Assiniboine River Water Demand Study Climate Change Assessment

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EXECUTIVE SUMMARY

The Assiniboine River is one of the most important water sources in Manitoba, with the availability of quality water from the river vital to maintaining continued community, agricultural, economic, recreational and environmental sustainability in the surrounding region.

During most years, vast amounts of water are available from the Assiniboine River. However, there are concerns regarding the security of the water supply under prolonged drought conditions. It is anticipated that climate change will impact the availability of water throughout the year leading to possible water deficits. This vulnerability will require adaptation by current users in the areas of domestic/municipal water, water for agri-business and irrigation, recreational opportunities, power generation cooling and instream environmental requirements.

To ensure a secure water supply, the resource must be properly managed thorough understanding of future demands, socio-economic issues and influences of a changing climate. The best available science of the day applied through global and regional climate modelling will support risk-based decision-making for water policy and planning moving forward. Studying future water demands is an important step in this planning process.

GENIVAR, in association with Stantec and Associated Engineering, was engaged by Manitoba Conservation and Water Stewardship in January 2011 to complete a water demand study on the Assiniboine River. The study considered current licensed water uses and, through an analysis of growth, economic, environmental, social and climate factors, projected future water needs on the river into the future. The study results will assist in understanding and managing this essential resource.

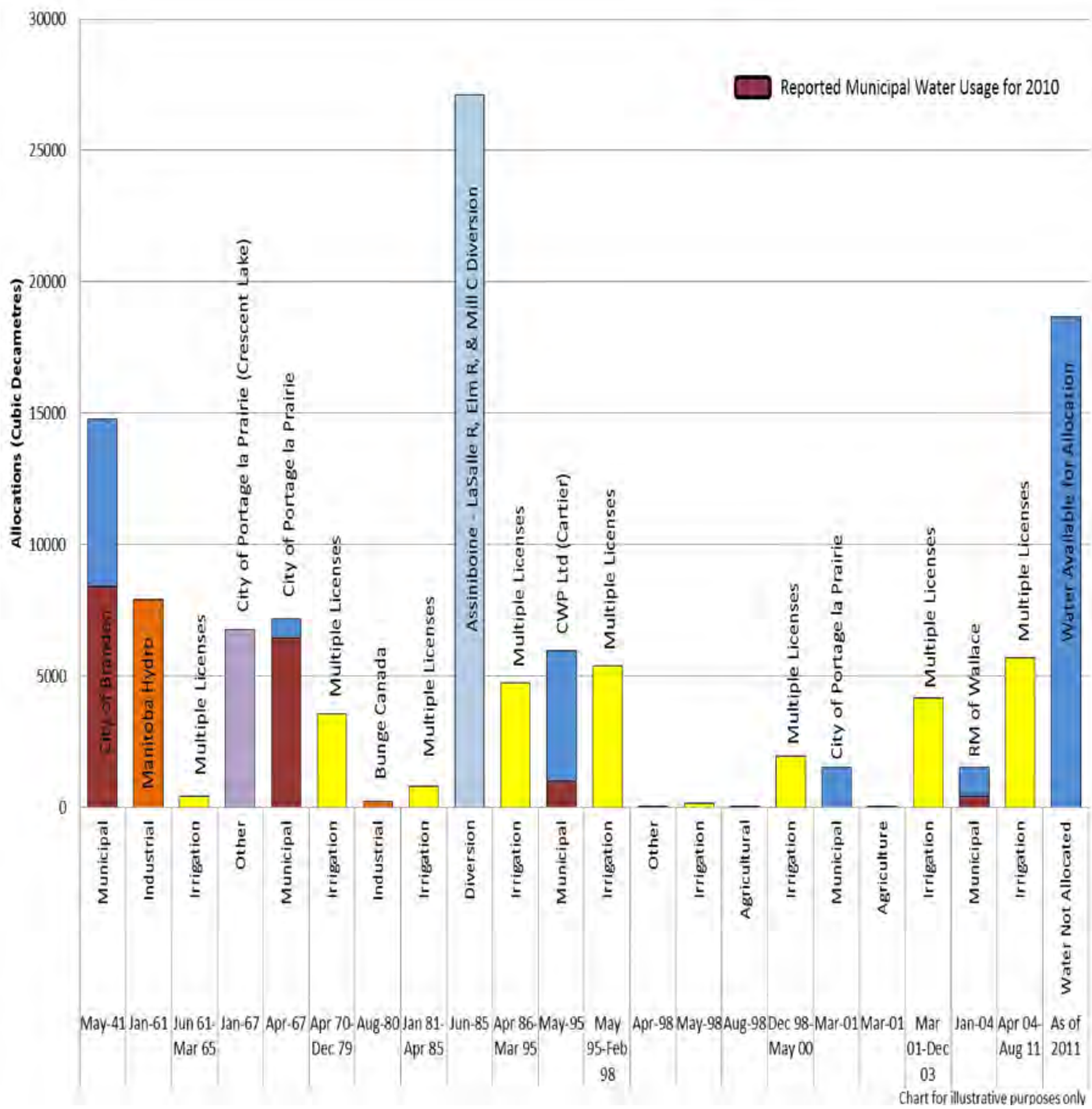
ASSINIBOINE RIVER

The Assiniboine River Basin covers approximately 163,000 square kilometers in Manitoba, Saskatchewan and North Dakota. Generally flowing in a southeast direction, the river passes through many populated areas in Manitoba, including three of the Province's largest urban centers; Brandon, Portage la Prairie and Winnipeg. The Assiniboine River joins the Red River close to downtown Winnipeg. The hydrology of the Assiniboine River Basin is consistent with that of prairie river systems. There is large variability in annual stream flows with peaks occurring during the spring freshet and low flows during fall and winter.

The Province of Manitoba issues licenses to users of the river. License categories include; agricultural, domestic, industrial, irrigation, municipal and other. The license stipulates the conditions of use including maximum quantities of water that may be taken from the river. Licensed water demands from the Shellmouth Dam east to Winnipeg were considered in this study.

BASELINE WATER DEMAND

The Central Plains Inc. Water Study, completed in 2006, studied the existing water rights licenses and allocations along the Assiniboine River. This information was reviewed and updated. Figure 1E, summarizes Assiniboine River water rights licenses into early 2011.



(Manitoba Conservation and Water Stewardship)

Figure 1E: Assiniboine River Water Rights Licenses

This demand data was further modified to represent a dry year scenario, where demands on the river are greatest. Pending water licenses were included. The final update formed the basis of the current Assiniboine River demand conditions and served as the 2010 baseline for the study.

PROJECTIONS AND WATER DEMAND REVIEW

Projections on population, economic growth and agricultural trends for the study periods (2020, 2050 and 2080) were then developed. This included a visioning process with river stakeholders. These factors and trends were translated into water demands conditions for each study year.

In the evaluation, influences that affected each category of use were considered. A second level of study considering climate change factors was also developed. A detailed climate analysis looked at regional and specific climactic data, including modeling to predict and quantify the sensitivity of the demands to climate on the river for the study period.

STAKEHOLDER ENGAGEMENT – VISIONING PROCESS

Observations from the river stakeholders included:

- People's attitudes regarding future water availability are influenced by current events including severe weather and spring flooding.
- Participants are cautiously optimistic about the future prosperity of the Assiniboine River Basin due to increased population growth, economic development and agricultural capacity.
- Extreme water levels (low and high) are currently the main issue for users.
- Many participants indicated that additional storage was the key to control flooding and maintain river levels at close to year-round averages.
- Integrated watershed management would help address issues of water quality, rapid runoff and habitat loss.
- The cost of water supply and especially treatment is a concern for municipalities and water co-ops.
- The demand for Assiniboine River water and competition among user groups will increase in the coming decades, but a crisis may not be eminent if an integrated and cooperative approach to the problem is taken.
- In the minds of participants, water conservation methods fall into two main categories: domestic conservation and improved irrigation equipment and application methods.
- Increased government regulation is a feared by-product of possible future water shortages.
- Among participants, water users indicated a high level of confidence that their current licenses would be protected in the event of an extreme drought.
- Governments need to lead and not just regulate, i.e. be proactive and not just reactive.
- Climate change, as it is predicted to affect Manitoba, is perceived as a potential benefit to the basin in terms of a longer growing season and more crop options.
- Climate related challenges will be met by improved science, technological advances, the adaptive capacity of the agricultural sector, and human resilience and resourcefulness.

CLIMATE CHANGE IMPACTS ON WATER DEMANDS

To assess the potential for a changing climate to impact water demands on the Assiniboine River, it is necessary to obtain estimates of potential and quantifiable changes in climate for the region at particular future time horizons of interest. To accomplish this, the Study Team reviewed supplied climate projection data pertaining to the region and also reviewed available literature to assess the envelope of predicted potential climate change and possible future trends estimated for North America, Western Canada, and Southern Manitoba. Projected changes in the region in the study period are listed below and in Table 1E.

Temperatures:

- Winter temperatures are expected to increase between 2-6°C.
- Spring temperatures are expected to increase between 1-4°C.
- Summer temperatures are expected to increase between 1.5-5°C.
- Fall temperatures are expected to increase between 2-5°C.

Precipitation:

- Precipitation increases are predicted for winter, spring and fall, with the largest increases in the spring.
- Precipitation reductions are expected in the summer season, with reductions growing with time for this season.

General:

- More frost-free days are anticipated.
- Earlier seeding opportunities could occur by approximately two to three weeks; however,
- Increased potential for spring flooding.
- Increased potential for summer drought.

Table 1E: Climate Projections for the Assiniboine River Basin

Climate Parameter	AET, AEV, AGX Ensemble Average (Brandon, MB)			Southern MB (2050) (Compiled by D. Blair: S. MB Trends and Projections)	Southern MB (2050) Institute for Catastrophic Loss Reduction
	2020	2050	2080		
Winter Temperature	+2	+3.6	+5.5	+3 to +5	+3 to +4
Spring Temperature	+0.8	+1.7	+3.7	+1 to +2	+3 to +4
Summer Temperature	+1.5	+3.0	+5.0	+1 to +2	+2 to +4
Fall Temperature	+1.9	+3.2	+5.2	+1 to +2	+1 to -2
Winter Precipitation	+5%	+17%	+20%	Substantial increase	+0 to 15%
Spring Precipitation	+8%	+19%	+23%	Increase	+5 to 15%
Summer Precipitation	-3%	-2%	-7%	Reduction	-10 to +10%
Fall Precipitation	+10%	+10%	+18%	Increase	-10 to +10%
Cooling-degree Days	↑	↑	↑	↑	↑
Heating-degree Days	↓	↓	↓	↓	↓
Growing-degree Days	↑	↑	↑	↑	↑

PROJECTED WATER DEMANDS

Water demands (projected usage) for the time horizons 2010 (baseline), 2020, 2050 and 2080 are presented in Figure 2E.

Based on the review of the projected water demands for the study period, the following conclusions can be made related to the study:

- Water demand on the Assiniboine River will continue to increase over the study period and may exceed the firm annual yield estimate currently used for licensing allocations in the later part of the study period.

- Climate change is expected to have a significant impact on the demand and supply requirements of the river. More detailed study is required to understand the potential for peak usage in months when river flows are low.
- The instream needs (Reference Section 2.9) of the river are not well quantified and should be studied further as they account for a considerable allocation of water.

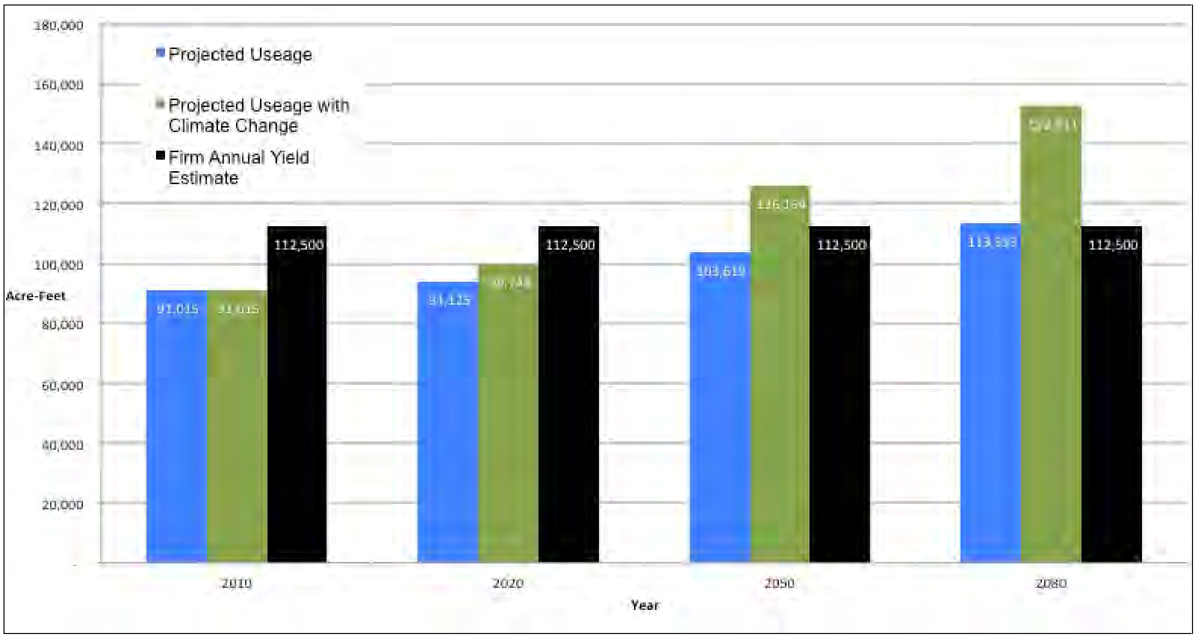


Figure 2E: Assiniboine River Projected Water Demands

- The firm annual yield estimate should be reviewed to reflect the demand scenarios developed in this study as well as to account for climate change.
- Population growth in the City of Brandon may require an additional licensing allocation late in the study period. Existing license allocations should satisfy all other municipal growth.
- It is expected that climate change will increase municipal water use increasing demand on their current (or future) allocations.
- Industrial license demands are expected to remain constant for the study period.
- Irrigation license demands are projected to dramatically increase in the future. Demand is expected to be even greater considering climate change.
- The existing recreational license (Crescent Lake) demand is expected to remain constant for the study period.
- The existing La Salle Diversion allocation demand is expected to remain constant for the study period.

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

The Assiniboine River is one of the most important water sources in Manitoba, with the availability of quality water from the river vital to maintaining continued community, agricultural and economic development as well as recreational and environmental sustainability in the surrounding region.

During most years, vast amounts of water are available from the Assiniboine River. However, there are concerns regarding the security of the water supply under prolonged drought conditions. It is anticipated that climate change will impact the availability of water throughout the year leading to increased water deficits in key summer months. This vulnerability will require adaptation by users in the areas of municipal water, water for agriculture and irrigation, recreational opportunities, industries and instream environmental requirements.

To ensure a secure water supply, the resource must be properly managed requiring a thorough understanding of future demands, socio-economic issues and influences of changing climate. The best available science of the day applied through global and regional climate modeling will support risk-based decision-making for water policy and planning moving forward.

1.2 STUDY PURPOSE

GENIVAR in conjunction with sub-consultant Stantec were engaged by Manitoba Conservation and Water Stewardship to review current water use/demand along the Assiniboine River and quantify future water demands for 2020, 2050 and 2080 time horizons while considering population and economic growth as well as climate change impacts. Associated Engineering was added as a sub-consultant during the study period.

The project scope was broken down as follows:

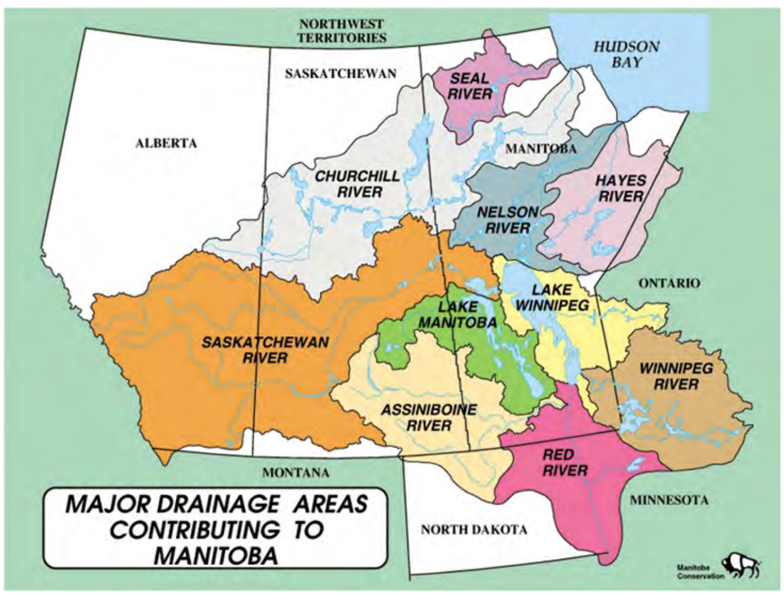
- Review of background materials, relevant studies, forecasts and water conservation strategies, climate change adaptation studies, population and economic forecasts related to the Assiniboine River Basin).
- Update of the “Central Plains Inc. Water Study (2008)”, report prepared by GENIVAR in terms of water use information. This update formed the basis of the current Assiniboine River demand conditions and acted as the baseline for the study. This study will focus on water demand.
- Incorporation of a visioning process with affected users and stakeholders of the Assiniboine River (municipalities, conservation districts, government agencies and irrigators).
- Development of projections, in conjunction with work on the visioning process, on population, economic growth and agricultural trends for the study periods (2010, 2020, 2050 and 2080).
- Conversion of these projections into future water demands for the Assiniboine River for the various users based on domestic, commercial, industrial and agricultural uses for existing and future population and economic growth for time horizons of 2010, 2020, 2050 and 2080.
- Further development of projections into future water demands incorporating the influence of projected climate change scenarios for the study time horizons.

2.0 ASSINIBOINE RIVER

The Assiniboine River Basin (Figure 1) covers approximately 163,000 km^2 in Manitoba, Saskatchewan and North Dakota. Generally flowing in a southeast direction, the river passes through many populated areas in Manitoba, including three of the Province's largest urban centers; Brandon, Portage la Prairie and Winnipeg. The Assiniboine River joins the larger northward flowing Red River close to downtown Winnipeg at a confluence known as "The Forks".

The hydrology of the Assiniboine River Basin is consistent with that of prairie river systems. There is large variability in annual stream flows with peaks occurring during the spring freshet and low flows during fall and winter. In 2011, unprecedented flows were recorded along the Assiniboine River stressing the flood control infrastructure and creating many challenges to those situated in the vicinity of the river and beyond.

Due to the large variability of stream flow on the Assiniboine and high peak flows during the spring melt, large water control infrastructure has been constructed to provide flood and drought protection including the Shellmouth Dam near Russell, and the Portage Diversion at Portage la Prairie.



(http://www.gov.mb.ca/waterstewardship)

Figure 3: Major Drainage Basins of Manitoba

2.1 SHELLMOUTH DAM

The Shellmouth Dam (Figure 2) was completed in 1970 and fully operational in 1971. The dam is 22 m high with a crest length of 1,270 m. Outflow from the dam is controlled by a 4.6 m reinforced concrete conduit. The dam's reservoir is named Lake of the Prairies and extends approximately 60 km northwest. The storage capacity of the Reservoir is 370,000 dam3 (300,000 acre-feet) at the normal summer water level of 427.5 m (1402.5 ft), and 477,000 dam3 (387,000 acre-feet) at the spillway crest elevation of 429.31 m (1408.5ft). The reservoir is a multipurpose reservoir and downstream flows are regulated by the dam for flood control and water supply.

(http://en.wikipedia.org/wiki/File:Shellmouth.jpg)

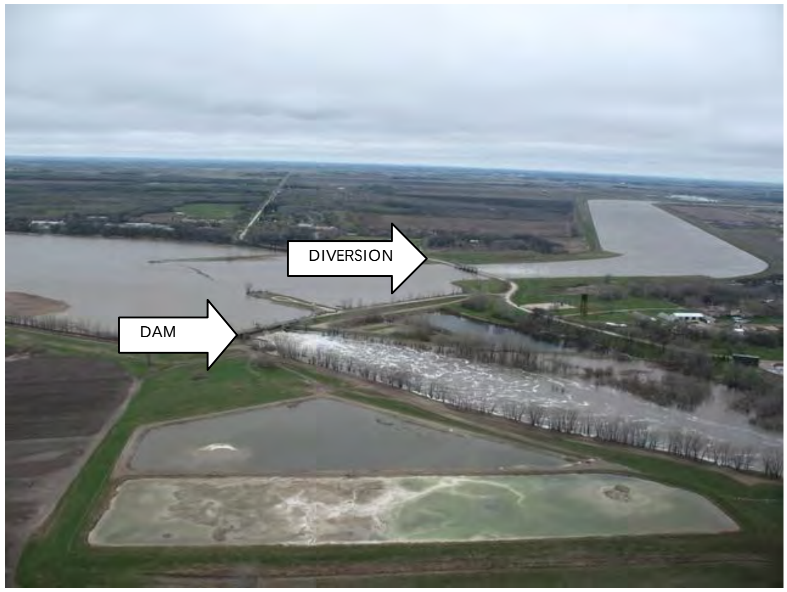
Figure 4: Shellmouth Dam and Lake of the Prairies

The lake is drawn down throughout the winter to provide capacity for the spring melt runoff. As melt waters cause the water level to rise, a maximum outflow is maintained to minimize local flooding. If the water level approaches the crest of the spillway the outflow may be increased to minimize the eventual peak outflow in the event that the water rises above the spillway. The water level is dropped to a summer target level to optimize recreation and fishery conditions. If dry conditions are anticipated, the summer level can be increased to augment flows later in the season. During periods of heavy summer rainfall the reservoir storage can be used to reduce or prevent flooding along the river downstream of the dam. If the summer lake level rise, outflows can be increased to prevent the flooding of recreation facilities on the lake and reduce the probability that the spillway is overtopped.

The primary consideration for determining outflow from the reservoir is maintaining adequate downstream flow rates to meet water allocation commitments to licensed users and minimum flow needs for healthy river ecosystems. Release rates are varied to maintain minimum target flows downstream of 2.835cms (100cfs) at Brandon and 5.67cms (200cfs) at Headingley.

2.2 PORTAGE DIVERSION

The Portage Diversion (Figure 3) was constructed in 1970 to help alleviate flooding between Portage la Prairie and Winnipeg. Water is forced into the diversion channel by a control dam on the Assiniboine River and an adjustable spillway at the entrance to the diversion channel. The diversion channel conveys water 29 km north into the south end of Lake Manitoba.



(http://www.apegm.mb.ca/Heritage/FloodProtection.html)

Figure 5: Portage Diversion Structures

2.3 WATER RIGHTS LICENSING

The Water Use Licensing Section of Manitoba Conservation and Water Stewardship is responsible for issuing water rights licenses in the Province of Manitoba. Any individual or corporation who wishes to use water for agricultural, municipal, industrial, irrigation or other purposes must first obtain a water rights license. Licenses are categorized by the type of source, either groundwater or surface water, and type of water use. The Water Rights Act categorizes the types of water use as follows:

- Agricultural: The use of water at a rate of more than 25,000 litres per day (7.3 acre-feet per year) for the production of primary agricultural products, but does not include the use of water for irrigation purposes.

- Domestic: The use of water, obtained from a source other than a municipal or community water distribution system, at a rate of not more than 25,000 litres per day, for household and sanitary purposes, for watering lawns and gardens, and the watering of livestock and poultry. A license is not required for domestic use purposes.

- Industrial: The use of water obtained from a source other than a municipal or community water distribution system, for operation of an industrial plant producing goods or services other than primary agricultural products. It does not include the sale or barter of water for those purposes or the use of water for recreation.

- Irrigation: The use of water at a rate of more than 25,000 litres per day for the artificial application to soil to supply moisture essential for plant growth.

- Municipal: The use of water by a municipality or a community for the purpose of supplying a municipal or community water distribution system for household and sanitary purposes, for industrial use or uses related to industry, for watering streets, walks, paths, boulevards, lawns and gardens, for protection of property, for flushing sewers and for other purposes usually served by a municipal or community water distribution system.

- Other: The use of water for purposes that do not fit into any of the above noted categories. Some examples include recreation, firefighting and heating/cooling systems.

Upon approval of an application by Manitoba Conservation and Water Stewardship, a water rights license will be issued for a time period up to a maximum of 20 years.

For this region of the Assiniboine River, water licenses are summarized into three reaches:

- Reach 1: From Shellmouth Dam to the east side of the City of Brandon at the Manitoba Hydro Dam across the River in SE 19-10-18W.

- Reach 2: From the Manitoba Hydro Dam at Brandon to the control dam across the river just downstream of the Portage Diversion channel entrance, approximately in the south of Parish Lot 23, Parish of Portage la Prairie.

- Reach 3: From the Portage control dam through the City of Winnipeg to the confluence with the Red River.

The three reaches and key water management infrastructure on the Assiniboine River are displayed in the Figure 4.

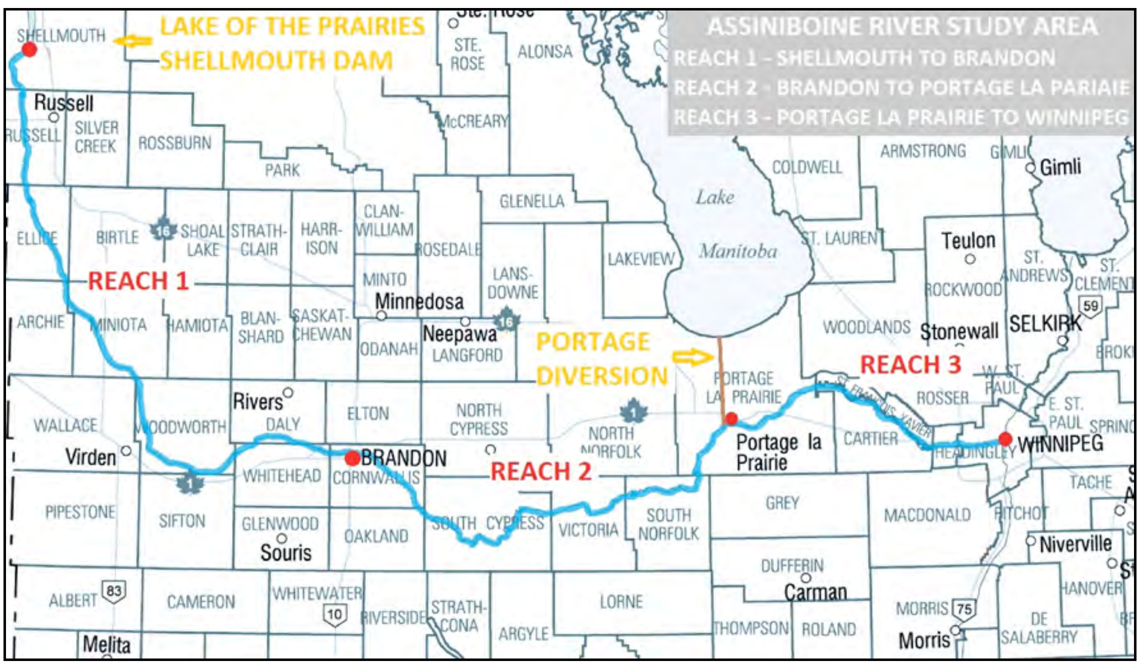


Figure 6: Reaches and Water Resource Structures of the Assiniboine River

The Water Rights Act regulates all water rights licenses in Manitoba for all water sources. Licenses have precedence in relation to one another according to the date of submission of the application for each license.

Figures 5, 6, 7 and 8 represented licensing information for 2010. Figure 5 shows the order in which licenses were issued on the Assiniboine River and Figures 6, 7 and 8 show the information further broken down into individual reaches of the river. Information for Figures 5, 6, 7, 8 was obtained from Manitoba Conservation and Water Stewardship.

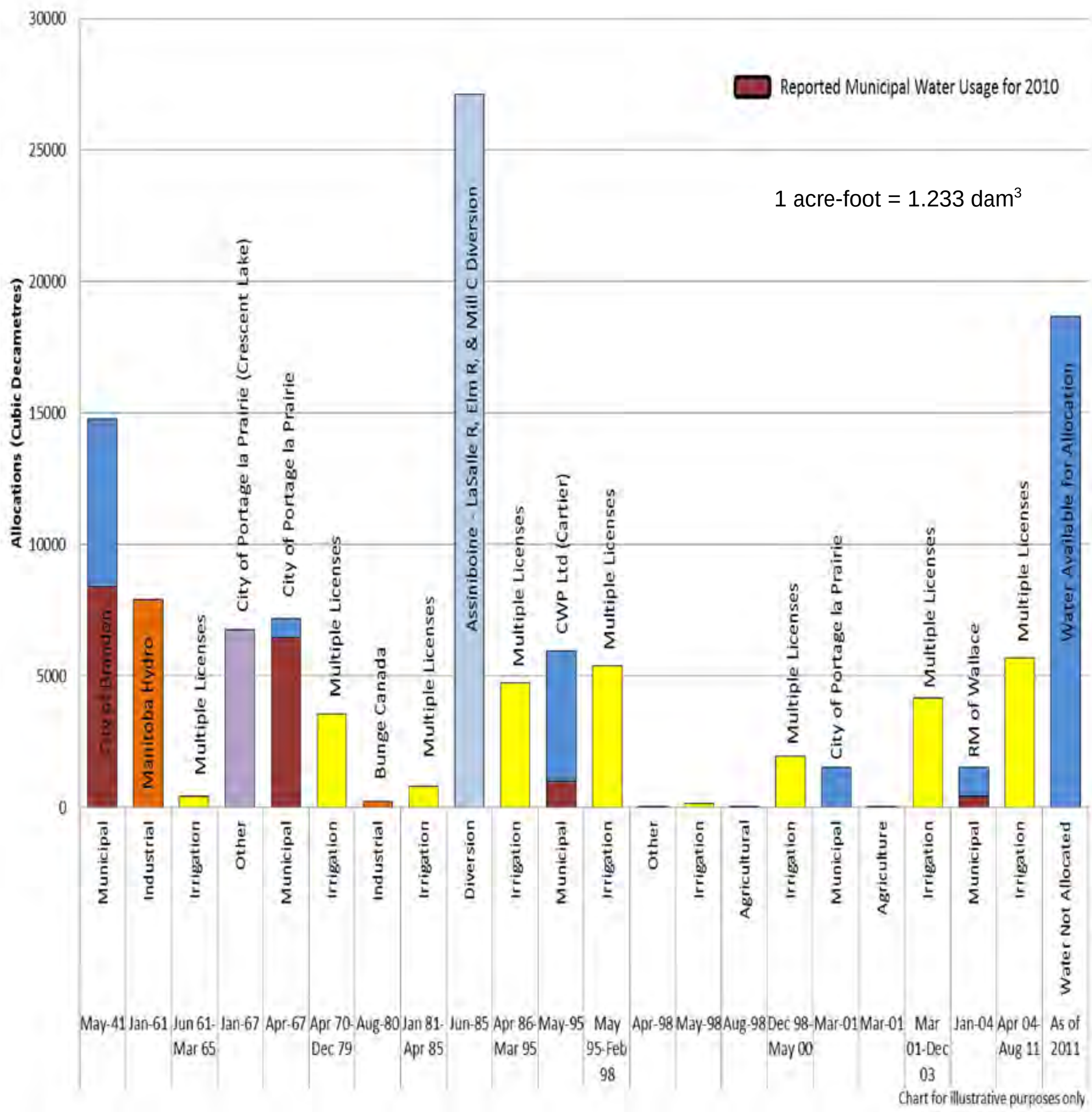


Figure 7: Order of Precedence of Assiniboine River Water Rights Licenses (2010)

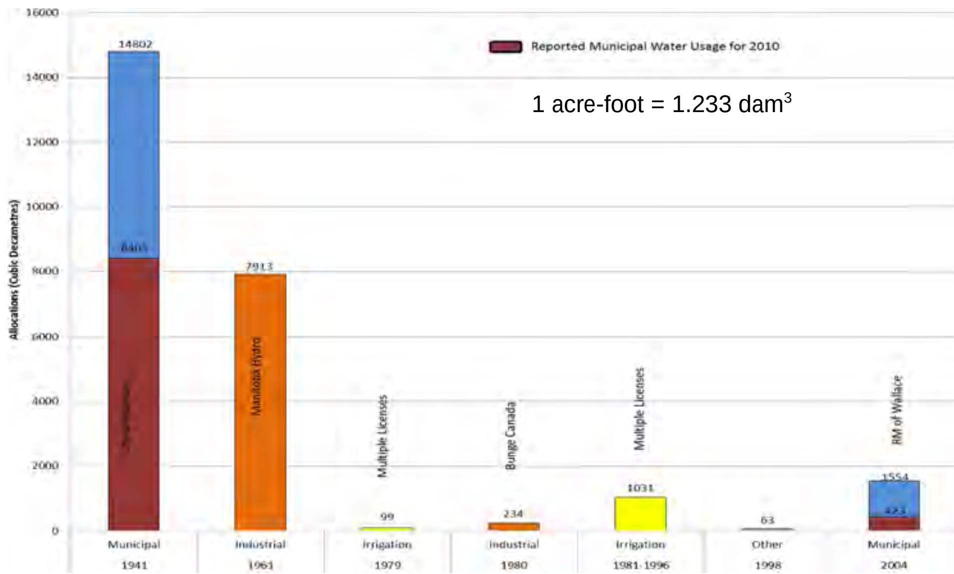


Figure 8: Order of Precedence of Reach 1 Water Rights Licenses (2010)

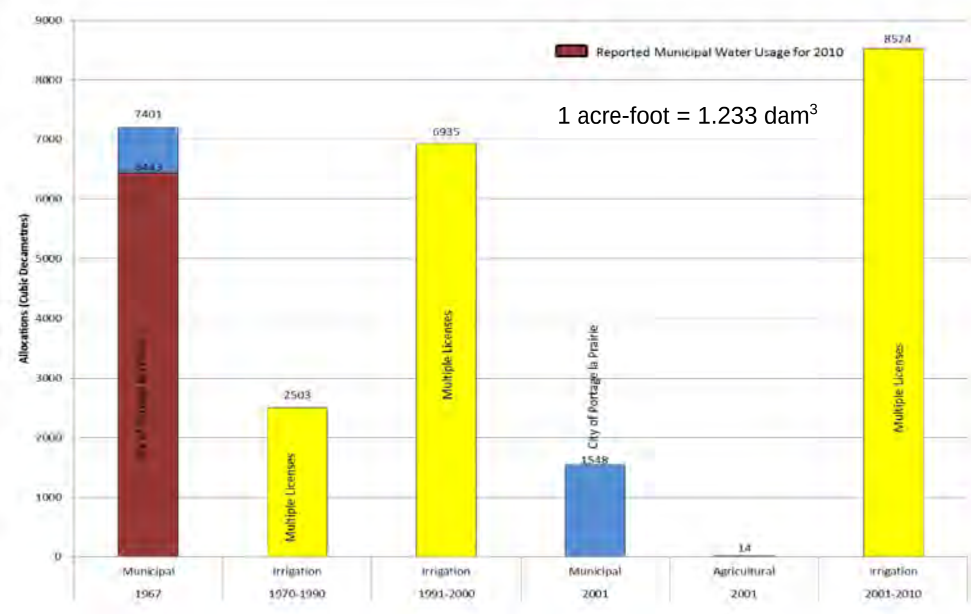


Figure 9: Order of Precedence of Reach 2 Water Rights Licenses (2010)

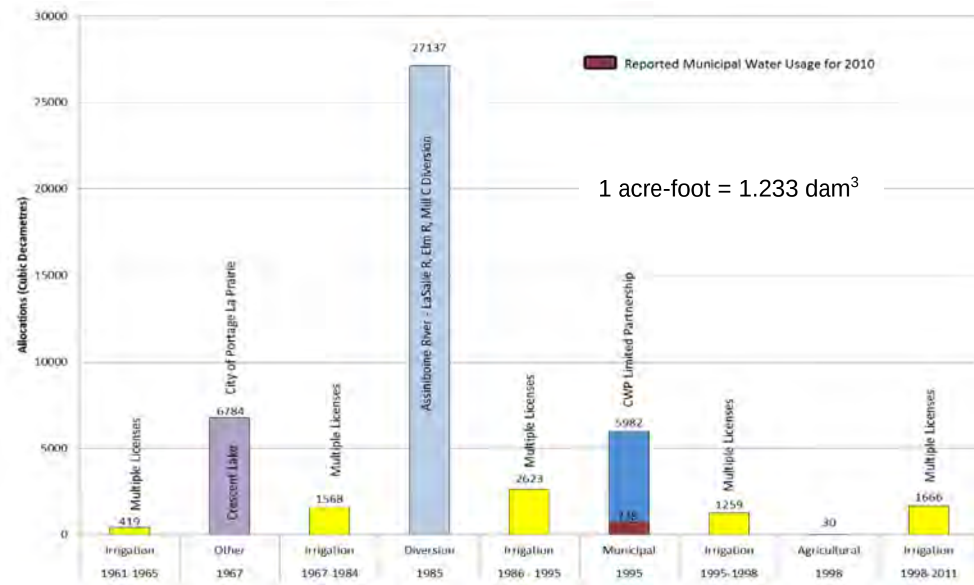


Figure 10: Order of Precedence of Reach 3 Water Rights Licenses (2010)

2.4 MUNICIPAL LICENSES

There are four major licensed municipal users on the Assiniboine River, the R.M. of Wallace, the City of Brandon, the City of Portage la Prairie, and the Cartier Regional Water Co-op. The R.M. of Wallace and Cartier Regional Water Co-op draw water from the Assiniboine River for regional water distribution systems. The R.M. of Wallace has its intake wells south of Miniota close to the P.T.H. 83 Assiniboine River crossing. Although the R.M. of Wallace draws water from a well, because of the well's proximity to the river Manitoba Conservation and Water Stewardship assumes the two to be hydraulically connected so water withdrawn from the well is allocated from the water budget of the Assiniboine River. The Cartier Regional Water Co-op treatment plant has its intake near the Baie St. Paul Bridge near the community of St. Eustache. The City of Brandon's intake is located within city limits. The City of Portage la Prairie's intake is located in the Portage Diversion spillway structure.

Table 1 shows the volume of water allocated to each municipal license and annual use in 2010.

Table 2: Municipal Water License Volumes and Use (2010)

Licensee	Annual Volume (acre-feet)	Annual Water Use (Acre-feet)
RM of Wallace Regional Water System	1,260	342
City of Brandon	12,010	6,811
City of Portage la Prairie	7,255	5,221
Cartier Regional Water Co-op	4,850	589
Total	25,375	12,963

(Manitoba Conservation and Water Stewardship)

2.5 INDUSTRIAL LICENSES

There are two industrial users licensed to withdraw water from the Assiniboine River, Manitoba Hydro and Bunge. As of 2010, Manitoba Hydro was licensed to withdraw 6,415 acre-feet (7,916 dam^3) per year for use in the Brandon thermal electric energy generation station and Bunge was licensed for a withdrawal limit of 190 acre-feet per year. Bunge operates a canola crushing and refining plant near Russell, Manitoba.

2.6 IRRIGATION LICENSES

Most of the licenses issued by Manitoba Conservation and Water Stewardship are for irrigation purposes. Although irrigation licenses are typically for much smaller volumes than the licenses for major municipal users, about 20% of the total licensed and committed volumes are for irrigation water use.

Irrigation water is used to manage a water deficit created when crops require more moisture than what is naturally provided. Due to the high capital cost of irrigation infrastructure, irrigation is mainly used for high value crops such as fruits, vegetables and potatoes. Although the moisture provided by irrigation is small, it is essential to increase yields and provide high quality products. Many areas in southern Manitoba have excellent soil conditions for producing potatoes, and most irrigation projects are developed for potato production.

As of October 2010, 19,608 acre-feet (24,182 dam^3) were licensed to irrigators with another 4,297 acre-feet (5,300 dam^3) committed to applications under review.

2.7 RECREATION

The City of Portage la Prairie has a water rights license for an annual allocation of 5,500 acre-feet (6,784 dam^3) for supplementing Crescent Lake when the water level is low.

2.8 ASSINIBOINE – LA SALLE DIVERSION

The Assiniboine – La Salle Diversion was constructed in 1984 and includes three pumping stations along the Assiniboine River. The diversion supplements the supply of water to the Macdonald Regional Water System servicing the villages of Starbuck, Sanford and La Salle, as well as domestic, agricultural and irrigation use along the La Salle River. The diversion is allocated 22,000 acre-feet (27,126 dam^3) per year for operation. The diversion consists of three separate pumping sites: Site W – to the Elm River, Site Y – to the La Salle River and Site Z – to Mill Creek.

Manitoba Infrastructure and Transportation (MIT) operates each site based on precipitation and downstream demand.

The 22,000 acre-feet (27,126 dam3) allocation to the diversion accounts for all three sites. The total volume of water licensed along the La Salle River, Elm River and Mill Creek is 2,860 acre-feet (3,527 dam3). This is only 13% of the annual volume allocated to the diversion. The excess remaining flow is used to improve water quality along the La Salle River.

2.9 INSTREAM FLOW NEEDS

Instream flow is the flow required within the river in order to sustain aquatic and terrestrial biota production as well as riverine functions and processes. The Assiniboine River supports many species of fish including Channel Catfish, Goldeye, Sand Shiner, Sauger, Walleye, White Sucker, Mooneye, Shorthead Redhorse, Flathead Chub, Quillback, and others with the most common being the Shorthead Redhorse.

Manitoba Conservation and Water Stewardship currently reserves 16,000 acre-feet (19,744 dam^3) to account for instream flow needs.

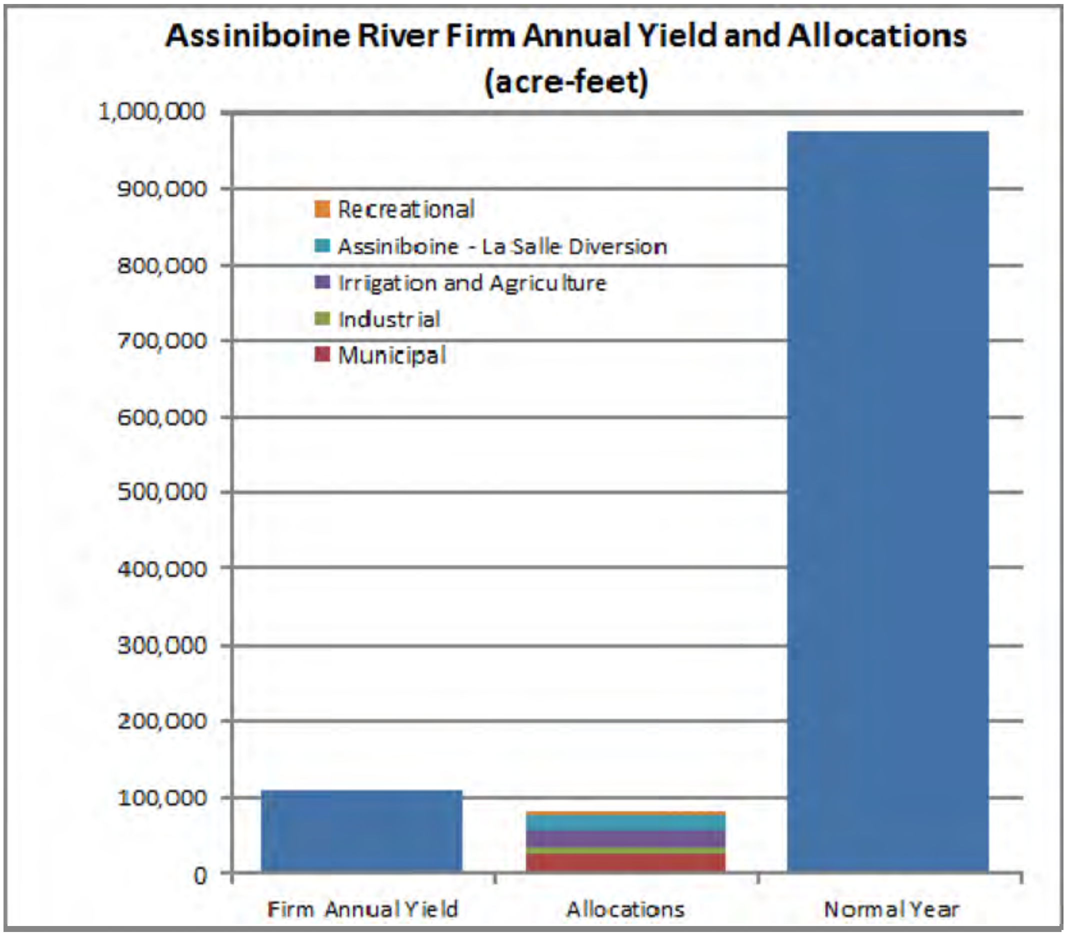
Manitoba Conservation and Water Stewardship also use minimum flow objectives at Brandon and Headingley for waste dilution for these larger urban centers.

2.10 FIRM ANNUAL YIELD OF THE ASSINIBOINE RIVER

The amount of water Manitoba Conservation and Water Stewardship will currently allocate on the Assiniboine River is based on the firm annual yield of the river. The firm annual yield is the maximum annual volume that can be supplied on an assured basis for consumptive uses via a combination of releases from Shellmouth Dam and the tributary flow into the river after instream flow needs are satisfied.

Manitoba Conservation and Water Stewardship use a river routing model called the Assiniboine River Water Management Model (ARWMM) to determine the yield on the river. Using the ARWMM, the firm annual yield of the Assiniboine River is estimated to be 112,500 acre-feet (138,825 dam^3). This is the amount of water that can be withdrawn for consumptive use until the Shellmouth Reservoir is drawn down to an empty level.

Figure 9 compares the firm annual yield, total licensed allocations and normal yearly total flows (represented by the median year, 1967) on the on the Assiniboine River for 2010.



(Manitoba Conservation and Water Stewardship)
Note: Normal year is represented by the median year, 1967.

Figure 11: Summary of Assiniboine River Firm Annual Yield and Allocations

2.11 ALLOCATION SUMMARY

A summary of the allocated water volumes for 2010 is presented in the following table. This data will be used to determine baseline numbers for future water demand projections later in the report. Note that the current minimum flow criteria are 2.835cms (100cfs) at Brandon and 5.67cms (200cfs) at Headingley to maintain a live stream during low flow conditions.

Table 3: Assiniboine River Allocation Summary (2010)

Allocation Purpose	Licensed or Committed Volume 2010 (acre-feet)	Water Use / Allocation 2006 (acre-feet)	Water Use / Allocation 2010 (acre-feet)
Reach 1			
Municipal -RM of Wallace	1,260	178	342
Municipal – Brandon	12,010	9,865	6,811
Agricultural	0	0	0
Industrial - Manitoba Hydro	6,415	6,415	6,415
Industrial – Bunge	190	190	190
Irrigation	665	665	665
Recreational	0	0	0
Outstanding Applications	340	0	0
Reach Total	20,880	17,313	14,423
Reach 2			
Municipal - Portage la Prairie	7,255	4,322[3]	5,221
Agricultural	0	0	0
Industrial	0	0	0
Irrigation	12,584	12,584	12,584
Recreational	0	0	0
Outstanding Applications	3,692	0	0
Reach Total	23,531	16,906	17,805
Reach 3			
Municipal – Cartier Water Coop	4,850	467	589
Agricultural	0	0	0
Industrial	0	0	0
Irrigation	6,359	6,359	6,359[4]

Allocation Purpose	Licensed or Committed Volume 2010 (acre-feet)	Water Use / Allocation 2006 (acre-feet)	Water Use / Allocation 2010 (acre-feet)
La Salle Diversion	22,000	22,000	22,000[4]
Recreational – Crescent Lake	5,500	5,500	5,500[4]
Outstanding Applications	265	0	0
Reach Total	38,974	34,326	34,448
Reach 1	20,880	17,313	14,423
Reach 2	23,531	16,906	17,805
Reach 3	38,974	34,326	34,448
Total Allocations	83,385	68,545	66,676
Instream Flow Needs Reserve	16,000		
TOTAL	99,385		
Firm Annual Yield Estimate*	112,500		
Uncommitted Estimate	13,115		

(Manitoba Conservation and Water Stewardship)

3.0 POPULATION, ECONOMIC AND AGRICULTURAL GROWTH PROJECTIONS

Determining agricultural and economic trends for 2020, 2050 and 2080 is inherently challenging due to uncertainties that extend well beyond climate considerations. A multi-dimensional approach was used to help overcome the challenges and arrive at meaningful predictions of future water demand. This involved examining trends in population, the economy and agricultural/irrigation practices.

3.1 WATERSHED POPULATION CHANGE (1991 TO 2006)

Population counts for the study area were obtained from Statistics Canada for census years from 1991 to 2006. Population change for this 15 year period was calculated for all of the rural municipalities bordering the Assiniboine River and the incorporated communities they contain within the three reaches that comprise the study area. Table 3 shows the actual and percentage change in population experienced by watershed municipalities between 1991 and 2006. This data was used as a starting point for projecting future population change. Trend-line population forecasts are at best a general indicator of future population change, especially given the lengthy planning horizon of the present study of 70 years, to the year 2080. Over such a long period of time, even small changes of a percent or less can dramatically inflate or deflate a community's population beyond what could reasonably be expected given a normal course of events.

Table 4: Assiniboine River Watershed – Population Change by Reach 1991 to 2006

Reach	Location	Census Years				Annual Percentage Change
		1991	1996	2001	2006	
1	Shellmouth-Boulton	760	733	946	906	1.28%
	RM of Russell	528	553	544	661	1.68%
	RM of Ellice	494	526	509	423	-0.96%
	RM of Miniota	1,048	1,027	969	904	-0.92%
	RM of Wallace	1,889	1,835	1,547	1,501	-1.37%
	RM of Woodnorth (Pipestone)	1,795	1,710	1,567	1,419	-1.40%
	RM of Daly	880	895	906	868	-0.09%
	RM of Whitehead	1,421	1,535	1,457	1,402	-0.09%
	RM of Cornwallis	4,214	4,279	3,779	4,058	-0.25%
	Sub-total	13,029	13,093	12,224	12,142	-0.45%
	Average Change					-0.23%
	Town of Russell	1616	1605	1587	1428	-0.78%
	Village of Binscarth	469	463	445	395	-1.05%
	Town of St. Lazare	495	526	265	265	-3.10%
	Village of Elkhorn	505	514	470	461	-0.58%
	Town of Virden	2894	2956	3109	3010	0.27%
	Town of Rivers	1076	1117	1119	1193	0.72%

Reach	Location	Census Years				Annual Percentage Change
		1991	1996	2001	2006	
	City of Brandon	38575	39175	39716	41511	0.50%
	Sub-total	45630	46356	46711	48263	0.38%
	Average Change					-0.57%
	Reach 1 Average Change					0.20
2	RM of South Cypress	862	862	821	834	-0.22%
	RM of Victoria	1405	1275	1181	1149	-1.21%
	RM of Westbourne	1957	2035	2017	1906	-0.17%
	RM of North Norfolk	2967	3024	2941	2742	-0.51%
	RM of South Norfolk	1234	1282	1246	1170	-0.35%
	RM of Portage la Prairie	7156	6627	6791	6793	-0.34%
	Sub-total	15581	15105	14997	14594	-0.42%
	Average Change					-0.47%
	Village of Glenboro	674	663	656	633	-0.41%
	Town of Gladstone	928	927	848	802	-0.91%
	Village of MacGregor	852	898	882	921	0.54%
	Town of Treherne	661	675	644	646	-0.15%
	City of Portage la Prairie	13186	13077	12976	12728	-0.23%
	Sub-total	16301	16240	16006	15730	-0.23%
	Average Change					-0.28%
	Reach					-0.33
3	RM of Cartier	3115	3009	3120	3162	0.10%
	RM of St. Francois Xavier	898	992	1027	1087	1.40%
	RM of Headingley	1575	1587	1907	2726	4.87%
	RM of Macdonald	3999	4900	5320	5653	2.76%
	Sub-total - Reach 3	9587	10488	11374	12628	2.11%
	Average Change - Reach 3					2.13%
	TOTALS	38197	38686	38595	39364	0.20%
	Rural Municipalities (RM)	38197	38686	38595	39364	0.20%
	Urban Municipalities	61931	62596	62717	63993	0.22%
	TOTALS	100128	101282	101312	103357	0.21%
	Average Change - All Reaches					0.21%

3.2 KNOWN POPULATION INFLUENCES

The most talked about demographic change impacting the study area and the prairies as a whole has been the de-population of rural areas over the past half-century or so. The contributing factors include:

- Mechanization: Improvements in equipment lessening the demand for farm labour.
- Industrialization: The corporatization of rural Canada characterized by the disappearance of the small scale family farm and the emergence of large scale farming.
- Family Size: Decrease in average family size, partly related to mechanization and partly related to changing lifestyles and socio-economic circumstances.
- Urbanization: The shift from a resource-based agrarian society to an urban society with a service based economy, drawing the children of farm families and communities to the cities and larger centres and hastening the decline and disappearance of small rural centres. The increased scale and centralization of major community services like education and health care has also been a factor here.
- Transportation: Improvements in road infrastructure and vehicles lead to decreased travel times enabling a centralization of agricultural-related services and businesses in larger centres.

Population change and human settlement patterns in the Assiniboine River basin show clear evidence of being impacted by all of the above factors, especially within Reach 2, the area between Brandon and Portage la Prairie. Fortunately, there are signs that the dramatic population decline experienced in the 80s and 90s has bottomed out in rural areas and the populations of urban centres are holding steady if not growing. Reach 3 from Portage la Prairie to Headingley is within the Winnipeg commutershed where ex-urban growth is helping to stabilize the population of the RM of Cartier while contributing to relatively substantial increases in the RM of St. Francois Xavier, the RM of Headingley, and the RM of McDonald communities of La Salle, Sanford and Starbuck served from the La Salle Diversion. In Reach 1, recent growth in the City of Brandon is attributed to a diversified economy and the City's stature as a centre of regional trade, health, education and government services. Immigration has also accounted for most of Brandon's growth in recent years and it is reported that immigrant workers and their families have boosted Brandon's population by some 4,000 in the past decade.

The Province of Manitoba, as a whole, grew by an average annual rate of 0.34% between census years 1991 and 2006. The provincial rate of growth picked up between 2001 and 2006, to 0.52% annually. The four cities of Winnipeg, Steinbach, Brandon and Winkler accounted for 65% of the growth during the last census period, with Winnipeg accounting for 50% of provincial population growth.

3.3 POPULATION CHANGE BY REACH (1991-2006)

Table 4, below, summarizes population change between census years 1991 and 2006 for the three reaches of the Assiniboine River currently under study.

Table 5: Population Change by Reach (Total Watershed)

Reach	Rural Municipalities			Urban Municipalities			Combined Population Change
	1991	2006	Annual Change	1991	2006	Annual Change	Annual Change
1	13029	12142	-0.45%	45630	48263	0.36%	0.20%
2	15581	14594	-0.42%	16301	15730	-0.23%	-0.33%
3	9587	12628	2.11%	0	0	n.a.	2.11%
Totals	38197	39364	0.20%	61931	63993	0.22%	0.21%

Reach 1 (Shellmouth Reservoir to Brandon) experienced an annual growth rate of 0.20% between 1991 and 2006, with rural municipalities losing population at the rate of -0.45% per year and urban municipalities gaining population at the annual rate of 0.36% per year. Brandon's annual population growth of 0.51% from 1991 to 1996 accounts for much of the urban growth, offsetting average yearly losses in places like Russell (-0.78%), Binscarth (-1.05%) and St. Lazare (-3.1%). Urban municipalities in Reach 1 currently account for about 80% of the total population.

Reach 2 (Brandon to Portage la Prairie) experienced an annual decline of -0.33% between 1991 and 2006, with a rural decline of -0.42% and an urban decline of -0.23%. Located between the population centres of Brandon and Portage la Prairie, Reach 2 has a distinctly rural character with the farming community accounting for almost 50% of the total population of the reach.

Reach 3 (Portage la Prairie to Headingley) experienced an annual increase of 2.11% between 1991 and 2006. Over this period, relatively rapid growth occurred in the RMs of St. Francois Xavier (+1.40%), Headingley (+4.87%) and Macdonald (+2.76%), all located well within the Winnipeg commutershed.

In total, the urban and rural municipalities within all three reaches of the study area experienced an increase in population of 3,229 over the period 1991 to 2006, from 100,128 to 103,357, representing an average annual increase of 0.21%. Overall, rural municipalities experienced an average annual increase of 0.20%, while urban municipalities increased by 0.22% annually. The rural number is deceiving as the inclusion of commutershed RMs like Macdonald and Headingley masks population declines within the remainder of the study area RMs with the exception of Shellmouth-Boulton, Russell and Cartier. Also, while the percentages might seem significant, the absolute numbers are not. For instance, the average growth of 1.68% for the RM of Russell only amounts to 133 people over the 15 years from 1991 to 2006. The rural municipalities and incorporated communities that border the Assiniboine River within the study area accounted for 9% of the provincial population in 2006. This is down slightly from the 1991 figure of 9.2%.

3.4 WATERSHED POPULATION GROWTH SCENARIOS, 2010 TO 2080

Table 5 provides an estimate of future population growth in 10 to 30 year increments over the planning period to 2080. In forecasting future population growth within the watershed, low, medium and high percentage rates of population growth were applied to the total estimated 2006 population rounded to 103,400. The low rate of 0.21% per year is the actual average annual growth rate experienced by the municipalities comprising the 3 reaches of the watershed between 1991 and 2006. The medium rate of 0.55% and high rate of 0.84% per year were selected from a series of population projections prepared for the Province of Manitoba by Statistics Canada in June 2010 (Catalogue no. 91-520-XWE).

Table 6: Assiniboine Watershed Population Scenarios, 2010 to 2080

Annual Growth Rate	Year					Increase over 2006 baseline (103,400*) *rounded	
	2010 Baseline	2020	2030	2050	2080		
Low (Actual) (0.21%)	104,300	106,400	108,700	113,400	120,700	17,300	+17%
Medium (0.55%)	105,700	111,600	117,900	131,600	155,100	51,700	+50%
High (0.84%)	106,900	116,200	126,300	149,300	191,900	88,500	+86%

Note: Medium growth rate was selected for the study population projections.

At the 2080 planning horizon, the population estimates for the watershed under the low, medium, and high growth scenarios are 120,700, 155,100 and 191,900 respectively. Of these, the medium population scenario based on a 0.55% average annual growth rate is regarded as an achievable, conservative forecast and was considered for the population projection. The rationale for this is that the medium growth forecast falls in the middle range of the Statistics Canada projections for Manitoba and allows for an increase in the current rate of population growth for the watershed while avoiding a level of optimism unjustified by known prospects for economic and employment growth over the coming decades. The 2080 forecast watershed population of 155,100 under the medium growth scenario represents an increase of 51,700 people or 50% over the 2006 census population for the watershed. By way of illustration, this amounts to adding a city almost the size of Brandon to the watershed by the year 2080. Figure 10 depicts projected growth under all three growth scenarios.

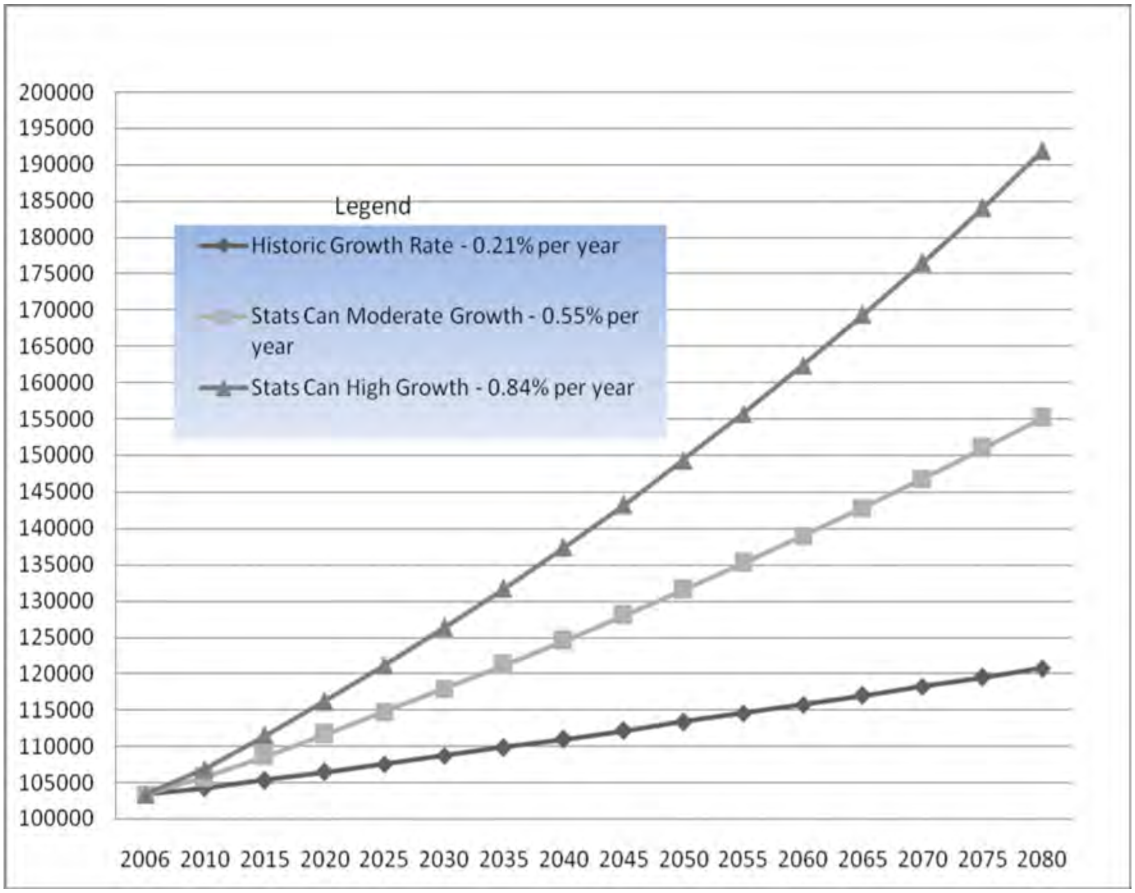


Figure 12: Watershed Population Scenarios 2010 - 2080

3.5 POPULATION CHANGE AND MUNICIPAL WATER DEMAND FORECASTS

The population change experienced within all of the municipalities comprising the Assiniboine River will be used to estimate among the current licensed municipal and water cooperative users. Table 6 compares, in percentage terms, the population change experienced by the municipalities comprising the current licensed municipal users with the adjusted growth factors ultimately used in this report for forecasting increases in annual municipal water usage over the study period to 2080.

Table 7: Municipal Water Demand Growth Factors (2011 Licensed Users)

Reach	Municipal Water Licensee	Population Change (Annual %, 1991-2006)	Municipal Water Usage Growth Factor (Annual % 2010 to 2080)
1	City of Brandon	0.51	0.50
	RM of Wallace	-1.37	0.20
	City of Portage la Prairie	-0.23	0.10*
	RM of Portage la Prairie	-0.34	
3	Cartier Water Co-op:		2.00*
	RM of Cartier	0.10	
	RM of St. Francois Xavier	1.40	
	RM of Headingley	4.87	
*Blended Rate			

Despite a decrease in population experienced in some municipalities drawing water from the river for industrial or domestic use, Table 6 projects year-over-year increase in water usage among municipal licensees over the study period. It assumes regional water systems will grow the service area populations at a rate disproportionate to non-serviced areas as more and more rural customers are added and settlement centres situated along the pipeline corridors attract growth by virtue of water availability.

3.6 ECONOMIC GROWTH

The long term economic outlook for the Assiniboine River basin is dependent upon the health of the Canadian and Manitoban economies.

Overall, the Canadian economy weathered the recent worldwide recession better than most of the G7 economies thanks in part to a healthy financial services sector, manageable debt levels and low inflation and interest rates. Over the short term, the strength of the Canadian dollar will continue to negatively impact the manufacturing and export sectors causing the current trade deficit to persist. The country's long term economic prospects are favourable given its stature as a commodity producing country, led by the energy, agriculture and mining sectors. However, as the country's largest trading partner, the US will continue to have influence over the Canadian economy in both positive and negative ways. Efforts to expand into new markets, principally the Far East and South America, will only help the Canadian economy as it moves through the coming decades. On the provincial front, Manitoba has been especially active in strengthening trade with Mexico and Asia in particular. By any measure –economic, political, socio-cultural, environmental, to name a few - Canada is a privileged country and consistently ranks at or near the top of quality-of-life surveys.

Prospects for the country's ongoing prosperity over the coming century are enhanced by its bountiful resources combined with a reputation as a stable country and a safe haven for immigrants and international investment.

Economists are cautiously optimistic about the Manitoba economy and its long term prospects, predicting near term increases in GDP on par with the country as a whole, in the order of 2.4%. The ease with which Manitoba weathered the 2008 recession surprised many economists and pundits. This is generally credited to the province's diversified economy and the stability afforded by a balance between its service, manufacturing, processing and commodity sectors. Manitoba has also been a Canadian leader in promoting economic immigration which has been of particular benefit to the south-east and south-central parts of the province. This has helped offset net losses in inter-provincial migration over the past couple of decades caused by rapid economic and employment growth first in British Columbia followed by Alberta and more recently Saskatchewan. Manitoba Hydro's ongoing investment in northern hydroelectric infrastructure is a major contributor to the provincial economy, contributing to Canada's third place ranking behind China and the United States in terms of hydroelectric generation. As the world moves towards energy production from renewable sources, the province is well positioned to help meet this continent's increasing demand for hydroelectric power.

Economic immigrants to the province are bringing money, education, skills, families and a younger demographic to southern Manitoba. New immigrants are taking over from retired farmers, filling jobs, buying houses and businesses and injecting prosperity into communities like Steinbach, Altona, Winkler and Morden. The Assiniboine River basin would greatly benefit from the economic and social stimulus brought about by increased immigration. Apart from Brandon, most of the communities in the Assiniboine River area are either holding steady or declining as their population ages, birth rates remain historically low, and rural-depopulation continues to be felt. At the same time, the watershed as a geographical region has its fundamental strengths, and its urban and rural communities have much to offer. The geographic, environmental and socio-cultural attributes of the watershed cannot remain overlooked for long. Some of the major attributes, natural and otherwise, include the following:

- Excellent soil characteristics for a wide variety of crops.
- A long growing season and relatively predictable weather patterns.
- Abundant sources of water from surface and sub-surface sources.
- Excellent transportation linkages with proximity to trans-continental road and rail facilities, expansion of Winnipeg International Airport.
- Well-serviced, self-reliant, caring and inclusive communities.
- Low urban and agricultural land cost.
- Municipal infrastructure available in major centres for industrial development.
- Abundant resources and opportunities for outdoor recreation, contributing to a healthy lifestyle for area residents.

3.7 AGRICULTURAL GROWTH

Key agricultural trends that were examined for their impact on water demand from the Assiniboine River included:

- The shift from traditional grain-for-export production to high-value specialty crops (e.g. potatoes, other vegetables, oilseeds and pulses).
- The shift from small, mixed farms to large-scale, focused production systems (e.g. intensive livestock operations, large potato farms).
- Irrigation of crops not traditionally irrigated in Manitoba (e.g. oilseeds, pulses, forage/hay).
- Conservation management to allow more efficient use of existing or future water supply.
- Alternative irrigation water sources (e.g. off-stream storage, groundwater, municipal wastewater, industrial wastewater, recycled irrigation/drainage water).

According to the 2006 Manitoba Irrigation Survey (Gaia Consulting 2007), the rate of expansion of irrigated crop production in Manitoba appears to be slowing. In 2006, the reported irrigated area using the Assiniboine River as the water source was found to be 24,288 acres. At that time, the 5 year future expansion plans associated with the Assiniboine River was estimated to be 5,075 acres, or 20.9% of the 2006 irrigated acreage, which represented about half of the anticipated expansion reported in past surveys. The majority of the expansion (82.9%) anticipated in Manitoba was related to anticipated increases in potato production acreages. As of 2006, approximately 75% of irrigated acres were associated with potato production.

Therefore, at the current time, the future of the expansion of irrigation from the Assiniboine River is intimately associated with the demand for potato production or the increase of other specialty or high-value crop production requiring supplement irrigation. The demand for potato production is largely based on global factors which influence the local demand for potato processing at the three major processing facilities in Manitoba. The future of the high value crop production is uncertain and will be largely dependent on the need to utilize existing irrigation capacity for other crops, or based on other factors, such as climate change.

Based on a scenario of increased demand for potato production in the future, water demand from the Assiniboine River for irrigation will increase proportionally to the increase in crop production. However, should the demand for potato production remain the same or decrease in the future, the expected demand on the Assiniboine River as an irrigation water source will be expected to remain the same or decline over time.

Potatoes have a high crop water demand relative to the other major crop types grown in Manitoba, including grains, oilseeds and pulses. The average irrigation depth for potatoes in Manitoba was found to be 214 mm (8.4 inches), while irrigated pulses received an average irrigation depth of 25 mm (1 inch). Should a shift occur in the future from irrigated potato production to other irrigated crop production, and based on current crop production in Manitoba, it is anticipated that a decrease in irrigation application depths would occur even if irrigated crop acreages remain the same.

However, a more likely scenario if the industry in Manitoba is faced with a reduced demand in potato production in the future would be the increase of other high value crop production (e.g. soybeans). The resultant demand under this type of scenario would be based on the substitution crop(s) and the concomitant water demands. It is highly unlikely that a substitution crop would have a higher crop water demand than potatoes when current climatic conditions are considered.

3.8 PROJECTING FUTURE IRRIGATED ACRES AND WATER DEMAND IN THE ASSINIBOINE RIVER WATERSHED

As previously discussed, increased potato production and hence higher irrigation water demand would mostly be driven by positive global market conditions. A report on Crops in Manitoba, (Crops in Manitoba 2009-2010, prepared for the Department of Agribusiness and Agricultural Economics, University of Manitoba) showed potato production (1981-2010) to have peaked in 2003 with a harvested area of 101,500 acres (Figure 11) with processing potatoes comprising about 80% of seeded acres.

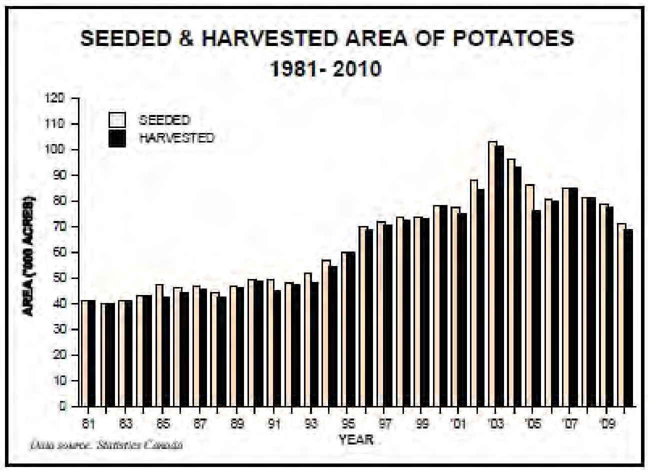


Figure 13: Seeded and harvested area of potatoes in Manitoba (1981-2010).

Assuming a turn-around in recent declines in potato production or, at minimum, a plateau, it would be reasonable to consider a modest increase in irrigated potato acres. Assuming the average growth over the past ten-year period (which was much lower than the previous ten-year period) is representative of future growth, a 1.1% yearly increase in irrigated potato acres and hence water demand would be a reasonable expectation for future growth without considering climate change (Figure 12). This would result in approximately 28,000, 35,000 and 42,000 acres of irrigated potato production in the Assiniboine River Basin for the time horizons of 2020, 2050 and 2080, respectively, relative to the current approximately 24,000 acres.

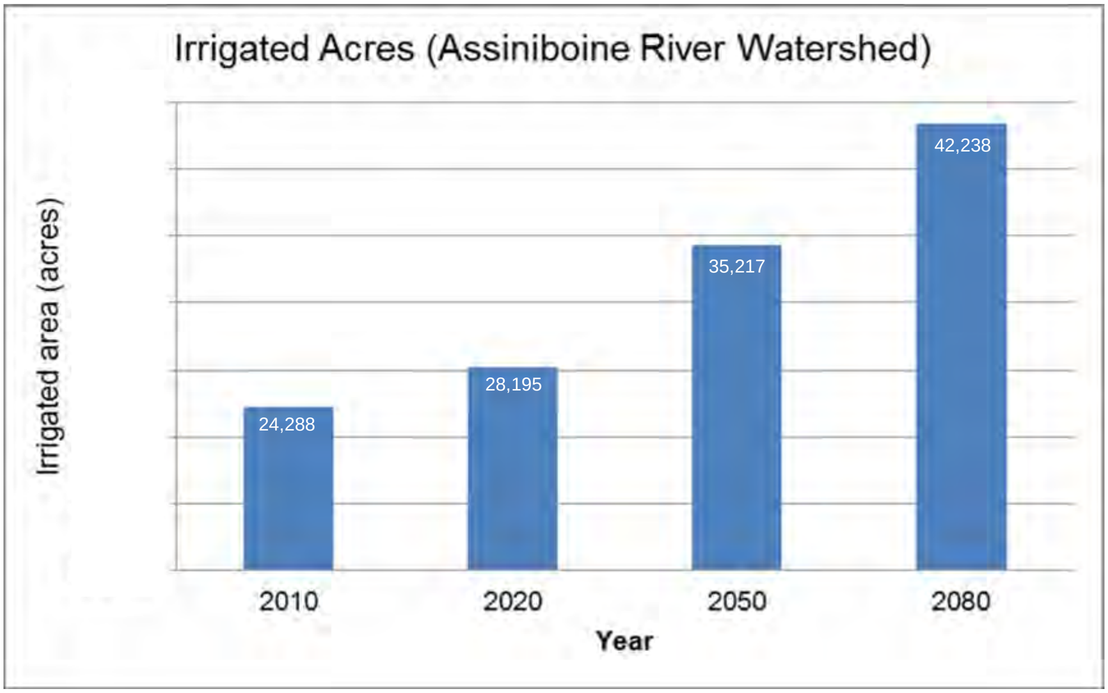


Figure 14: Projected future acreages of land under irrigation in the Assiniboine River Watershed

3.9 BOYNE RIVER DIVERSION

A potential water demand on the Assiniboine River is the Boyne River Diversion project. In 2008, KGS completed a study, "Boyne River Study: Task No. 1 - Water Allocation and Demand"' on the Boyne River Watershed to characterize current and potential water demands into the future, similar to many tasks completed in this study. The report identified the Assiniboine River as a potential water source primarily through a high volume water transfer (diversion) to the Boyne River during the spring freshet. A summary of finding of the report as they relate to the Assiniboine River are:

- The Boyne River Watershed is fully allocated.
- Real time management is being implemented to maximize efficiency of use of existing allocations.
- Additional future water could be provided by diversion and storage of Assiniboine River water at spring freshet or during fall drawdowns of Shellmouth Dam, neither of which would affect Assiniboine River allocations.

Based on the above, this potential demand will not be included in future projections in this study.

3.10 AGRICULTURAL, INDUSTRIAL, RECREATIONAL GROWTH

The study team reviewed the potential for an increase in water demand from the Assiniboine River attributable to growth and expansion in the agricultural, industrial and recreational sectors.

Agricultural use is distinct from crop irrigation and primarily involves the watering of livestock. Water demand for livestock operations is not a significant component of licensed use and the study team was unable to identify any trend or development within the livestock industry that could potentially result in a dramatic increase in water demand within this sector over the course of the study period. Livestock operations will have secure water sources consisting of dugouts, streams or wells. Water supply from regional waterlines for barns or feedlot supply will be accounted for in municipal licensing.

Industries within the Assiniboine River watershed do not currently account for a significant amount of water consumption. Only two industries are currently separately licensed, the Manitoba Hydro generating station in Brandon and the Bunge Canada canola processing plant near Russell, Manitoba. Water usage is a significant component of food processing and, within the study area, water supply to the McCain Foods and Simplot potato processing plants in Portage la Prairie and the Maple Leaf Pork processing plant in Brandon is accounted for in the municipal water licenses for the two communities. Contact with economic development agencies within the watershed did not identify any definitive plans for new wet industries in the study area that would require separate licensing. And while it is conceivable that new wet industries in the food processing or bio-fuels sectors may be drawn to the watershed in future, the water use projections do not include a separate allowance for an expansion in industrial water use. However, some potential for industrial expansion is accounted for in the projections of future municipal water demand.

It was noted that here is currently significant potash and oil development in Saskatchewan. This development could spill over into western Manitoba and possibly affect population and water demand into the future. It is assumed that this demand will be satisfied though the growth of the existing water systems identified in this study.

The Portage la Prairie Crescent Lake is the only recreational facility on the Assiniboine River that is issued a license for water use. The amount is minor and only required in dry years. The lake has an outfall to the river and in wet years is a net water contributor to the river. While the Shellmouth Reservoir has cottage development and is a boating and fishing destination, downstream reaches of the Assiniboine River are not a major source of recreation for residents or tourists beyond leisure activities like canoeing and fishing. As such, no new recreational licenses are expected within the three reaches of the study area and an increase in recreational water use has not been allowed for in the future projections.

4.0 CLIMATE CHANGE

The climate associated with the Assiniboine River basin is one of several key factors influencing the overall demand for water required from the Assiniboine River.

To assess the potential of a changing climate for water demands on the Assiniboine River, it was necessary to obtain changes in climate for the region at particular time horizons. For this study, the years 2010, 2020, 2050, 2080 were selected. Manitoba Conservation and Water Stewardship provided climate change model projections for temperature and precipitation. This data, in conjunction with available literature, was used to assess the envelope of potential climate change and possible future trends in the basin.

4.1 HISTORICAL CLIMATE DATA AVAILABILITY

Historical and observed climate data associated with locations within the Assiniboine River basin were reviewed. This data was downloaded from Environment Canada's National Climate Data and Information Archive for the Canadian portion of the Assiniboine River Basin. As shown in Figure 13, the climate data record for many locations within the basin does not cover a full historical record over the possible years of monitored data.

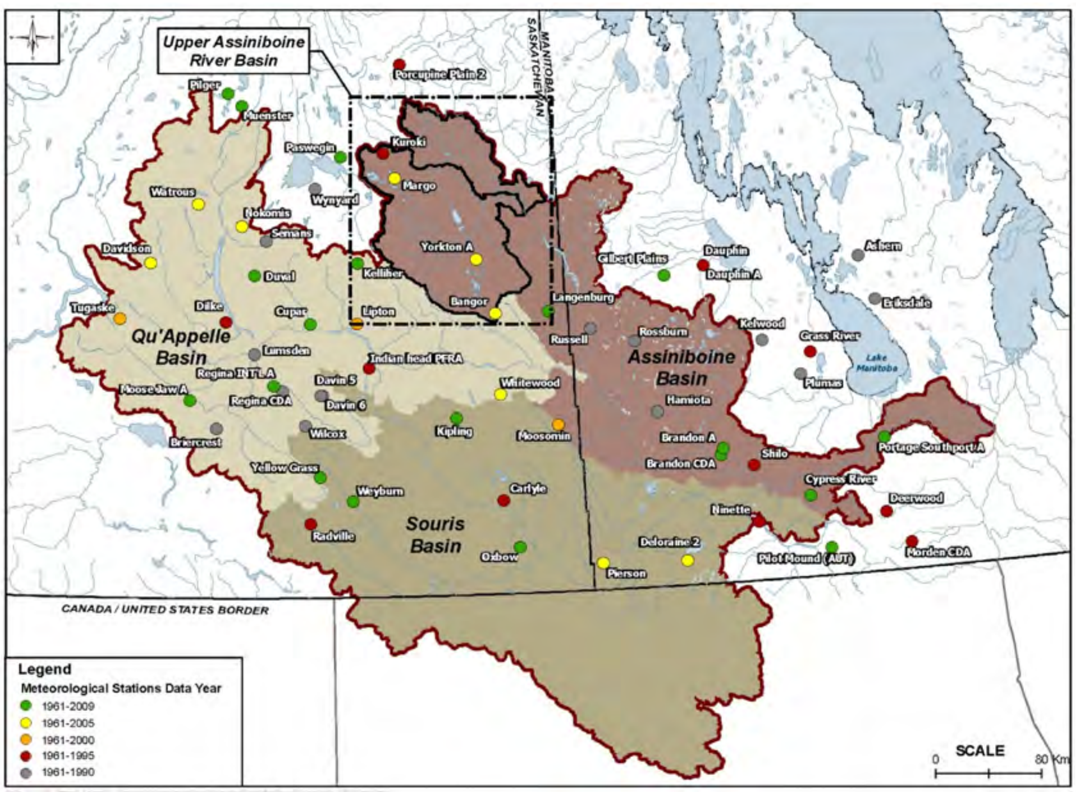


Figure 15: Assiniboine River Drainage Basin: Observed, Historical Monitoring Locations and Limits of Historical Data Record

Brandon was selected as the reference location to discuss climate normals and predicted climate changes for the three time horizons (2011-2040, 2041-2070, and 2071-2099). Brandon is considered central to the geographic region and also possesses a historical meteorological record with continuity across the full 1961-2000 time period that defines the baseline time horizon for this study.

4.2 CANADA - OBSERVED TRENDS AND PROJECTIONS IN CLIMATE

The report "From Impacts to Adaptation: Canada in a Changing Climate (2007)" documents the current understanding of Canada's vulnerability to climate change during the past decade. In this report, Territories and Provinces within Canada are described in terms of several regional analyses where each chapter within the report discusses current and future climate, relevant socioeconomic trends, current sensitivities to climate, and the risks and opportunities presented by climate change.

In this report, the influence of anthropogenic climate change on Canada is evident in observed trends and temperatures simulated by global climate models (Zhang et al., 2006). These changes are already impacting human and natural systems (cf. Gillett et al., 2004).

Observational data have been collected in southern Canada for more than a century and in other parts of Canada since the mid–twentieth century. This data, together with satellite data from the past 25 years or so, provide a detailed picture of how Canadian climate and associated biophysical variables have changed in recent decades.

4.3 OBSERVED NATIONAL TRENDS IN TEMPERATURE

On average, Canada has warmed by more than 1.3°C since 1948, a rate of warming that is about twice the global average. During this time period, the greatest temperature increases have been observed in the Yukon and Northwest Territories. All regions of the country have experienced warming during more recent years (1966-2003), including the eastern Arctic where there has been a reversal from a cooling trend to a warming one, starting in the early 1990s.

On a seasonal basis, temperature increases have been greater and more spatially variable during the winter and spring months. In northwestern Canada, winter temperatures increased more than 3°C between 1948 and 2003. Summer warming has been both more modest and less variable spatially, whereas warming in the autumn period has largely been confined to Arctic regions and British Columbia.

4.4 OBSERVED NATIONAL TRENDS IN PRECIPITATION

National trends in precipitation are more challenging to determine due to the discontinuous nature of precipitation and its various states (rain, snow and freezing rain). Generally, Canada has become wetter during the past half-century, with mean precipitation increasing by about 12% across the country.

The "From Impacts to Adaptation: Canada in a Changing Climate (2007)" document reports that changes in precipitation have varied by region and season in Canada since 1950. Annually averaged, the largest percentage increase in precipitation has occurred in the high Arctic, while parts of southern Canada, particularly the Alberta and western Saskatchewan Prairies have seen little change or even a decrease. Seasonal trends since 1950 indicate that most of the Arctic has become wetter in all seasons. Southern British Columbia and southeastern Canada also show regions with significant increases in precipitation in spring and autumn. In contrast, most of southern Canada, except the western part of southern Ontario, which has seen increased lake effect snow, has experienced a significant decline in winter precipitation.

4.5 NATIONAL PROJECTIONS: TEMPERATURE AND PRECIPITATION

"From Impacts to Adaptation: Canada in a Changing Climate (2007)" reports that all of Canada, with the exception of the Atlantic offshore area, is projected to warm during the next 80 years. In most cases, future changes in climate will involve a continuation of these patterns, and often an acceleration of identified trends. Consequently, warming amounts will not be uniform across the country. During the present century, temperature increases will be greatest in the high Arctic, and greater in the central portions of the country than along the east and west coasts.

On a seasonal basis, warming is expected to be greatest during the winter months, due in part to the feedback effect that reduced snow and ice cover has on land-surface albedo. Winter warming by the 2050s is expected to be greatest in the Hudson Bay and high Arctic areas, and least in southwestern British Columbia and the southern Atlantic region. Rates of warming will be lower in the summer and fall, and summer warming is projected to be more uniform across the country.

The frequency of extreme warm summer temperatures (exceeding 30ºC) is expected to increase across Canada. Heat waves are projected to become more intense and more frequent. At the same time, extreme cold days are projected to decline significantly.

Future precipitation is more difficult to project, and changes in precipitation are generally of a lower statistical significance than changes in temperature. This is reflected in the wide range of model results for projected precipitation.

Annual total precipitation is projected to increase across the country during the current century. By the 2080s, projected precipitation increases range from 0-10% in the far south up to 40-50% in the high Arctic. Due to enhanced evapotranspiration, driven by increasing temperatures, many regions will experience an increased moisture deficit despite greater amounts of precipitation.

Seasonal changes in precipitation will generally have greater regional-scale impacts than the annual totals. Throughout most of southern Canada, precipitation increases are projected to be low (0-10% by the 2050s) during the summer and fall months. In some regions, especially the south-central prairies and southwestern British Columbia, precipitation is even expected to decline in summer. This means less available precipitation during the growing season in important agricultural regions. Other important changes in precipitation include an increase in the percentage of precipitation falling as rain rather than snow, and an increase in extreme daily precipitation.

4.6 CLIMATE PROJECTIONS – FINDINGS FOR THE PRAIRIE REGION OF CANADA

Most climate models project the largest increases in mean annual temperature in the high latitudes of the Northern Hemisphere (Cubasch et al., 2001). Consistent with these projections, temperature records from the prairies show significant positive trends, especially since the 1970s. The favourable consequences of this general warming, and higher spring temperatures in particular, are a warmer and longer growing season and enhanced productivity of forests, crops and grassland where there is adequate soil moisture.

Unfortunately, summertime drying of the Earth's mid-continental regions is also projected, as greater water loss by evapotranspiration is not offset by increased precipitation (Gregory et al., 1997; Cubasch et al., 2001). Projections vary from slight (Seneviratne et al., 2002) to severe (Wetherald and Manabe, 1999) moisture deficits, depending mainly on the complexity of the simulation of land-surface processes. Elevated aridity has major implications for the prairies, the driest major region of Canada. Recurrent short-term water deficits (drought) impact the economy, environment and culture of the Prairies. Seasonal water deficits occur in all regions of Canada. However, only in the prairies can precipitation cease for more than a month, surface waters disappear for entire seasons, and water deficits persist for a decade or more, putting landscapes at risk of desertification.

Declining levels of prairie lakes also suggest drying of the prairie environment. Closed-basin lakes are sensitive indicators of hydrological and climatic change (van der Kamp and Keir, 2005; van der Kamp et al., 2006). Fluctuations in lake levels can be related to land use and water diversions, but similar patterns for lakes across the prairies implicate the influence of climate parameters, particularly rising temperatures, changes in the amount of snow (Gan, 1998) and changes in the intensity of rain (Akinremi et al., 1999), on the water budgets of these lakes. It has also been reported that some Manitoba closed basin lakes have soared to record highs in recent years demonstrating that extreme variability of wet and dry cycles will be a feature of the future.

4.7 SUMMARIES OF OVERALL PROJECTED TRENDS FOR SOUTHERN MANITOBA

Summaries of overall projected trends were assembled for southern Manitoba by Dr. Danny Blair of the University of Winnipeg. Dr. Blair's summary climate projections for southern Manitoba are comprised of a summary of projected trends as reported in "From Impacts to Adaptation: Canada in a Changing Climate (2007)", "The New Normal: Prairies in a Changing Climate (2010)", and "Intergovernmental Panel on Climate Change (IPCC) Climate Change 2007: The Physical Science Basis (2007)" and other sources. Dr. Blair's summary includes projected changes (to the year 2050) and confidence levels associated with these projected changes for a number of key climate variables, many of which with potential to affect water demands in the region.

Table 7 presents key climate variables, projected changes (to 2050) and confidence levels for projected changes for southern Manitoba.

Table 8: Climate Projection Summary for Southern Manitoba

Climate Variable	Projected Change	Confidence
Winter Mean Temperature	+3 to +5 by 2050	Very high
Spring Mean Temperature	+1 to +2 by 2050	Very high
Summer Mean Temperature	+1 to +2 by 2050	Very high
Fall Mean Temperature	+1 to +2 by 2050	Very high
Winter Precipitation	Substantial increase	Very high
Spring Precipitation	Increase	Medium
Summer Precipitation	Lower	Low
Fall Precipitation	Increase	Low

Warm Season Heatwaves	Warmer and more frequent	Very high
Heat Extremes	Warmer and more frequent	Very high
Cooling-degree Days	Much higher	Very high
Heating-degree Days	Much lower	Very high
Growing-degree Days	Much higher	Very high
Frost-free Season	Much longer	Very high
Length of Winter Season	Much shorter	Very high
Winter Rain Events	Much more	Very high
Snow Storms	Fewer	Medium
Droughts	More and longer	High
Intense Rain Events	More and more intense	High
Blair, "Climate Change in Manitoba: A Review of the Science Trends and Projections (2011)"		

The projected trends present challenges and opportunities with respect to water demands in the southern Manitoba region. Significant increases in growing-degree days may allow for changes in current crop practices which in turn would alter the timing and water demands associated with the traditional growing season. For southern Manitoba, this could allow shifts to an earlier average spring growing season start and an extended window for growth running deeper into the fall period. This has potential to translate into more crop options and perhaps more crops per year. The potential for heat extremes and warm season heat waves to be warmer and more frequent will create potential for increased heat stress to crops and livestock, and higher rates of evapotranspiration could cause increased water demand for cooling, irrigation and drinking.

4.8 MANITOBA WATER STEWARDSHIP SUPPLIED CLIMATE PROJECTION DATA

In conjunction with the review of published global, national and regional climate projection estimates available in the scientific literature, the study also analyzed a dataset of model run output files provided by Manitoba Conservation and Water Stewardship for application in this assessment.

The data provided was limited to projections for two climate parameters; precipitation and surface air temperature data; with all simulations originally run over the North American geographic domain under Emissions Scenario SRES A2, an emissions scenario that assumes continued global increases in worldwide greenhouse gas emissions.

The dataset was based on the Canadian Regional Climate Model (CRCM) for the three scenario-based precipitation and temperature data (i.e. the 2011-2040, 2041-2070, and 2071-2099 dataset). The geographic domain for this model output is shown in Figure 14. Climate modeling projections were prepared and furnished to Manitoba Conservation and Water Stewardship by Manitoba

Hydro's climate change group using model runs conducted by Ouranos, a Canadian Climate Modelling Research Centre based in Quebec. Manitoba Hydro participates in a climate change research consortium which is led by Ouranos, and the Province of Manitoba receives climate model output datasets from Manitoba Hydro in its role with the Ouranos consortium. The datasets provided were based on the version 4.2 of the Canadian Regional Climate Model (CRCM4.2). The regional model was driven by the Canadian Centre for Climate Modelling and Analysis' CGCM3 (coupled global climate model), a third generation global couple climate model and ECHAM5, a European global climate model. For this assessment, Manitoba Conservation provided future climate change scenarios data projections for the following future time horizons:

- 2011-2040 (the 2020 Horizon)
- 2041-2070 (the 2050 horizon)
- 2071-2099 (the 2080 Horizon)

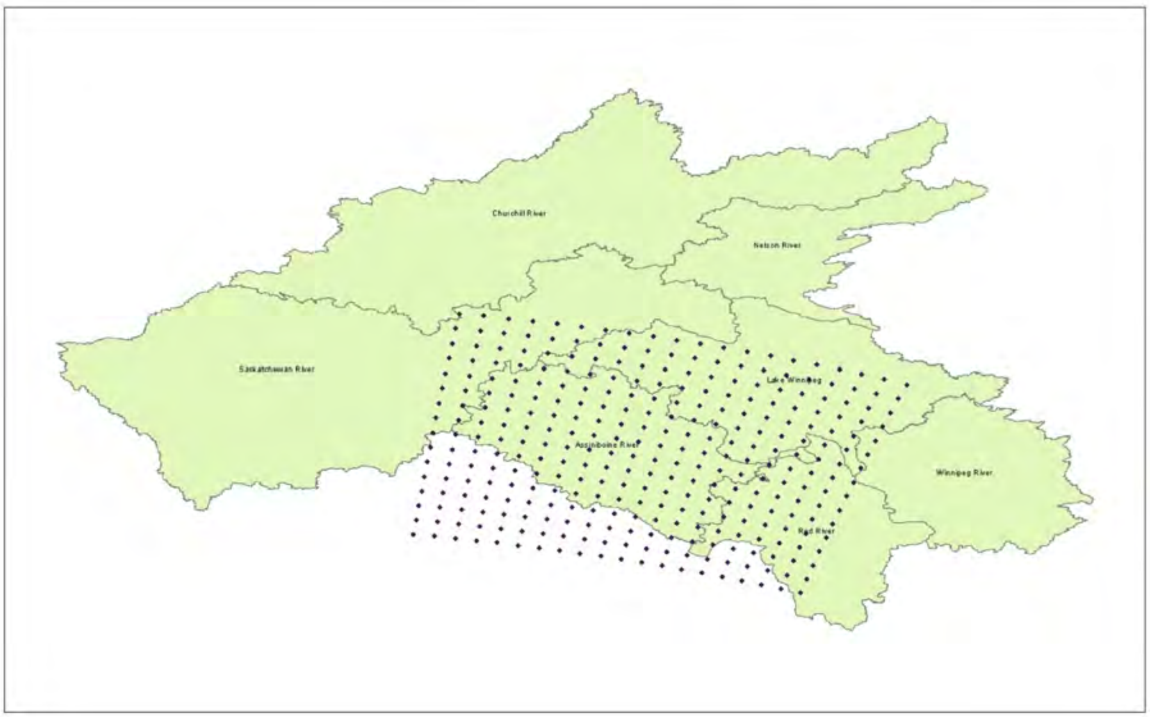


Figure 16: Canadian Regional Climate Model Coverage for the Assiniboine River Basin

The Study Team reviewed the collection of regional climate model (RCM) climate projection data sets provided by Manitoba Conservation and Water Stewardship and assessed the applicability of the provided data. After some adjustment of the modeling results, a total of three groupings of model runs were selected, with these groupings each containing sufficient model runs covering the three time horizons of interest to this study. The model runs utilized in the analysis of future climatic conditions including the model runs and time series are summarized in Table 8.

The three sets of climate projection runs were compared to historical records for precipitation and surface temperature for Environment Canada meteorological stations available from the Environment Canada National Climate Data and Information Archive. Data obtained were generally restricted to the Manitoba portion of the Assiniboine River Basin. A listing of the historical data obtained for the climate analysis is provided in Table 9. Figure 14 illustrates the geographic distribution of these stations within the Assiniboine River basin.

Table 9: Future Climate Change Scenario Model Runs: Summary of Runs Applied to Assessment

Run Name	Run #	Model Name	Driver	Time Series
AET	#4	CRCM4.2.3	CGMC3	1961-2000
	#4	CRCM4.2.3	CGMC3	2011-2040
	#4	CRCM4.2.3	CGMC3	2041-2070
	#4	CRCM4.2.3	CGMC3	2071-2099
AEV	#5	CRCM4.2.3	CGMC3	1961-2000
	#5	CRCM4.2.3	CGMC3	2011-2040
	#5	CRCM4.2.3	CGMC3	2041-2070
	#5	CRCM4.2.3	CGMC3	2071-2099
AGX	#1	CRCM4.2.3	ECHAM5	1961-2000
	#1	CRCM4.2.3	ECHAM5	2011-2040
	#1	CRCM4.2.3	ECHAM5	2041-2070
	#1	CRCM4.2.3	ECHAM5	2071-2099

Table 10: Meteorological Stations within the Assiniboine River Basin

Station Name	Data Year		Province	Location	
				Latitude	Longitude
BRANDON CDA	1961	2010	MB	49°52’00.000"	99°59’00.000"
BRANDON A	1961	2011	MB	49°54’36.000"	99°57’07.000"
SHILO	1961	1999	MB	49°46’58.000"	99°38’35.000"

Station Name	Data Year		Province	Location	
				Latitude	Longitude
NINETTE	1961	1999	MB	49°24’00.000"	99°38’00.000"
HAMIOTA	1961	1991	MB	50°11’00.000"	100°37’00.000"
CYPRESS RIVER	1961	2011	MB	49°33’00.000"	99°05’00.000"
DELORAINE 2	1961	2005	MB	49°10’00.000"	100°24’00.000"
PLUMAS	1961	1994	MB	50°22’00.000"	99°05’00.000"
KELWOOD	1961	1993	MB	50°37’00.000"	99°28’00.000"
GRASS RIVER	1961	1997	MB	50°31’00.000"	98°58’00.000"
PILOT MOUND (AUT)	1961	2011	MB	49°11’27.700"	98°54’17.500"
ROSSBURN	1961	1990	MB	50°40’00.000"	100°49’00.000"
PIERSON	1961	2007	MB	49°11’00.000"	101°16’00.000"
DAUPHIN A	1961	2011	MB	51°09’00.000"	100°02’00.000"
PORTAGE SOUTHPORT A	1961	2011	MB	49°54’00.000"	98°16’00.000"
DAUPHIN	1961	1997	MB	51°09’00.000"	100°02’00.000"
GILBERT PLAINS	1961	2011	MB	51°06’00.000"	100°28’00.000"
DEERWOOD	1961	1995	MB	49°24’00.000"	98°19’00.000"
MOOSOMIN	1961	2000	SK	50°08’00.000"	101°40’00.000"
RUSSELL	1961	1990	MB	50°46’00.000"	101°17’00.000"
MORDEN CDA	1961	1998	MB	49°11’00.000"	98°05’00.000"
ERIKSDALE	1961	1992	MB	50°50’00.000"	98°14’00.000"
LANGENBURG	1961	2011	SK	50°54’00.000"	101°43’00.000"
OXBOW	1961	2011	SK	49°19’00.000"	102°07’00.000"
ASHERN	1961	1991	MB	51°08’00.000"	98°22’00.000"

Station Name	Data Year		Province	Location	
				Latitude	Longitude
CARLYLE	1961	1996	SK	49°38’00.000"	102°16’00.000"
KELLIHER	1961	2011	SK	51°15’26.700"	103°45’10.900"
CUPAR	1961	2011	SK	50°51’00.000"	104°16’00.000"
LIPTON	1961	2000	SK	50°51’00.000"	103°46’00.000"
SEMANS	1961	1994	SK	51°25’00.000"	104°44’00.000"
WYNYARD	1961	1991	SK	51°46’00.000"	104°12’00.000"
DUVAL	1961	2011	SK	51°11’00.000"	104°52’00.000"
NOKOMIS	1961	2007	SK	51°31’00.000"	105°00’00.000"
PASWEGIN	1961	2003	SK	51°59’00.000"	103°55’00.000"
INDIAN HEAD PFRA	1961	1996	SK	50°33’00.000"	103°39’00.000"
MARGO	1961	2007	SK	51°50’00.000"	103°20’00.000"
LUMSDEN	1961	1994	SK	50°39’00.000"	104°52’00.000"
DAVIN 6	1961	1993	SK	50°22’00.000"	104°09’00.000"
DAVIN 5	1961	1993	SK	50°22’00.000"	104°10’00.000"
KUROKI	1961	1999	SK	52°00’00.000"	103°27’00.000"
DILKE	1961	1996	SK	50°52’00.000"	105°10’00.000"
REGINA CDA	1961	1993	SK	50°24’00.000"	104°34’00.000"
REGINA INT’L A	1961	2011	SK	50°26’00.000"	104°40’00.000"
WILCOX	1961	1993	SK	50°10’00.000"	104°20’00.000"
WATROUS	1961	2007	SK	51°40’00.000"	105°28’00.000"
MUENSTER	1961	2011	SK	52°20’00.000"	105°00’00.000"
YORKTON A	1961	2005	SK	51°16’00.000"	102°28’00.000"

Station Name	Data Year		Province	Location	
				Latitude	Longitude
PILGER	1961	2011	SK	52°25’00.000"	105°09’00.000"
BRIERCREST	1961	1992	SK	50°09’00.000"	105°16’00.000"
YELLOW GRASS	1961	2011	SK	49°49’00.000"	104°11’00.000"
MOOSE JAW A	1961	2011	SK	50°20’00.000"	105°33’00.000"
DAVIDSON	1961	2005	SK	51°16’00.000"	105°59’00.000"
BANGOR	1961	2005	SK	50°54’00.000"	102°17’00.000"
KIPLING	1961	2011	SK	50°12’00.000"	102°44’00.000"
PORCUPINE PLAIN 2	1961	1995	SK	52°36’00.000"	103°15’00.000"
WEYBURN	1961	2011	SK	49°39’00.000"	103°50’00.000"
WHITEWOOD	1961	2007	SK	50°21’00.000"	102°16’00.000"
TUGASKE	1961	2009	SK	50°53’00.000"	106°18’00.000"
RADVILLE	1961	1996	SK	49°30’00.000"	104°17’00.000"

4.9 PREDICTED FUTURE CLIMATE TRENDS BASED ON CLIMATE MODEL PROJECTIONS

Climate models currently provide the major source of data for constructing scenarios of climate change. Global climate models (GCMs) are considered to be the only credible tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations, since they are based upon mathematical representations of atmosphere, ocean, ice cap and land surface processes (Canadian Climate Change Scenarios Network (CCCSN.ca)). Global climate models are considered to be the only tools that estimate changes in climate due to increased greenhouse gases for a large number of climate variables in a physically consistent manner (CCCSN.ca). However, while global climate models accurately represent global climate, their simulations of current regional climate are often not accurate (IPCC, 1886; Giorgi et al, 2001 – CCCSN.ca), and they do not produce output on a geographical and temporal scale fine enough for many impact assessments. Due to this limitation post processing and downscaling techniques have been developed to address this. For the model runs selected for use in this study, the Canadian Regional Climate Model 4.2.3 was driven by the CGCM and ECHAM5 global climate models. This approach nests the regional climate models within the driving global climate model so the high resolution model simulates the climate features and physical processes in much greater detail for a limited area of the globe, while drawing information about initial conditions, time-dependent lateral meteorological conditions and surface boundary conditions from the global climate model (CCCSN.ca).

This study analysed Canadian regional climate model datasets using the principles outlined in the guide issued by CCCSN.ca for climate scenario development.

The Canadian Climate Change Scenarios Network indicates that among the two main approaches generally used in climate impact studies, the most commonly applied and simplest means to develop climate change information is to use the delta method and apply the global climate model signal calculated in the future to the observed/ historical record climate (CCCSN.ca). The analysis applied this delta method to the climate projection dataset.

For each model run dataset (AET, AEV, AGX), climate model output was used to determine future changes in temperature and precipitation by calculating either the difference (for temperature values) or the ratio (for precipitation values) between simulated future conditions and simulated present day conditions. Once these delta values were calculated they were then applied to the observed historical climate data as input to impacts planning models or processes.

Each model run will generate output data influenced by the algorithms specific to and assumptions within each distinct model. The study combined the three selected model run output datasets using a multi-model mean. The multi-model mean is an average of simulations in a multi-model ensemble, treating all models in the ensemble equally (i.e. an unweighted multi-model mean). According to the IPCC, there is some evidence that the multi-model mean field is often in better agreement with observations than any of the fields simulated by an individual model, which supports continued reliance on a diversity of modeling approaches in projecting future climate change (Climate Models and their Evaluation, Randall et al., AR4 WG 1 Chapter 8).

For this study, multi-model ensemble averages were developed for each time horizon for the supplied temperature and precipitation model outputs. This ensemble incorporates results sets for three models for each time horizon. An ensemble average scenario simulation consists of a number of climate change runs undertaken with identical forcing scenarios. The multi-model mean values were then used to determine future changes in temperature and precipitation, which were then applied to observed historical data to define an estimated future climate condition (temperature or precipitation). From these estimated future climate conditions, trends can be identified for future planning and adaptation efforts.

Trends derived from the multi-model mean ensemble data were compared to projected trends in climate for North America published in IPCC Reports. As another layer of comparison, the trends derived from ensemble average model output was also compared to another available set of projected changes in temperature and precipitation for Southern Manitoba presented in the report "Climate Change Information for Adaptation (Climate Trends and Projected Values from 2010 to 2050)", data published by the Institute for Catastrophic Loss Reduction.

4.10 APPLYING CLIMATE PROJECTIONS TO ESTIMATE CLIMATE CHANGE-INDUCED WATER DEMAND

The provided climate projection dataset included future temperature and precipitation projections with a daily time step. Each file contained daily data, comprising approximately 94,000 data entries (129 years x 365 days x 2 variables) over the Assiniboine River basin domain. A number of anomalies in the provided dataset were identified. In one case, two data series were found to be identical, and so the Study Team asked for verification of the supplied model output. In another dataset, data were found to be missing for the 2041-2070 time series. Due to the massive size of the dataset and the scope/budget constraints within this study, repeated manipulation and processing of this massive dataset was not possible. In the Assiniboine River Basin Hydrologic Modelling Study, a parallel study conducted for Manitoba Conservation and Water Stewardship, the assessment team reviewed three baseline model runs providing modeled projection output data for the baseline period (1961-2000) and the three other future time period horizons: 2011-2040 ("2020 horizon"), 2041-2070 ("2050 horizon") and 2071-2099 ("2080 horizon"). A comparison was made and one model run was chosen based upon the best agreement between model-predicted baseline (1961-2000) output and recorded historical values over the same period.

The selection of the AET model run allowed the application of this projected climate output over a grid spaced at 45 km intervals across the entire basin. This approach allowed integration of climate model projected output over the full basin domain for detailed basin-wide modeling purposes. However, the presentation of climate projections across the entire basin was considered to be too large. Therefore Brandon, Manitoba was selected as the representative location for the domain to predicting climate change trends and potential impacts on water demands for this study. This resulted in the application of three sets of model runs (model runs AET, AEV, AGX) incorporated into a multi-model ensemble average for the study time horizons. Table 10 presents a summary of the ensemble average projections comprised of the inclusion of the AET, AEV, AGX model run sets, and comprises these projections with other projection summaries developed for the southern Manitoba region.

Table 11: Ensemble Average ARB Climate Projection Comparisons

Climate Parameter	AET, AEV, AGX Ensemble Average (Brandon, MB)			Southern MB (2050) (Compiled by D. Blair: S. MB Trends and Projections)	Southern MB (2050) Institute for Catastrophic Loss Reduction
	2020	2050	2080		
Winter Temperature	+2	+3.6	+5.5	+3 to +5	+3 to +4
Spring Temperature	+0.8	+1.7	+3.7	+1 to +2	+3 to +4
Summer Temperature	+1.5	+3.0	+5.0	+1 to +2	+2 to +4
Fall Temperature	+1.9	+3.2	+5.2	+1 to +2	+1 to -2
Winter Precipitation	+5%	+17%	+20%	Substantial increase	+0 to 15%
Spring Precipitation	+8%	+19%	+23%	Increase	+5 to 15%
Summer Precipitation	-3%	-2%	-7%	Reduction	-10 to +10%
Fall Precipitation	+10%	+10%	+18%	Increase	-10 to +10%
Cooling-degree Days	↑	↑	↑	↑	↑
Heating-degree Days	↓	↓	↓	↓	↓
Growing-degree Days	↑	↑	↑	↑	↑

In summary, looking over the three future time horizons, important changes affecting the basin were simulated in the ensemble average project dataset:

- Temperatures:
  - Winter temperatures are expected to increase, between 2-6°C.
  - Spring temperatures are expected to increase, between 1-4°C.
  - Summer temperatures are expected to increase, between 1.5-5°C.
  - Fall temperatures are expected to increase, between 2-5°C.
- Precipitation:
  - Precipitation increases are predicted for winter, spring and fall, with the largest increases in the spring.
  - Precipitation reductions are expected in the summer season, with reductions growing with time for this season.
- General:
  - More frost-free days are anticipated.
  - Earlier seeding opportunities could occur by approximately two to three weeks; however,
  - Increased potential for flooding events.
  - Increased potential for summer drought.

4.11 REVIEW OF ADDITIONAL RELEVANT CLIMATE CHANGE REPORTS AND STUDIES

In addition to the Canadian-based information sources related to climate trends discussed in the previous sections above, a large volume of peer-reviewed technical information is available through the Intergovernmental Panel on Climate Change (IPCC). The IPCC is a scientific intergovernmental body tasked with reviewing and assessing the most recent scientific, technical and socio-economic information from sources throughout the world relating to the understanding of climate change. Its function is to provide the world with a clear, peer-reviewed scientific view on the current state of climate change and the consequences resulting from it. The IPCC was established in 1988 by the World Meteorology Organization and the United Nations Environment Program. National and international responses to climate change generally regard the IPCC as authoritative in the realm of climate change current understanding.

A major function of the IPCC is the preparation of assessment reports, which are compendiums of peer-reviewed and published science pertaining to climate change. The current Fourth Assessment Report is known as AR4. Each subsequent IPCC report details areas where the state of climate change-related science has improved since the previous report and also indicates areas where further research is required.

The study reviewed the Fourth Assessment Report (AR4), with an emphasis on the chapters written by working groups 1 and 2. Working group 1 content focused on the physical science basis for climate change. Working group 2 content focused on impacts, adaptation and vulnerabilities to climate change. Within the technical chapters published by the AR4 working groups, specific chapters were selected for review on the basis of seeking content relevant to the Assiniboine River basin geographic location, relevant physical systems. The review found the IPCC information to be consistent with the Canadian-based information discussed in previous sections.

4.12 WATER DEMAND FOR PROJECTED CLIMATE SCENARIOS

The ability to assess water demand responses to projected changes in climate is highly dependent on the quantity and quality of meteorological data.

4.13 DOMESTIC DEMAND

For domestic water demands, future demands could be altered by the presence of more intense rain and the presence of warmer temperatures. Climate change induced alteration to the hydrologic cycle could manifest in increased demand for residential activities such as lawn and garden watering. However such increases can be reduced through policy changes (lawn watering restrictions) and also the uptake of more efficient technologies.

A study conducted in the UK in 2003 suggests that domestic demand for water is driven primarily by the interplay between warmer climates, household choices regarding water consuming appliances and technologies and the regulatory environment (CCDeW: Climate Change and the Demand for Water, Research Report, Stockholm Environment Institute Oxford Office, Oxford. Stockholm Environment Institute, 2003). Increased frequency of drought could drive the adoption of more aggressive water saving technologies and other adjustments to reduce domestic demand.

4.14 INDUSTRIAL/COMMERCIAL DEMAND

Aside from agricultural production and farming, food processing is the prominent industry in the region. This is complemented by industries and commerce supporting the agriculture industry for the Assiniboine River basin, including seed processors, thermal generation of electricity, agricultural chemical manufacturing and distribution terminals. Industries with the potential for highest water demands, such as soft drink production and brewing operations are not present in the region.

4.15 AGRICULTURAL DEMAND

Due to the dominance of crop irrigation in the overall agricultural water demand for this region, changes in irrigation demand are considered the primary driver in demand estimates under future climate projections.

Irrigation demand is sensitive to factors with significant exposure to changes in climate, such as crop type/species, changes in plant physiology, soil-water storage balances, timing and amounts of precipitation, evapotranspiration, cropping spatial patterns, as well as local to global social and economic factors, such as population demand changes for different food crops, and commodity prices.

4.16 GROWING SEASON FACTORS

In projecting agricultural water demands for the future, it is important to first consider the effects of changing climate on the ability of the agro-climate to support crop types. A couple of key agro-climatic factors are growing season length (and frost-free period) and accumulated crop heat units. One approach to evaluate this is by using the predicted temperatures to calculate growing degree days (GDD) for future years. Growing degree days give an indication of the energy available for plants to grow and develop, and are expressed as heat accumulated above a given base temperature.

A base temperature of 5°C is commonly used in Manitoba for determining accumulated growing degree days. Using a base temperature of 5°C and the predicted daily temperatures for the horizons 2020, 2050 and 2080, accumulated growing degree days were found to increase with time from 2020 to 2050 for Brandon, MB.

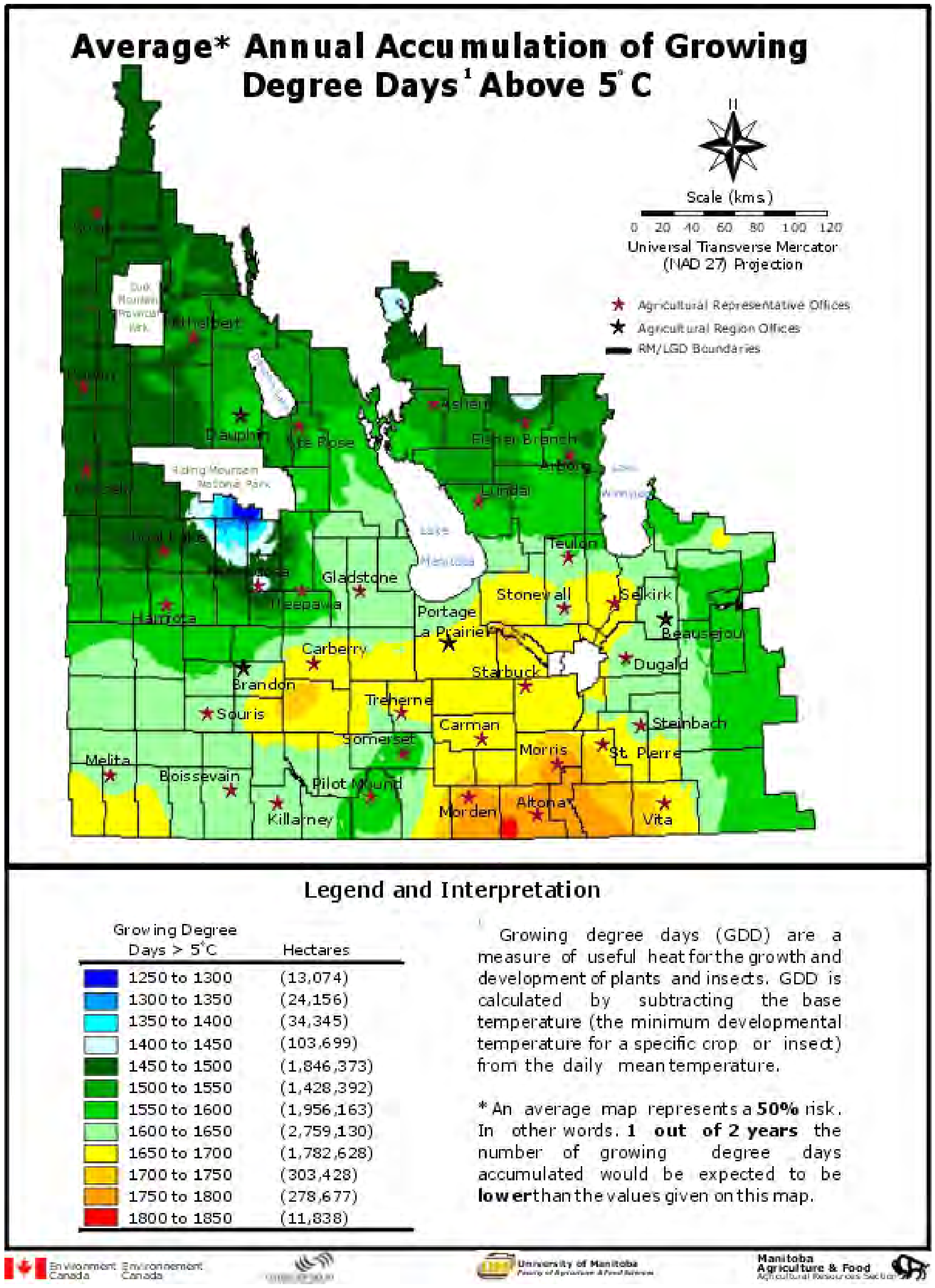
Table 12: Predicted Growing Degree Days for Brandon, Manitoba

Year	Annual accumulation of GDD above 5°C	Annual accumulation of GDD above 10°C (equivalent GDD in °F)	Frost free days (above 0°C)[1]
(Normals) (baseline)[2]	1650	1000	110
2020	1636	1579 (1644)	156
2050	1721	1560 (1829)	161
2080	2382	1854 (2821)	186

Notes:
[1] Frost free days for 2020, 2050 and 2080 estimated to be the total number of days with minimum temperature > 0°C from April 1st to October 31st.

[2] Average annual GDD for Brandon from a map representing 50% risk based on Environment Canada normals (1971-2000). Source MAFRI, available at : http://www.gov.mb.ca/agriculture/climate/waa50s00.html

In the short-term (2020 horizon), growing degree days (above 5°C) is estimated to fall within the current average range for the area as seen in Table 11 and Figure 15. However, in the long-term, the growing degree days for Brandon is predicted to rise markedly to resemble currently observed for warmer southern Manitoba areas (Morris in 2020, and the hotspot between Morden and Altona in 2050). As such, a climate-driven shift in the crops grown in the Brandon area might only be expected after 2020. Strongly related to growing degree days are frost-free periods which are also predicted to increase with time. Frost free days are predicted to be 156, 161 and 186 days for 2020, 2050 and 2080, respectively. Increasing growing degree days and frost-free periods will encourage the growing of crops like corn and soybeans which require warmer base temperatures (~10°C) compared to other crops and crops requiring a longer growing season, such as corn and sunflowers. Generally, the Red River Valley area in southern Manitoba currently offers the northern fringe of productive growing conditions for these warmer climate crops.



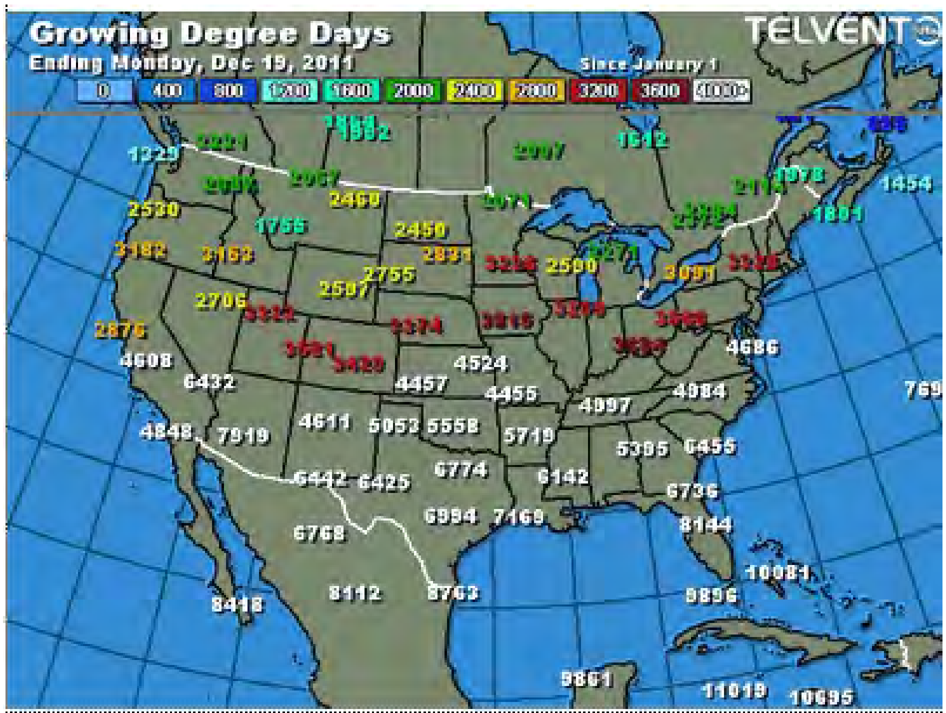
(http://www.gov.mb.ca/agriculture/climate/images/figure11.gif)

Figure 17: Average Growing Degree Days for Manitoba

It is useful to compare the predicted growing degree days for Brandon versus current growing degree days in agricultural regions in the northern and mid-western United States. Based on an examination of the season, accumulated growing degree days (above 10°C) were approximately 2450, 2825, 3375 and 4500 for the agricultural regions of North Dakota, South Dakota, Iowa and Kansas, respectively as seen in Figure 16. While the predicted Brandon growing degree days for

2050 is similar to that of the most northern areas of the United States (e.g. northern Minnesota), the growing degree days predicted for 2080 appears similar to that of the South Dakota agricultural region.

Given that the top five crops grown in South Dakota (total acres) are corn, soybeans, wheat, forage and sunflower (2010 South Dakota Crop Insurance Profile), it seems reasonable to predict that the Brandon area could provide a climate that would be favorable to a similar crop mix by 2080. While this evaluation does not consider crop water demands, crop-available water and crop water deficits, such a shift in the crops grown would have the potential to increase agricultural water demand including an increase in irrigated acres.



(http://farmersca.com/index.cfm?show=1&mapID=35)

Figure 18: Accumulated Year-to-Date Growing Degree Days (°F) for North America (January 01 to December 19, 2011

4.17 IRRIGATION WATER DEMAND

From the discussion above, changes in growing degree days and frost free periods will likely affect crop water demand. However, predicting the change in the water demand for irrigation from the Assiniboine River is difficult given that the historical basis for irrigation expansion in the area has been generally limited to the expansion of potato processing in Manitoba. A logical first step in estimating future water demands for irrigation from the Assiniboine River is to determine the potato crop water demand based on predicted climate change scenarios. For the Brandon area, the current average water demand to maturity for potatoes is 15.6-16.5 inches (or approximately 400-420 mm) and the average water deficit to maturity for potatoes is 4.1-5 inches (or approximately 105-125 mm) when contributions from soil-water storage and precipitation is considered.

Predicted potato crop water deficits for the time horizons 2020, 2050 and 2080 were determined and used as the basis for commenting on future irrigation requirements for crops in Manitoba since the vast majority of irrigation water from the Assiniboine River is used on potato crops and will continue to be for the foreseeable future. The approach used examined the change in potato crop water deficit at future periods of interest using daily predicted average temperature (°C) for the potato growing season, daily predicted precipitation (mm/day) for the potato growing season and daily crop water demand (mm/day) for potatoes as modified from Table 12 (Manitoba Agriculture, Food and Rural Initiatives. 2011. Commercial Potato Production – Irrigation).

Table 13: Average Daily Water Use after Emergence (NSDU, 1988)

Average Potato Water Use (inches/day)(NDSU, 1988)															
Temp (ºC)	Weeks After Emergence														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
10-15	.02	.03	.04	.05	.07	.08	.08	.08	.08	.08	.08	.07	.06	.05	.04
16-20	.03	.04	.07	.09	.11	.13	.14	.14	.14	.13	.13	.12	.10	.09	.07
21-26	.04	.06	.09	.12	.15	.17	.19	.19	.19	.19	.18	.17	.14	.12	.10
27-31	.05	.08	.12	.16	.19	.22	.25	.25	.25	.24	.23	.21	.18	.16	.13
32-37	.06	.10	.14	.19	.24	.27	.30	.30	.30	.29	.29	.26	.23	.19	.16
Growth Stage	Vegetative			Tuber Set		Tuber Bulking								Maturation	
A pre-emergence period of 3 weeks after planting date (average date May 15). Zero contribution from soil water storage. Plant water demand at temperatures below 10°C is half the quantity of water demand at 10-15°C.															

Water deficit predictions for potatoes were made for the 2020, 2050 and 2080 growing seasons following the given approach and assuming the following:

Based on the changes to growing season precipitation and temperature data discussed above, water deficits were estimated to be approximately 130 mm, 180 mm and 300 mm in 2020, 2050 and 2080, respectively as seen in Figure 17. These estimated water deficits are approximately 16%, 55% and 162% above the 2010 baseline water deficit for the periods represented by 2020, 2050 and 2080 horizons respectively.

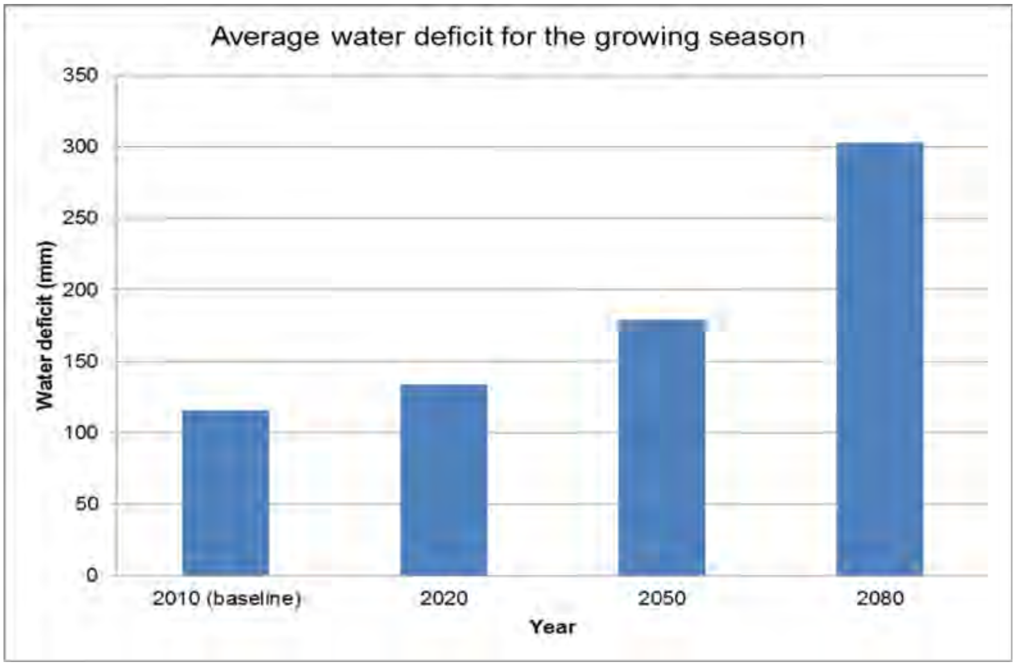


Figure 19: Predicted average water deficit for the Brandon area growing season

The predicted water allocations required for irrigated crops in Manitoba in 2020, 2050 and 2080, based on the irrigated acreage increases and increased water allocations proportional to the increased water demands for potatoes, are displayed in Figure 18. It is reasonable to predict that a licensed water allocation for irrigated crops in the Assiniboine River basin would be close to 38,000 acre-feet by 2080, or approximately double the baseline water allocation. Assuming the climate change scenario, this volume was estimated to be much higher at approximately 73,000 acre-feet.

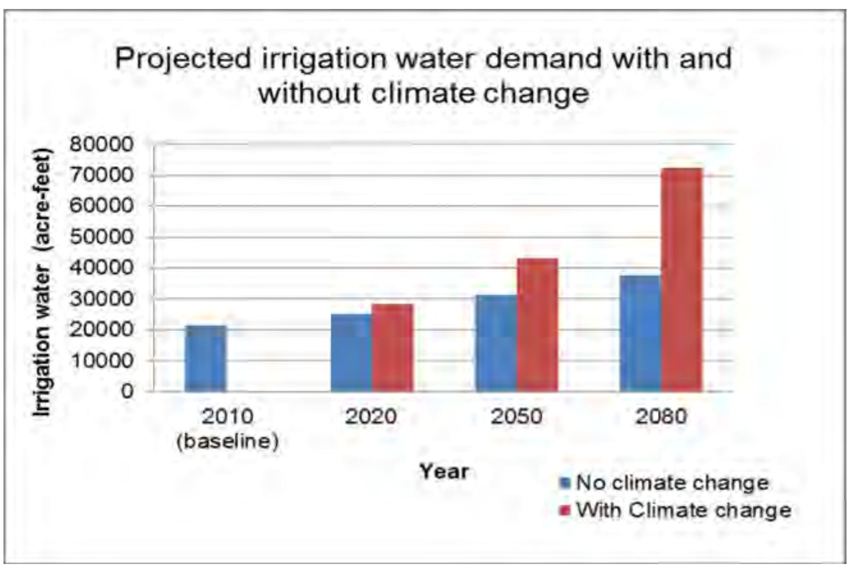


Figure 20: Predicted Future Irrigation Water Demand for "With Climate Change" and "Without Climate Change" Scenarios in the Assiniboine River Basin

The growth of irrigation in the Assiniboine River basin has been largely driven by the expansion of the potato processing industry. Exclusive of irrigation demand changes caused by climate change, market conditions causing reduced demand for irrigation water to supplement potato crop water demands, could only be countered by a significant increase in cropping of other specialty or high-value crops requiring less supplemental irrigation. Although additional suitable land is available within the region for irrigation development, over the short-term it is not likely that these crop changes could take place on a scale to replace the irrigation demand required by potato crops during their peak production years in this region.

However, based on climate change predictions, the projected upward trend in temperature and accumulated crop heat units might have the potential to shift the current crop mix from cereal, oilseeds, hay and potato mix to include long season, warmer temperature crops like corn and sunflowers (MAFRI, Agricultural Climate of Manitoba, 2011). From the previous discussion on predicted increase in growing season factors like growing degree days and frost free days, and considering these factors alone, the Brandon climate could shift towards something comparable to that of South Dakota by 2080 and support the growth of crops currently grown in that region (e.g., corn, soybeans, wheat, forage and sunflowers) (2010 South Dakota Crop Insurance Profile). Similar to potatoes; corn, soybeans and sunflowers are high water demand crops (Table 13). Therefore, a shift in, or expansion of, the crops grown in the basin to include corn, soybean and sunflower (in the long-term) could potentially increase irrigation water demand – both through increased water requirements on the current irrigated land base or an increase in irrigated acres, or both. Further, increased crop water deficits for crops not traditionally irrigated in Manitoba, or representing a minor portion of irrigated acres in Manitoba (e.g., cereals, oilseeds and pulses), will likely benefit from, or require for survival, additional supplemental crop water through irrigation. Although wheat and forage are currently grown in the region, warmer temperatures and longer growing seasons might result in the expansion of irrigated wheat and high value forage (e.g. alfalfa) production. Such an expansion of irrigated crops would elevate plant water use and hence irrigation water demand.

Although the expansion of irrigated crop production (and hence irrigation water demand) in the Assiniboine River basin has historically been positively correlated with expanded potato production, continuity of this trend does not appear likely in the foreseeable future due to the global decline in demand for potatoes. However, given the long-term potential shift in crops grown under the predicted climate change scenario to include crops that have similar/ higher water demand than potatoes, it appears reasonable that irrigation water demand will potentially increase under these conditions, even in the absence of a corresponding increase in irrigated acres.

Table 14: Approximate Growing Season Total Water Use for Some Commonly Grown Crops in Alberta and Midwestern United States

Crop	Total Growing Season Water Use (mm)
Alfalfa hay (3 cuts)	540-680
Barley	380-430
Canola	400-480
Corn	658
Soybean	550-660
Flax	340-440
Pea	300-370
Potato	400-550
Sugar beet	500+
Wheat (spring)	420-480
Sunflower	458-635

References:

- Government of Alberta 2011. Crop water use and requirements.
- Average water use for corn grown in South Central Nebraska. NebGuide, Irrigation Management for Corn.
- Water use of oilseed crops- derived from the Colby, KS trials. Proceedings of 23rd Annual Central Plains Irrigation Conference, Burlington, CO., February 22-23, 2011.

5.0 VISIONING PROCESS

5.1 ASSINIBOINE RIVER STAKEHOLDERS

An important component of the study involved consulting with licensed water users and Assiniboine River stewards. Key stakeholders included the following:

- Agricultural Producers - irrigated crop producers currently using or planning on using Assiniboine River water.
- Industry groups - Association of Irrigators in Manitoba (AIM), Keystone Agricultural Producers (KAP) and Keystone Vegetable Producers Association (KVPA).
- Government Agencies – Federal and Provincial agricultural, water and climate change administrators, Rural Municipalities and Conservation Districts.
- Major Food Processors – McCain Foods, Simplot and Maple Leaf.
- Industrial Users - Manitoba Hydro and Bunge.
- Municipal Users - City of Brandon, City of Portage la Prairie, Cartier Regional Water Co-op and the RM of Wallace Regional Water System.

A visioning workshop was held to bring stakeholders together in order to present climate change data and to discuss baseline water demand data from the Assiniboine River and future trends based on climate change scenarios. A combined workbook and questionnaire was prepared in order to obtain feedback on the climate change scenarios presented at the workshop and to acquire additional information regarding major demand components and aspects of the water regime such as:

- Water demand, current and future within all user groups.
- Irrigation, present and future.
- Crops currently irrigated and planned to be irrigated.
- Irrigation management practices.
- Water quantity, quality, and withdrawal issues.

- Watershed management.
- Conservation practices.

The visioning workshop was held at the Portage la Prairie CanadInn on July 28th, 2011. The purpose of the workshop was:

- To obtain user-specific information and data on water consumption for study input.
- To foster dialogue among users on potential climate change impacts.
- To obtain estimates of future water demand based on status-quo and climate change scenarios.
- To brainstorm strategies for strategic management of water resources.
- To provide a starting point for future contingency planning.

The full day workshop was attended by 43 people representing Assiniboine River stakeholders including water users, water providers, government, policy makers and conservation district representatives.

The workshop was broken down into three sessions:

- Session 1: The Assiniboine River Basin Today.
- Session 2: Future Water Practices: Historic Climate.
- Session 3: Future Water Practices with Climate Change Scenarios.

Presentations were made on:

- Background information on the study purpose and objectives, an economic and demographic overview of the Assiniboine Basin.
- Characteristics of the basin water regime.
- An overview of the climate science and modeling used in the study.
- Current water allocation and usage patterns under historic climate patterns.
- Climate change scenarios used for predicting future water demand over the study's planning horizon.

Workshop participants were each provided with a workbook containing a series of individual questions and group exercises relevant to each of the workshop sessions. Participants were asked to work through the individual questions before participating in round table discussions during the group exercises.

The major observations and conclusions from the visioning exercise are summarized as follows:

- Climate change, as it is predicted to affect Manitoba, is perceived as a potential benefit to the basin in terms of a longer growing season and more crop options.
- Climate related challenges will be met by improved science, technological advances, the adaptive capacity of the agricultural sector, and human resilience and resourcefulness.
- People's attitudes regarding future water availability are influenced by current events including severe weather and spring flooding.
- Participants are cautiously optimistic about the future prosperity of the Assiniboine River Basin due to increased population growth, economic development and agricultural capacity.
- Extreme water levels (too low, too high) are the main issue for users currently.
- Many participants indicated that additional storage was the key to control flooding and maintain river levels at close to year round averages.
- Integrated watershed management is regarded as a complimentary if not alternative to additional storage and would help address issues of water quality, rapid runoff and habitat loss.
- The cost of water supply and especially treatment is a concern for municipalities and water co-ops.
- Water is not a price-sensitive commodity.
- The prospect of a longer growing season will promote new crop varieties and an increase in irrigable acreage.
- The demand for Assiniboine River water and competition among user groups will increase in the coming decades, but a crisis may not be eminent if an integrated and cooperative approach to the problem is taken.
- In the minds of participants, water conservation methods fall into two main categories: domestic conservation and improved irrigation equipment and application methods.
- Increased government regulation is a feared by-product of possible future water shortages.
- Among participants, water users indicated a high level of confidence that their current licenses would be protected in the event of an extreme drought.
- Governments need to lead and not just regulate, i.e. be proactive and not just reactive.

6.0 PROJECTED WATER DEMANDS

The projections for population, economic growth and agricultural trends were identified in previous sections of the report. These projections have been used to conceptualize potential water demands for the Assiniboine River for the various categories of licenses for the time horizons 2010 (report baseline), 2020, 2050 and 2080.

Demand projections were developed assuming no climate change (without climate change) for these horizons as well as the possible effects of climate change (with climate change).

The climate change series of demand projections were developed assuming that the climate will change over the study period where the historic weather regime will be replaced by a warmer, wetter climate with the possibility of more severe drought and flooding.

Details of these projected demands and their assumptions are presented in the following sections.

6.1 BASELINE WATER DEMANDS

The report uses 2010 as the baseline year in analyzing water demand scenarios. Upon review of the actual 2010 data, it was noted that 2010 was a much wetter year than average, including historical flooding in the basin’s 2011 spring freshet. The 2010 data therefore required factoring to be more representative of a dryer year. Water demand in a dryer year is higher for each licensed user category.

To factor the 2010 data, information on water use from the “Central Plains Inc. Water Study (2008)” was used. The study looked at data for the year 2006 which is considered by Manitoba Conservation and Water Stewardship to be a representative dry year. Table 14 summarizes the 2010 baseline allocation data for the study. It includes the 2006 water use, 2010 licensed allocations and water use and the estimated 2010 baseline water use that will be used for projecting demands for the study time horizons of 2020, 2050 and 2080. Comments and assumption are also included.

Table 15: Assiniboine River Baseline Allocation Summary (2010)

Category	Licensed or Committed Volume 2010 (acre-feet)	Water Use 2006* (acre-feet)	Water Use 2010 (acre-feet)	Comments and Assumptions	Water Use Estimate 2010 Baseline (acre-feet)
Reach 1					
Municipal - RM of Wallace	1,260	178	342	2010 actual data increased based on projected usage on per capita consumption in 2006 and accounting for increased customers on the regional water system.	440
Municipal – Brandon	12,010	9,865	6,811	2010 actual data increased based on projected usage on per capita consumption in 2006 and accounting for recent population growth in Brandon.	9,900
Agricultural	0	0	0	No change.	0
Industrial - Manitoba Hydro	6,415	6,415	6,415	Full licensed allocation usage assumed.	6,415
Industrial – Bunge	190	190	190	Full licensed allocation usage assumed.	190
Irrigation	665	665	665	Outstanding 2010 applications included to this license category. Full licensed allocation usage assumed for baseline. In a dry year it is assumed that irrigators will use their full license volume.	1,005
Recreational	0	0	0	No change.	0
Outstanding Applications	340	0	0	Outstanding licenses are assumed to be all irrigation and therefore added to that category of license.	0
Reach 1 Total	20,880	17,313	14,423		17,950

Category	Licensed or Committed Volume 2010 (acre-feet)	Water Use 2006* (acre-feet)	Water Use 2010 (acre-feet)	Comments and Assumptions	Water Use Estimate 2010 Baseline (acre-feet)
Reach 2					
Municipal - Portage la Prairie	7,255	4,322	5,221	2010 actual data increased based on projected usage on per capita consumption in 2006.	6,000
Agricultural	0	0	0	No change.	0
Industrial	0	0	0	No Change.	0
Irrigation	12,584	12,584	12,584	Outstanding 2010 applications included to this license category. Full licensed allocation usage assumed for baseline. In a dry year it is assumed that irrigators will use their full license volume.	16,276
Recreational	0	0	0	No change.	0
Outstanding Applications	3,692	0	0	Outstanding licenses are assumed to be all irrigation and therefore added to that category of license.	0
Reach 2 Total	23,531	16,906	17,805		22,276
Reach 3					
Municipal – Cartier Water Coop	4,850	467	589	2010 actual data increased based on projected usage on per capita consumption in 2006 and accounting for increased customers on the regional water system.	765
Agricultural	0	0	0	No change.	0
Industrial	0	0	0	No change.	0
Irrigation	6,359	6,359	6,359	Outstanding 2010 applications included to this	6,624

Category	Licensed or Committed Volume 2010 (acre-feet)	Water Use 2006* (acre-feet)	Water Use 2010 (acre-feet)	Comments and Assumptions	Water Use Estimate 2010 Baseline (acre-feet)
				license category. Full licensed allocation usage assumed for baseline. In a dry year it is assumed that irrigators will use their full license volume.	
La Salle Diversion	22,000	22,000	22,000	Full licensed allocation usage assumed.	22,000
Recreational – Crescent Lake	5,500	5,500	5,500	Full licensed allocation usage assumed.	5,500
Outstanding Applications	265	0	0	Outstanding licenses are assumed to be all irrigation and therefore added to that category of license.	0
Reach 3 Total	38,974	34,326	34,448		34,889
Total					
Total	83,385	68,545	66,676		75,115
Instream Flow Needs	16,000				16,000
TOTAL	99,385				91,115
Firm Annual Yield Estimate	112,500				112,500
Uncommitted Estimate	13,115				21,385
* Data from the Central Plains Inc. Water Study (2008).					

6.2 PROJECTED MUNICIPAL WATER DEMAND (2010, 2020, 2050, 2080)

Municipal water demands were projected for the study period using population growth projections developed earlier in the report. It is assumed that municipal water demands will grow at an equal percentage with future population growth at similar per capita water use volumes. For example, if the City of Brandon is expected to grow at a rate of 5% from 2010 to 2020 (0.5% per year), it is assumed that daily water use will increase by 5% as well. Therefore a growth factor of 0.5% per year will be used. Each new person will use the same amount of water daily as an existing Brandon resident. Estimated annual increases for municipal licenses (without climate change) are summarized in the Table 15.

Municipal water demands were also projected to account for climate change. It is assumed that that per capita water use will increase slightly related to outdoor water use based on a dryer, warmer summer season. For the case of the City of Brandon, a growth factor of 0.55% per year will be used. Estimated annual increases considering climate change for municipal licenses are summarized in the Table 15.

Table 16: Municipal License Water Demand Projections

Municipal License Water Demand Projections (2010, 2020, 2050, 2080)(acre-feet)											
	Licensed Allocation 2010	Growth Factor	Growth Factor	2010	2020	2050	2080	2010	2020	2050	2080
				Baseline	Without climate change	Without climate change	Without climate change	Baseline	With climate change	With climate change	With climate change
Reach 1											
RM of Wallace	1,260	0.20%	0.25%	440	449	477	506	440	451	486	524
Brandon	12,010	0.50%	0.55%	9,800	10,301	11,964	13,895	9,800	10,353	12,204	14,387
Reach 2											
Portage la Prairie	7255	0.10%	0.15%	6,000	6,060	6,245	6,435	6,000	6,091	6,371	6,664
Reach 3											
Cartier Water Coop	4,850	0.20%	0.25%	765	780	829	880	765	784	845	911

6.3 PROJECTED AGRICULTURAL WATER DEMAND (2010, 2020, 2050, 2080)

There are no current agricultural licenses in any reaches of the study area and no new licenses are expected for the study period with or without the effects of climate change being considered.

6.4 PROJECTED INDUSTRIAL WATER DEMAND (2010, 2020, 2050, 2080)

The current Industrial licenses Reach 1 and Reach 2 were assumed to remain constant for the study period with no new industrial licenses expected with or without the effects of climate change being considered.

Industrial license water demand projections are summarized in Table 16.

Table 17: Industrial License Water Demand Projections

Industrial License Water Demand Projections (2010, 2020, 2050, 2080)(acre-feet)									
	Licensed Allocation 2010	2010	2020	2050	2080	2010	2020	2050	2080
		Baseline	Without climate change	Without climate change	Without climate change	Baseline	With climate change	With climate change	With climate change
Reach 1									
Manitoba Hydro	6,415	6,415	6,415	6,415	6,415	6,415	6,415	6,415	6,415
Bunge	190	190	190	190	190	190	190	190	190
Reach 2									
Industrial	0	0	0	0	0	0	0	0	0
Reach 3									
Industrial	0	0	0	0	0	0	0	0	0

6.5 PROJECTED IRRIGATION WATER DEMAND (2010, 2020, 2050, 2080)

Analysis completed in earlier sections of the report has speculated that additional irrigated lands with accompanying water demands will be required from the Assiniboine River in the Reaches 1, 2 and 3 for the study period. For all irrigation licenses, it is assumed that the existing licenses will be used to the maximum volume in any given year with all new increases requiring additional licenses. This demand will be greater considering climate change. Irrigated land area projections for the study period are summarized in the Table 17. Estimated annual increases considering climate change for irrigation licenses are summarized in the Table 18.

Table 18: Irrigated Land Area Projections and Growth Factors

Irrigated Land Area Projections and Growth Factors (2010, 2020, 2050, 2080)(acre-feet)				
Year	Irrigated Lands in Manitoba (Acres)	Irrigated Lands in Assiniboine River Region (Acres)	Estimated Annual Increases (Acre-feet)	Estimated Annual Increases With Climate Change (Acre-feet)
2010 (Baseline)	71,000	24,288	21,580	21,580
2020	82,421	28,195	25,051	28,424
2050	102,947	35,217	31,290	43,170
2080	123,473	42,238	37,529	72,508
Growth Factor			1.10%	3.40%

Baseline 2010 irrigated acres approximated to be same as 2006 Irrigation Survey Result.
Assumes demand by crop will not change.
Assumes irrigated crop mix will not change.

Table 19: Irrigation License Water Demand Projections

Irrigation License Water Demand Projections (2010, 2020, 2050, 2080)(acre-feet)											
	Licensed Allocation 2010	Growth Factor	Growth Factor	2010 Baseline	2020 Without climate change	2050 Without climate change	2080 Without climate change	2010 Baseline	2020 With climate change	2050 With climate change	2080 With climate change
Reach 1											
Irrigation	665	1.1%	3.4%	1,005	1,111	1,429	1,748	1,005	1,344	2,360	3,377
Reach 2											
Irrigation	12584	1.1%	3.4%	16,276	17,994	23,150	28,305	16,276	21,763	38,225	54,687
Reach 3											
Irrigation	6359	1.1%	3.4%	6,624	7,323	9,421	11,520	6,624	8,857	15,557	22,256

6.6 PROJECTED RECREATIONAL WATER DEMAND (2010, 2020, 2050, 2080)

The current recreational license in Reach 3 was assumed to remain constant for the study period with no new licenses expected. There are no other recreational other licenses in any reaches of the study area and no new licenses are expected for the study period with or without the effects of climate change being considered.

Recreational license water demand projections are summarized in Table 19.

Table 20: Recreational Water Demand License Projections

Recreational License Water Demand Projections (2010, 2020, 2050, 2080)(acre-feet)									
	Licensed Allocation 2010	2010	2020	2050	2080	2010	2020	2050	2080
		Baseline	Without climate change	Without climate change	Without climate change	Baseline	With climate change	With climate change	With climate change
Reach 1									
Recreation	0	0	0	0	0	0	0	0	0
Reach 2									
Recreation	0	0	0	0	0	0	0	0	0
Reach 3									
Crescent Lake	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500

6.7 PROJECTED DIVERSION WATER DEMAND (2010, 2020, 2050, 2080)

The existing La Salle Diversion in Reach 3 is expected to remain unchanged in the study period. There are no other diversion licenses in any reaches of the study area and no new licenses are expected affecting allocations for the study period with or without the effects of climate change being considered.

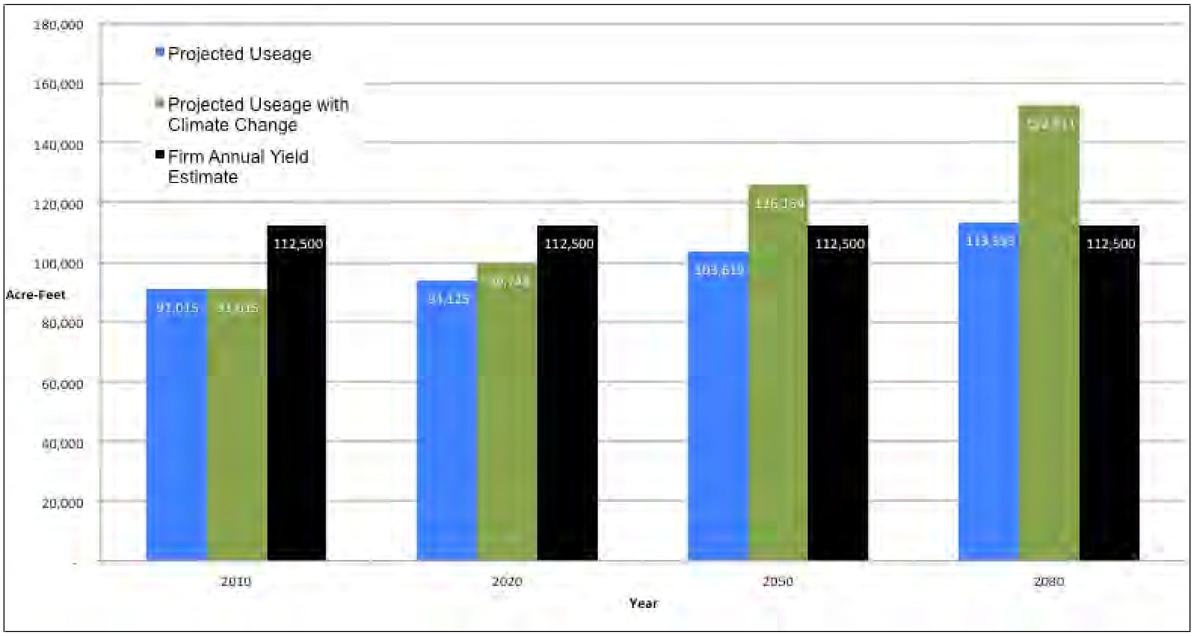
Diversion water demand projections are summarized in Table 20.

Table 21: Diversion Water Demand Projections

Diversion Water Demand Projections (2010, 2020, 2050, 2080)(acre-feet)									
	Licensed Allocation 2010	2010	2020	2050	2080	2010	2020	2050	2080
		Baseline	Without climate change	Without climate change	Without climate change	Baseline	With climate change	With climate change	With climate change
Reach 1									
Diversion	0	0	0	0	0	0	0	0	0
Reach 2									
Diversion	0	0	0	0	0	0	0	0	0
Reach 3									
La Salle	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000

6.8 PROJECTED WATER DEMAND SUMMARY (2010, 2020, 2050, 2080)

The Assiniboine River projected water demands for the time horizons 2010 (baseline), 2020, 2050 and 2080 are presented in Figure 19. Water demand summaries are shown in Table 21. Uncommitted water volumes for each time horizon (2020, 2050 and 2080) were calculated considering instream flow needs of 16,000 acre-feet and a firm annual yield estimate of 112,500 acre-feet includes instream flow needs. Summaries considering without and with climate change effects are included in the table.



Note: Firm yield estimate includes instream flow needs of 16,000 acre-ft.

Figure 21: Assiniboine River Projected Water Demands

Table 22: Water Demand Projection Summary (2010, 2020, 2050, 2080)

Water Demand Projection Summary (2010, 2020, 2050, 2080)(acre-feet)									
	Licensed Allocation 2010	2010	2020	2050	2080	2010	2020	2050	2080
		Baseline	Without climate change	Without climate change	Without climate change	Baseline	With climate change	With climate change	With climate change
Reach 1									
Licensed Municipal -RM of Wallace	1,260	440	449	477	506	440	451	486	524
Licensed Municipal - Brandon	12,010	9,800	10,301	11,964	13,895	9,800	10,353	12,204	14,387
Licensed Agricultural	0	0	0	0	0	0	0	0	0
Licensed Industrial - Manitoba Hydro	6,415	6,415	6,415	6,415	6,415	6,415	6,415	6,415	6,415

Water Demand Projection Summary (2010, 2020, 2050, 2080)(acre-feet)									
	Licensed Allocation 2010	2010	2020	2050	2080	2010	2020	2050	2080
		Baseline	Without climate change	Without climate change	Without climate change	Baseline	With climate change	With climate change	With climate change
Licensed Industrial - Bunge	190	190	190	190	190	190	190	190	190
Licensed Irrigation	665	1,005	1,111	1,429	1,748	1,005	1,344	2,360	3,377
Licensed Recreational	0	0	0	0	0	0	0	0	0
Outstanding Applications	340	0	0	0	0	0	0	0	0
Reach Total	20880	17,850	18,466	20475	22,754	17,850	18,752	21,656	24,893
Reach 2									
Licensed Municipal - Portage la Prairie	7,255	6,000	6,060	6,245	6,435	6,000	6,091	6,371	6,664
Licensed Agricultural	0	0	0	0	0	0	0	0	0
Licensed Industrial	0	0	0	0	0	0	0	0	0
Licensed Irrigation	12,584	16,276	17,994	23,150	28,305	16,276	21,763	38,225	54,687
Licensed Recreational	0	0	0	0	0	0	0	0	0
Outstanding Applications	3,692	0	0	0	0	0	0	0	0
Boyne Diversion	0	0	0	0	0	0	0	0	0
Reach Total	23,531	22,276	24,055	29,394	34,740	22,276	27,854	44,596	61,350
Reach 3									

Water Demand Projection Summary (2010, 2020, 2050, 2080)(acre-feet)									
	Licensed Allocation 2010	2010	2020	2050	2080	2010	2020	2050	2080
		Baseline	Without climate change	Without climate change	Without climate change	Baseline	With climate change	With climate change	With climate change
Licensed Municipal - Cartier Water Coop	4,850	765	780	829	880	765	784	845	911
Licensed Agricultural	0	0	0	0	0	0	0	0	0
Licensed Industrial	0	0	0	0	0	0	0	0	0
Licensed Irrigation	6,359	6,624	7,323	9,421	11,520	6,624	8,857	15,557	22,256
Licensed Recreational - Crescent Lake	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500	5,500
La Salle Diversion	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000	22,000
Outstanding Applications	265	0	0	0	0	0	0	0	0
Reach Total	38,974	34,889	35,604	37,750	39,899	34,889	37,142	43,902	50,667
Total	83,385	75,015	78,125	87,619	97,393	75,015	83,748	110,154	136,911
Instream Flow Needs Reserve	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000	16,000
TOTAL	99,385	91,015	94,125	103,619	113,393	91,015	99,748	126,154	152,911
Firm Annual Yield Estimate	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500	112,500
Uncommitted Estimate	13,115	21,485	18,375	8,881	-893	21,485	12,752	-13,654	-40,411

Note: 1 acre-foot = 1.233 dam^3

7.0 SUMMARY

The Central Plains Inc. Water Study, completed in 2008, studied the existing water rights licenses and allocations along the three reaches of the Assiniboine River. This information was reviewed and updated to represent the 2010 baseline data used in this study. This baseline was used to project water demands into the future study horizons of 2020, 2050 and 2080 with and without climate change.

In order to project these future demands, an analysis was completed on influences that may affect each type of user and their associated water use and needs on the river. Population growth, agricultural and irrigation trends and economic and environmental factors were considered. To assist in understanding the future, a visioning workshop was conducted with stakeholders to further understand the water demands on the Assiniboine River into the future.

Climate change scenarios were also considered a major factor in the future water demands on the Assiniboine River. A detailed climate analysis looked at regional and specific climactic data, including modeling to predict and quantify the sensitivity of the climate to demands on the river into the study period of 2020, 2050 and 2080. An analysis was also conducted assuming that there was no climate change.

Based on the review of the projected water demands for the study period as presented in Figure 19 and Tables 21, the following conclusions can be made related to the study:

- Water demand on the Assiniboine River will continue to increase over the study period and may exceed the firm annual yield estimate currently used for licensing allocations in the later part of the study period.
- Climate change is expected to have a significant impact on the demand and supply requirements of the Assiniboine River. More detailed study is required to understand the potential for peak usages in months where river flows are low.
- The instream needs of the Assiniboine River are not well quantified and should be studied further as they account for a considerable allocation of water.
- The firm annual yield estimate should be reviewed to reflect the demand scenarios developed in this study as well as to account for climate change.
- Population growth in the City of Brandon may require an additional licensing allocation late in the study period. Existing license allocations should satisfy all other municipal growth.
- It is expected that climate change will increase municipal water use increasing demand on their current (or future) allocations.
- Industrial license demands are expected to remain constant for the study period.
- Irrigation license demands are projected to dramatically increase in the future. Demand is expected to be even greater considering climate change.
- The existing recreational license (Crescent Lake) demand is expected to remain constant for the study period.
- The existing La Salle Diversion allocation demand is expected to remain constant for the study period.

8.0 LIMITATIONS

The findings and recommendations provided in this report were prepared by GENIVAR (the Consultant), and its sub-consultants, Stantec and Associated Engineering; in accordance with generally accepted professional engineering principles and practices. The information contained in this report represents the professional opinion of the Consultant and their best judgment under the natural limitations imposed by the Scope of Work.

This report is limited in scope to only those items that are specifically referenced in this report. There may be existing conditions that were not recorded in this report. Such conditions were not apparent to the Consultant due to the limitations imposed by the scope of work. The Consultant, therefore, accepts no liability for any costs incurred by the Client for subsequent discovery, manifestation or rectification of such conditions.

This report is intended solely for the Client named as a general indication of the visible or reported condition of the items addressed in the report at the time of the assessment. The material in this report reflects the Consultant's best judgment in light of the information available to it at the time of preparation.

This report and the information and data contained herein were prepared for the Client and its officers and employees in relation to the specific project. Any use a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. The Consultant accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

The report has been written to be read in its entirety, do not use any part of this report as a separate entity.

All files, notes, source data, test results and master files are retained by GENIVAR and remain the property of the Consultant.

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REGISTERED PROFESSIONAL ENGINEER

APEGM
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GENIVAR Inc.
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