,306 dam^3 to 3,615 dam^3, an increase of 176.8%, which is slightly lower than Saskatoon's bedroom communities' growth rate of 194%.

Table 6.5: Estimated Bedroom Communities' Water Demand for Saskatchewan by River Basins under Baseline Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Qu'Appelle	1,306	1,634	2,430	3,615	176.8%
South Saskatchewan	559	776	1,211	1,645	194.3%
Total Water Demand	**1,865**	**2,410**	**3,641**	**5,260**	**182.0%**

6.3.1.2 Bedroom Communities Water Demand under Climate Change Scenario

The total of bedroom communities' water demand in the basin under climate change is expected to be higher than that for the baseline scenario. Readjusted water demand per capita coefficients are shown in Table B.5, Appendix B, and water demand estimates are presented in Table 6.8. Relative to 2010, water demand for this purpose in Saskatchewan is expected to nearly triple by 2060 (Table 6.6). This is primarily a result of higher temperatures and an increased frequency of extreme events. Total municipal water demand under this scenario is expected to be 5,523 dam^3 by 2060. Climate change could bring forth an increase of 5% over the baseline scenario in bedroom communities' water demand by 2060.

Table 6.6: Estimated Bedroom Communities' Water Demand for Saskatchewan by River Basins under Climate Change Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	**2020**	**2040**	**2060**	
Qu'Appelle	1,306	1,634	2,489	3,796	190.7%
South Saskatchewan	559	776	1,240	1,727	208.9%
Total Water Demand	**1,865**	**2,410**	**3,729**	**5,523**	**196.1%**
Change % over Baseline Scenario	0.0%	0.0%	2.4%	5.0%	

6.3.1.3 Bedroom Communities Water Demand under Water Conservation Scenario

The estimation of bedroom communities' water demand under a water conservation scenario for Saskatchewan's River Basins was similar to that followed for the urban communities. Table B.6, Appendix B, shows the adjusted coefficients' values for the water demand per capita for bedroom communities located in both the Qu'Appelle and South Saskatchewan River Basins.

The estimated municipal water demand for this scenario is shown in Table 6.7. Employing a conservational scenario is expected to produce a reduction in municipal water demand. Total water demand in 2060 is expected to be 5,107 dam^3, which is nearly 3% lower than it is under the baseline scenario.

Table 6.7: Estimated Bedroom Communities' Water Demand for Saskatchewan by River Basins under Water Conservation Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	**2020**	**2040**	**2060**	
Qu'Appelle	1,306	1,624	2,402	3,510	168.8%
South Saskatchewan	559	772	1,196	1,597	185.7%
Total Water Demand	**1,865**	**2,396**	**3,598**	**5,107**	**173.8%**
Change % over Baseline Scenario	0.0%	-0.6%	-1.2%	-2.9%	

6.3.2 Water Demand in Larger Towns

All towns in a river basin were sub-divided into two classes: Larger towns with a population of 1,000 or more in 2009, and smaller towns with a population of less than 1,000 in 2009. Water demand for larger towns is provided in this section.

In Saskatchewan larger towns now account for 15% of the total water demand. The water demanded by these communities, displays a wide variation from basin to basin, as can be noted in Figure 6.5. These communities account for 45% of the total water demand in Cypress Hills NS Basin whereas in other watersheds, such as the Qu'Appelle and South Saskatchewan River Basin the percentile is lower than 5% and in the Missouri River Basin is 0% (not shown in Figure 6.5).

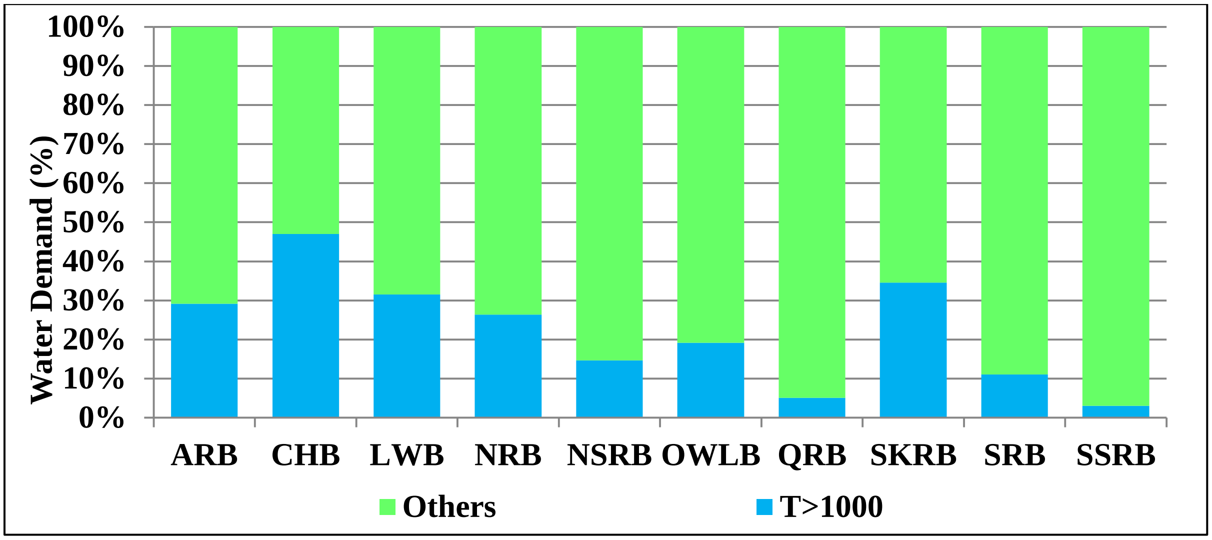

Figure 6.5: Larger Towns' Water Demand as Share of Total Municipal/Domestic Water demand, by River Basins, Saskatchewan, 2010

Towns with a population higher than 1000 are expected to slightly reduce their water demand by 1% by 2060. Even though the populations of these communities are foreseen to increase during the studied period, as noted in Table B.7, the water demand at the per capita level is expected to be reduced in some basins.

6.3.2.1 Larger Towns Water Demand under Baseline Scenario

Estimating future values under the baseline scenario included the assumption that previous developments in these communities' water demand will follow the same pattern in the future. Future water demand for large towns was calculated by using water demand per capita coefficients, shown in Table B.8, Appendix B, and the population of these communities, previously shown in Appendix Table B.7.

Under a baseline scenario, the total water demand is expected to decrease by approximately 3%, from currently 16,669 dam^3 to 16,151 dam^3, as shown in Table 6.8. Most of the basins are expected to record declines in the total water demand for these communities. Interbasin Transfers include Bruno, a town located in the Qu'Appelle River Basin but supplied by the South Saskatchewan River Basin.

Table 6.8: Estimated Larger Towns Water Demand for Saskatchewan, by River Basins under Baseline Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	1,959	2,024	2,155	2,286	16.7%
Cypress Hills	632	670	747	824	30.4%
Lake Winnipegosis	782	759	700	624	-20.2%
North Saskatchewan	3,884	3,801	3,609	3,389	-12.7%
Northern Four	1,927	2,019	2,102	2,088	8.4%
Old Wives	582	534	442	361	-38.0%
Qu'Appelle	2,326	2,067	1,674	1,355	-41.7%
Saskatchewan	1,785	2,002	2,349	2,757	54.5%
Souris	956	948	915	862	-9.8%
South Saskatchewan	1,753	1,726	1,652	1,560	-11.0%
Interbasin Transfers					
Qu'Appelle *	83	77	58	45	-45.8%
Total	**16,669**	**16,627**	**16,403**	**16,151**	**-3.1%**

*Bruno is a town located in the QRB but is supplied by SSRB.

Figure 6.6 presents the distribution of large towns' water demand by basin. It can be noted that there are several significant basins in terms of water demand for these communities, such as North Saskatchewan, Assiniboine, Northern Four, Qu'Appelle, Saskatchewan, and South Saskatchewan River Basins.

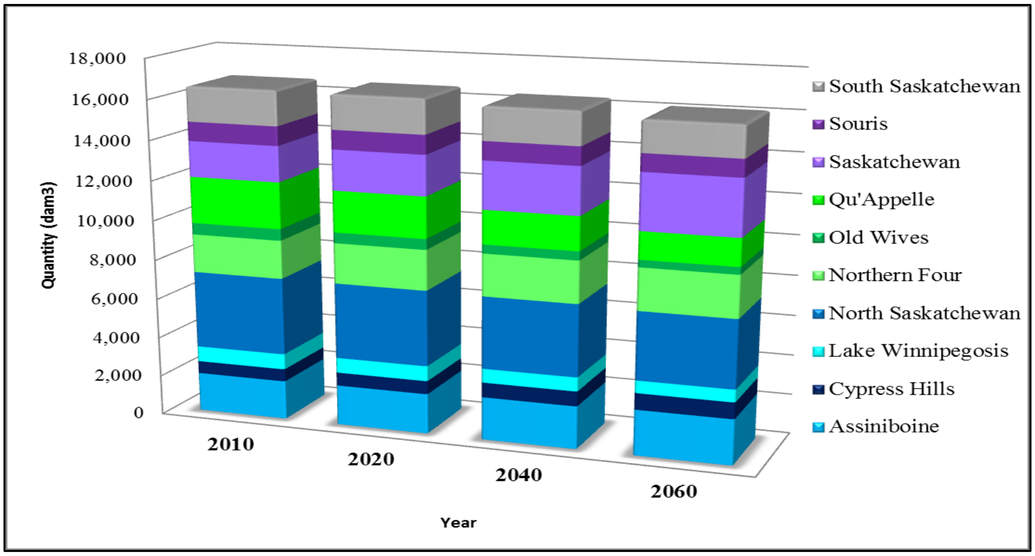

Figure 6.6: Distribution of Saskatchewan Total Larger Towns' Water Demand by River Basin, 2010-2060

6.3.2.2 Larger Towns Water Demand under Climate Change Scenario

A Climate Change Scenario hypothesizes that effects will occur after 2020 and that the water demand per capita will increase by 2.5% in 2040 and by 5% in 2060. To estimate the future water demand for larger towns, water demand per capita coefficients were readjusted as shown in Table B.9. Estimations for total water demand for these communities were calculated by the same method as for the baseline scenario.

The estimated total water demand for larger towns, by river basins is shown in Table 6.9. Under a climate change scenario the water demand for these communities is expected to rise from the current 16,669 dam^3 to 17,357 dam^3 by 2060, an overall increase of 4.1%. In comparison to the baseline scenario, an increase of 7.5% is assumed.

Table 6.9: Estimated Larger Towns' Water Demand for Saskatchewan by River Basins under Climate Change Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	1,959	2,024	2,207	2,400	22.5%
Cypress Hills	632	670	765	865	36.9%
Lake Winnipegosis	782	759	717	656	-16.1%
North Saskatchewan	3,884	3,801	3,970	3,917	0.8%
Northern Four	1,927	2,019	2,153	2,193	13.8%
Old Wives	582	534	453	379	-34.9%
Qu'Appelle	2,326	2,067	1,714	1,423	-38.8%
Saskatchewan	1,785	2,002	2,406	2,895	62.2%
Souris	956	948	937	905	-5.3%
South Saskatchewan	1,753	1,726	1,713	1,672	-4.6%
Interbasin Transfers					
Qu'Appelle	83	77	63	52	-37.3%
Total	**16,669**	**16,627**	**17,098**	**17,357**	**4.1%**
Change % over Baseline Scenario	0.0%	0.0%	4.2%	7.5%	

6.3.2.3 Larger Towns' Water Demand under Water Conservation Scenario

Under this scenario water demand is expected to be slightly lower than in the baseline scenario. Table B.10 shows the adjusted coefficients for this specific scenario which were used to estimate the total water demand for larger towns.

Employing conservation practices could determine a faster decrease in the total water demand from the present 16,669 dam^3 to 15,691dam^3 by 2060. Table 6.10 shows the estimated values for larger towns water demand under this scenario. Under a water conservation scenario, savings of 2.8% are possible by 2060.

6.3.3 Smaller Towns Water Demand

In Saskatchewan there are around 51 thousand people who reside in smaller towns and by 2060 this number is expected to increase by 23%, as shown in Table B.11, Appendix B. The Qu'Appelle and North Saskatchewan River Basins house the majority of these communities. The water consumption of smaller towns varies slightly from one river basin to another, as shown in Figure 6.7. In relative terms, smaller communities in the Missouri River Basin and Old Wives Lake Basin record the highest water demand percentages. Cypress Hills Basin is the only one that does not house any communities with less than 1,000 people (Not shown in Figure 6.7).

Table 6.10: Estimated Larger Towns' Water Demand for Saskatchewan by River Basins under Water Conservation Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	1959	2012	2129	2220	13.3%
Cypress Hills	632	666	738	800	26.6%
Lake Winnipegosis	782	755	692	606	-22.5%
North Saskatchewan	3884	3778	3566	3290	-15.3%
Northern Four	1927	1905	2077	2028	5.2%
Old Wives	582	530	437	351	-39.7%
Qu'Appelle	2326	2055	1655	1316	-43.4%
Saskatchewan	1785	1990	2321	2677	50.0%
Souris	956	942	904	837	-12.4%
South Saskatchewan	1753	1716	1632	1514	-13.6%
Interbasin Transfers					
Qu'Appelle	83	77	57	45	-45.8%
Total	**16,669**	**16,426**	**16,214**	**15,691**	**-5.9%**
Change % over Baseline Scenario	0.0%	-1.2%	-1.2%	-2.8%	

6.3.3.1 Smaller Towns Water Demand under Baseline Scenario

Smaller towns' water demand was estimated using the estimated population of these communities and their respective water demand per capita. These methodologies for the baseline scenario were presented earlier in this chapter. In Table B.12, the water demand per capita coefficients are presented.

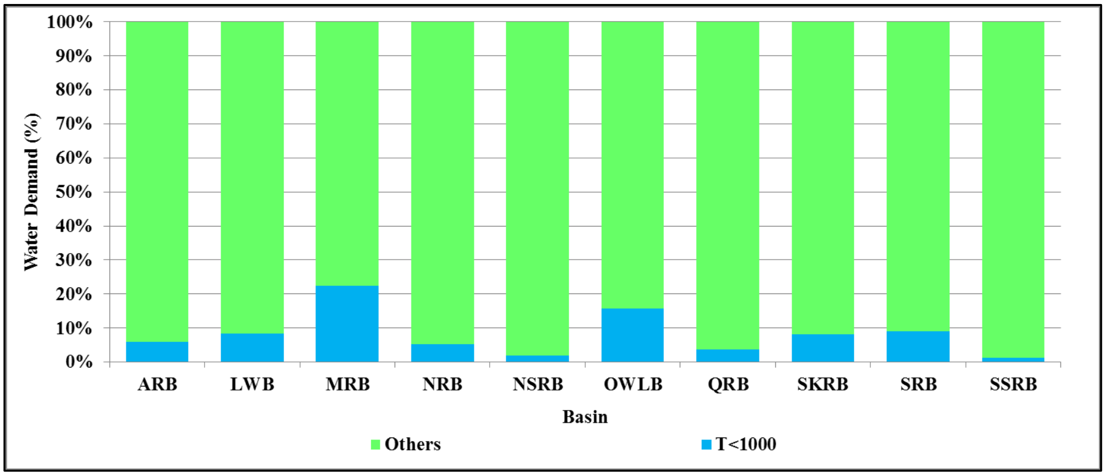

Figure 6.7: Smaller Towns' Water Demand as Share of Total Municipal/Domestic Water Demand by River Basin, Saskatchewan, 2010

As indicated by Figure 6.8, the water demand per capita coefficients reveal a large variation from one basin to another. The highest coefficients belong to Missouri and Old Wives Basin, 225 m^3 and 217 m^3, whereas the lowest ones are recorded in the Northern Basins, 94 m^3.

Estimated water demand levels are presented in Table 6.11. With the exception of four river basins (which are expected to decrease in size in the future), all smaller towns water demand is expected to increase over the 2010-2060 period. Overall, 2060 water demand is estimated at 6,860 dam^3, which is 6% higher than that in 2010. This increase is mainly contributed by increased water demand in the North Saskatchewan, Northern Four, and Saskatchewan River Basins.

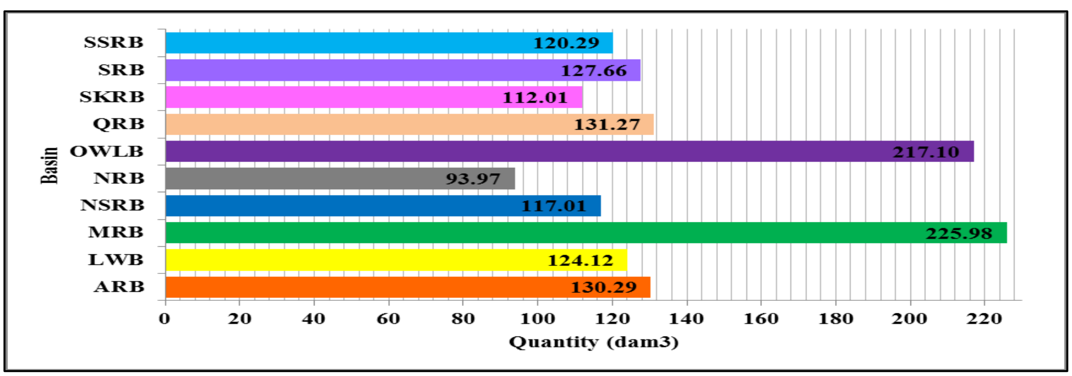

Figure 6.8: Coefficients for Water Demand per Capita for Smaller Towns, Saskatchewan by River Basin, 2010

Figure 6.9 shows the distribution of total water demand of smaller towns by river basins. The North Saskatchewan and Qu'Appelle River Basins remain the largest water consumers for these communities.

Table 6.11: Estimated Smaller Towns' Water Demand for Saskatchewan by River Basins under Baseline Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	403	408	420	431	6.9%
Lake Winnipegosis	207	210	216	222	7.2%
Missouri	299	285	229	184	-38.5%
North Saskatchewan	1,367	1,497	1,882	2,258	65.2%
Northern Four	136	154	200	260	91.2%
Old Wives	475	455	417	383	-19.4%
Qu'Appelle	1,705	1,579	1,363	1,174	-31.1%
Saskatchewan	422	461	541	620	46.9%
Souris	775	781	791	802	3.5%
South Saskatchewan	702	657	588	526	-25.1%
Total	**6,491**	**6,487**	**6,647**	**6,860**	**5.7%**

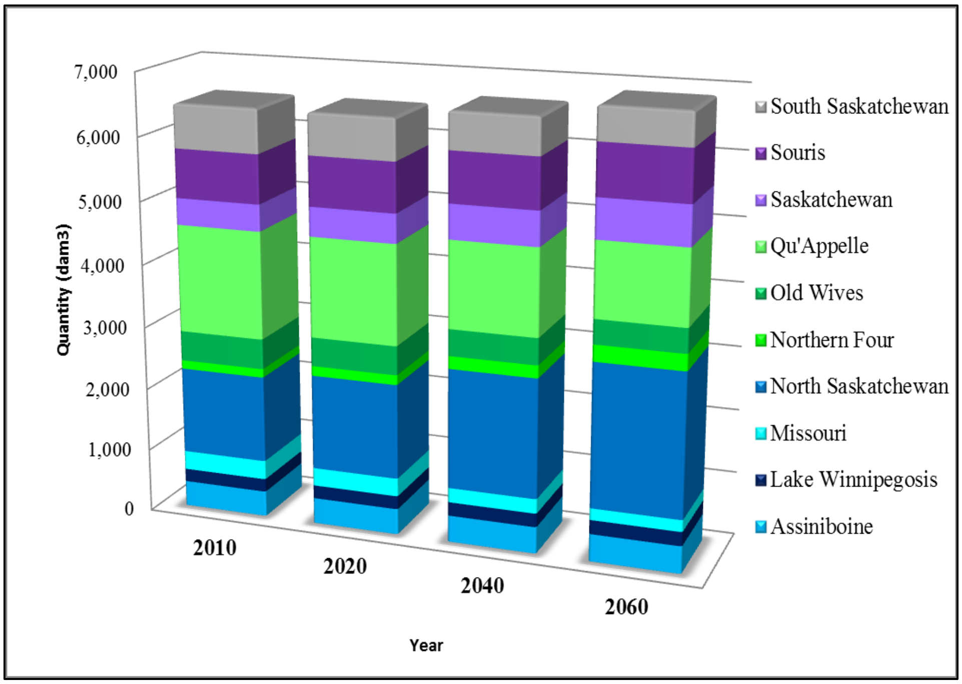

Figure 6.9: Distribution of Saskatchewan Total Smaller Towns' Water Demand by River Basins, 2010-2060

6.3.3.2 Smaller Towns Water Demand under Climate Change Scenario

Estimating water demand for smaller towns under a climate change scenario implied adjustment of water demand per capita coefficients. These are shown in Table B.13, Appendix B. Under this scenario total water demand is expected to increase by 12.3% by 2060 over 2010 and by approximately 6% over the baseline scenario. The estimated total water demand for smaller towns is shown in Table 6.12.

Table 6.12: Estimated Smaller Towns' Water Demand for Saskatchewan by River Basins under Climate Change Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Qu'Appelle	1,705	1,579	1,455	1,280	-24.9%
South Saskatchewan	702	657	629	593	-15.5%
North Saskatchewan	1,367	1,497	1,927	2,370	73.4%
Souris	775	781	810	842	8.6%
Missouri	299	285	234	193	-35.5%
Old Wives	475	455	427	402	-15.4%
Saskatchewan	422	461	554	651	54.3%
Assiniboine	403	408	430	453	12.4%
Lake Winnipegosis	207	210	221	233	12.6%
Northern Four	136	154	205	273	100.7%
Total	**6,491**	**6,487**	**6,892**	**7,290**	**12.3%**
Change % over Baseline Scenario	0.0%	0.0%	3.7%	6.3%	

6.3.3.3 Smaller Towns Water Demand under Water Conservation Scenario

The methodology for estimating the domestic water demand for smaller towns was similar to that followed for the climate change scenario. Water demand coefficients were adjusted, as shown in Table B.14. Total water demand under this scenario is shown in Table 6.13. Under water conservation, a reduction in total domestic water demand is noted. Total water demand in 2060 is only 6,658 dam^3, which is 2.9% lower than the level under the baseline scenario.

6.3.4 Summary of Domestic Water Demand

Total domestic water demand under a baseline scenario is expected to increase from 24,942 dam^3 in 2010 to 28,226 dam^3 by 2060, an increase of approximately 13%. Bedroom communities are expected to record high growth rates whereas larger towns are foreseen to reduce their water consumption by nearly 3% in 2060. Under a climate change scenario, an increase of 6.7% over the baseline scenario levels in total domestic water demand is expected by 2060. Employing a water conservation scenario could bring forward savings of nearly 3% over the baseline one. Table 6.14 shows a summary of the total domestic water demand for all study scenarios.

Table 6.13: Estimated Smaller Towns' Water Demand for Saskatchewan by River Basins under Water Conservation Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	403	406	415	419	4.0%
Lake Winnipegosis	207	209	213	215	3.9%
Missouri	299	283	226	178	-40.5%
North Saskatchewan	1,367	1,488	1,859	2,192	60.4%
Northern Four	136	153	198	252	85.3%
Old Wives	475	452	412	372	-21.7%
Qu'Appelle	1,705	1,568	1,347	1,138	-33.3%
Saskatchewan	422	459	534	602	42.7%
Souris	775	776	782	779	0.5%
South Saskatchewan	702	653	581	511	-27.2%
Total Demand	**6,491**	**6,447**	**6,567**	**6,658**	**2.6%**
Change % over Baseline Scenario	0.0%	-0.6%	-1.2%	-2.9%	

Table 6.14: Summary of Estimated Total Domestic Water Demand for Saskatchewan by Community Type and Study Scenarios, 2010- 2060

Community Type	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Baseline Scenario					
Bedroom Communities	1,865	2,410	3,641	5,260	182.0%
Towns > 1000	16,586	16,550	16,345	16,106	-2.9%
Towns < 1000	6,491	6,487	6,647	6,860	5.7%
Total Domestic Demand	**24,942**	**25,447**	**26,633**	**28,226**	**13.2%**
Climate Change Scenario					
Bedroom Communities	1,865	2,410	3,729	5,523	196.1%
Towns > 1000	16,586	16,550	17,035	17,305	4.3%
Towns < 1000	6,491	6,487	6,892	7,290	12.3%
Total Domestic Demand	**24,942**	**25,447**	**27,656**	**30,118**	**20.8%**
Change % over Baseline	0.0%	0.0%	3.8%	6.7%	
Water Conservation Scenario					
Bedroom Communities	1,865	2,396	3,598	5,107	173.8%
Towns > 1000	16,586	16,349	16,151	15,639	-5.7%
Towns < 1000	6,491	6,447	6,567	6,658	2.6%
Total Domestic Demand	**24,942**	**25,192**	**26,316**	**27,404**	**9.9%**
Change % over Baseline	0.0%	-1.0%	-1.2%	-2.9%	

6.4 Rural Domestic Water Demand

Rural domestic water demand in this study was defined as a sum of water demands of villages, farm and rural non-farm communities. These communities now comprise 21% of Saskatchewan's population. With the increased urbanization in the province, it is expected that their share would shrink to 12% by 2060. In terms of water demand, these communities demand 17% of the total provincial municipal/domestic water demand, but their share is expected to drop to only 10% by 2060. In the following sections, water demand for each one of these types of communities is presented.

6.4.1 Villages Water Demand

As a population group, the number of people living in villages is declining. Their population levels are presented in Table B.15 (Appendix B). Villages in Saskatchewan currently have 60 thousand people, but by 2060 the population will decrease by 5.7%. The water demand of villages represents only a small share of the total municipal/domestic water demand in the majority of the basins, as shown in Figure 6.10.

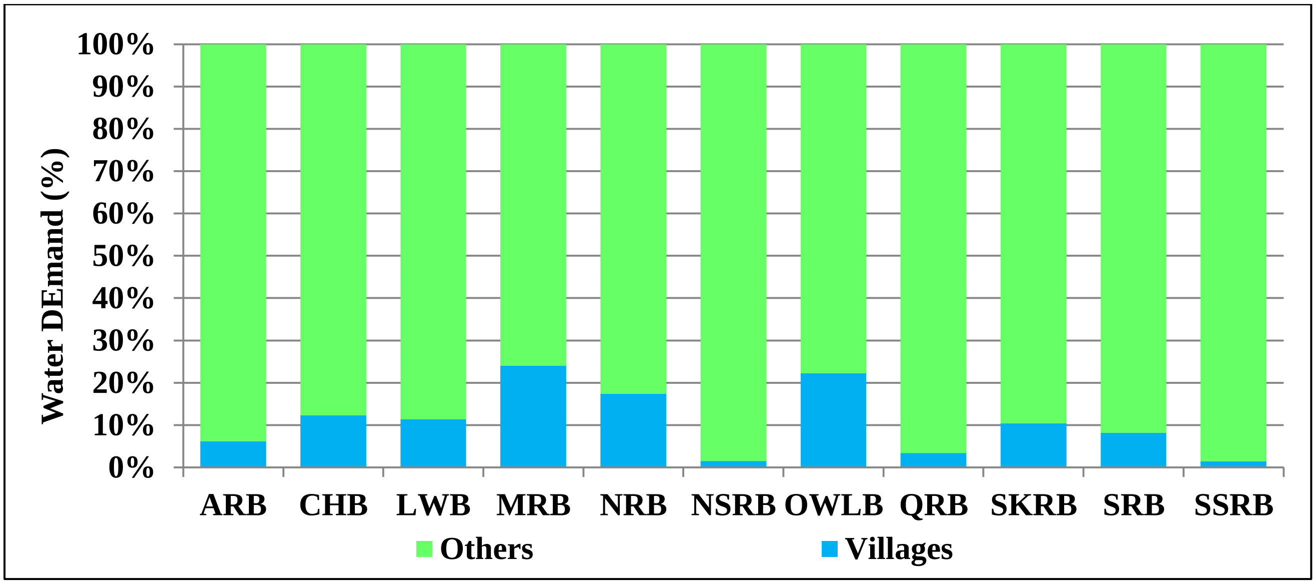

Figure 6.10: Water Demand for Villages as Share of Total Municipal/Domestic Water Demand by River Basins, Saskatchewan, 2010

6.4.1.1 Villages Water Demand under Baseline Scenario

The method of estimation for rural water demand was the same as the one used for other types of municipal/domestic water demands. The per capita water demand coefficients were multiplied by estimated population for a given time period. Adjusted coefficients are shown in Table B.16, and estimated water demand is shown in Table 6.15.

On account of declining village population trends in most basins, the water demand is expected to decline in 2060 from the 2010 level. Under the baseline scenario, this2010 water demand level is estimated at 7,424 dam^3, which could decline to 6,498 dam^3 (Table 6.15). This decline is predicated on the present trends in the population.

Table 6.15: Estimated Water Demand for Villages by River Basin under Baseline Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	417	396	376	369	-11.5%
Cypress Hills	166	158	150	147	0.0%
Lake Winnipegosis	282	238	168	118	-58.2%
Missouri	322	310	281	246	0.0%
North Saskatchewan	1,273	1,246	1,230	1,219	-4.2%
Northern Four	401	502	665	829	106.7%
Old Wives Lake	675	659	615	560	0.0%
Qu'Appelle	1,566	1,433	1,188	981	-37.4%
Saskatchewan	539	513	490	480	-10.9%
Souris	703	674	620	570	-18.9%
South Saskatchewan	831	789	768	753	-9.4%
Interbasin Transfers					
Qu'Appelle	145	137	133	131	-9.7%
Saskatchewan	104	99	97	95	-8.7%
Total Water Demand	**7,424**	**7,154**	**6,781**	**6,498**	**-12.5%**

It is conceivable that this rate of decline in the future may be stabilized at a slightly higher level than that assumed in this study. Perhaps, as more people leave these areas, there will be fewer people remaining there and thus, fewer people out-migrating to towns or cities. At present, Qu’Appelle and North Saskatchewan River Basins are the largest water demand basins for this community group. In some basins, notably Qu’Appelle and Saskatchewan River Basins, some of the villages received water from other basins

6.4.1.2 Villages Water Demand under Climate Change Scenario

Under the climate change scenario, water demand per capita coefficients were adjusted to reflect climate change impact. These adjusted coefficients are shown in Table B.17. Estimated population was multiplied by these coefficients to yield total water demand. Estimated water use is shown in Table 6.16. The total rural water demand will still decline over time, but not as quickly as that under the baseline scenario. Total water demand in 2060 would be 6,819 dam^3, 5% higher than that under the baseline scenario.

Table 6.16: Estimated Water Demand for Villages by River Basins under Climate Change Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	417	396	385	387	-7.2%
Cypress Hills	166	158	154	154	0.0%
Lake Winnipegosis	282	238	172	123	-56.4%
Missouri	322	310	287	259	0.0%
North Saskatchewan	1,273	1,246	1,260	1,280	0.5%
Northern Four	401	502	681	870	117.0%
Old Wives Lake	675	659	629	588	0.0%
Qu'Appelle	1,566	1,433	1,216	1,029	-34.3%
Saskatchewan	539	513	501	503	-6.7%
Souris	703	674	635	598	-14.9%
South Saskatchewan	831	789	787	791	-4.8%
Interbasin Transfers					
Qu'Appelle	145	137	137	138	-4.8%
Saskatchewan	104	99	99	99	-4.8%
Total Water Demand	**7,424**	**7,154**	**6,943**	**6,819**	**-8.1%**

6.4.1.3 Villages Water Demand under Water Conservation Scenario

Villages' water demand under water conservation followed the same methodology as described for the municipal water demands. The adjusted water demand coefficients for this category of communities are shown in Table B.18. Estimated water demand is shown in Table 6.17. This water demand falls below that seen under the baseline scenario by 2.9% or 6,307 dam^3.

6.4.1.4 Summary of Villages Water Demand

A summary of villages' water demand is presented in Table 6.18 for the three study scenarios. As noted above there is a tendency in this water demand to decline over time, partly because of a declining population base. Although climate change would increase this water demand by 5%, the water conservation scenario could produce approximately a 3% reduction compared to the baseline scenario. However, water conservation in rural settings is a relatively unstudied subject. These estimates are therefore, based on water demand coefficients that are not supported by science or observations. More attention needs to be paid to this aspect of the study, perhaps in the form of primary research that could produce concrete evidence for future work.

Table 6.17: Estimated Water Demand for Villages by River Basins under Water Conservation Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	417	394	372	358	-14.1%
Cypress Hills	166	157	148	143	0.0%
Lake Winnipegosis	282	237	166	114	-59.6%
Missouri	322	308	277	239	0.0%
North Saskatchewan	1,273	1,238	1,216	1,183	-7.1%
Northern Four	401	473	657	805	100.7%
Old Wives Lake	675	655	607	544	0.0%
Qu'Appelle	1,566	1,424	1,174	952	-39.2%
Saskatchewan	539	510	483	466	-13.5%
Souris	703	670	612	553	-21.3%
South Saskatchewan	831	784	759	731	-12.0%
Interbasin-Transfers					
Qu'Appelle	145	137	132	127	-12.4%
Saskatchewan	104	99	95	92	-11.5%
Total Water Demand	**7,424**	**7,086**	**6,698**	**6,307**	**-15.0%**

Table 6.18: Summary of Villages' Water Demand in All Saskatchewan River Basins, Study Scenarios, 2010 - 2060

Scenarios	Total Domestic Water Demand in dam^3				2060 level % of Baseline
	2010	2020	2040	2060	
Baseline	7,175	6,918	6,551	6,272	100.0%
Climate Change	7,175	6,918	6,707	6,582	104.9%
Water Conservation	7,175	6,850	6,471	6,088	97.1%

6.4.2 Rural Non-Farm Water Demand

The other type of rural water demand occurs through people living in open spaces in the rural setting. The population of rural non-farm communities in Saskatchewan is expected to decrease by 30% by 2060. These results on population levels are presented in Table B.19. These communities currently number 57 thousand people, but by 2060, the population will decrease to 40 thousand. Water demand estimates for these communities are presented in the following sections.

6.4.2.1 Rural Non-farm Water Demand under Baseline Scenario

Estimates of total water demand for these communities were calculated using the same methodology as for the municipal and domestic water demand. Because of a lack of information on water demand per capita coefficients for these communities, coefficients for village water demand were used. Total water demand values for rural non-farm communities are shown in Table 6.19. These communities are expected to reduce their current water demand by nearly 33% by 2060. All river basins contain rural non-farm communities, with a decreasing trend in water demand.

Table 6.19: Estimated Rural Non-Farm Water Demand for Saskatchewan by River Basins under Baseline Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	314	282	251	220	-29.9%
Cypress Hills	66	59	53	46	-30.3%
Lake Winnipegosis	226	182	129	89	-60.6%
Missouri	3	3	3	3	0.0%
North Saskatchewan	2,475	2,294	1,862	1,829	-26.1%
Northern Four	224	202	180	157	-29.9%
Old Wives	26	26	26	25	-3.8%
Qu'Appelle	745	615	460	339	-54.5%
Saskatchewan	424	381	339	297	-30.0%
Souris	133	120	107	93	-30.1%
South Saskatchewan	1,132	1,019	906	793	-29.9%
Total Water Demand	**5,768**	**5,183**	**4,316**	**3,891**	**-32.5%**

6.4.2.2 Rural Non-farm Water Demand under Climate Change Scenario

Under a climate change scenario the total water demand for rural non-farm communities is estimated to decrease as well, but at a slower rate than in the baseline scenario. Current water demand is assumed to decrease by 29% by 2060. Results are shown in Table 6.20.

6.4.2.3 Rural Non-farm Water Demand Water Conservation Scenario

Employing a water conservation scenario could further decrease the total water demand for these communities, as shown in Table 6.21. Under this scenario, it is expected that the total water demand of rural non-farm communities will decrease by 34.5% in 2060 over one-third below the current levels. In comparison with the baseline scenario, a water conservation one could determine savings of nearly 3%.

Table 6.20: Estimated Rural Non-Farm Water Demand for Saskatchewan by River Basins under Climate Change Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	314	282	257	231	-26.4%
Cypress Hills	66	59	54	48	-27.3%
Lake Winnipegosis	226	182	132	93	-58.8%
Missouri	3	3	3	3	0.0%
North Saskatchewan	2,475	2,294	1,906	1,920	-22.4%
Northern Four	224	202	184	165	-26.3%
Old Wives	26	26	27	27	3.8%
Qu'Appelle	745	615	471	356	-52.2%
Saskatchewan	424	381	347	311	-26.7%
Souris	133	120	109	98	-26.3%
South Saskatchewan	1,132	1,019	928	832	-26.5%
Total Water Demand	**5,768**	**5,183**	**4,418**	**4,084**	**-29.2%**

Table 6.21: Estimated Rural Non-Farm Water Demand for Saskatchewan by River Basins under Water Conservation Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	314	281	248	213	-32.2%
Cypress Hills	66	59	52	45	-31.8%
Lake Winnipegosis	226	181	127	86	-61.9%
Missouri	3	3	3	3	0.0%
North Saskatchewan	2,475	2,280	1,839	1,776	-28.2%
Northern Four	224	191	177	153	-31.7%
Old Wives	26	26	26	25	-3.8%
Qu'Appelle	745	612	455	329	-55.8%
Saskatchewan	424	379	335	288	-32.1%
Souris	133	119	105	91	-31.6%
South Saskatchewan	1,132	1,013	895	770	-32.0%
Total Water Demand	**5,768**	**5,144**	**4,262**	**3,779**	**-34.5%**

6.4.2.4 Summary of Rural Non-Farm Water Demand

A summary of rural non-farm water demand is presented in Table 6.22 for the three study scenarios. Under a baseline scenario, there is a tendency of water demand decrease in these communities. Climate change would increase this water demand by 5%, and the water conservation scenario could create an approximately 3% reduction compared to the baseline scenario.

Table 6.22: Summary of Rural Non-Farm Water Demand in Saskatchewan by Study Scenarios, 2010 - 2060

Scenarios	Total Domestic Water Demand in dam^3				2060 level % of Baseline
	2010	2020	2040	2060	
Baseline	5,768	5,183	4,316	3,891	100.0%
Climate Change	5,768	5,183	4,418	4,084	104.9%
Water Conservation	5,768	5,144	4,262	3,779	97.1%

6.4.3 Rural Farm Water Demand

Saskatchewan's rural farm communities comprise a population of 115,416 people. In all river basins, these communities are assumed to be declining by 30% by 2060, as shown in Table B.20, Appendix B. Qu'Appelle, North Saskatchewan and Souris River Basins house the majority of people living in rural farm communities. The water demand for this population group was calculated in a similar manner to the one used for rural non-farm communities.

6.4.3.1 Rural Farm Water Demand under Baseline Scenario

The total water demand for rural farm communities is expected to decline from its present level of 15,673 dam^3 to 10,534 dam^3 by 2060, a decrease of nearly 33%. Lake Winnipegosis and Qu'Appelle River Basins are expected to record higher decline rates than the rest of the river basins. Results of these estimates are presented in Table 6.23.

6.4.3.2 Rural Farm Water Demand under Climate Change Scenario

Under a climate change scenario, the decline in total water demand for rural farm communities is reduced. Table 6.24 shows the estimates of water demand for this community. Water demand by these communities would be 11.1 thousand dam^3, as seen against 10.5 thousand dam^3 under the baseline scenario.

Table 6.23: Estimated Rural Farm Water Demand for Saskatchewan by River Basins under for Baseline Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Qu'Appelle	3,285	2,712	2,029	1,494	-54.5%
South Saskatchewan	1,995	1,795	1,436	1,396	-30.0%
North Saskatchewan	2,967	2,750	2,480	2,193	-26.1%
Souris	1,514	1,363	1,090	1,060	-30.0%
Missouri	714	698	642	697	-2.4%
Cypress Hills	475	427	342	332	-30.1%
Old Wives	1,280	1,242	1,133	1,225	-4.3%
Saskatchewan	981	883	706	687	-30.0%
Assiniboine	941	847	677	659	-30.0%
Lake Winnipegosis	892	720	459	351	-60.7%
Northern Four	629	566	453	440	-30.0%
Total Water Demand	**15,673**	**14,003**	**11,447**	**10,534**	**-32.8%**

Table 6.24: Estimated Rural Farm Water Demand for Saskatchewan by River Basins under Climate Change Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Qu'Appelle	3,285	2,712	2,077	1,569	-52.2%
South Saskatchewan	1,995	1,795	1,471	1,466	-26.5%
North Saskatchewan	2,967	2,750	2,539	2,302	-22.4%
Souris	1,514	1,363	1,116	1,113	-26.5%
Missouri	714	698	657	731	2.4%
Cypress Hills	475	427	350	349	-26.5%
Old Wives	1,280	1,242	1,160	1,287	0.5%
Saskatchewan	981	883	723	721	-26.5%
Assiniboine	941	847	694	691	-26.6%
Lake Winnipegosis	892	720	470	369	-58.6%
Northern Four	629	566	464	462	-26.6%
Total Water Demand	**15,673**	**14,003**	**11,721**	**11,060**	**-29.4%**

6.4.3.3 Rural Farm Water Demand under Water Conservation Scenario

A water conservation scenario can bring forward higher decline rates in water demand for the rural farm communities located in various river basins, as shown in Table 6.25. A reduction to 10.2 thousand dam^3 is estimated for these communities, which is about 2.9% below the baseline scenario level.

6.4.3.4 Summary of Rural Farm Water Demand

A summary of rural farm water demand is presented in Table 6.26 for the three study scenarios. Under a baseline scenario, there is a tendency of water demand decrease in these communities. Climate change would increase this water demand by 5% and the water conservation scenario could bring about approximately a 3% reduction compared to the baseline scenario.

6.5 First Nations' Water Demand

As a population group, First Nations communities are the fastest growing communities in the province. Population in these communities is expected to grow, although out migration patterns may reduce their size in the future. These results are presented in Table B.21.

In terms of water demand, the First Nations' communities represent only a small share of the total municipal/domestic water demand in the majority of the basins, as shown in Figure 6.11. These communities record 40% of the total water demand in the NorthernRiver Basins.

Table 6.25: Estimated Rural Farm Water Demand for Saskatchewan by River Basins under Water Conservation Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Qu'Appelle	3,285	2,697	2,005	1,451	-55.8%
South Saskatchewan	1,995	1,785	1,419	1,356	-32.0%
North Saskatchewan	2,967	2,734	2,450	2,129	-28.2%
Souris	1,514	1,355	1,077	1,029	-32.0%
Missouri	714	694	634	676	-5.3%
Cypress Hills	475	425	338	323	-32.0%
Old Wives	1,280	1,235	1,119	1,190	-7.0%
Saskatchewan	981	878	698	667	-32.0%
Assiniboine	941	842	669	639	-32.1%
Lake Winnipegosis	892	716	453	341	-61.8%
Northern Four	629	534	448	428	-32.0%
Total Water Demand	**15,673**	**13,895**	**11,310**	**10,229**	**-34.7%**

Table 6.26: Summary of Rural Farm Water Demand in Saskatchewan by Study Scenarios, 2010 - 2060

Particulars	Water Demand in dam^3			
	2010	2020	2040	2060
Total Water Demand	**165,904**	**170,544**	**185,470**	**205,346**
Surface Water	123,433	128,079	141,328	156,884
Groundwater	42,471	42,465	44,142	48,462
Surface water as % of total water demand	**74.4%**	**75.1%**	**76.2%**	**76.4%**

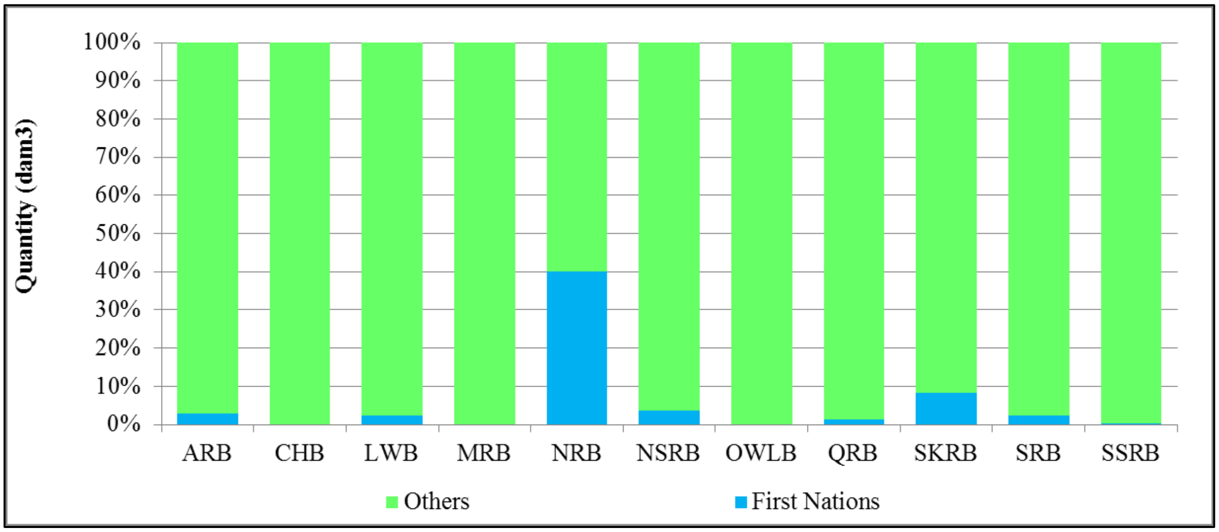

Figure 6.11: First Nations' Water Demand as Share of Total Municipal/Domestic Water Demand by River Basins for Saskatchewan, 2010

6.5.1 First Nations' Water Demand under Baseline Scenario

First Nations' communities' water demand was estimated using the per capita water demand coefficient presented in Table B.23, multiplied by the population for a given time period. Total water demand for these communities is expected to grow at a rapid rate. Under the baseline scenario, their total water demand is expected to grow almost threefold (increase of 183%) over the 2010 level. In 2010 it was estimated at 5,461 dam^3, which would likely increase to 15,459 dam^3 by 2060 (Table 6.27).

Table 6.27: Estimated First Nations Water Demand for Saskatchewan by River Basins under Baseline Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	190	210	256	313	64.7%
Lake Winnipegosis	56	65	92	119	112.5%
North Saskatchewan	950	1,269	1,800	2,332	145.5%
Northern Four	2,930	3,185	4,987	6,789	131.7%
Qu'Appelle	590	940	2,205	4,173	607.3%
Saskatchewan	427	549	792	1,035	142.4%
Souris	198	232	302	373	88.4%
South Saskatchewan	120	161	243	325	170.8%
Total	**5,461**	**6,611**	**10,677**	**15,459**	**183.1%**

Figure 6.12 shows the distribution of First Nations' communities' total water demand by river basin. As mentioned previously, currently most of the water demand for these communities can be attributed to the NorthernRiver Basins. By 2060 it is expected that First Nations communities in the Qu'Appelle River Basin will represent a fair share of the total water consumption of these population groups.

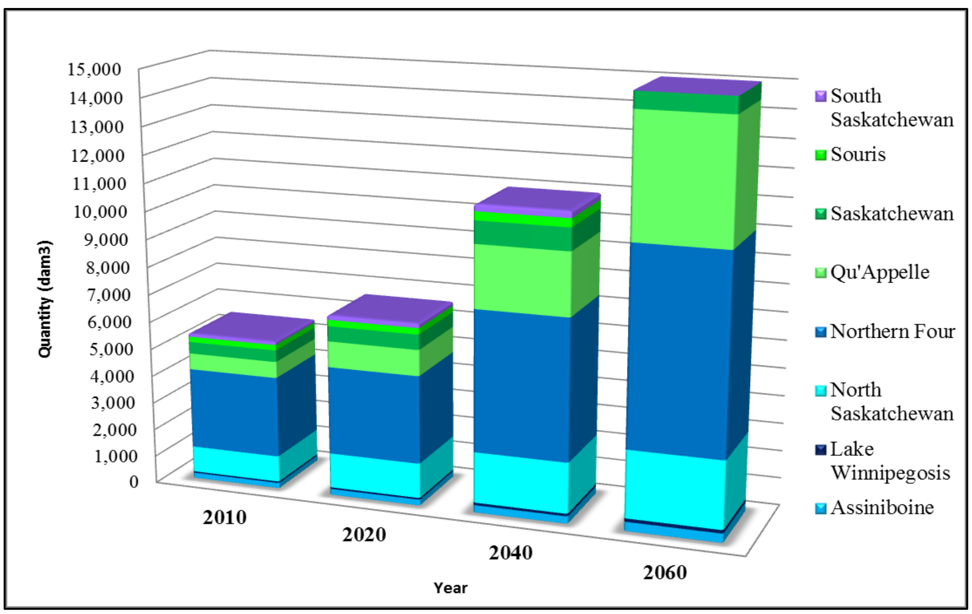

Figure 6.12: Distribution of Saskatchewan Total First Nations' Water Demand by River Basin, 2010-2060

6.5.2 First Nations' Water Demand under Climate Change Scenario

Climate change was assumed to have the same type of impact on First Nations as on other water demand groups. Adjusted coefficients for this scenario are shown in Table B.24. As a result water demand estimates for 2060 were 16,232 dam^3, some 5% higher than that for the baseline level (Table 6.28). It should be noted that available studies on this subject did not shed any light on the nature of these impacts. Thus, as a crude proxy, these communities were treated just like other communities. Additional research needs to be devoted to this issue in the future.

Table 6.28: Estimated First Nations Water Demand, Saskatchewan by River Basins under Climate Change Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	190	210	263	329	73.2%
Lake Winnipegosis	56	65	94	125	123.2%
North Saskatchewan	950	1,269	1,843	2,449	157.8%
Northern Four	2,930	3,185	5,107	7,128	143.3%
Qu'Appelle	590	940	2,258	4,382	642.7%
Saskatchewan	427	549	811	1,087	154.6%
Souris	198	232	310	391	97.5%
South Saskatchewan	120	161	248	341	184.2%
Total	**5,461**	**6,611**	**10,934**	**16,232**	**197.2%**
Change % over baseline	0.0%	0.0%	2.4%	5.0%	

6.5.3 First Nations' Water Demand under Water Conservation Scenario

No information is available on the subject of water conservation and First Nations communities. However, in the future it is assumed that these communities will follow the same pattern of adoption of water conservation measures as with the rest of the basin. This is predicated on improved education levels of First Nations' people in future and on improved dissemination by provincial agencies on the need for adopting water conservation measures in these communities. Under this assumption, water demand for these communities was estimated by using the adjusted coefficients presented in Table B.25. Estimates on First Nations' Reserves water use are shown in Table 6.29. The water demand under this scenario is still expected to increase, but at a slower rate than it would under a baseline scenario.

Table 6.29: Estimated First Nations Water Demand, Saskatchewan by River Basins for Water Conservation Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	190	209	253	304	60.0%
Lake Winnipegosis	56	64	91	116	107.1%
North Saskatchewan	950	1,261	1,779	2,264	138.3%
Northern Four	2,930	3,166	4,927	6,592	125.0%
Qu'Appelle	590	935	2,180	4,052	586.8%
Saskatchewan	427	545	782	1,005	135.4%
Souris	198	231	299	362	82.8%
South Saskatchewan	120	160	240	315	162.5%
Total	**5,461**	**6,571**	**10,551**	**15,010**	**174.9%**

6.5.4 Summary of First Nations' Water Demand

Water demand for First Nations' Reserves is expected to rise at a very rapid rate relative to 2010. In all study scenarios, approximately a threefold increase in this water demand is expected by 2060. A summary of the First Nations communities total water demand is presented in Table 6.30.

6.6 Communal (Public institutions) Water Demand

Communal water demand was estimated for two institutions: Moose Jaw Forces Base which is supplied by the Moose Jaw municipal system, and the Regina Correctional Centre which receives water from the City of Regina municipal system. Both institutions are located in the Qu'Appelle River Basin. Water demand for these two institutions was estimated under the three study scenarios.

Table 6.30: Summary of First Nations' Water Demand in Saskatchewan by Study Scenarios, 2010 - 2060

Scenarios	Total Domestic Water Demand in dam^3				2060 level % of Baseline
	2010	2020	2040	2060	
Baseline	5,461	6,611	10,677	15,459	100.0%
Climate Change	5,461	6,611	10,934	16,232	105.6%
Water Conservation	5,461	6,571	10,551	15,010	89.9%

6.6.1 Communal (Public institutions) Water Demand under Baseline Scenario

Total institutional water demand for the baseline scenario is shown in Table 6.31. The current level of water demand by these institutions is estimated at 327 dam^3, which is expected to decrease to 204 dam^3 by 2060. This decrease is primarily a result of reduced personnel at the Moose Jaw Canadian Forces Base.

Table 6.31: Estimated Institutions' Water Demand for Saskatchewan by Study Scenarios, 2010- 2060

Scenarios	Total Domestic Water Demand in dam^3				2060 level % of Baseline
	2010	2020	2040	2060	
Baseline	327	300	252	204	100.0%
Climate Change	327	300	271	230	112.7%
Water Conservation	327	300	249	194	95.1%

6.6.2 Communal (Public institutions) Water Demand under Climate Change Scenario

Behavior of institutions in the wake of climate change is not a well-studied subject. In fact, no information was found as to how institutions in the Qu'Appelle River Basin will react in terms of water demand or how they might be impacted by it. Since these institutions are located in urban areas, their impacts were assumed to be similar to those for the municipal water demand. These estimates are shown in Table 6.31 as well. Under the assumption that the number of inmates would be the same as that in 2010, the water demand level under climate change for the Regina Correctional Centre will increase by 12.5% of the 2010 level. Water demand for the Moose Jaw Canadian Forces Base would still decline on account of reduced personnel employed there.

6.6.3 Communal (Public institutions) Water Demand under Water Conservation Scenario

Institutional water demand can also be subject to water conservation. However, no study was found that has reported feasible measures that can be adopted for such institutions. Among the two institutions, Regina Correctional Facility was hypothesized[35] as an institution with a potential for water conservation. For this research, institutions were treated just like municipal water demands the same impact of water conservation measures was assumed to be applicable here as well. Water demands by institutions would decrease to 194 dam^3 per annum. This is 59.3% of the 2010 level demand for these institutions.

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[35] Please note that this is an assumption made in this study. This issues needs to be examined further by experts in water use in public institutions.

6.6.4 Summary of Communal (Public institutions) Water Demand

The current water demand level is estimated at 327 dam^3. In all three study scenarios, the future water demand would be lower than that in 2010. Part of the reason for this change is the reduced number of personnel at the Moose Jaw Canadian Forces Base.

6.7 Other Municipal/Domestic Water Demands

6.7.1 Unorganized Division 18 Water Demand

This category includes other northern communities not included under previous groups. Unorganized Division 18 communities are located for the most part in Churchill, Athabasca, Kasba and Tazin Basins, grouped under the Northernfor this study. Currently there are 1,641 people included under this category and by 2060; a decline of 32% in population numbers is expected.

6.7.3.1 Unorganized Division 18 Water Demand under Baseline Scenario

Estimated water demand for this group is currently estimated at 202 dam^3 and is expected to decline to 139 dam^3 by 2060, a decline of 31%. Results are shown in Table 6.32. Population decline is the major factor for the future development of water demand in this community.

6.8.3.2 Unorganized Division 18 Water Demand under Climate Change Scenario

Estimates of water demand for the climate change scenario were realized following the same methodology as that employed for the municipal and domestic communities. Under a climate change scenario, water demand is expected to increase by 5% over the baseline scenario. Results are also presented in Table 6.32.

Table 6.32: Estimated Unorganized Division 18 Water Demand, Saskatchewan by Study Scenarios, 2010- 2060

Scenarios	Total Domestic Water Demand in dam^3				2060 level % of Baseline
	2010	2020	2040	2060	
Baseline	202	188	162	139	100.0%
Climate Change	202	188	165	146	105.0%
Water Conservation	202	186	160	135	97.1%

6.8.3.3 Unorganized Division 18 Water Demand under Water Conservation Scenario

Water conservation practices are assumed to produces savings in total water demand for this group as well. It is expected that under this scenario a decline of 2.9% over the baseline scenario is possible. Estimated values for the water conservation scenario are shown in Table 6.32.

6.7.2 Other Water Demands

Other water demands include water used by, for the most part, trailer courts communities located in several River Basins. Their water demand estimates were calculated by using the total water demand records.

6.7.2.1 Other Water Demands under Baseline Scenario

The total other water demand in Saskatchewan is currently 385 dam^3 and is expected to increase to 534 dam^3 by 2060, an increase of nearly 39%. Table 6.33 presents the results for this scenario.

Table 6.33: Estimated Other Water Demands for Saskatchewan by River Basin under Baseline Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	82	82	82	82	0.0%
Cypress Hills	6	6	6	6	0.0%
Lake Winnipegosis	35	35	35	35	0.0%
North Saskatchewan	152	152	152	152	0.0%
Souris	9	8	7	7	-16.5%
South Saskatchewan	102	132	192	253	148.4%
Total	**385**	**414**	**474**	**534**	**38.8%**

6.7.2.2 Other Water Demands under Climate Change Scenario

Under a climate change scenario, the water demand for this category of demand is expected to increase faster than in the previous scenario, as shown in Table 6.34. Climate change could raise current water demand levels of 385 dam^3 to 560 dam^3 by 2060, accounting for an increase of almost 36%.

6.7.2.3 Other Water Demands under Water Conservation Scenario

No information is available on the subject of water conservation and trailer courts communities. However, in the future, it is assumed that these communities will follow the same pattern in the adoption of water conservation measures as will the rest of the communities. Under this assumption, water demand estimates are shown in Table 6.35. The water demand under this scenario is expected to still increase, but at a slower rate than it would under a baseline scenario

Table 6.34: Estimated Other Water Demand for Saskatchewan by River Basins under Climate Change Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	82	82	84	86	4.9%
Cypress Hills	6	6	6	6	5.0%
Lake Winnipegosis	35	35	36	37	5.7%
North Saskatchewan	152	152	155	159	5.0%
Souris	9	8	8	7	-22.1%
South Saskatchewan	102	132	197	265	160.8%
Total	**385**	**414**	**485**	**560**	**45.6%**

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Table 6.35: Estimated Other Water Demand for Saskatchewan by River Basins under Water Conservation Scenario, 2010- 2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	82	82	81	80	-2.4%
Cypress Hills	6	6	6	5	-2.9%
Lake Winnipegosis	35	35	34	34	-2.9%
North Saskatchewan	152	151	149	145	-4.6%
Souris	9	8	7	6	-28.0%
South Saskatchewan	102	131	190	245	141.2%
Total	**385**	**413**	**467**	**516**	**34.0%**

6.8 Source of Water for Municipal/Domestic Water Demand

Municipal/domestic water demands are served both by surface water bodies and by underground aquifers. A summary of this water demand for the baseline scenario is shown in Table 6.36. Almost three quarters of the total water demand is supplied by surface water bodies. The relative proportion of surface to groundwater varies slightly among the three scenarios. The demand for surface water dominates the total water demand for municipal/domestic purposes in Saskatchewan. In 2010, 74% of the total water demand was served from such sources. It increases to approximately 76% by 2060.

Table 6.36: Total Municipal/Domestic Water Demand by Source, Saskatchewan, Baseline Scenario, 2010 - 2060

Particulars	Water Demand in dam^3			
	2010	2020	2040	2060
Total Water Demand	**165,904**	**170,544**	**185,470**	**205,346**
Surface Water	123,433	128,079	141,328	156,884
Groundwater	42,471	42,465	44,142	48,462
Surface water as % of total water demand	**74.4%**	**75.1%**	**76.2%**	**76.4%**

The source of water for municipal/domestic water demand varies greatly from one basin to another. Surface water represents only 29% of the total water supply in the Missouri River Basin and 34% in the Assiniboine River Basin. In the Northernand in the South Saskatchewan River Basins, the share is much higher, 85% and 96% respectively. Figure 6.13 shows specific shares of surface and groundwater for each river basin.

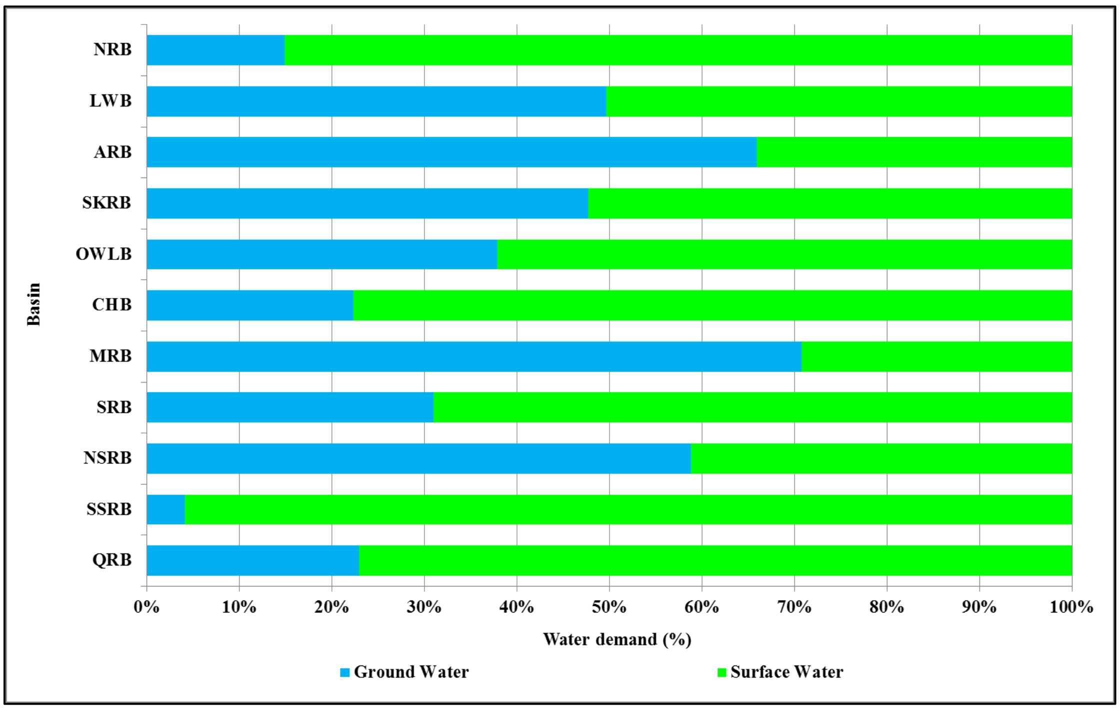

Figure 6.13: Share of Surface/Groundwater demand in Saskatchewan by River Basins, 2010-2060

6.9 Water Consumption for Municipal/domestic Water Demand

Not all water withdrawn (also called intake) is lost. A part of this water is returned back to the original surface water bodies. Although some water may be returned to groundwater sources, the knowledge of aquifer recharge rates and related information is relatively poor and therefore, it is typically assumed that all groundwater withdrawn is lost. The total consumption of water for municipal/domestic purposes is shown in Table 6.37.

Table 6.37: Total Municipal/Domestic Water Consumption, Saskatchewan, under Baseline Scenario 2010 - 2060

Particulars	Water Demand in dam^3			
	2010	**2020**	**2040**	**2060**
Total Water Demand	**165,904**	**170,544**	**185,470**	**205,346**
Water Consumption	77,145	77,768	82,534	91,174
Return flow	88,759	92,776	102,936	114,172
Water Consumption as % of Total Water Demand	**46.5%**	**45.6%**	**44.5%**	**44.4%**

Total water consumption under the baseline scenario for 2010 was estimated at 77,529 dam^3, which is about 47% of the total water withdrawn. Thus 63% of the water withdrawn is returned to the original water source in some shape[36]. By 2060, the amount of water consumed increases slightly but its proportion to total water intake does not change appreciably.

Under climate change and water conservation scenarios, although consumption levels do change, their proportion to total water demand does not. The level of water intake and consumption for municipal/domestic purposes by river basin are shown in Figure 6.14. It can be noted that at the river basin level, the water consumption share can vary extensively.

6.10 Total Municipal/Domestic Water Demand

In this section, all different water demands described above are summarized. These estimates are grouped into six categories of municipal/domestic water demand: municipal water demand (cities); domestic water demands (towns); rural water demands (villages and open areas); First Nations' communities' water demands; institutional water demands; and others. Results for the three study scenarios are summarized in this section.

[36] Cities with a municipal water and sewer system have facilities to treat this water before releasing it to a given surface water body. Whether all towns have similar facilities needs further investigation.

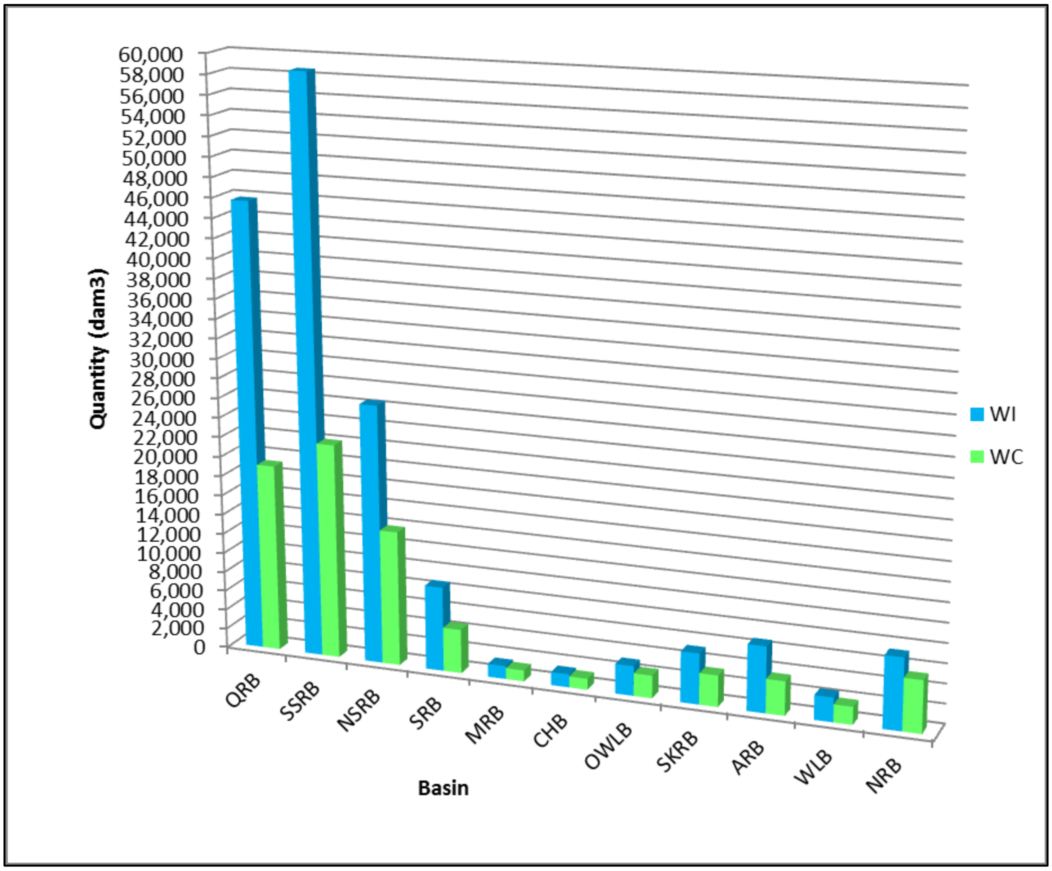

Figure 6.14: Water Intake and Consumption in Saskatchewan by River Basins, 2010-2060

6.10.1 Total Municipal/Domestic Water Demand under Baseline Scenario

Total municipal/domestic water demand in Saskatchewan is currently 166,916 dam^3, of which cities have the largest share. In fact, almost half of the total municipal/domestic water demand (64%) is for the large urban centers. The next largest level of water demand in 2010 is for rural communities which included farm and rural non-farm level water demands, totalling 28,616 dam^3. Following these two larger demands are domestic water demands (towns). Table 6.38 provides a summary of results for total water demand under a baseline scenario.

By 2060, although municipal water demand still has the largest share, the rank of other water sub-sectors does change. Now domestic water demand has the second highest water demand level, followed by rural water demand. Rural water demand level is now 20,697 dam^3, which has been reduced by nearly 28% in comparison with 2010 levels. The largest relative increase in 2060 is expected to be in the First Nations' communities' water demand level, which is expected to increase from 5,461 dam^3 in 2010 to 15,459 dam^3 by 2060.

Table 6.38: Total Municipal/Domestic Water Demand Estimates for Saskatchewan by Community Type under Baseline Scenario 2010, 2020, 2040 and 2060

Community Type	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Cities	105,971	111,480	124,958	140,087	32.2%
Total Municipal Water	**105,971**	**111,480**	**124,958**	**140,087**	**32.2%**
Towns > 1000	16,586	16,550	16,345	16,106	-2.9%
Towns < 1000	6,491	6,487	6,647	6,860	5.7%
Bedroom Communities	1,865	2,410	3,641	5,260	182.0%
Total Domestic Water	**24,942**	**25,447**	**26,633**	**28,226**	**13.2%**
Villages	7,175	6,918	6,551	6,272	-12.6%
Rural non-farm	5,768	5,183	4,316	3,891	-32.5%
Rural farm	15,673	14,003	11,447	10,534	-32.8%
Total Rural Water Demand	**28,616**	**26,104**	**22,314**	**20,697**	**-27.7%**
First Nations	5,461	6,611	10,677	15,459	183.1%
Institutions	327	300	252	204	-37.6%
Unorganized Division 18	202	188	162	139	-31.2%
Other	385	414	474	534	38.8%
Total Municipal/Domestic	**165,904**	**170,544**	**185,470**	**205,346**	**23.8%**
IBT	1,012	1,034	1,100	1,184	17.0%
Total Municipal/Domestic Water Demand Including IBT	**166,916**	**171,578**	**186,570**	**206,530**	**23.7%**

Table 6.39 shows the total domestic/municipal water demand as well but this time by river basin. The majority of river basins are expecting growth in water demand over the next period. The south Saskatchewan and NorthernRiver Basins are assumed to have the highest increase in water demand by 2060. Lake Winnipegosis will have a decline in water demand from the current 2,480 dam^3 to 1,558 dam^3, a decrease of approximately 37%.

In 2010 South Saskatchewan was the largest river basin in terms of domestic/municipal water consumption, accounting for 35% of the total water demand and it is expected to further increase by 7% in 2060. Qu'Appelle and North Saskatchewan River Basins represent 27% and 16%, respectively, of the total water demand in Saskatchewan, as shown in Figure 6.15. Qu'Appelle River Basin is assumed to reduce its water demand by 5% in 2060, whereas North Saskatchewan River Basin is expected to maintain its water demand levels.

Table 6.39: Total Municipal/Domestic Water Demand Estimates for Saskatchewan by River Basin under Baseline Scenario, 2010-2060

Community Type	Total Water Demand (dam^3)				Change by 2060 as
	2010	2020	2040	2060	
Assiniboine	6,712	6,852	7,266	7,931	18.2%
Cypress Hills	1,345	1,320	1,298	1,355	0.7%
Lake Winnipegosis	2,480	2,209	1,799	1,558	-37.2%
Missouri	1,338	1,296	1,155	1,130	-15.5%
North Saskatchewan	26,425	27,009	29,620	32,293	22.2%
Northern Four	7,310	7,792	9,954	12,137	66.0%
Old Wives	3,038	2,916	2,633	2,554	-15.9%
Qu'Appelle	45,689	44,852	44,512	45,607	-0.2%
Saskatchewan	5,270	5,456	5,846	6,470	22.8%
Souris	8,622	8,683	8,834	9,215	6.9%
South Saskatchewan	57,676	62,160	72,553	85,097	47.5%
Total Municipal/Domestic Water	**165,904**	**170,544**	**185,470**	**205,346**	**23.8%**
IBT	1,012	1,034	1,100	1,184	17.0%
Total **166,916** **171,578**	**186,570**	**206,530**		**23.7%**	

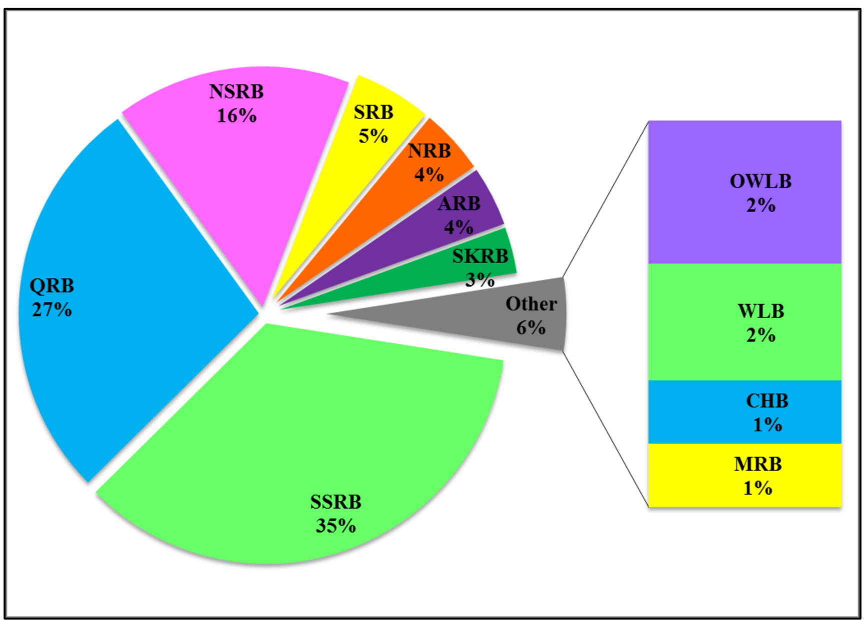

Figure 6.15: Total Municipal/Domestic Water Demand by River Basin, for Saskatchewan, 2010

The distribution of total domestic/municipal water demand within a basin by category of users is largely different from basin to basin, as shown in Figure 6.16. Higher municipal water demand was noted for the South Saskatchewan, Qu'Appelle, and North Saskatchewan River Basins. Some basins, such as the Cypress Hills Basin, Lake Winnipegosis Basin, and Missouri River Basin, did not have any larger cities to have any municipal water demand. Noticeable water demand by First Nations' Reserves was estimated for the Northern Basins and the Saskatchewan River Basin. Although domestic and rural water demands were present in all basins, their share of the total was higher in Missouri, Lake Winnipegosis, and Cypress Hills Basins.

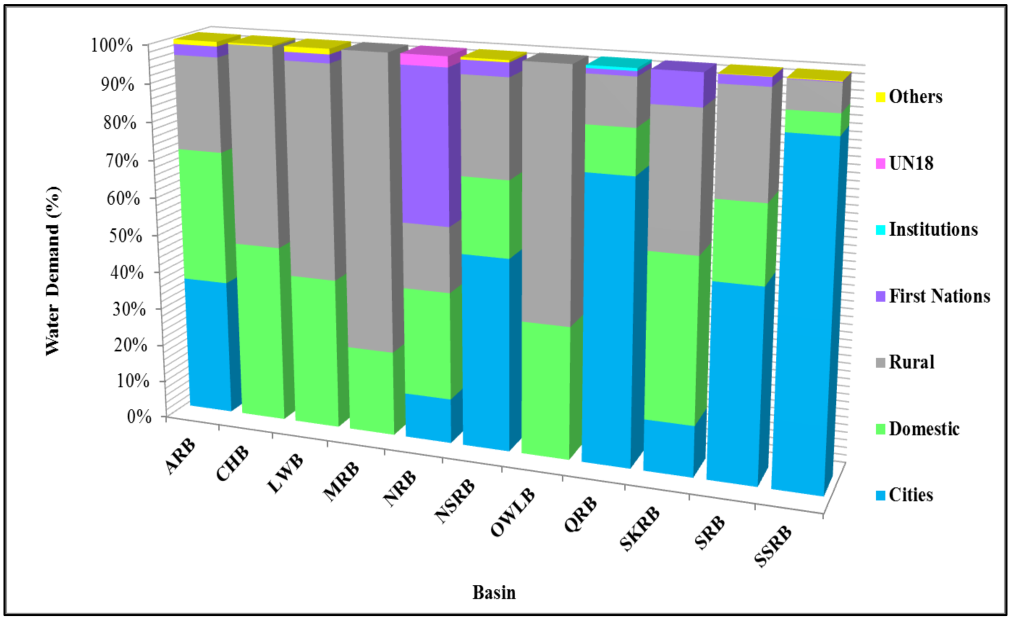

Figure 6.16: Distribution of Total Municipal/Domestic Water Demand by River Basins and Water Demand Type, Saskatchewan, 2010

6.10.2 Total Municipal/Domestic Water Demand under Climate Change Scenario

Municipal/domestic water demand levels are expected to increase under the climate change scenario. Increases are expected in all categories of municipal/domestic water demand. Total water demand in 2060 would increase to 218,266 dam^3 per annum, which is nearly 31% higher than in 2010, as shown in Table 6.40. Table 6.41 shows the total municipal/domestic water estimates under the climate change scenario for each river basin located in Saskatchewan.

6.10.3 Total Municipal/Domestic Water Demand under Water Conservation Scenario

The level of municipal/domestic water demand will be lower under the water conservation scenario. In comparison to the baseline scenario, the water conservation scenario is assumed to account for a reduction of nearly 7.9% by 2060. Total water demand for these purposes in 2060 would be 190,216 dam^3. These results are summarized in Table 6.42.

Table 6.40: Total Municipal/Domestic Water Demand Estimates for Saskatchewan by Community Type under Climate Change Scenario, 2010-2060

Community Type	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Cities	105,971	111,480	128,540	148,006	39.7%
Total Municipal Water	**105,971**	**111,480**	**128,540**	**148,006**	**39.7%**
Towns > 1000	16,586	16,550	17,035	17,305	4.3%
Towns < 1000	6,491	6,487	6,892	7,290	12.3%
Bedroom Communities	1,865	2,410	3,729	5,523	196.1%
Total Domestic Water	**24,942**	**25,447**	**27,656**	**30,118**	**20.8%**
Villages	7,175	6,918	6,707	6,582	-8.3%
Rural non-farm	5,768	5,183	4,418	4,084	-29.2%
Rural farm	15,673	14,003	11,721	11,060	-29.4%
Total Rural Water Demand	**28,616**	**26,104**	**22,846**	**21,726**	**-24.1%**
First Nations	5,461	6,611	10,934	16,232	197.2%
Institutions	327	300	271	230	-29.7%
Unorganized Division 18	202	188	165	146	-27.7%
Other	385	414	485	560	45.6%
Total Municipal/Domestic	**165,904**	**170,544**	**190,897**	**217,018**	**30.8%**
IBT	1,012	1,034	1,130	1,248	23.3%
Total Municipal/Domestic Water Demand Including IBT	**166,916**	**171,578**	**192,027**	**218,266**	**30.7%**
Change % over Baseline	0.0%	0.0%	2.9%	5.7%	

Table 6.41: Total Municipal/Domestic Water Demand Estimates for Saskatchewan by River Basins under Climate Change Scenario, 2010-2060

Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	6,712	6,852	7,442	8,326	24.0%
Cypress Hills	1,345	1,320	1,329	1,422	5.7%
Lake Winnipegosis	2,480	2,209	1,842	1,636	-34.0%
Missouri	1,338	1,296	1,181	1,186	-11.4%
North Saskatchewan	26,425	27,009	31,200	35,236	33.3%
Northern Four	7,310	7,792	10,193	12,744	74.3%
Old Wives	3,038	2,916	2,696	2,683	-11.7%
Qu'Appelle	45,689	44,852	45,652	47,950	4.9%
Saskatchewan	5,270	5,456	5,986	6,791	28.9%
Souris	8,622	8,683	9,047	9,674	12.2%
South Saskatchewan	57,676	62,160	74,330	89,370	55.0%
Total	**165,904**	**170,544**	**190,897**	**217,018**	**30.8%**
IBT	1,012	1,034	1,130	1,248	23.3%
Total	**166,916**	**171,578**	**192,027**	**218,266**	**30.7%**

Table 6.42: Total Municipal/Domestic Water Demand Estimates for Saskatchewan by Community Type under Water Conservation Scenario, 2010-2060

Community Type	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Cities	105,971	109,376	117,574	125,798	18.7%
Total Municipal Water Demand	**105,971**	**109,376**	**117,574**	**125,798**	**18.7%**
Towns > 1000	16,586	16,349	16,151	15,639	-5.7%
Towns < 1000	6,491	6,447	6,567	6,658	2.6%
Bedroom Communities	1,865	2,396	3,598	5,107	173.8%
Total Domestic Water Demand	**24,942**	**25,192**	**26,316**	**27,404**	**9.9%**
Villages	7,175	6,850	6,471	6,088	-15.1%
Rural non-farm	5,768	5,144	4,262	3,779	-34.5%
Rural farm	15,673	13,895	11,310	10,229	-34.7%
Total Rural Water Demand	**28,616**	**25,889**	**22,043**	**20,096**	**-29.8%**
First Nations	5,461	6,571	10,551	15,010	174.9%
Institutions	327	300	249	194	-40.7%
Unorganized Division 18	202	186	160	135	-33.2%
Other	385	413	467	516	34.0%
Total Municipal/Domestic Water Demand Excluding IBT	**165,904**	**167,927**	**177,360**	**189,153**	**14.0%**
IBT	1,012	1,016	1,035	1,063	5.0%
Total Municipal/Domestic Water Demand Including IBT	**166,916**	**168,943**	**178,395**	**190,216**	**13.9%**
% Change over Baseline Scenario	0.0%	-1.5%	-4.4%	-7.9%	

Table 6.43 shows the effect of employing water conservation practices by river basin. All river basins are assumed to record savings in water demand, determining a slower overall growth rate. It is expected that under the water conservation scenario water demand will increase only by approximately 14% by 2060.

Table 6.43: Total Municipal/Domestic Water Demand Estimates for Saskatchewan by River Basins under Water Conservation Scenario, 2010-2060

River Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Assiniboine	6,712	6,764	6,987	7,357	9.6%
Cypress Hills	1,345	1,313	1,282	1,316	-2.1%
Lake Winnipegosis	2,480	2,197	1,776	1,512	-39.0%
Missouri	1,338	1,288	1,140	1,096	-18.1%
North Saskatchewan	26,425	26,579	28,217	29,535	11.8%
Northern Four	7,310	7,560	9,759	11,648	59.3%
Old Wives	3,038	2,898	2,601	2,482	-18.3%
Qu'Appelle	45,689	44,631	43,900	44,404	-2.8%
Saskatchewan	5,270	5,411	5,735	6,224	18.1%
Souris	8,622	8,544	8,412	8,424	-2.3%
South Saskatchewan	57,676	60,742	67,551	75,154	30.3%
Total Municipal/Domestic Water Demand Excluding IBT	**165,904**	**167,927**	**177,360**	**189,153**	**14.0%**
IBT	1,012	1,016	1,035	1,063	5.0%
Total Municipal/Domestic Water Demand Including IBT	**166,916**	**168,943**	**178,395**	**190,216**	**13.9%**

6.11.4 Total Municipal/Domestic Water Demand – Summary

Trends in the municipal/domestic water demand in Saskatchewan are shown in Figure 6.17. All scenarios provide the same pattern. In all cases, climate change (after 2020) will bring forth increases in water demand for municipal/domestic purposes, an increase of 5.7% over the baseline scenario. Adoption of water conservation practices would reduce this water demand level by 7.9%.

Figure 6.18 shows the total municipal/domestic water demand by each river basin. It is expected that developments in the South Saskatchewan River Basin will determine the trend in municipal/domestic water demand in Saskatchewan, as its share of the total water demand is expected to grow over the next period.

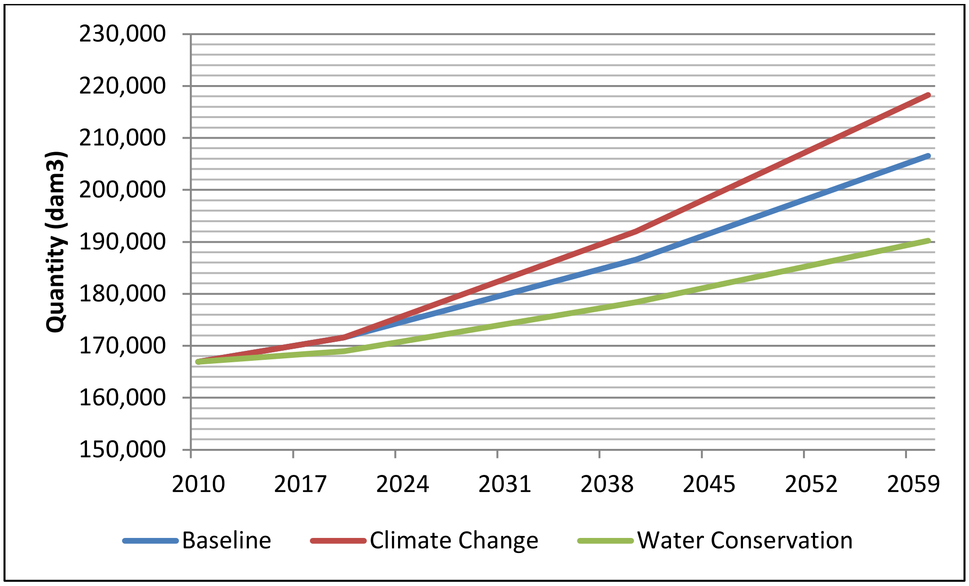

Figure 6.17: Total Municipal/Domestic Water Demand for Saskatchewan Under Study Scenarios, 2010 – 2060

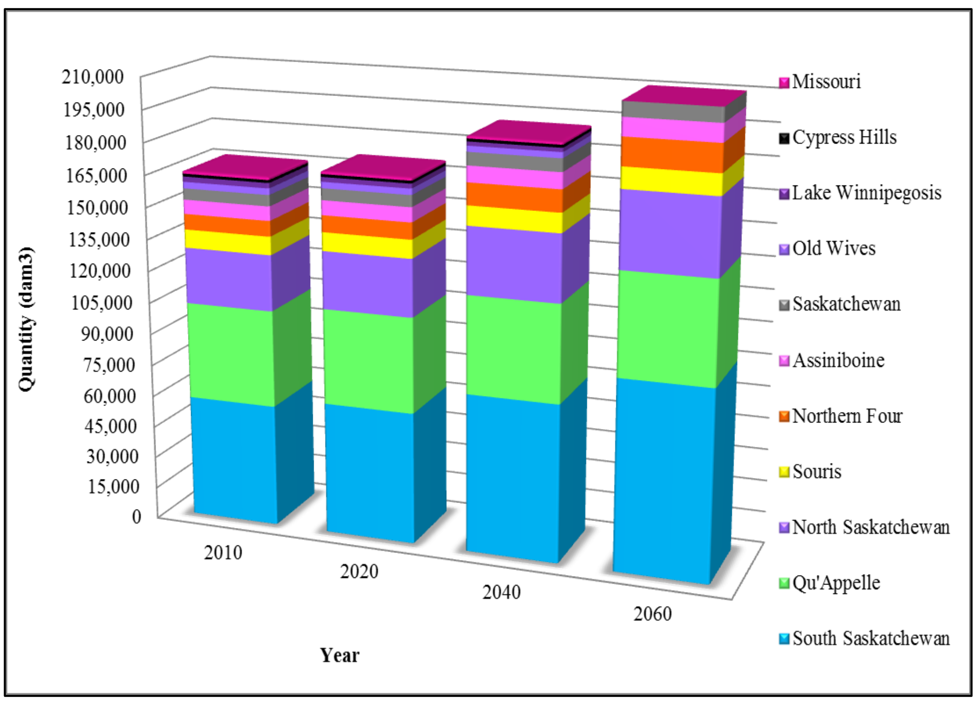

Figure 6.18: Municipal/Domestic Water Demand in Saskatchewan by River Basin, Baseline Scenario 2010 – 2060

Chapter 7

Recreational Water Demand

7.1 Overview of Saskatchewan Recreational Sites

Water-based recreation activities are typically of two types: Consumptive, which includes water demand by cottager owners, residents of resort or recreational communities, and other residents near or at the surface water bodies; and non-consumptive in nature. The non-consumptive recreation can be further divided into two types: water-contact recreation (such as swimming, fishing, etc.), and non-water-contact recreation (such as boating, aesthetic pleasure seeking activities, walking near the water bodies, among others). The non-consumptive recreational water demand cannot be estimated since the only loss is through evaporation, but it is supplemented by natural flows. The consumptive water demand needs to be estimated as a part of the total water demand in Saskatchewan. This is reported in this chapter.

7.2 Consumptive Recreational Water Demand

Consumptive water demand for recreational activities is needed for two types of water demands: residents living in recreational communities and water needed to maintain recreational facilities. The latter type includes various federal and provincial parks and other recreational sites in the basin. Since there are no federal parks in the basin, only provincial and other recreational sites need to be included. Here, water is used for administrative purposes as well as for maintaining the park sites.

7.3 Recreational Communities' Water Demand

Under the consumptive recreational water demand, several communities in various river basins were analyzed. For other river basins, detailed data on various communities were not available. This investigation is therefore limited to three river basins: Qu'Appelle, South Saskatchewan, and North Saskatchewan River Basins. For recreational communities, water demand was estimated by using the population of these communities and the water demand per capita coefficients.

7.3.1 Recreational Communities' Water Demand under Baseline Scenario

Water demand by residents of recreational villages is shown in Table 6.1. The data for this category of water demand are very poor. Past population changes in these recreational villages have been uneven, as the population will increase/decrease and stay at that level for a number of years. In the future, population growth will be restricted by real estate development in these villages as the area for development is limited. Since the recreational villages are attractive to retirees, the increase in the retired population to 2035-40 will have an effect on the demand for these resort properties. Qu'Appelle, South Saskatchewan and North Saskatchewan are the only river basins housing recreational villages in the province. Water demand for recreational communities will likely increase from currently 262 dam^3 to 361 dam^3 in 2060 (Table 7.1, Top Panel).

Table 7.1: Recreational Villages' Water Demand in All Saskatchewan River Basins, Study Scenarios, 2010 – 2060

River Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Baseline Scenario					
Qu'Appelle	183	199	214	185	0.9%
South Saskatchewan	32	33	34	34	6.3%
North Saskatchewan	47	71	94	142	205.4%
Total Water	**262**	**303**	**342**	**361**	**37.9%**
Climate Change Scenario					
Qu'Appelle	183	199	219	194	6.0%
South Saskatchewan	32	33	35	36	12.5%
North Saskatchewan	47	71	97	150	220.8%
Total Water	**262**	**303**	**350**	**380**	**45.0%**
Change over baseline	0.0%	0.0%	2.4%	5.1%	
Water Conservation Scenario					
Qu'Appelle	183	195	209	181	-1.1%
South Saskatchewan	32	32	31	30	-6.3%
North Saskatchewan	47	70	93	138	196.6%
Total Water	**262**	**297**	**334**	**350**	**33.4%**
Change over baseline	0.0%	-1.9%	-2.5%	-3.3%	

7.3.2 Recreational Communities' Water Demand under Climate Change Scenario

Water demand under climate change scenario was adjusted upwards using a 2.4% and 5% increase over the estimated baseline for 2040 and 2060, respectively. Using these coefficients and projected population figures, water demand was estimated. These estimates are shown in Table 7.1 (Middle Panel). By 2060, it is expected that this water demand will be 380 dam^3, some 5% higher than that under the baseline scenario.

7.3.3 Recreational Communities Water Demand under Water Conservation Scenario

Water conservation measures can be adopted by residents of recreational villages. However, reliable knowledge of the nature of water demand by these residents is not available, thus making adjustments through water conservation practices is difficult. For this reason, these residents were treated just like any other urban resident. Water demand for these communities will be lower after such measures are adopted, relative to the baseline scenario. Estimated water demand under this scenario is expected to be 350 dam^3, some 3.3% lower than that under the baseline scenario (Table 7.1, Bottom Panel).

7.4 Recreational Sites' Water Demand

Provincial and regional parks require water for maintenance and for supporting visitor services. In the future, recreational demand is expected to increase. Increased population in the province, accompanied with increased urbanization, would result in higher levels of water demand for these purposes. These water demand estimates are presented in this section.

7.4.1 Recreational Sites' Water Demand under Baseline Scenario

This water demand has two components: one, variable level of demand related to visitor services, which is determined by the number of visitors to the site; and, two, fixed level of water required to maintain office services, lawns and other facilities. Unfortunately, details on these two types of water demands were not available and therefore, analysis was undertaken by using total water demand by the recreational sites.

Estimation of the total water demand for this category was based on past experience. Water demand by these sites was analyzed for each river basin. Where no significant trend was noted, the past five years average water demand level was assumed to be applicable to current and future water demand for this category of water demand. Estimated water demand by river basins is shown in Table 7.2.

Table 7.2: Recreational Sites' Water Demand, in All Saskatchewan River Basins, Baseline Scenario, 2010 – 2060

River Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Qu'Appelle	113	115	118	123	9.7%
South Saskatchewan	35	35	36	39	11.6%
North Saskatchewan	43	43	43	43	0.0%
Souris	42	37	29	21	-50.7%
Missouri	58	65	79	93	60.2%
Saskatchewan	2	3	3	3	53.9%
Assiniboine	43	54	72	90	107.3%
Lake Winnipegosis	21	21	26	32	50.8%
Northern Four	17	15	15	15	-10.5%
Total Water	**373**	**389**	**420**	**458**	**22.8%**

The current demand for these sites is estimated at 373 dam^3. By 2060, this water demand may rise to 458 dam^3. This is a 22.8% increase over the 2010 level. The future projection of visitors is a complex exercise since many factors could affect these levels. One of the major factors among these is the size of the water body at the sites, and other quality-related aspects. The quality of a site deteriorates as congestion to a site increases, unless infrastructure and other facilities are improved accordingly. The size of the water body is related to changes in the hydrological regime of the region. Such projections were considered to be beyond the scope of this study.

7.4.2 Recreational Sites' Water Demand under Climate Change Scenario

Urban and rural recreation, scenery, wildlife habitat, and fisheries are all strongly affected by the quantity and quality of water, and all of these are affected by climate change (Cooper, 1990). Hydrological droughts result in low stream flows and low lake levels. These conditions would likely reduce some of the recreational activities, such as boating and sport fishing, among others. Drought conditions may also place some restrictions on recreational activities (open fires for campers), and loss of proximity of water from the beach area, among others. These activities may also be reduced.

Recreational site maintenance may increase due to higher temperatures and lower precipitation. Assuming the same change as assumed for the domestic water demand (2.4% and 5% increase in water demand by 2040 and 2060, respectively), estimated water demand is shown in Table 7.3. Total amount of water for this demand would likely increase from 373 dam^3 in 2010 to 479 dam^3 by 2060 – an increase of 28% over the 2010 level.

Table 7.3: Recreational Sites' Water Demand in All Saskatchewan River Basins, Climate Change Scenario, 2010 – 2060

River Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Qu'Appelle	113	115	120	130	15.2%
South Saskatchewan	35	35	37	39	11.6%
North Saskatchewan	43	43	44	45	4.9%
Souris	42	37	30	22	-48.2%
Missouri	58	65	81	98	68.3%
Saskatchewan	2	3	3	3	61.7%
Assiniboine	43	54	74	94	117.6%
Lake Winnipegosis	21	21	27	33	58.3%
Northern Four	17	15	16	16	-6.0%
Total Water	**373**	**389**	**431**	**479**	**28.4%**

7.4.3 Recreational Sites' Water Demand under Water Conservation Scenario

Water conservation in recreational related water demands is hard to estimate, since some of the recreational activities depend on water availability. For recreational site maintenance, some water conservation practices can be applicable. Assuming that these measures would result in a similar reduction as for the municipal water systems current and future water demand was estimated. These estimates are shown in Table 7.4. This water demand for the adoption of water conservation measures could be as low as 431 dam^3 by 2060.

Table 7.4: Recreational Sites Water Demand in All Saskatchewan River Basins, Water Conservation Scenario, 2010 – 2060

River Basin	Total Water Demand (dam^3)				Change by 2060 as % of 2010
	2010	2020	2040	2060	
Qu'Appelle	113	112	111	113	0.8%
South Saskatchewan	35	34	33	32	-7.0%
North Saskatchewan	43	42	41	40	-8.1%
Souris	42	37	29	20	-52.1%
Missouri	58	65	78	90	55.6%
Saskatchewan	2	3	3	3	49.7%
Assiniboine	43	54	71	87	101.3%
Lake Winnipegosis	21	21	26	31	46.4%
Northern Four	17	15	15	15	-13.1%
Total Water	**373**	**383**	**407**	**431**	**15.5%**

7.5 Summary of Recreational Water Demand

Total recreational water demand was estimated as a sum of recreational communities' demand and that water used for maintenance of recreation sites. Results are presented in Table 7.5. Increases in these levels are in the neighborhood of 29% in 2060 as compared to the 2010 level. Climate change may bring about a higher increase in these water demand levels – 5% over the baseline scenario, although water conservation does offer some reduction in this water demand.

Table 7.5: Summary of Recreational Water Demand under Study Scenarios, 2010 - 2060

Scenario	Water Demand in dam^3				% of Baseline Scenario
	2010	2020	2040	2060	
Baseline	635	692	762	819	100.0%
Climate Change	635	692	781	859	104.8%
Water Conservation	635	681	740	780	90.9%

Chapter 8

Indirect Anthropogenic Water Demand

Indirect anthropogenic water demands include four types of water demand: That lost through evaporation from the water bodies; water demanded for maintaining environmental projects; maintaining instream minimum water flows for flora and fauna; and for apportionment. Each of these demands was examined for various Saskatchewan river basins. Results are summarized in this chapter.

8.1 Water Losses through Evaporation

Evaporation losses from surface water bodies vary spatially. As shown in Figure 2.14, northern basins would face lower evaporation levels than those of southern ones. For example, the Northern Basins have an estimated 81% of the surface area of lakes and reservoirs in Saskatchewan, but they account for only 41% of the evaporation (Table 8.1). The higher temperatures, combined with longer ice-free periods, results in higher evaporation in the south of the province relative to the Northern Basins. An estimated 3 million dam^3 of water is evaporated in the province for the baseline scenario. Five lakes account for 48% of the evaporation in Saskatchewan; Lake Athabasca, Reindeer Lake, Lake Diefenbaker, Old Wives and Quill Lake s.

Table 8.1: Baseline Water Evaporation from Lakes and Reservoirs

River Basin	Total Area in Km^2	% of Provincial Area	Evaporation Level in 2010 in dam^3	% of Total Evaporation Losses
Assiniboine	110	0.4%	32,399	1.1%
Cypress Hills	54	0.2%	37,445	1.2%
Missouri	109	0.4%	74,509	2.4%
North Saskatchewan	1,146	3.7%	285,568	9.3%
Northern	24,928	81.2%	1,246,390	40.7%
Old Wives	532	1.7%	325,634	10.6%
Qu'Appelle	1,039	3.4%	458,988	15.0%
Saskatchewan	2,055	6.7%	200,920	6.6%
Souris	80	0.3%	36,168	1.2%
South Saskatchewan	592	1.9%	358,966	11.7%
Winnipegosis	38	0.1%	7,516	0.2%
Total	**30,683**	**100.0%**	**3,064,501**	**100.0%**

Climate change will affect the evaporation loses as higher water temperatures and longer ice-free periods will increase the rate of evaporation. Precipitation amounts and timing, as influenced by climate change, will also affect the net evaporation. The estimated evaporation to 2060 is presented in Table 8.2.

Table 8.2: Climate Change Water Evaporation from Lakes and Reservoirs (dam^3)

River Basin	Amount of Evaporation Losses in dam^3		
	2020	2040	2060
Assiniboine	32,399	34,018	35,638
Cypress Hills	37,445	39,317	41,190
Missouri	74,509	78,234	81,960
North Saskatchewan	285,568	299,846	314,125
Northern	1,246,390	1,308,710	1,371,029
Old Wives	325,634	341,915	358,197
Qu'Appelle	458,988	481,937	504,887
Saskatchewan	200,920	210,966	221,012
Souris	36,168	37,976	39,784
South Saskatchewan	358,966	376,914	394,862
Lake Winnipegosis	7,516	7,892	8,268
Total	**3,064,501**	**3,217,726**	**3,370,951**

8.2 Apportionment Water Demand

Saskatchewan has two types of watersheds (constituting river basins): Open and closed. The closed basins are totally confined within the province, and thus there is no need for apportionment for their water. Water in rivers in Saskatchewan in open watershed/basins can eventually flow into four jurisdictions; Manitoba, United States of America, Alberta or the Northwest Territories. The major rivers that belong to this category of basins are the Saskatchewan, Qu'Appelle, Assiniboine, Souris, and Northern Basins. The data from the Prairie Provinces Water Board indicates that, on average, the natural flow of the rivers has been sufficient to meet the required flow into neighboring jurisdictions. These results are summarized in Table 8.3.

Table 8.3: Apportionment of Flows from Basin to Jurisdiction

River Basin	Destination of Flows	Apportionment
Souris Basin	Manitoba and United States	Natural Flow
Missouri Basin	United States of America	Natural Flow
Cypress Hills Basin	Closed Basin	
Old Wives Lake Basin	Closed Basin	
Saskatchewan River Basin	Manitoba	Natural Flow
Assiniboine River Basin	Manitoba	Natural Flow
Winnipegosis Basin	Manitoba	Natural Flow
Northern Basins	Manitoba; North West Territories	Natural Flow
North Saskatchewan Basin	Flows into Saskatchewan River (Closed Basin)	
South Saskatchewan Basin	Flows into Saskatchewan River (Closed Basin)	
Qu'Appelle Basin	Manitoba	Natural Flow

8.3 Environmental Water Demand

Minimal to no data was found to estimate the demand for water for environmental demands. Ducks Unlimited has many projects for wetlands and marshes throughout Saskatchewan. However, no data as to the amount of water needed to sustain the wetlands is available.

Table 8.4: Environmental Water Demand by Basin

BASIN	Environment Water Demand
Souris Basin	3,905 acres*
Missouri Basin	no data
Cypress Hills Basin	no data
Old Wives Lake Basin	no data
Saskatchewan River Basin	no data
Assiniboine River Basin	no data
Winnipegosis Basin	no data
Northern Basins	no data
North Saskatchewan Basin	41,937 dam^3
South Saskatchewan Basin	minimum rate of $42.5m^3$ second
Qu'Appelle Basin	DU 5,674 acres

* Duck Unlimited projects

8.4 Instream Water Demand

The water demand for instream requirements of rivers within the basins was generally not available. The only evidence that was found was for the South Saskatchewan River Basin, as shown in Table 8.5.

Table 8.5: Instream Water Requirements by Basin

BASIN	Environment Water Demand
Souris Basin	no requirements found
Missouri Basin	no requirements found
Cypress Hills Basin	no requirements found
Old Wives Lake Basin	no requirements found
Saskatchewan River Basin	no requirements found
Assiniboine River Basin	no requirements found
Winnipegosis Basin	no requirements found
Northern Basins	no requirements found
North Saskatchewan Basin	no requirements found
South Saskatchewan Basin	minimum rate of $42.5m^3$ second
Qu'Appelle Basin	no requirements found

8.5 Summary of Indirect Anthropogenic Water Demands

Evaporation from lakes and reservoirs in Saskatchewan is the only indirect anthropogenic water demand that could be consistently estimated for the province of Saskatchewan. Lack of data on instream demand and for environmental purposes severely restricted any attempts at estimating these demands. The natural flow of rivers into adjacent jurisdictions to Saskatchewan has, on average, met the requirements for apportionment.

Chapter 9

Summary of Saskatchewan Water Demand

Water demand in Saskatchewan River Basins is estimated for 2010 at 4,172 thousand dam^3, of which direct anthropogenic demands accounted for 930 thousand dam^3 of the total or 22.3%. The projected water demand is estimated for three years (2020, 2040, and 2060) and for three scenarios.

9.1 Summary of Total Water Demand for the Baseline Scenario

The baseline scenario used the estimated activity levels for various direct anthropogenic and indirect anthropogenic activities combined with water demand coefficients to estimate water demand levels for Saskatchewan River Basins. Increasing amounts of irrigated area and expansion of the mining/industrial sector are the main forces behind the change in water demand. Direct anthropogenic activities are projected to account for 34.3% of the total water demand by 2060 (Table 9.1). In addition, another 5.3 million dam^3 of water is needed to generate hydroelectric power in the South Saskatchewan, Saskatchewan, and Northern (Four) River Basins. This water demand would increase to 6.2 million dam^3 by 2060. Although it is a non-consumptive water demand, it does compete with other water users as well as complements others. Complementarity may exist between this water release and apportionment needs for the basins. However, competition does exist at a given site (site of water release) with various anthropogenic water demands.

9.2 Summary of Total Water Demand for the Climate Change Scenario

Effects of climate change on the direct anthropogenic and indirect anthropogenic water demand activities in Saskatchewan River Basin are presented in Table 9.2. Higher growing season temperatures will have a significant impact on the agricultural sector, as both crops and livestock will demand more water. Evaporation of water from water bodies which is already a major indirect anthropogenic water demand is one of the major increased demands that can be expected with climate change. The climate change would not affect the water needed to generate hydroelectric power in various basins. However, on account of needed storage to release this quantity of water, there would be higher evaporative losses.

9.3 Summary of Total Water Demand for the Water Conservation Scenario

The effect of water conservation measures on the water demand activities in Saskatchewan River basins are presented in Table 9.3. Agricultural and industrial adoption of water conservation techniques and technologies has the greatest impact on the direct anthropogenic demand for water.

Table 9.1: Water Demand in Saskatchewan River Basins for the Baseline Scenario, 2010-2060

Sector	Sub-Activity	Total Amount of Water Demand in dam^3			
		2010	2020	2040	2060
DIRECT ANTHROPOGENIC ACTIVITIES					
Agriculture					
	Irrigation	609,972	661,579	1,026,394	1,281,258
	Livestock	43,591	46,604	48,477	50,106
	Pesticide	1,492	1,470	1,452	1,452
	Other (Greenhouse and	1,006	1,012	1,040	1,070
	Sub-total	**656,062**	**710,664**	**1,077,363**	**1,333,885**
Industry/Mining					
	Potash	25,804	116,900	127,957	147,352
	Oil & Gas	9,588	12,873	7,724	1,931
	Manufacturing	18,464	19,047	19,970	20,936
	Other Mining	10,415	9,625	9,840	9,628
	Irrigation Induced	-	-	-52,667	-52,627
	Power Generation	42,376	44,362	38,917	25,518
	Sub-total	**106,647**	**202,807**	**151,741**	**152,738**
Municipal/domestic					
	Municipal	166,589	171,278	186,318	206,326
	Public Institutions	327	300	252	204
	Sub-total	**166,916**	**171,578**	**186,570**	**206,530**
Recreation					
	Recreation	262	303	342	361
	Parks/Recreation	373	389	420	458
	Sub-Total	**635**	**692**	**762**	**819**
Sub-total Direct Anthropogenic Activities		**930,260**	**1,085,741**	**1,416,436**	**1,693,972**
INDIRECT ANTHROPOGENIC ACTIVITIES					
Other Water Demands					
	Evaporation	3,189,867	3,189,867	3,189,867	3,189,867
	Apportionment	-	-	-	-
	Instream Flow	9,892	9,892	9,892	9,892
	Environment	41,937	41,937	41,937	41,937
Sub-Total Indirect Anthropogenic Water Demand		**3,241,696**	**3,241,696**	**3,241,696**	**3,241,696**
Total Water Demand		**4,171,956**	**4,327,437**	**4,658,132**	**4,935,668**
Hydroelectric Power Generation Water Release		5,337,220	5,337,220	6,627,081	6,627,081

Table 9.2: Water Demand in Saskatchewan River Basins for the Climate Change Scenario, 2010- 2060

Sector	Sub-Activity	Total Amount of Water Demand in dam^3			
		2010	2020	2040	2060
DIRECT ANTHROPOGENIC ACTIVITIES					
Agriculture					
	Irrigation	609,972	661,579	1,187,891	1,601,989
	Livestock	43,591	46,604	50,312	53,856
	Pesticide	1,492	1,470	1,521	1,579
	Other (Greenhouse and	1,006	1,012	1,040	1,070
	Sub-total	**656,062**	**710,664**	**1,240,763**	**1,658,493**
Industry/Mining					
	Potash	25,804	116,900	127,957	147,351
	Oil & Gas	9,588	12,873	7,724	1,931
	Manufacturing	18,464	19,047	20,072	21,591
	Other Mining	10,415	9,625	9,912	9,775
	Irrigation Induced	-	-	-52,636	-52,563
	Power Generation	42,376	44,362	34,544	20,511
	Sub-total	**106,647**	**202,807**	**147,573**	**148,596**
Municipal/domestic					
	Municipal	166,589	171,278	192,886	219,284
	Public Institutions	327	300	271	230
	Sub-total	**166,916**	**171,578**	**193,157**	**219,514**
Recreation					
	Recreation	262	303	350	380
	Parks/Recreation	373	389	431	479
	Sub-Total	**635**	**692**	**781**	**859**
Sub-total Direct Anthropogenic		**930,260**	**1,085,741**	**1,582,274**	**2,027,462**
INDIRECT ANTHROPOGENIC ACTIVITIES					
Other Water Demands					
	Evaporation	3,189,867	3,189,867	3,349,326	3,508,819
	Apportionment	-	-	-	-
	Instream Flow	9,892	9,892	9,892	9,892
	Environment	41,937	41,937	41,937	41,937
Sub-Total Indirect Anthropogenic Water Demand		**3,241,696**	**3,241,696**	**3,401,155**	**3,560,648**
Total Water Demand		**4,171,956**	**4,327,437**	**4,983,429**	**5,588,110**
Hydroelectric Power Generation Water Release		5,337,220	5,337,220	6,627,081	6,627,081

Table 9.3: Water Demand in Saskatchewan River Basins for the Water Conservation Scenario, 2010- 2060

Sector	Sub-Activity	Total Amount of Water Demand in dam^3			
		2010	2020	2040	2060
DIRECT ANTHROPOGENIC ACTIVITIES					
Agriculture					
	Irrigation	609,972	609,734	890,203	1,093,220
	Livestock	43,591	46,604	46,754	48,076
	Pesticide	1,492	1,470	1,307	726
	Other (greenhouse	1,006	1,012	1,040	1,070
	Sub-total	**656,062**	**658,820**	**939,304**	**1,143,091**
Industry/Mining					
	Potash	25,804	112,522	112,704	119,119
	Oil & Gas	9,588	10,942	6,565	1,641
	Manufacturing	18,464	18,653	19,539	20,451
	Other Mining	10,415	9,410	9,618	9,435
	Irrigation Induced	-	-	-50,674	-48,711
	Power Generation	42,376	42,132	34,544	20,511
	Sub-total	**106,647**	**193,659**	**132,296**	**122,446**
Municipal/domestic					
	Municipal	166,589	168,643	178,146	190,022
	Public Institutions	327	300	249	194
	Sub-total	**166,916**	**168,943**	**178,395**	**190,216**
Recreation					
	Recreation	262	297	334	350
	Parks/Recreation	373	383	407	431
	Sub-Total	**635**	**680**	**741**	**781**
Sub-total Direct Anthropogenic		**930,260**	**1,022,102**	**1,250,736**	**1,456,534**
INDIRECT ANTHROPOGENIC ACTIVITIES					
Other Water Demands					
	Evaporation	3,189,867	3,189,867	3,189,867	3,189,867
	Apportionment	-	-	-	-
	Instream Flow	9,892	9,892	9,892	9,892
	Environment	41,937	41,937	41,937	41,937
Sub-Total Indirect Anthropogenic		**3,241,696**	**3,241,696**	**3,241,696**	**3,241,696**
Total Water Demand Including IBT		**4,171,956**	**4,263,798**	**4,492,432**	**4,698,230**
Hydroelectric Power Generation Water Release		5,337,220	5,337,220	6,627,081	6,627,081

The Policy Research Initiative (2005) reported that Canada has made little demand of economic instruments for water management. These instruments are often promoted as the least-cost approaches to efficient water management. They also have the merit in terms of water supply cost recovery, internalizing environmental costs, and signaling to users to reduce their water demand. Such sentiments have also been voiced by the recent National Roundtable on Environment and the Economy (NRTEE, 2011); the potential of two emerging policy instruments — water pricing and voluntary initiatives — to improve water conservation and efficiency may offer effective conservation tools.

9.4 Conclusions

Water management is a complex issue that will face various Saskatchewan river basins in the future. Many changes are already happening and will happen in the future are going to change the way in which water is managed. A summary of these changes is shown in Figure 9.1.

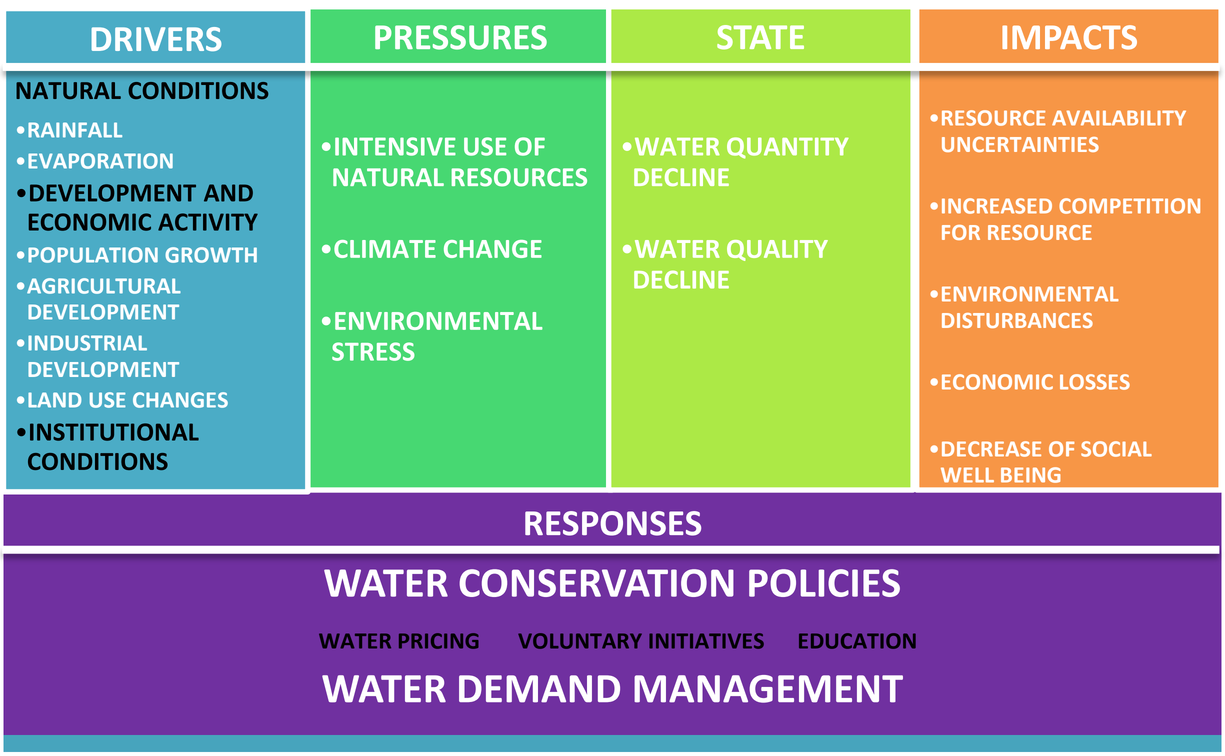

Figure 9.1: Overview of Issues Related to Water management in the Qu'Appelle River Basin

The methodology followed here is that developed in Europe for environmental assessment. The DPSIR framework, or the Drivers, Pressures, State, Impacts, and Responses framework, illustrates the interconnectedness of various factors and changes that need to be considered in formulating policy responses. This study has shown the state of water demand in the basin at present and in the future. Also, the effect of some of the pressures (such as climate change) and policy responses (water conservation) were incorporated.

Based on the estimated water demand, a number of conclusions can be drawn. The most significant conclusion is that water demand in various river basins is going to rise in the future. This would be a result of three major trends: one, expansion of more irrigation in some basins, notably Qu'Appelle and South Saskatchewan River Basins, such as development of the Westside Irrigation District, Qu'Appelle South Irrigation District, among others; two, expansion of the urban population around the cities of Regina and Saskatoon, plus several of their bedroom communities; and, three, in addition, in the Qu'Appelle River Basin, in particular, future potash mining activities are also expected to increase. This would increase pressure on the within basin water availability, but also on the amount of water that would need to be transferred from the South Saskatchewan Rover Basin. These three water demands combined would constitute over 90% of the total anthropogenic water demand in the basin by 2060. Whether this would result in water scarcity or tough competition among its various water demand sectors remains to be determined. Although municipal water demand is a very important demand of water in the basin, its share is expected to increase in the future. All these increases are predicated on the best knowledge that we have at this time. New potash mines are proposed, and therefore included in these estimates. Whether these will actual be in production of potash remains to be seen.

Furthermore, the importance of surface water in the future is expected to be higher. In the future, economic activities, such as irrigation and potash mining will draw more surface water. Although groundwater demand will still be important, it will be a smaller portion of the total water demand (claiming 2% of total water demand by 2060). As competition for the available water increases, there may be a need for demand management. Measures encouraging water conservation may become more important in the future.

Water conservation offers the region a way to reduce future water scarcity/stress in the future. However, one should realize that there must be some incentives for water use sectors to adopt such measures. Water pricing and educating users about the merits of adopting such measures are often noted as the most important factors affecting adoption of water conservation practices. The National Roundtable on the Environment and Economy (NRTEE, 2012) has also advanced such prescriptions. The Table has suggested the potential of two emerging policy instruments for water conservation — water pricing and voluntary initiatives. Improved water-demand management starts with strong principles that value water so it can be conserved and used efficiently. Sustainable water demand will come from better knowledge and application of four key knowledge areas: water forecasts, water quantity data and information, policy instruments, and collaborative water governance (NRTEE 2012).

Additionally, climate change is very likely to increase water demand in the future, although, our knowledge base for determining its impact on water demand is rather weak. More data need to be collected during the period of droughts and extreme rain events in order to finalize such estimates. Parry et al. (2007) have concluded that semi-arid and arid areas are particularly exposed to the impacts of climate change in freshwater. Furthermore, these demands may not be feasible to meet without further infrastructure development.

Water conservation may also be very important during the period when climate change impacts on the basin are felt. Although such measures may not be able to offset the increases triggered by climate change, particularly during periods of droughts, they do offer an avenue for future water management.

9.5 Areas for Further Research

In this study, several assumptions were made for the sake of completing the water demand estimates for current and future time periods. Like all assumptions, these can be improved when better data/information are available. A summary of these issues is shown in Figure 9.2.

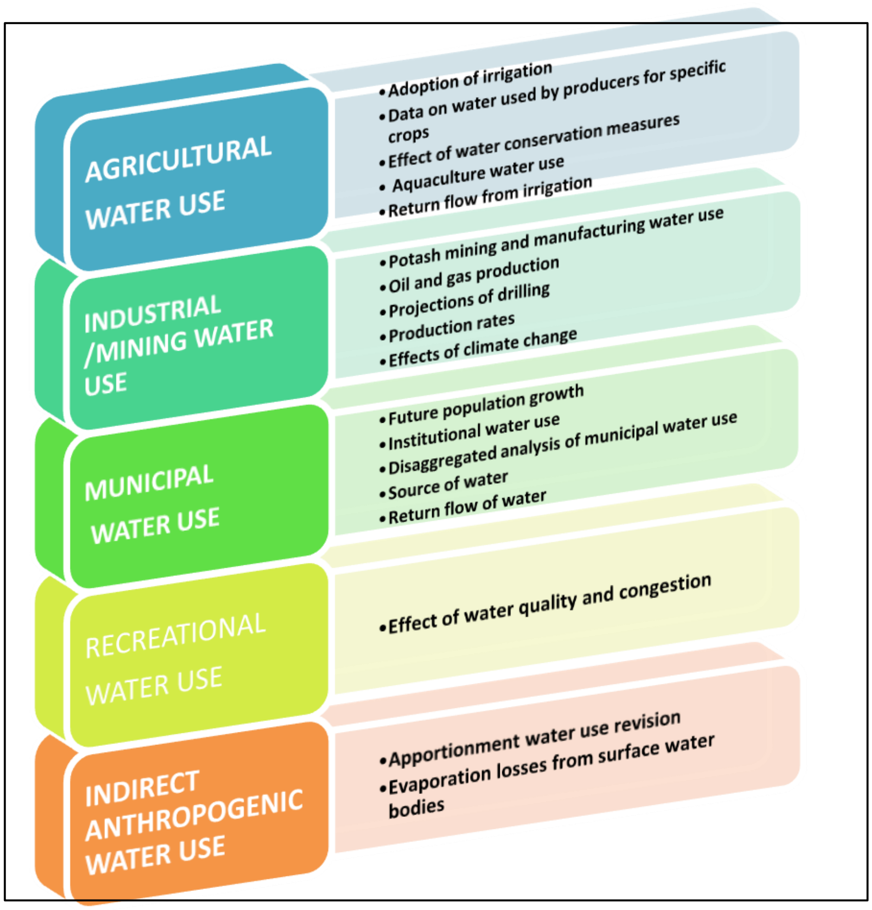

Figure 9.2: Summary of Further Research by Sector

Major limitations of the study are noted below. In addition, there are data related issues/gaps that have been reported in reports for individual river basins.

- One of the major weaknesses of the forecasting methodology used in this study is that water demand is also affected by its availability. Since water supply data were not available, this aspect could not be included and perhaps needs to be considered in any future analyses.

- This study did not develop water demand coefficients using primary data. These values were either borrowed from other studies, or calculated by using the best available data, notably Saskatchewan Watershed Authority (now called Water Security Agency) data bases.

- Estimation of a demand function is important if decision making is to involve adjustments in water pricing or water conservation. These demand functions would require primary data collection involving information on quantity, cost to the user, and other factors that affect water demand. One of the most pieces of information for water management is to collect data on water users. In this study, irrigation water use was estimated using crop and livestock water requirements. Data on private irrigators were not available and were estimated. Water licensing for agricultural uses is an important step in removing such data deficiencies.

- Municipal/domestic water demand was estimated by employing a trend projection method. In many cases, it yielded unreasonable results. Better forecasting models need to be developed for these water demands.

- For cities and towns, water demand was estimated at the community level. Within these communities, there are several types of demands in addition to the residential demand for water: manufacturing, commercial, firefighting, street cleaning, and other public demands. Further research is needed to estimate these water demands in order to obtain a clear picture of these water demands for the province.

- Information about the impact of climate change on various sectors needs to be investigated fully. There is a shortage of studies in this area, particularly for the basin.

- Information on adoption of water conservation measures in the basin (as well as in Saskatchewan) is not a well-studied subject. This aspect needs to be investigated as better data on the effect of provincial regulation/incentives become available.

Assesment of water demamd requries primary data collection from various types of water demand sector, not only in terms of their level of water demand but also on the factors that affect their decision to modify their water demand level. This type of study would be increasingly helpful in water management decisions[37].

[37] In addition to the overall limitations listed above, various sectoral limitations are noteworthy. These are presented in various river basin reports (Kulshreshtha et al. 2012a).

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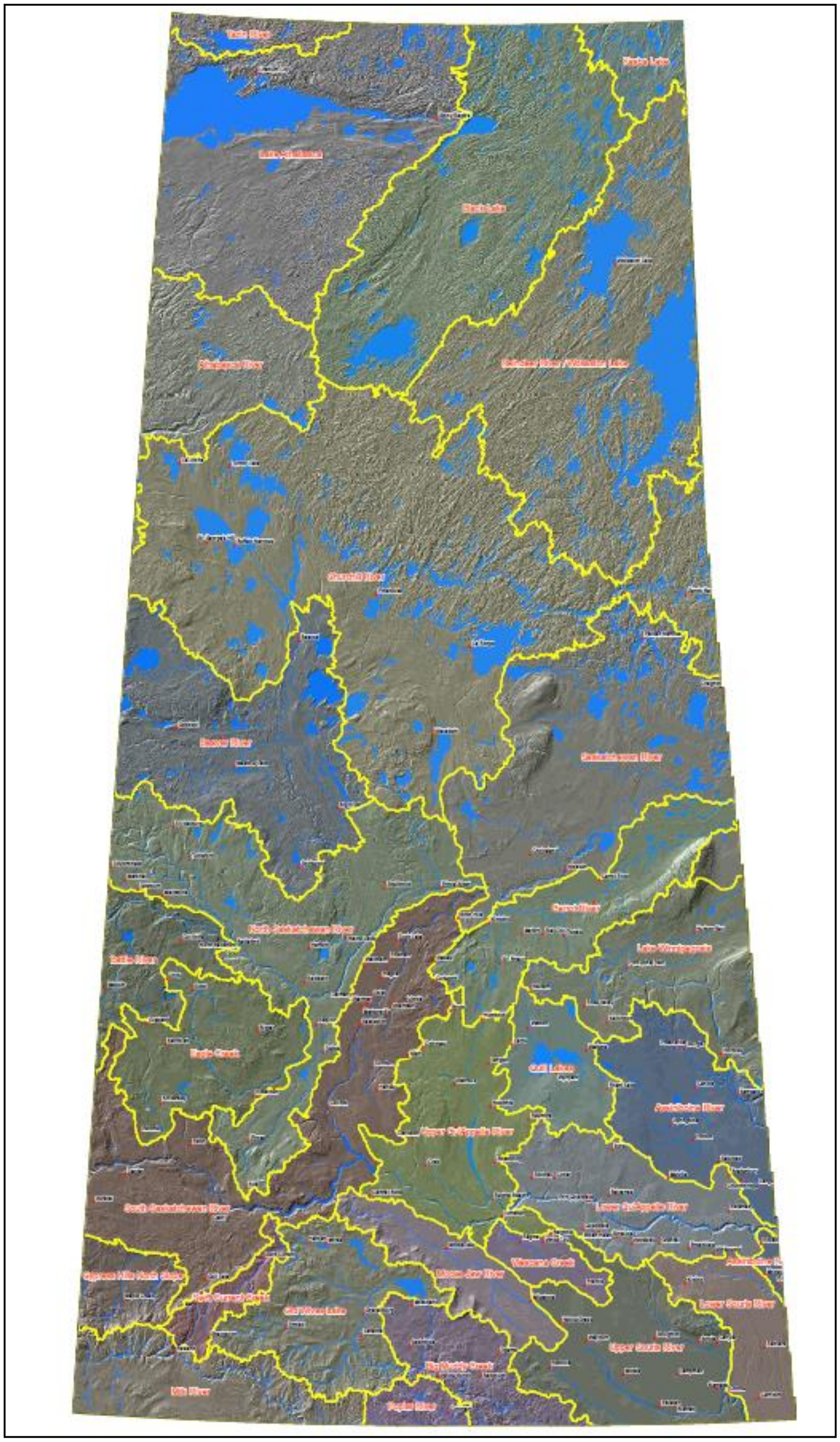
Appendix A

Correspondence between River Basins and Watershed in Saskatchewan



Source: SWA (2010b)

Figure A.1: Location of Saskatchewan Watersheds

Table A.1: Correspondence between River Basins and Watersheds, Saskatchewan

River Basin Number	Name of the River Basin	Name of the Watershed
1	Souris River Basin	Lower Souris Watershed Upper Souris Watershed
2	Missouri River Basin	Milk River Watershed Poplar River Watershed Big Muddy Creek (partial) Watershed
3	Cypress Hills (North Slope)	Cypress Hills (North Slope) Watershed
4	Old Wives Lake Basin	Old Wives Lake Watershed Big Muddy Creek (partial) Watershed
5	Qu'Appelle River Basin	Lower Qu'Appelle Watershed Upper Qu'Appelle Watershed Wascana Creek Watershed Quill Lakes Watershed Moose Jaw River Watershed
6	South Saskatchewan River Basin	South Saskatchewan River Watershed Swift Current Creek Watershed
7	North Saskatchewan River Basin	North Saskatchewan River Watershed Eagle Creek Watershed Battle River Watershed
8	Saskatchewan River Basin	Saskatchewan River Watershed Carrot River Watershed
9	Churchill River Basin	Beaver River Watershed Churchill River Watershed Reindeer River/ Wollaston Lake Watershed
10	Lake Athabasca Basin	Lake Athabasca Watershed Athabasca River Watershed Black Lake Watershed
11	Assiniboine River Basin	Assiniboine River Watershed
12	Lake Winnipegosis Basin	Lake Winnipegosis Watershed
13	Tazin River Basin	Tazin River Watershed
14	Kasba River Basin	Kasba River Watershed

Appendix B

Supplementary Information for Saskatchewan River Basins

Table B.1: Estimated Municipal (Cities') Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Baseline Scenario, 2010- 2060

Basin	Cities	Water Demand per Capita (m^3)			
		2010	2020	2040	2060
Assiniboine	Yorkton	122.81	122.81	122.81	122.81
North Saskatchewan	Lloydminster	150.79	140.94	123.13	107.57
North Saskatchewan	North Battleford	119.52	119.52	119.52	119.52
North Saskatchewan	Prince Albert	147.77	147.77	147.77	147.77
Northern Four	Meadow Lake	112.22	112.22	112.22	112.22
Qu'Appelle	Humboldt	117.02	117.02	117.02	117.02
Qu'Appelle	Moose Jaw	179.84	179.84	179.84	179.84
Qu'Appelle	Regina	142.61	136.33	122.04	109.26
Saskatchewan	Melfort	118.55	118.55	118.55	118.55
Souris	Estevan	188.46	188.46	188.46	188.46
Souris	Weyburn	161.87	161.87	161.87	161.87
South Saskatchewan	Martensville	86.64	86.64	86.64	86.64
South Saskatchewan	Saskatoon	210.23	210.23	210.23	210.23
South Saskatchewan	Swift Current	171.57	171.57	171.57	171.57
South Saskatchewan	Warman	88.68	92.21	99.27	106.34

Table B.2: Estimated Municipal (Cities') Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Climate Change Scenario, 2010- 2060

Basin	Cities	Water Demand per Capita (m^3)			
		2010	2020	2040	2060
Assiniboine	Yorkton	122.81	122.81	125.76	128.95
North Saskatchewan	Lloydminster	150.79	140.94	139.52	130.27
North Saskatchewan	North Battleford	119.52	119.52	122.39	125.49
North Saskatchewan	Prince Albert	147.77	147.77	151.31	155.16
Northern Four	Meadow Lake	112.22	112.22	114.91	117.83
Qu'Appelle	Humboldt	117.02	117.02	119.83	122.87
Qu'Appelle	Moose Jaw	179.84	179.84	184.16	188.83
Qu'Appelle	Regina	142.61	136.33	124.97	114.72
Saskatchewan	Melfort	118.55	118.55	121.39	124.47
Souris	Estevan	188.46	188.46	192.98	197.88
Souris	Weyburn	161.87	161.87	165.76	169.97
South Saskatchewan	Martensville	86.64	86.64	88.72	90.97
South Saskatchewan	Saskatoon	210.23	210.23	215.28	220.74
South Saskatchewan	Swift Current	171.57	171.57	175.69	180.15
South Saskatchewan	Warman	88.68	92.21	100.74	108.36

Table B.3: Estimated Municipal (Cities') Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Water Conservation Scenario, 2010- 2060

Basin	Cities	Water Demand per Capita (m^3)			
		2010	2020	2040	2060
Assiniboine	Yorkton	122.81	119.74	113.6	107.46
North Saskatchewan	Lloydminster	150.79	137.42	113.9	94.13
North Saskatchewan	North Battleford	119.52	116.53	110.56	104.58
North Saskatchewan	Prince Albert	147.77	144.07	136.68	129.3
Northern Four	Meadow Lake	112.22	109.42	103.8	98.19
Qu'Appelle	Humboldt	117.02	114.09	108.24	102.39
Qu'Appelle	Moose Jaw	179.84	175.34	166.35	157.36
Qu'Appelle	Regina	142.61	136.33	122.04	109.26
Saskatchewan	Melfort	118.55	115.58	109.66	103.73
Souris	Estevan	188.46	183.75	174.33	164.9
Souris	Weyburn	161.87	157.83	149.73	141.64
South Saskatchewan	Martensville	86.64	84.48	80.14	75.81
South Saskatchewan	Saskatoon	210.23	204.98	194.46	183.95
South Saskatchewan	Swift Current	171.57	167.28	158.7	150.12
South Saskatchewan	Warman	88.68	89.91	91.83	93.04

Table B.4: Estimated Bedroom Communities' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Baseline Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Qu'Appelle	123.60	126.82	126.82	126.82
South Saskatchewan	93.22	93.22	93.22	93.22

Table B.5: Estimated Bedroom Communities' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Climate Change Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Qu'Appelle	123.60	126.82	129.86	133.16
South Saskatchewan	93.22	93.22	95.45	97.88

Table B.6: Estimated Bedroom Communities' Water Demand per Capita Coefficients or Saskatchewan River Basins by River Basin for Water Conservation Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Qu'Appelle	123.60	126.08	125.35	123.14
South Saskatchewan	93.22	92.66	92.10	90.51

Table B.7: Population Projection for Larger Towns' Communities by River Basin for 2010 - 2060

Basin	Population				2060 Population as % of 2010
	2010	2020	2040	2060	
Assiniboine	15,843	16,372	17,430	18,488	16.7%
Cypress Hills	4,400	4,668	5,204	5,740	30.5%
Lake Winnipegosis	4,440	4,762	5,477	6,301	41.9%
Missouri	0	0	0	0	0.0%
North Saskatchewan	27,341	28,226	29,996	31,766	16.2%
Northern Four	13,439	15,570	19,833	24,096	79.3%
Old Wives	4,104	3,908	3,543	3,212	-21.7%
Qu'Appelle	17,352	16,909	16,461	16,025	-7.6%
Saskatchewan	14,094	15,804	18,546	21,764	54.4%
Souris	6,858	7,341	8,410	9,635	40.5%
South Saskatchewan	12,609	13,506	15,300	17,094	35.6%
Total Population	**120,480**	**127,066**	**140,200**	**154,121**	**27.9%**

Table B.8: Estimated Larger Towns' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Baseline Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	123.64	123.64	123.64	123.64
Cypress Hills	143.57	143.57	143.57	143.57
Lake Winnipegosis	159.23	144.16	115.56	89.61
North Saskatchewan	142.06	133.89	118.43	103.67
Northern Four	143.37	129.64	106.00	86.67
Old Wives	141.91	136.55	124.87	112.44
Qu'Appelle	134.07	122.27	101.69	84.58
Saskatchewan	126.67	126.67	126.67	126.67
Souris	139.46	129.10	108.81	89.46
South Saskatchewan	139.02	127.79	107.98	91.24

Table B.9: Estimated Larger Towns' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Climate Change Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	123.64	123.64	126.61	129.82
Cypress Hills	143.57	143.57	147.02	150.75
Lake Winnipegosis	159.23	144.16	118.33	94.09
North Saskatchewan	142.06	134.66	132.35	123.32
Northern Four	143.37	129.64	108.54	91.00
Old Wives	141.91	136.55	127.87	118.07
Qu'Appelle	134.07	122.27	104.13	88.81
Saskatchewan	126.67	126.67	129.71	133.01
Souris	139.46	129.10	111.43	93.93
South Saskatchewan	139.02	127.79	111.99	97.79

Table B.10: Estimated Larger Towns' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Water Conservation Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	123.64	122.90	122.16	120.05
Cypress Hills	143.57	142.71	141.85	139.41
Lake Winnipegosis	159.23	143.29	114.17	87.01
North Saskatchewan	142.06	133.86	118.88	103.58
Northern Four	143.37	122.38	104.73	84.15
Old Wives	141.91	135.73	123.37	109.18
Qu'Appelle	134.07	121.56	100.51	82.13
Saskatchewan	126.67	125.91	125.15	123.00
Souris	139.46	128.33	107.51	86.86
South Saskatchewan	139.02	127.02	106.68	88.59

Table B.11: Population Projection for Larger Towns' Communities by River Basin for 2010 - 2060

Basin	Population				2060 Population as % of 2010
	2010	2020	2040	2060	
Souris	6,074	6,115	6,199	6,284	3.5%
Missouri	1,325	1,261	1,012	812	-38.7%
Cypress Hills	0	0	0	0	0.0%
Old Wives	2,186	2,094	1,921	1,763	-19.4%
Saskatchewan	3,766	4,119	4,826	5,532	46.9%
Assiniboine	3,091	3,135	3,222	3,310	7.1%
Lake Winnipegosis	1,374	1,393	1,432	1,471	7.1%
Northern Four	1,443	1,643	2,131	2,764	91.5%
Qu'Appelle	14,308	14,340	14,303	14,299	-0.1%
South Saskatchewan	5,852	6,073	6,700	7,370	25.9%
North Saskatchewan	11,686	12,791	16,081	19,295	65.1%
Total Population	**51,105**	**52,964**	**57,827**	**62,900**	**23.1%**

Table B.12: Estimated Smaller Towns' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Baseline Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	130.29	130.29	130.29	130.29
Lake Winnipegosis	124.12	124.12	124.12	124.12
Cypress Hills	225.98	225.98	225.98	225.98
North Saskatchewan	117.01	116.33	115.16	113.71
Northern Four	93.97	93.97	93.97	93.97
Old Wives	217.10	217.10	217.10	217.10
Qu'Appelle	131.27	121.59	104.31	89.49
Saskatchewan	112.01	112.01	112.01	112.01
Souris	127.66	127.66	127.66	127.66
South Saskatchewan	120.29	107.12	84.94	67.36

Table B.13: Estimated Smaller Towns' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Climate Change Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	130.29	130.29	133.42	136.81
Lake Winnipegosis	124.12	124.12	127.10	130.32
Cypress Hills	225.98	225.98	231.41	237.28
North Saskatchewan	117.01	117.01	119.81	122.86
Northern Four	93.97	93.97	96.22	98.67
Old Wives	217.10	217.10	222.31	227.96
Qu'Appelle	131.27	121.59	106.82	93.97
Saskatchewan	112.01	112.01	114.70	117.61
Souris	127.66	127.66	130.72	134.04
South Saskatchewan	120.29	107.12	91.35	76.70

Table B.14: Estimated Smaller Towns' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Water Conservation Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	130.29	129.51	128.73	126.51
Lake Winnipegosis	124.12	123.37	122.63	120.52
Cypress Hills	225.98	224.63	223.27	219.43
North Saskatchewan	117.01	116.30	115.60	113.61
Northern Four	93.97	93.40	92.84	91.24
Old Wives	217.10	215.80	214.50	210.80
Qu'Appelle	131.27	120.88	103.10	86.90
Saskatchewan	112.01	111.34	110.66	108.76
Souris	127.66	126.89	126.12	123.95
South Saskatchewan	120.29	106.48	83.92	65.40

Table B.15: Population Projection for Villages by River Basin for 2010 - 2060

Basin	Population				2060 Population as % of 2010
	2010	2020	2040	2060	
Assiniboine	3,988	3,789	3,599	3,527	-11.6%
Cypress Hills	1,130	1,074	1,020	999	-11.6%
Lake Winnipegosis	1,201	1,131	1,003	890	-25.9%
Missouri	2,030	1,800	1,416	1,114	-45.1%
North Saskatchewan	9,863	9,370	9,123	8,941	-9.3%
Northern Four	3,289	4,118	5,462	6,805	106.9%
Old Wives	4,385	3,968	3,248	2,660	-39.3%
Qu'Appelle	16,309	16,251	16,222	16,201	-0.7%
Saskatchewan	5,163	4,905	4,678	4,585	-11.2%
Souris	6,027	5,779	5,313	4,885	-18.9%
South Saskatchewan	6,637	6,305	6,139	6,016	-9.4%
Total Population	**60,022**	**58,490**	**57,223**	**56,623**	**-5.7%**

Table B.16: Estimated Villages' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Baseline Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	104.59	104.59	104.59	104.59
Cypress Hills	147.12	147.12	147.12	147.12
Lake Winnipegosis	172.62	154.87	123.39	97.10
Missouri	158.53	172.31	198.10	221.08
North Saskatchewan	129.50	133.32	136.95	135.57
Northern Four	121.77	121.77	121.77	121.77
Old Wives Lake	153.90	166.02	189.20	210.56
Qu'Appelle	112.92	103.59	87.17	73.35
Saskatchewan	100.57	100.57	100.57	100.57
Souris	116.66	116.66	116.66	116.66
South Saskatchewan	125.16	125.16	125.16	125.16

Table B.17: Estimated Villages' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Climate Change Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	104.59	104.59	107.10	109.82
Cypress Hills	147.12	147.12	150.65	154.47
Lake Winnipegosis	172.62	154.87	126.35	101.95
Missouri	158.53	172.31	202.86	232.13
North Saskatchewan	129.11	132.95	138.11	143.11
Northern Four	121.77	121.77	124.70	127.86
Old Wives Lake	153.90	166.02	193.74	221.09
Qu'Appelle	112.92	103.59	89.26	77.02
Saskatchewan	100.57	100.57	102.98	105.59
Souris	116.66	116.66	119.46	122.50
South Saskatchewan	125.16	125.16	128.16	131.42

Table B.18: Estimated Villages' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Water Conservation Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	104.59	103.96	103.33	101.55
Cypress Hills	147.12	146.24	145.35	142.85
Lake Winnipegosis	172.62	153.94	121.91	94.28
Missouri	158.53	171.28	195.73	214.67
North Saskatchewan	129.11	132.16	133.25	132.34
Northern Four	121.77	114.95	120.31	118.24
Old Wives Lake	153.90	165.03	186.93	204.46
Qu'Appelle	112.92	102.99	86.16	71.23
Saskatchewan	100.57	99.96	99.36	97.65
Souris	116.66	115.96	115.26	113.28
South Saskatchewan	125.16	124.41	123.66	121.53

Table B.19: Population Projection for Rural Non-Farm communities by River Basin for 2010 - 2060

Basin	Population				2060 Population as % of 2010
	2010	2020	2040	2060	
Assiniboine	3,000	2,700	2,400	2,100	-30.0%
Cypress Hills	447	402	358	313	-30.0%
Lake Winnipegosis	1,307	1,176	1,046	915	-30.0%
Missouri	17	15	14	12	-29.4%
North Saskatchewan	22,983	20,685	18,386	16,088	-30.0%
Northern Four	1,843	1,659	1,474	1,290	-30.0%
Old Wives	172	155	138	120	-30.2%
Qu'Appelle	6,599	5,939	5,279	4,619	-30.0%
Saskatchewan	4,212	3,791	3,370	2,948	-30.0%
Souris	1,144	1,030	915	801	-30.0%
South Saskatchewan	15,939	14,345	11,476	11,157	-30.0%
Total Population	**57,663**	**51,897**	**44,856**	**40,363**	**-30.0%**

Table B.20: Population Projection for Rural Farm communities by River Basin for 2010 - 2060

Basin	Population				2060 Population as % of 2010
	2010	2020	2040	2060	
Assiniboine	8,995	8,096	6,476	6,297	-30.0%
Cypress Hills	3,228	2,905	2,324	2,260	-30.0%
Lake Winnipegosis	5,166	4,649	3,720	3,616	-30.0%
Missouri	4,501	4,051	3,241	3,151	-30.0%
North Saskatchewan	19,170	17,253	13,802	13,419	-30.0%
Northern Four	5,166	4,649	3,720	3,616	-30.0%
Old Wives	8,314	7,483	5,986	5,820	-30.0%
Qu'Appelle	29,093	26,184	23,274	20,365	-30.0%
Saskatchewan	9,755	8,780	7,024	6,829	-30.0%
Souris	12,980	11,682	9,346	9,086	-30.0%
South Saskatchewan	9,048	8,143	7,238	6,334	-30.0%
Total Population	**115,416**	**103,875**	**86,151**	**80,793**	**-30.0%**

Table B.21: Population Projection for First Nations' Reserves by River Basin for 2010 - 2060

Basin	Population				2060 Population as % of 2010
	2010	2020	2040	2060	
Souris	1,774	2,080	2,709	3,338	88.2%
Missouri	-	-	-	-	0.0%
Cypress Hills	-	-	-	-	0.0%
Old Wives	-	-	-	-	0.0%
Saskatchewan	5,470	7,028	10,144	13,261	142.4%
Assiniboine	2,277	2,516	3,074	3,754	64.9%
Lake Winnipegosis	384	486	690	894	132.8%
Northern Four	23,783	25,857	40,481	55,106	131.7%
Qu'Appelle	6,710	8,102	12,346	16,104	140.0%
South Saskatchewan	869	1,166	1,759	2,353	170.8%
North Saskatchewan	12,774	17,066	24,220	31,373	145.6%
Total Population	**54,041**	**64,301**	**95,423**	**126,183**	**133.5%**

Table B.22: Estimated First Nations' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Baseline Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	83.42	137.93	137.93	137.93
Lake Winnipegosis	133.27	111.60	111.60	111.60
North Saskatchewan	74.33	78.07	78.07	78.07
Northern Four	121.77	116.02	178.61	259.13
Qu'Appelle	87.92	121.77	121.77	121.77
Saskatchewan	78.07	74.33	74.33	74.33
Souris	111.60	133.27	133.27	133.27
South Saskatchewan	137.93	83.42	83.42	83.42

Table B.23: Estimated First Nations' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Climate Change Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	83.42	83.42	85.42	87.59
Lake Winnipegosis	133.27	133.27	136.47	139.93
North Saskatchewan	74.33	74.33	76.12	78.05
Northern Four	123.19	123.19	126.15	129.35
Qu'Appelle	87.92	116.02	182.90	272.09
Saskatchewan	78.07	78.07	79.94	81.97
Souris	111.60	111.60	114.28	117.18
South Saskatchewan	137.93	137.93	141.24	144.82

Table B.24: Estimated First Nations' Water Demand per Capita Coefficients for Saskatchewan River Basins by River Basin for Water Conservation Scenario, 2010- 2060

Basin	Water Demand per Capita (m^3)			
	2010	2020	2040	2060
Assiniboine	83.42	82.92	82.42	81.00
Lake Winnipegosis	133.27	132.47	131.67	129.41
North Saskatchewan	74.33	73.89	73.44	72.18
Northern Four	123.19	122.45	121.72	119.62
Qu'Appelle	87.92	115.35	176.54	251.62
Saskatchewan	78.07	77.60	77.13	75.80
Souris	111.60	110.93	110.27	108.37
South Saskatchewan	137.93	137.10	136.27	133.93