Saskatchewan Research Council

Vulnerability of Prairie Communities' Water Supply During the 2001 & 2002 Droughts: A Case Study of Cabri and Stewart Valley, Saskatchewan

By V. Wittrock[1], D. Dery[2], S. Kulshreshtha[2], E. Wheaton[1]
[1]Saskatchewan Research Council, Environment and Forestry Division
and [2]University of Saskatchewan

SRC Publication No. 11899-2E06

June 2006

SRC
smart science solutions

Vulnerability of Prairie Communities' Water Supply During the 2001 & 2002 Droughts: A Case Study of Cabri and Stewart Valley, Saskatchewan

By V. Wittrock[1], D. Dery[2], S. Kulshreshtha[2], E. Wheaton[1]
[1]Saskatchewan Research Council, Environment and Forestry Division
and [2]University of Saskatchewan

SRC Publication No. 11899-2E06

June 2006

Saskatchewan Research Council
125 – 15 Innovation Blvd.
Saskatoon, SK   S7N 2X8
Tel: 306-933-7432
Fax: 306-933-7817

EXTENDED ABSTRACT

by S. Kulshreshtha, V. Wittrock and E. Wheaton

The purpose of this study was to investigate the impact of 2001 and 2002 droughts on the rural communities of Cabri and Stewart Valley in Saskatchewan with emphasis on water resources. These impacts were studied in the context of the communities, as well as in the context of the larger region – Rural Municipality of Riverside (for Cabri) and Rural Municipality of Saskatchewan Landing (for Stewart Valley). Drought impacts were assessed in terms of bio-physical changes as well as economic changes that were observed during 2001 to 2002.

The community of Cabri is dependent on the South Saskatchewan River for its water needs, both for domestic as well as irrigation purposes. Stewart Valley depends on groundwater sources for meeting its water use. With the exception of the Miry Creek irrigation project, most of the agricultural production is under dryland production systems. Both the communities are predominantly rural, with a population of 483 and 101 people in 2001 for Cabri and Stewart Valley, respectively. In addition, like other smaller rural communities in the Prairies, both of these communities have a declining population trend and an increasing elderly population.

Agriculture is the main driving force for the two communities. Most businesses in these communities are related to agricultural production. Oil and gas industry is the second most important industry in the region. Some tourism activities are also present, particularly in the Cabri and surrounding region.

Both the regions experienced the droughts of 2001 and 2002, although the degree of their exposure was different for the two communities and the surrounding regions. Stewart Valley area received more precipitation compared to the Cabri area during these periods.

Among various bio-physical impacts of the drought were decreased stream flow, minimal recharge to groundwater, and only one-quarter full dugouts. However, the community of Stewart Valley had a more reliable source of water than Cabri.

Crop production in the surrounding region is dominated by the production of durum wheat, spring wheat, and lentil and dry beans, although other crops are also grown in the region. Yields of all major crops were lower during the drought period.

The major conclusions of the study include:

- More precipitation was received in the Cabri and Stewart Valley regions during the summer months of 2002 and during the agricultural year (September to August) 2002 than 2001. A drought index (PDSI) indicated that the hydrologic drought was very strong in 2002 compared to 2001.

- Total crop revenues in both the rural municipalities were negative during 2001 and 2002 drought years, although the impact of the drought in 2002 was less severe in both the municipalities.

- Cattle marketings were slightly higher in 2001 and 2002. Economic impacts could not be assessed due to lack of data.

- Cabri residents had to adapt to water shortages in various ways including hauling water from municipal wells. In Stewart Valley this was not a major issue because the town uses a groundwater source which remained reliable during the 2001 and 2002 droughts.

- Producers had less income due to poor crop yields, and relatively unchanged input costs. Non-agricultural businesses also suffered since farmers had less money to spend.

- The community of Cabri adapted to the hydrologic drought conditions by various methods including water rationing, pipeline extension, and better management practices. The community did attempt to find an alternative water source but could not find groundwater in close proximity to the town.

Recommendations for further research include:

- Extension of a similar approach to other communities under study including Outlook and Blood Indian Reserve.

- Undertake an assessment of future water supplies and future water uses of the communities to facilitate understanding of vulnerability

- Assess potential barriers and opportunities for each community regarding adaptation to water scarcity.

- Assessment of economic costs of the droughts on livestock farms.

- Translate the above changes into socio-economic impacts.

Table of Contents

List of Figures

List of Tables

List of Acronyms, Symbols, Units

BSE	bovine spongiform encephalopathy
bu/ac	bushels per acre
°C	degrees Celsius
CAR	census agricultural region
dam^3	cubic decametres
$/cwt	dollars/hundred weight
IACC	Institutional Adaptation to Climate Change
km	kilometre
m^3	cubic metres
m^3/s	cubic metres per second
%	percent
PDSI	palmer drought severity index
PET	potential evapo-transpiration
REDA	Regional Economic Development Administrative
RM	Rural Municipality
SPI	standardized precipitation index

1. INTRODUCTION

1.1 Background

The Institutional Adaptation to Climate Change (IACC) project is designed to "develop a systematic and comprehensive understanding of the technical and social capacities of regional institutions to formulate and implement strategies of adaptation to climate change risks and the forecasted impacts of climate change on the supply and management of water resources in dryland environments" (Diaz et al. 2003). Among other objectives, this study looks at providing information on the current physical and social vulnerabilities related to water resource scarcity, and to assess the technical and social adaptive capacity of various institutions in the study region.

The IACC project has identified two rural communities in Saskatchewan – Stewart Valley and Cabri – for an in-depth investigation. Both of these communities are located in a relatively arid region of the South Saskatchewan River Basin. Under these climatic regimes, droughts are frequent events. Under a changing climate, frequency of drought and other extreme events is expected to increase. Such occurrences could bring a high cost to the society through impacts on those directly affected by them, but also through other linkages that exist within an economy.

1.2 Objectives of the Study

The primary objective of this study is to investigate the impacts of 2001 and 2002 droughts on the rural communities of Cabri and Stewart Valley, with emphasis on water resources. An associated objective of the study is to identify the nature of adaptation measures undertaken, and their efficacy, by individuals and institutions in response to or to cope with these droughts.

1.3 Scope and Methods of the Study

The study methodology involved a combination of three types of techniques including: (1) Conceptual, which would include review of previous drought studies (e.g., Wheaton et al. 2005) as well other secondary literature relevant to this study. (2) Primary and secondary data-based research, which included an assessment of historical pattern of the droughts in the region, features of 2001 and 2002 droughts, and the associated bio-physical and economic impacts. (3) Primary data-based research, which included information on enterprise-specific and location specific data interpretation on impacts, vulnerability and adaptation measures attempted by members of the two communities. These data were collected by a combination of focus group meeting and interviews conducted by colleagues in the IACC project.

1.4 Organization of the Report

In addition to this section, the Introduction, the report has five other sections:

- Description of the Communities (section 2.0)
- Drought Description (section 3.0)
- Drought Impacts on the Communities (section 4.0)
- Results of Focus Groups and Other Interviews (section 5.0)

- Summary and Conclusions (section 6.0)

Section 2.0 includes a description of the communities of Cabri and Stewart Valley and their associated Rural Municipalities. Included in this section is a description of the physical geography as well as the socio-economic baseline of the region. Section 3.0 provides a climatological description of the 2001 and 2002 drought. Section 4.0 describes impacts each of the communities encountered because of the 2001 and 2002 droughts. This section examined both the bio-physical and socio-economic impacts. Section 5 examined the results of the focus groups and interviews conducted in the summer of 2005.

2. DESCRIPTION OF THE COMMUNITIES

2.1 Physical Geography of the Communities

2.1.1 Climatology

The Rural Municipalities (RM) of Riverside (168) and Saskatchewan Landing (169) are located in south west Saskatchewan adjacent to the South Saskatchewan River (Figure 2.1). This is a region that has ranges in extreme high and low temperatures, extreme rain and snowfall events, and extreme flood and drought events. Stewart Valley and Cabri are two communities located within these RMs and are approximately 46 km apart. Stewart Valley has a climate station but the nearest climate station to Cabri is Abbey (Table 2.1). Abbey is approximately 25 km west of Cabri (Figure A.1).

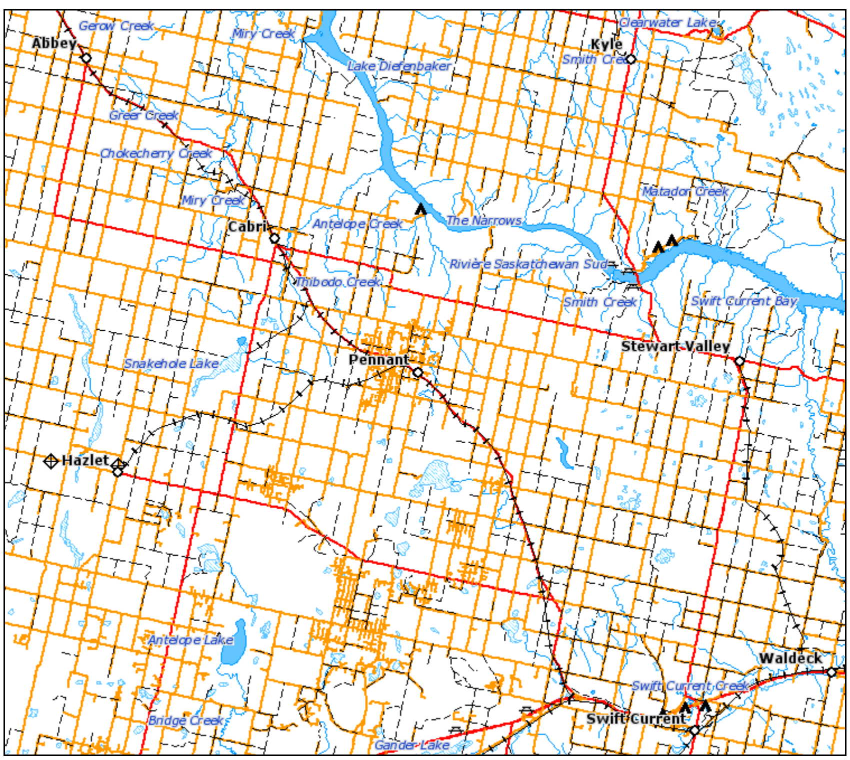

Figure 2.1 Study Area Map (Atlas of Canada 2006)

Table 2.1 Selected Climate Stations for the Study Area (Environment Canada 2006a)

Station Name	Station Number	Location (Latitude / Longitude)	Period of Record
Abbey	4020020	50° 42'N 108° 47' W	1956-2005
Stewart Valley	4027775	50° 36'N 107° 48'W	1984-2005

Precipitation and temperature information were obtained from Environment Canada (2006). The normals (or averages) are from the 1971-2000 period.

This area has a mean annual temperature of 4.3 °C. The coldest month is generally January and the warmest is usually July. While temperature is similar between the two locations, precipitation is different. Stewart Valley receives on average more than 94 mm of precipitation than Abbey (Figures A.2 and A.3 and Table 2.2) (Data Source: Environment Canada 2006a).

Table 2.2 Difference from Average* for Water Consumption, Temperature, Precipitation (2001 & 2002)

	Water Consumption (m^3)		Temperature (°C)		Precipitation (mm)	
	Cabri	Stewart Valley	Abbey	Stewart Valley	Abbey	Stewart Valley
2001	25%	-17%	1.4	1.1	-48%	-41%
2002	-15%	-27%	-0.5	-0.9	23%	23%
Average	99,664	11,150	4.3	4.3	314.6	409.1

* Averaging Periods:

Water Consumption Average (Data Source: Anderson 2006)
- Cabri (1976-2005)
- Stewart Valley (1981 to 2005, missing 1996 to 2000)

Temperature and Precipitation Averages (1971-2000) (Data Source: Environment Canada 2006a).

2.1.2 Water Supply and Sources

2.1.2.1 Stream flow

The South Saskatchewan River is an important water source for both RM's including being a source of water for irrigation, recreation and potable water. The town of Cabri is dependent on the river for potable water, particular in drier than average years, therefore river flow and Lake Diefenbaker level is important.

There is no hydrometric station in the study area, therefore two upstream stations in the South Saskatchewan River and one down stream station were used to indicate the amount of river flow during the 1999 to 2003 period (Table 2.2). Several streams run through the two RMs, however only two, Antelope Creek located close to Cabri and Swift Current Creek near Stewart Valley, have hydrometric gauging stations (Table 2.3).

Lake Diefenbaker is an important reservoir to Saskatchewan and to the RMs of Saskatchewan Landing and Riverside. The water in this reservoir is used for hydro-electric generation, water level control, irrigation and recreation. The reservoir is subject to water fluctuations. This reservoir has an effective drainage area of 86,900 km^2 (Table 2.3).

Table 2.3 Selected Hydrometric Gauging Stations for the Study Area (Environment Canada 2006b)

Station Name	Station Number	Location (Latitude/Longitude)	Period of Record	Effective Drainage Area (km^2)	Mean Annual Discharge (m^3/sec)
South Saskatchewan River at Medicine Hat	05AJ001	50 2’25”N 110 40’40”W	1911-2004	42,100	188
Red Deer River near Bindloss	05CK004	50 54’10”N 110 17’50”W	1960-2004	31,700	55.8
South Saskatchewan River at Saskatoon	05HG001	52 8’25”N 106 38’36”W	1911-2004	88,100	250
Antelope Creek Near Cabri	05HC005	50 39’41”N 108 22’50”W	1970-2004	105	
Swift Current Creek Near Leinan	05HD039	5029’38”N 10739’31”W	1973-2004	2,600	1.22
Lake Diefenbaker at Gardiner Dam	05HF003	51 16’49”N 106 50’18”W	1966-2004	86,900	

Stream flow and reservoir levels were obtained from Environment Canada (2006). The averaging period for was each stream and reservoir’s period of record.

2.1.2.2 Groundwater

Groundwater is used by both rural and urban residents of the study area for multiple uses including rural residents’ household potable water, water for livestock and water used for spraying. The Tyner and Verlo wells are the groundwater observation wells located closest to the Stewart Valley/Cabri region (Figure A.4).

The Verlo observation well is located in Southwest Saskatchewan near the Great Sand Hills or approximately 35 km SSW of Cabri. The well is in lacustrine clayey silt overlain by approximately 6 metres of fine grand sand. It is considered to be monitoring a shallow aquifer with the direction of groundwater flow northwards (SWA website).

The Tyner observation well is monitoring the west-central section of the Tyner Valley Aquifer System, which is a deep aquifer (greater than or equal to 100 m depth) (SWA web site). The aquifer receives recharge from vertical downward flow and from lateral flow from adjacent aquifers. The groundwater flow is to the southwest or toward the South Saskatchewan River (SWA web site). The Tyner well (113.69 m below ground) has a pronounced response to barometric pressure changes (Maathuis et al. 2001). This well is approximately 42 km north of Cabri.

Groundwater levels were obtained from Saskatchewan Watershed Authority (2006).

2.1.2.3 Dugouts

Dugouts are used by farmers in the study area for household usage, livestock and crop spraying. Dugouts are generally designed to withstand two years of drought conditions (Bell, pers. comm. 2002a with Wittrock 2005).

From 1935 to 1999, over 75,000 dugouts were established in Saskatchewan and more than 140,000 in the Prairies. The study area RMs have dugouts scattered throughout. Saskatchewan Landing RM has 121 dugouts while Riverside RM has 101 more (PFRA, RWDP Historical Records 2006) (Figure A.5).

Dugout levels information was obtain from the Prairie Farm Rehabilitation Administration Drought Watch Website (2006).

2.1.2.4 Municipal water supplies

Cabri receives its potable water supply from a reservoir northeast of the town (Figures A.6 and A.7). The reservoir gets its water from Antelope Creek runoff and when required from the South Saskatchewan River via a pipeline. The reservoir has a full supply level of 629.60 m with a water capacity of 162 dam^3 (Figure A.8).

Cabri consumes on average (1976 to 2005) 99,664 cubic meters per year (Table 2.2). In the last 10 years the annual consumption has risen to 109,458 cubic meters per year (Figure 10). The greatest consumption period is from May to September.

Stewart Valley's potable water supply is shallow groundwater wells located within town limits (Hagen, pers. comm. 2006). Two of the wells, drilled in 1963 are between 40 and 50 m in depth, are in a glacial formation. Two other wells are deeper, more than 70 m in depth and are located within the Bearpaw Formation (Ford, pers. comm. 2006). This community's average consumption is 11,150 cubic meters of water per year (1981 to 2005, missing 1996 to 2000) (Figure A.10 and Table 2.2). In the last five years (missing 1996 to 2000 data), the consumption has decreased to 8,994 cubic meters per year. The greatest consumption period is from May to August.

For the rural community usage in the Stewart Valley region, there is a municipal well located just west of the town. The well has good quality and quantity water (Hagen, pers. comm.. 2006).

Municipal water supply information was obtained from the Saskatchewan Watershed Authority (Anderson, pers. comm. 2006).

2.2 Socio-economic Baseline of the Communities

2.2.1 Location of the Communities within a Trading Region

The communities of Cabri and Steward Valley are a part of a larger socio-economic-cultural region. They both belong to the Southwest Regional Economic Development Administration (REDA) region, as shown in Figure 2.2. The region is bounded by the South Saskatchewan

River on the north (with the exception of Rural Municipality of 221 (which is located north of the river). Although there is no particular significance of the REDA region in the context of drought impacts, except that some of the commodity trades (either in terms of purchase and / or sales) are made by people and industries within this region. In particular, the two communities, on account of their proximity, trade with the city of Swift Current, either in terms of their household needs or business needs.

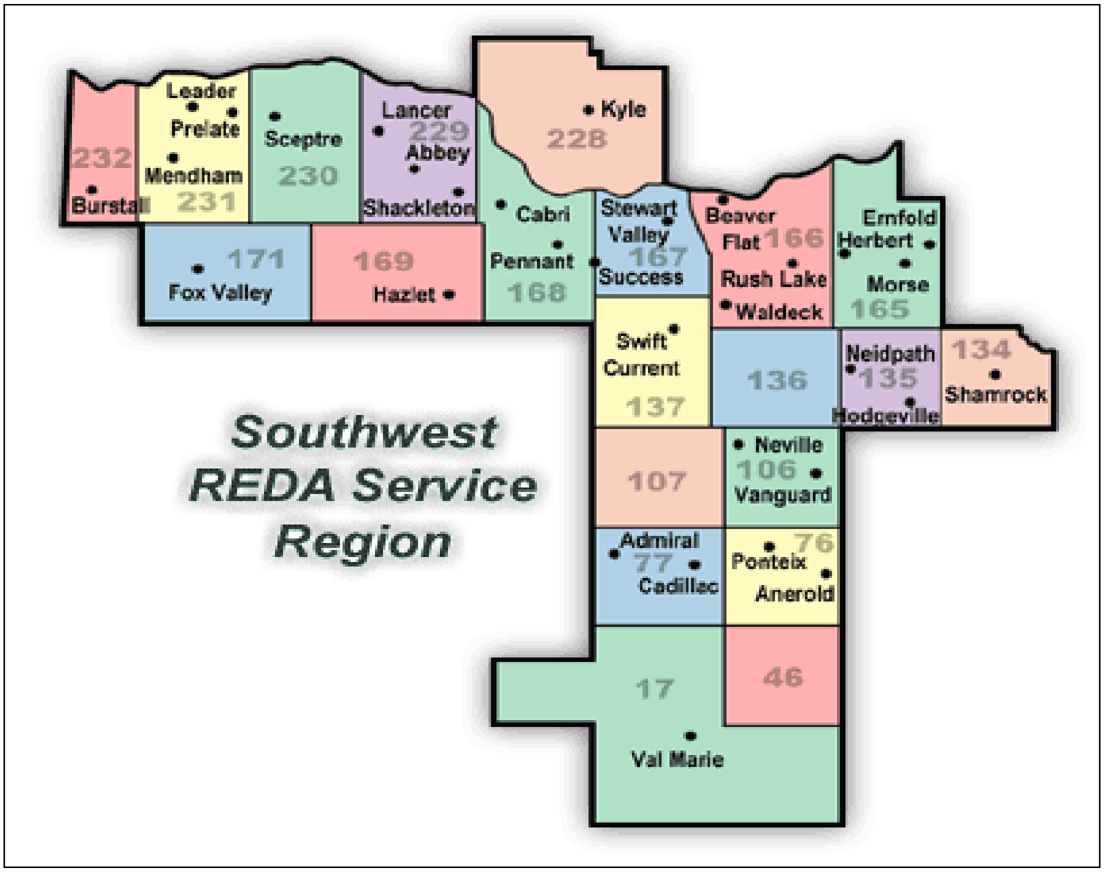

Figure 2.2 Map of the Southwest Regional Economic Development Area Service Region Showing Location of Cabri and Stewart Valley Communities

In the context of drought impacts, the region of particular significance is the more immediate region – the Rural Municipalities (RM) where these communities are located. Cabri is located in the RM # 168 (RM of Riverside), while Stewart Valley is situated in the RM # 167 (RM of Saskatchewan Landing). Both the RMs are predominantly rural, and depend on agricultural activities. In the RM of Riverside (No. 168) the only other community is Pennant (Population 150 in 2001, an increase of 15 persons over 1996). In the RM of Saskatchewan Landing (No. 167) there are no other non-farm communities, other than Stewart Valley[1].

[1] For the 2001 year, no population was reported separately for the village of Success. Since no explanation is provided, it is assumed that the community got small enough that it was absorbed in the RM population count.

2.2.2 Population Base

Like other rural communities in the province, population of the study region is declining, as illustrated in Table 2.4. This region is experiencing a decline in population. The trend is shown in Figure 2.3. Population of the two RMs in 1986 was 1,228, which decreased by almost 18% by the year 2001. If population of the region could be used to indicate the sustainability of a community, this then suggests a forecasted weak economic baseline.

Table 2.4 Population Trend in the Study's Rural Municipalities, 1986-2001

Year	Rural Municipality of Riverside (No. 168)		Rural Municipality of Saskatchewan Landing (No. 167)		Combined Population for RM 167 and 168
	Cabri	Total RM No. 168	Stewart Valley	Total RM No. 167	
1986	628	677	128	551	1,228
1991	561	619	115	509	1,128
1996	529	552	101	529	1,081
2001	483	495	101	506	1,001

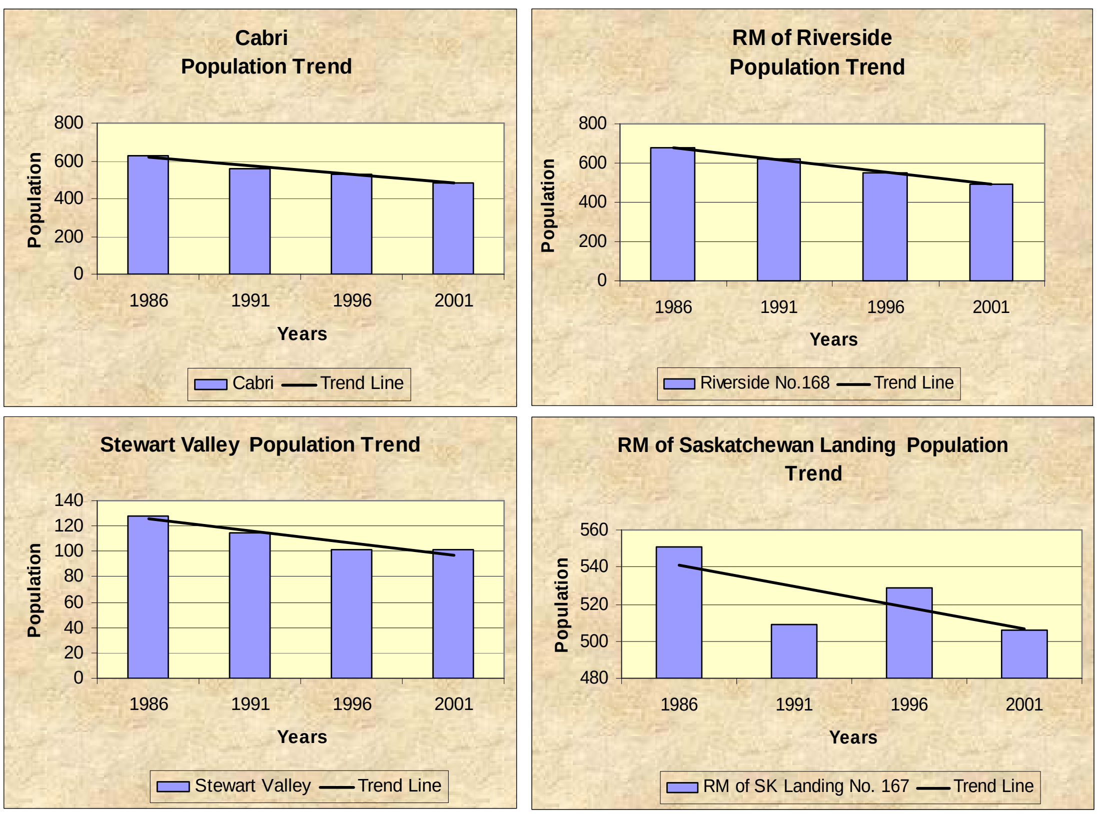

Figure 2.3 Population Trends, Cabri and Stewart Valley, and the Surrounding Rural Municipalities, 1986 - 2001

Furthermore this declining population trend is exacerbated by a much older population that resides in both of these communities relative to the province of Saskatchewan (which incidentally has an older population compared to some of the neighbouring provinces). In the town of Cabri, proportion of people aged 65 year or higher was 30%, while that for the Stewart Valley it was 25%. Both of these are higher than the Saskatchewan average of 15%. This combination of overall declining population and an increasing elderly population indicates that these communities in the short and long term future would face tough economic and social times if young ambitious individuals cannot be attracted to work and live within the local region.

2.2.2.1 Cabri

A certain number of businesses[2] exist in the two communities. For example, those in the Cabri service the town of Cabri and surrounding area. When a particular service is required by the resident of Cabri and surrounding area that is not available in the community, they commute to Swift Current. However, Cabri is represented by a wide range of businesses providing most of the services required by the community than Stewart Valley.

Within the regional area of Cabri there are main primary industries that stimulate the local economy at many levels. First, agriculture is the driving industry in both RMs that supports primary producers and the majority of local businesses. Most local businesses carry out retail trade, provide a service, and/or indirectly benefit from the primary agriculture sector. Retail trade is essential to provide producers with many farm inputs, and household supplies / needs such as groceries. An example of a service may be a mechanical shop or a fertilizer blending plant. Businesses transactions that did not originate directly from agriculture may be related indirectly from a business or employee who previously completed business with. Therefore primary agriculture is the economic foundation of this community.

Local agriculture related businesses that are directly reliant are the farm services. A few farm service businesses are Shaw's Seed Cleaning, Levorson Seeds, Pioneer Co-op, and Pioneer Grain (elevator). These farm service groups either provide retail goods such as fertilizer, chemical, livestock supplements, seed, parts, tools etc, or provide a service, such as marketing grain, cleaning grain, soil testing, equipment rental etc. All other businesses are, at some point, indirectly involved with the agriculture industry with the exception of the oil and gas industry.

Second, the oil and gas industry is the second most valuable industry in this community. In recent years, this industry has had greater monetary value than agriculture but has not involved as many businesses, directly or indirectly. The oil and gas industry is very valuable to this community because it provides high paying jobs and is less sensitive to climate / weather changes (unlike agriculture). *For example:*

> ".. residents in the dirty thirties were reliant on grain and livestock for monetary equity and also a source of food. Therefore, in years of drought they were vulnerable financially and physically. The resilient few who survived the dirty thirties witnessed the Fosterton oil well finds in January of 1953 (Cabri Community Development Council 1963).

[2] Most of these data were collected from the South West Regional Economic Development Authority (SWREDA).

From then on the community had a second source of income from an industry less vulnerable to drought than agriculture. Now in years of drought the community adapts by earning income in the oil and gas industry which provide monetary units to purchase their needs. A few directly involved oil and gas companies are TransCanada Pipeline, Apache Canada, Paramount Energy, and Profico. There are also local mechanic, trucking, construction, and trades businesses that support the oil and gas industry.

Some of the local services that are required by both oil & gas and agricultural industries include building construction, land excavation (road building or burying stone piles), welding needs, electrical work or automotive repair…, to name a few. These services can be met by the following local businesses: For construction and excavation -- Heron Services, Kennedy Construction, Ron's Construction, and/or Cherkowski's Wood and Works; Welding services -- Steve's Welding, and Shawzy's Welding. Finally, automotive repair services are provided by Gehl Automotive, Brian's Auto Body, and Pioneer Co-op.

A third important industry is tourism. The tourism industry consists of the Cabri Regional Park and game hunters in the fall. The park attracts families from across the province and a few Canada-wide travelers. The economic spin-off is the business generated in town as a result of having an increase in visitors. These families purchase groceries, fuel, giftware, and in some instances require automobile service. However, in drought years this recreational site is unattractive and the result is a decrease in tourism. Game hunters originate mainly from the United States and typically hunt waterfowl. These hunters are usually in the community for a week at a time and require many services. They need accommodations, meals, fuel, supplies, and usually purchase gifts for there families. Although this is a seasonal industry, it still contributes to the economy in a major way. However, this industry sector is also very vulnerable to droughts since there are fewer waterfowl in the area in drought years.

Two service sectors that are significant to this community's future are the Cabri School and Health Center. This school has combined elementary and high school programs which recognize this institution as a K-Gr.12 facility. The Health Center provides emergency and long term care for local residents.

What does a school bring to a community? This answer or reply would vary among individuals; however, many would agree that an education institution is essential in sustaining a community's future. The local Cabri School creates employment for professional teaching jobs, teaching assistants, and maintenance personnel. With each position brings a new family into the community which again sustains the community's future. Most importantly, if there was no available education for local families, they would move to larger centers (Swift Current) along with the businesses they were involved in. Therefore, the community is very dependent on the presence of the Cabri School.

The Health Center maintains an aging community and reassures the community's decision to continue residing there. This Center employs 45-55 individuals (Statistics Canada 2001) that, in turn, are from families that support local businesses. The Health Center also attracts people from the rural area for health care. Along with the Health Center are the Cabri Medical Clinic and

Devi Pharmacy. These service units compliment the Health Center and provide an overall solid medical presence for the community and the surrounding region.

Accommodation services are met by three local businesses. These are the Cabri Hotel, Sunrise Inn, and Cabri Campground. These businesses accommodate many workers in the oil and gas industry, tourists, travelers, and waterfowl hunters. Most importantly, they allow travelers to stay within the community for a longer period of time, which further supports other local businesses.

There is also restaurant service in Cabri. The Silver Café, House of Heart, and Cabri Hotel provide food services within their businesses and also for catering. Since these businesses rely on the community for support their success is a reflection of the agriculture and the oil and gas industry status.

A few more important services that provide employment are the RCMP, Canada Post, Bus service, Little Critters Pre-School Fire and Ambulance. These services rely on a threshold level of population within the community and would not be available if the community was not sustainable. A measure of a community’s status may be based on the services it has available.

A few home-based businesses are in this area. Example of these incluce: Grain X Trucking, Sandra’s Yard Care, Petersen’s Abattoir, Third Day Painting, Dianne’s Quality Jewelry, Hot Stuff Gas & Oil Inc, Prairie West Water, Sue Kennedy (hair dresser), BJ’s Books & Tax Service, Beauty Salon, Undseth Therapy (massage), and Limelite Promotions. These businesses provide a wide array of services from trucking to hair dressing but are all important to the community.

There are also many Community, Sporting, and Cultural organizations within the community. A few examples are the Cabri Ice Center, Fitness Center, Swimming Pool, Miry Creek Golf Course, Cabri Regional Park, Library, Museum, Community hall, Ball Diamonds, Lions Park and Playground, Lions, Legion Hall, Ladies Auxiliary, Seniors Hall, Cabri Prairie Players Drama Club and Historical Society to name a few. Most of these are non-profit organizations but they still add tremendous social value to the community.

A more detailed list of various services available in the Cabri community is provided in Table 2.5.

Table 2.5 A List of Business Establishments in Cabri, 2004

Churches Full Gospel St. Joseph's Catholic Scandia Lutheran United Cabri Cemetery	**Community Organizations** Lions Legion Hall Ladies Auxiliary Seniors Hall Cabri Prairie Players Drama Club Historical Society	**Farm Services** Shaw's Seed Cleaning Levorson Seeds Pioneer Co-op Milton Braaten Feed Lot Pioneer Grain (elevator)
Sporting and Cultural Cabri Ice Center Minor hockey Recreational Hockey Whitemud Hockey Curling Club Fitness Center Swimming Pool Miry Creek Golf Course Cabri Regional Park Library Museum Community Hall School Ball diamonds Tennis court Lions park and playground	**Home Based** Dianne's Quality Jewelry Candle Lite Norwex Tupperware Stampin' Up Scrapbooking Third Day Painting Grain X Trucking AM Inspection Petersen's Abattoir Hot Stuff Gas and Oil Inc. Sandra's Yard Care Pic's Liquor vendor, Lottery, Sears, Giftware Limelite Promotions Undseth Therapy (massage) Prairie West Water Sue Kennedy (hair dresser) BJ's Books and Tax Service Beauty Salon	**Services** Cabri Health Center Cabri Medical Clinic and Devi Pharmacy Cabri School and Community Center RCMP Fire and Ambulance Little Critters Pre-School Canada Post Leader Carriers Outlet Bus Service Courier Services Depot Air Strip Meals on Wheels
Accommodations Cabri Hotel Sunrise Inn Cabri Campground	**Restaurants** Silver Café House of Heart Cabri Hotel	**Grocery** Pioneer Co-op
Financial Institutions RBC Southwest Credit Union	**Insurance** Z F Cushing	**Media** Cabri Herald Newspaper Outfitters?
Automotive Gehl Automotive Brian's Auto Body Pioneer Co-op	**Welding** Steve's Welding Shawzy's Welding	**Electrical** Reynolds Electric
Construction and Excavation Heron Services Kennedy Construction Ron's Construction Cherkowski's Wood and Works	**Oil and Gas** (*names change frequently) TransCanada Pipeline Apache Canada Paramount Energy Profico	

Source: Southwest Regional Economic Development Authority (2006)

2.2.2.2 Stewart Valley

Stewart Valley is primarily an agricultural community with one central business servicing the surrounding producers. Like Cabri, oil and gas industry is not prominent in this area. Therefore the success of the town may be a reflective of the recent development affecting agriculture industry.

The only known business in Stewart Valley is the Pioneer Co-op. This is a combination of a grocery store and a farm center. Therefore this store services the farm sector and local residents.

A few services and products that are supplied by this establishment include groceries, produce, meat, post office, hardware, petroleum, card lock, oil, lumber, animal health, propane, farm equipment rentals, fertilizer, grain bins, grain augers, livestock feeds, fence posts, and tires to name a few. Overall, it is vital in servicing the community since it is the only store there.

2.2.3 Employment

Employment data for the Cabri and Stewart Valley and their respective surrounding regions were obtained from Statistics Canada (special tabulations). However, the quality of the data released for public use leaves something to be desired in terms of its accuracy. This is because for preserving confidentiality, some of the employment data categories are rounded up to a higher round number (such as a 10 or a 20). On account of this rounding, the sum of reported data does not add up to the total number of workers in the region (or community). In spite of this limitations, these data are however, presented in Table 2.6 for Cabri and the surrounding region, and in Table 2.7 for Stewart Valley and its surrounding region.

In the community of Cabri, major employment is in the health care and social assistance, accommodation and food services, and agriculture industry. These three industries make up of more than half (55%) of the total employment. One of the features in the employment pattern distributed by sex of the worker is that more female workers are employed in the community on account of their employment in health care and social assistance industry group. When employment pattern for the surrounding region is examined, agriculture employs three-quarters of the workers. Thus, the RM is predominantly agricultural.

Table 2.6 Employment by Industry in the Cabri and Region, 2001

Industry Group	Cabri				Riverside No. 168			
	Total	Male	Female	Percent	Total	Male	Female	Percent
Total Industry	245	120	125	100.0%	260	140	120	100.0%
11 Agriculture, forestry, fishing and hunting	40	35	0	16.3%	195	120	80	75.0%
21 Mining and oil and gas extraction	0	0	0	0.0%	15	15	0	5.8%
41 Wholesale trade	20	15	0	8.2%	10	10	0	3.9%
44-45 Retail trade	20	10	10	8.2%	0	0	0	0.0%
48-49 Transportation and warehousing	15	15	0	6.1%	10	0	0	3.9%
51 Information and cultural industries	10	0	10	4.1%	0	0	0	0.0%
52 Finance and insurance	15	0	10	6.1%	0	0	0	0.0%
54 Professional, scientific and technical services	10	0	10	4.1%	15	0	15	5.8%
61 Educational services	20	0	15	8.2%	15	0	15	5.78%
62 Health care and social assistance	55	0	55	22.4%	10	0	10	3.9%
72 Accommodation and food services	40	20	25	16.3%	10	0	10	3.9%
81 Other services (except public administration)	15	10	0	6.1%	0	0	0	0.0%

Note: In order to protect the confidentiality of Canadians, no count of less than 10 is displayed and individual counts have been subjected to random rounding with the exception of total population figures.

Source: Statistics Canada (2001)

Table 2.7 Employment by Industry in the Stewart Valley and Region, 2001

Industry Group	Stewart Valley				Saskatchewan Landing No. 167			
	Total	Male	Female	Percent	Total	Male	Female	Percent
Total Industry	50	30	15	100.0%	165	100	70	100.0%
11 Agriculture, forestry, fishing and hunting	20	15	10	40.0%	120	90	35	72.7%
44-45 Retail trade	15	0	10	30.0%	0	0	0	0.0%
48-49 Transportation and warehousing	10	15	0	20.0%	0	0	0	0.0%
56 Administrative and support, waste management and remediation services	0	0	0	0.0%	10	0	10	6.1%
72 Accommodation and food services	0	0	0	0.0%	30	0	25	18.2%

Note: In order to protect the confidentiality of Canadians, no count of less than 10 is displayed and individual counts have been subjected to random rounding with the exception of total population figures.

Source: Statistics Canada (2001).

Stewart Valley community is also dominated by workers in primary industries (agriculture, forestry, fishing, and hunting). However, there is a smaller presence of workers in industries related to retail trade, and transportation and warehousing. The rural municipality of Saskatchewan Landing is predominantly agricultural, with some workers employed in accommodation and food industries, and in administrative services.

2.2.4 Summary

These two communities are very similar with the exception of oil and gas abundance. They both have a very dominant agriculture industry, which is the major economic driver. Most businesses in the region are affected either directly or indirectly from fluctuation in the economic conditions facing agriculture. Moisture is a limiting factor for crop production in this area and therefore, because of the connection between the entire community and agriculture, this area can be vulnerable to drought, at least economically.

Stewart Valley is a special situation in that one retail center, the Pioneer Co-op, supports the entire community. This retail and service outlet services the agricultural industry directly and therefore this community is the most vulnerable to drought or anything else that detrimentally affect agricultural production. Also, oil and gas industry is not as abundant near Stewart Valley, as it is in comparison to Cabri. Therefore agriculture is the major economic engine within this community.

Cabri also depends on the condition of agriculture industry. However, the community is large and has a variety of businesses. However, these are affected positively or negatively by the condition of the agricultural industry either directly or indirectly. Cabri has some diversification through oil and gas reserves in the surrounding area. This resource provides much needed employment and is a significant economic driver along with agriculture. However, the oil and gas industry is not adversely affected from drought. Therefore this economic driver decreases the community’s vulnerability and helps local individuals adapt in years when agriculture is in a poor condition.

3. CLIMATOLOGICAL DESCRIPTION OF THE 2001 AND 2002 DROUGHTS

Canada experienced extreme drought conditions in several areas during 2001 and 2002. By the end of 2001, parts of Canada had experienced 4.5 years of consecutive season of warmer than average temperatures beginning in the summer of 1997 (Wheaton and Wittrock 2005). This section describes the antecedent conditions, evolution and nature of the 2001 and 2002 droughts in the RMs of Riverside and Saskatchewan Landing. The droughts are described using precipitation, temperature, drought indices and other parameters.

Antecedent conditions are known to contribute to the severity of subsequent droughts. Abbey, the closest climate station to Cabri, began 2000 with above normal precipitation amounts but ended up with seven months with below average precipitation amounts (Figure A.2). 2001 was an exceptionally dry year with 11 months below average with 7 of those months more than 50% below average. February was the only month with above average precipitation by less than 10%. The temperature at Abbey was near normal in 2000 but 2001 turned hot with summer monthly temperatures as high as 1.9 °C above average. The maximum temperatures in August and September were 4.5 and 3.7 °C above average.

2002 started out dry and cold in Abbey. March had above average snowfall but was more than 11.5 °C below normal in average temperature. The cold temperature continued through April and May with below normal precipitation amounts as well. June, August and September had above normal precipitation but the cool temperatures returned in August. The winter months of November, December and January were warm with colder than normal temperatures returning in February and March. April was wet with a high precipitation amount and it was also warm. However, the rest of 2003 was quite dry with only September recording above normal precipitation amounts. Except for November, most of 2003 had above normal temperatures.

Stewart Valley is approximately 0.5 °C cooler in 2001 and 2002 than Abbey but Stewart Valley received more precipitation (Figures A.2 and A.3). In 2000, Stewart Valley received 156.3 mm more precipitation than Abbey, the majority of this came in the critical growing season. In 2001, Stewart Valley received about 76 mm more precipitation than Abbey. The majority of this came in May and July. In 2002, July was the anomalous month with more than 60 mm of precipitation being received by Stewart Valley than Abbey. In 2003, Stewart Valley received more precipitation in March, May, June, and September than Abbey. The higher precipitation in Stewart Valley area may have been beneficial with higher crop yields and more reliable water supplies than Cabri.

The summer is the season when the majority of precipitation occurs, with about half the rainfall coming from thunderstorms. Thunderstorms can also bring hail (Paul 1991). There were seven hail storms resulted in hail claims in RMs 168 and 169 for 2000 and 2001. Unfortunately there is no data for 2002 and 2003 (Paul, pers. comm. 2006).

In 2000, four major thunderstorms occurred with minor to major hail events. July, 21st was the largest hail event with the storm tracking southwest of Cabri, through Success. There were a large number of hail claims due to that storm (Paul, pers. comm. 2006). Three major thunderstorms brought hail in 2001. The July 13th storm resulted in hail claim occurring in the area west of Pennant and south of Cabri. The July 28th thunderstorm brought significant hail to both RMs and a twister was sighted from that storm by a person at Herbert, Saskatchewan (Paul, pers. comm. 2006).

Evapo-transpiration is a major component of the water balance cycle in the Canadian Prairies. Wheaton and Wittrock (2005) described the potential evapo-transpiration (PET) patterns for the Prairie Provinces for the 2000 to 2002 period. They found that annual PET values were greater than 600 mm over a much large of the prairies in 2001 as compared to 2000. On average in Saskatchewan, 600 mm PET is exceeded in a small area in the far south (Lundqvist 1999)

The Prairie Farm Rehabilitation Administration, Agriculture and Agri-Food Canada (Warren, pers. comm. 2006) calculated potential evapo-transpiration (PET) using the Priestley-Taylor equation for four climate stations located in and surrounding the study area (Figure A.11). The RMs of Riverside and Saskatchewan Landing have an average (1971-2000) PET of between 719 mm/year at Swift Current to 740 mm/year at Abbey. The growing season (April to August inclusive) normally has PET of 555 mm (Swift Current) to 566 mm (High Point). The PET was above average in both 2000 and 2001 for the growing season period. In the 2002 growing season, the PET was above average by 12 mm (2.1%) at Abbey. The highest PET during the 1999 to 2005 period occurred in 2001 and 2003 at Abbey. This PET trend was similar for the other four climate stations (Figure A.12).

The highest monthly PET generally occurs in July (approximately 135 mm) followed by June, August, May and April. Eight out of 10 months reported average to above normal PET values in 2000 and 2001 (Figure A.13). Only June of both years reported below normal PET values for all four stations. There were 10 to 15 % lower than normal PET values in the spring of 2002. June and July of 2002 PET values were above average, falling to below average in August. At Abbey, July PET values were higher than normal for the 2000 to 2003 period inclusive.

The Palmer Drought Severity Index (PDSI) is a meteorological drought index and responds to weather conditions that have been abnormally wet or abnormally dry. It is based on precipitation, temperature and available water content of the soil. The index, developed by Palmer (1965) was intended to measure the cumulative departure of moisture supply from a water balance viewpoint. The PDSI is generally considered useful for agriculture and other activities sensitive to soil moisture and is widely used in North America, and available in map and data format. PDSI values usually range from +4 (or more) indicating extremely wet conditions to -4.0 (or less) indicating extreme drought conditions. Environment Canada published monthly PDSI information for the Canadian Prairies in map form during the 1999 to 2003 period (Figures A.14 to A.24). The method used for Environment Canada's PDSI is described in Hopkinson (2000).

These maps indicate how the drought conditions evolved on the province wide scale. The fall of 2000 showed dry conditions in south eastern Alberta and beginning to encroach into south western Saskatchewan. This trend continued during the winter of 2000/2001. The spring of 2001 (March, April and May) saw PDSI values in south western Saskatchewan ranging from -3 to -5. By August 2001, a large region of western Saskatchewan had PDSI values of between -5 to -7 indicating extreme drought conditions. These values continued through the fall of 2001 and winter of 2001/2002. The extreme values lessened slightly in the spring of 2002 with values of -4 to -5. The summer of 2002 continued to improve in south western Saskatchewan with values of -1 to -4. By the fall of 2002, the PDSI values were classified as normal to slightly above normal. This trend continued into the winter and spring of 2003.

Bonsal (pers. comm. 2006) has recently determined PDSI values using both Environment Canada's measured data as well as a gridded data set. The summer period (June, July, and August) of PDSI for the grid square in the Stewart Valley/Cabri Region had a lower value than the climate station information obtained from Swift Current (Bonsal, pers. comm. 2006). The grid square information indicates that a moderate drought was occurring in 2001 and a severe drought in the summer of 2002. The PDSI value for the agricultural year (September to August) indicates that 2001/2002 was severe drought while the 2000/2001 was near normal conditions for the Swift Current Climate Station data. The PDSI value for the agricultural year at the grid square indicates that 2000/2001 was near normal and 2001/2002 was an extreme drought year (Table 3.1).

The Standardized Precipitation Index (SPI) was calculated for both Swift Current using observed climate information and gridded data for the grid square over the Cabri/Stewart Valley region (Bonsal, pers. comm. 2006). SPI is an index based on the probability of precipitation for any time scale. SPI values range from +2 (or more) indicating wet conditions to -2 (or less) indicating dry conditions. The SPI values give another indication of the severity of the drought. The summer of 2001 is classified as being moderately dry and the 2000/2001 agriculture year is classified as being severely dry. Unlike the PDSI, the summer of 2002 SPI is classified as being very wet and the 2001/2002 classified as being near normal (Table 4). This is because the PDSI incorporates antecedent climate information while the SPI does not.

Table 3.1 Palmer Drought Severity Index (PDSI) and Standardized Precipitation Index (SPI) Values for the Cabri and Stewart Valley Region (1999-2002)

Swift Current (Data source: Bonsal, pers. comm. 2006)

	PDSI (JJA)	PDSI (Agriculture Year)	SPI (JJA)	SPI (Agriculture Year)
1999	2.26	0.40	-0.03	1.09
2000	1.59	0.43	0.58	0.42
2001	-1.75	0.45	-1.22	-1.33
2002	-2.76	-3.62	1.77	0.09

Grid Square (50° 35' 45.6"N, 107° 38' 2.4" W) (Data source: Bonsal, pers. comm. 2006)

	PDSI (JJA)	PDSI (Agriculture Year)	SPI (JJA)	SPI (Agriculture Year)
1999	2.05	0.13	-0.06	1.09
2000	1.56	0.39	0.68	0.45
2001	-2.09	0.24	-1.31	-1.54
2002	-3.49	-4.04	1.60	-0.19

Agriculture Year = September to August.
JJA = June, July August

4. DROUGHT IMPACTS ON THE COMMUNITIES

4.1 Bio-Physical Impacts

4.1.1 Water Availability

4.1.1.1 Municipal water

Cabri has some potable water supply issues during drought situations. Water consumption was the highest in 2001 even though water usage restrictions were put in place. The greatest water consumption in Cabri for the 1976 to 2005 was in 1998, followed closely by 2001 (Figure A.9). The water consumption records for Cabri indicate a 25 percent increase in 2001 and a 15 percent decrease in 2002 based on a 30 year averaging period (Figure A.25 and Table 2.2).

Stewart Valley has a dependable water supply and there have been no known problems with water supply or water quality during drought conditions (Hagen, pers. comm. 2006). The water consumption records for Stewart Valley indicate a 17 percent decrease in 2001 and a 27% decrease in 2002 based on a 20 year averaging period (Figure A.26 and Table 2.2). The reason for the decreases in water usage and not known but may be due to low population (approximately 100 people Table 2.4) plus possible water conservation measures implemented by the town.

It is projected that the populations of these communities will continue to decrease. However, if the population increases or droughts become more severe, it is not known if either community will be able to adapt to a more severe (intensity and duration) drought.

4.1.1.2 Stream flow

The drier than average conditions of the early 21st century led to lower than average stream flows and reservoir levels. The South Saskatchewan River has had a decrease in the mean annual stream flow for the 1911-2004 period at both Medicine Hat and Saskatoon. At Medicine Hat, the lowest flow year in recorded history was in 2001. The preceding year was below normal as well (Figure A.27). There were 27 consecutive months recording below average stream flow on the South Saskatchewan River at Medicine Hat from March 2000 to May 2002, inclusive (Figure A.28).

Red Deer River, a tributary of the South Saskatchewan River, recorded its lowest annual stream flows in 2001 and 2002 since recording began in 1961 (Figure A.29). The Red Deer River did not have as many consecutive months below average as the South Saskatchewan River. The Red Deer River discharge was above normal in the winter months of 2001 and 2002 (Figure A.30). At Saskatoon, 2001 was the third lowest flow year recorded since 1912 (Figure A.31) despite flows being highly regulated by Gardiner Dam. The South Saskatchewan River at Saskatoon had 19 months with below average stream flow for the March 2001 to September 2002 period (Figure A.32).

In 2001, Lake Diefenbaker was 1.7 m below its average water level. This was the lake's lowest level since 1984. The monthly mean water levels of October to December were the lowest recorded since 1967. During these months, the water level of the lake was approximately 3 m below the average. The water levels continued to be well below average until June/July 2002 due to mountain snowmelt and mid-June extreme precipitation events in Alberta (Figures A.33 and A.34). The level of this lake has an influence on the ability of upstream water users to access the water. For example, the water level was extremely low in 2001 resulting in Cabri extending its water intake line farther into the river. The Miry Creek Irrigation District had sediment problems in 2001 because of the low water levels.

Creeks in Saskatchewan have highly variable flow. For example, Swift Current Creek near Leinan had extreme high flow years in 1994, 1996 and 1997 but in 1998 to 2002 the annual flows were quite low. The average annual stream flow is 1.22 m^3/s. The flow in 2001 was 0.58 m^3/s below average and 2002 was 0.72 m^3/s below average (Figure A.35). The Swift Current Creek had 18 months of below average mean discharge flow for the February 2001 to July 2002 period (inclusive) (Figure A.36).

Antelope Creek generally only flows when there is spring run-off. The amount of flow in this creek, like other prairie creeks is highly variable. The period of 1998 to 2002 is the longest period with little to no flow at any time of the year. For the first time in recorded history three years (2000 to 2002 inclusive) had no stream flow recorded (Figure A.37). This had a significant impact on the Cabri reservoir as Antelope Creek is its major water source.

4.1.1.3 Groundwater

As described in 2.1.2.2, groundwater is widely used in the study area. The Tyner and Verlo wells are the groundwater observation wells located closest to the Stewart Valley/Cabri region (Figure A.4).

The Verlo observation well has had a general decrease in water levels since 1972. Most years had a spring recharge as shown on the graph but these recharge periods in 2000, 2001 and 2002 were minimal. The decline appears to have slowed since 2002 (Figure A.38).

The Tyner observation well has been generally increasing in depth since observations began in 1965. This general increase levelled out during mid-2000 to mid-2002 period. The water levels continued the overall trend of increasing from mid-2002 to record high level in mid-2005 (Figure A.39).

4.1.1.4 Dugouts

Prairie Farm Rehabilitation Administration, Agriculture Canada track dugout levels throughout Western Canada (Figures A.40 to A.42). The spring of 2000 survey indicated that the majority of the dugouts in the region were half full. By July, 2000, south of the South Saskatchewan River, the dugout levels were only one quarter full. The southern halves of the two RMs were still half full. Going into the 2000/2001 winter, the entire area of the two RMs had dugouts that were only one quarter full.

The dugouts remained one quarter full during the summer and early fall of 2001. By November 2001, only the dugouts just south of the South Saskatchewan River remained one quarter full. The survey indicates that southern half of the RMs had dry dugouts.

May 2002, the dugouts were classified as being one quarter full and early June the dugouts just south of the South Saskatchewan River were categorized as dry. The southern half of the RMs, had dugouts that were continued to be classified as one quarter full. By September, the dugouts were classified ranging from one quarter full, closest to the River to three quarter full on the southern most reaches of the two RMs.

All of 2003, the dugouts were classified as “no water shortages anticipated”.

4.1.2 Insects and pests

Two species of grasshoppers (clear-winged grasshopper and two-striped grasshopper) can have major detrimental effects on both cultivated crops and rangeland grasses. Weather conditions have a major role in determining the severity of a grasshopper outbreak. Areas that receive less than 750 mm of precipitation annually are most susceptible. Temperature is also a contributing factor in determining the spring grasshopper population numbers. The previous spring and summer temperatures determine how quickly the parents of the following year’s grasshoppers develop. Fall climatic conditions are limiting factors of successful egg laying (Calpas and Johnson 2003).

Spring temperatures are important to the timing of grasshopper hatching depending on whether it is a cool or warm spring. A warm spring results in early hatching and quick development and a cool spring delays the onset of the grasshoppers. A cool spring also has an impact on plant development (Calpas and Johnson 2003).

The amount of crop damaged by grasshoppers is controlled by the relationship between temperature and rainfall. Under hot, dry conditions, when a crop or grassland is already stressed, a small grasshopper population can do as much damage as a large population under cool wet conditions (Calpas and Johnson 2003).

Cool wet weather affects grasshoppers by hindering grasshopper development and by increasing the possibility of disease in the population. This helps reduce the next year’s grasshopper population (Calpas and Johnson 2003).

The economic threshold in cereal crops ranges from 8 to 12 grasshoppers per square metre depending on the crop. For example, a generally higher market value crop such as durum would only need 8 grasshoppers per square metre to make an impact while feed wheat would be at the higher end (Saskatchewan Agriculture and Food web accessed March 14, 2006). The average number of grasshoppers per square meter at the end of summer 2001 ranged from 7.2 to 12 in Alberta and from 4 to 5.0 in Saskatchewan. Due to the fall 2001 conditions, it was projected that southwestern Saskatchewan could have anywhere from 12 to more than 24 grasshoppers per square meter (Johnson et al. 2002 web accessed March 14, 2006).

Every year, Saskatchewan Agriculture and Food conducts a grasshopper survey (August to September) in order to publish a grasshopper forecast for the upcoming growing year (Figures 30 to 32) for the entire province. The forecasts for the coming year give a general indication of the grasshopper population for the previous year (Hartley, pers. comm. 2006). The forecasts did not distinguish between the pest and non-pest grasshoppers (Johnson, pers. comm. 2006).

The grasshopper forecast for 2001 in the Stewart Valley/Cabri area was very light to moderate. To the west of the RMs, the infestation forecast was from moderate to very severe. The forecast for the 2002 season ranged from severe to light, indicating that the grasshopper numbers were a possible issue in the southern portion of the RMs.

The unusually cold spring of 2002 resulted in the delay of grasshopper hatching. The delayed hatching resulted in the grasshoppers attaining adulthood late in the summer and thus laying fewer eggs than under normal climatic conditions (Johnson and Calpas 2003). The delay in grasshopper maturation likely delayed the impact of grasshoppers on the 2002 crop. The 2003 grasshopper forecast ranged from light to very severe indicating that grasshoppers may have been a problem in certain areas of the RMs in 2002.

4.1.3 Wind Erosion

Wind erosion is a serious hazard because of the loss of topsoil, plant damage, air pollution, traffic accidents and clean-up costs (Wheaton 1992). Wind erosion is very common during dry periods. Environment Canada stopped collecting blowing dust information in 2000 and previous to that date, collected the information at select locations. Therefore other sources of wind erosion information had to be obtained including print media and traffic accidents.

Saskatchewan Department of Highways and Transportation records information about traffic accidents and whether there was blowing dust or snow (combined into one category). If the date of the occurrence is in the summer, it is likely that the contributing factor was blowing dust.

Wheaton (2005) analyzed blowing dust/wind erosion events throughout Western Canada, concentrating mainly on the provincial scale. The data was reanalyzed to determine if there were any traffic accidents in the RMs of Saskatchewan Landing and Riverside. The traffic accident information does not indicate that blowing dust was a factor in the two RMs in 2001 (Bell, pers. comm. 2002b with Wheaton 2005). The media information indicates that the May 23, 24th 2001 period could have had some dust events, while on May 21, 2002, personal observations (Judisch and Cutforth 2003) noted that there was severe blowing dust in the Swift Current area.

4.1.4 Conclusions and Recommendations

There were differences and similarities in the bio-physical impacts each of the RMs experienced in the 2001 and 2002 drought years. The RM of Riverside appeared to have been more negatively impacted than the RM of Saskatchewan Landing. The reasons may be:

- the RM of Saskatchewan Landing received more rainfall at opportune times than Riverside.

- Stewart Valley has a reliable good quality potable groundwater source. Cabri relies upon surface runoff from Antelope Creek and a pipeline to access the South Saskatchewan River.

4.2 Socio-Economic Impacts of the Droughts

Social-economic impacts of droughts emanate from various bio-physical changes brought forth by the droughts. A review of the literature was undertaken. Findings of this review are presented in Appendix B. Estimation of these was undertaken using a private accounting stance – that is, economic cost to the producers in the study region. Furthermore, since the Cabri and Stewart Valley and their surrounding regions are predominantly agricultural, estimation focused on the agricultural impacts. Both crop and livestock enterprises were included. No estimates of the spill-over effects on other industries were undertaken.

4.2.1 Crop production

4.2.1.1 Crop production background

Rural Municipality of Saskatchewan Landing: The total area in cropland within the RM of Saskatchewan Landing (No. 167) which houses the community of Stewart valley, for the 2001 year was reported to be 125,332 acres. Table 4.1 illustrates the land use trend in the past 20 years (1981 to 2001 period). Within this RM, crop acreage consistently represents the largest portion of land use. Summerfallow area has decreased significantly since the early 1990s which reflects improved soil conservation practices and/or adoption of conservation tillage systems. Tame or seeded pasture has increased slightly while natural pasture has fluctuated around the 30,000 acre mark.

Distribution of the total crop area by major crops is shown in Table 4.2. Land in Durum production represents the largest portion of the total crop area within this RM. Durum acreage surpassed Spring Wheat production around the 1996 Census year. Spring Wheat is positioned fourth during this year as a percent of total crop acres. Pulse crops have become very popular in the past few years and currently represent a large portion of the crop acreage.

Rural Municipality of Riverside: The total area in cropland within the RM of Riverside (No. 168), which houses the community of Cabri, for the 2001 Census year was 178,528 acres. This is slightly smaller than that in the RM of Riverside. Table 4.3 illustrates the land use trend in the past 20 years in the RM. Here, crop acreage consistently represents the largest portion of land use. Summerfallow area is still present, however it is less common than in the 1990s which reflects improved soil conservation practices. Tame or seeded pasture has increased slightly while natural pasture has increased significantly equal to the summer fallow percentage. There are more acres in pasture within this RM. Most importantly, the following Land Use table illustrates that field crops represent the greatest portion of the total farm area.

Table 4.1 Land Use in Acres, RM of Saskatchewan Landing No. 167, 1981 – 2001

Land Use	Area in Acres				
	1981	1986	1991	1996	2001
Total Crop Area	73,710	61,676	81,565	94,209	125,332
Total Summer fallow Area	58,256	61,676	63,525	51,579	33,219
Tame or Seeded Pasture	9,893	5,205	6,515	7,653	12,231
Natural Pasture	31,125	28,763	31,660	23,951	28,866
Other Land	1,128	22,179	4,517	7,570	6,955
Total Farm Area	174,113	179,499	187,782	184,962	206,603

Source: Statistics Canada (Various issues of Census of Agriculture)

Table 4.2 Distribution of Total Crop Area by Crops, RM of Saskatchewan Landing No. 167, 1981 – 2001

Crops	Area in Acres during				
	1981	1986	1991	1996	2001
Durum Wheat	29,316	22,775	32,221	39,479	46,717
Lentils	130	439	1,189	3,685	16,077
Dry Beans	N.A.	0	0	N.A.	15,798
Spring Wheat	31,306	62,973	33,797	31,953	14,305
Dry Field Peas	0	0	205	690	7,452
Alfalfa and Alfalfa Mixtures	3,123		4,307	4,091	6,698
Barley	5,993	6,777	6,390	6,757	5,810
Tame Hay and Fodder Crops	3,570		624	742	4,920
Oats	820	705	877	2,141	2,876
Canola	0	0	0	1,730	2,701
Mustard Seed	0	566	N.A.	N.A.	778
Rye	1,610	1,580	1,115	770	197
Canary Seed	N.A.	0	0	1,165	N.A.
Chickpeas	N.A.	0	0	N.A.	N.A.
Total Area of Cropland	73,710	61,676	81,565	94,209	125,332

N.A. Not available
Source: Statistics Canada (Various issues of Census of Agriculture)

Table 4.3 Land Use in Acres, RM of Riverside No. 168, 1981 – 2001

Land Use	Area in Acres				
	1981	1986	1991	1996	2001
Total Crop Area	125,370	98,074	133,963	144,624	178,528
Total Summer fallow Area	111,693	98,074	105,825	101,095	64,228
Tame or Seeded Pasture	10,207	5,507	6,601	9,879	11,808
Natural Pasture	47,422	60,881	60,062	61,817	62,399
Other Land	1,692	46,392	22,562	8,552	6,013
Total Farm Area	296,385	308,928	329,013	325,967	322,976

Source: Statistics Canada (Various issues of Census of Agriculture)

Land in Durum production represents the largest portion of the crop acreage at 85,476 acres (Table 4.4). Durum acreage surpassed Spring Wheat production around the 1991 Census year. Spring Wheat is positioned 6th as a percent of total crop acres. Pulse crops have recently "filled the gap" as they now account for nearly 45% of the total crop acreage.

Table 4.4 RM of Riverside No. 168 Crop Acreage in Census Years

Crops	Area in Acres during				
	1981	1986	1991	1996	2001
Durum Wheat (ac)	87,344	-	87,380	90,821	85,476
Dry Beans (ac)	-	-	-	-	25,751
Chickpeas (ac)	-	-	-	-	25,751
Dry Field Peas (ac)	-	-	-	1,802	17,172
Lentils (ac)	-	-	3,785	6,855	11,711
Spring Wheat (ac)	20,835	105,911	24,348	22,026	11,370
Barley (ac)	4,459	4,424	4,051	3,688	9,061
Alfalfa and Alfalfa Mixtures (ac)	3,759	-	2,507	3,847	4,560
Tame Hay and Fodder Crops (ac)	4,499	-	2,159	875	2,148
Canary Seed (ac)	-	-	404	5,621	2,093
Mustard Seed (ac)	-	-	-	3,106	2,009
Oats (ac)	1,516	852	1,277	2,068	1,949
Canola (ac)	-	-	-	917	1,788
Rye (ac)	4,603	5,621	-	1,520	1,101
Total Area of Cropland (ac)	125,370	98,074	133,963	144,624	178,528

Source: Statistics Canada (Various issues of Census of Agriculture)

One of the major limitations of this data set is that area under crops for the drought years is not recorded at the rural municipality level. Provincial level data were perused, which suggested no major departure from the trend in the recent period. For this reason, distribution of area by crops for the 2001 was used as the basis for all calculations of economic impacts of drought.

4.2.1.2 Yield analysis

In order to assess impact of the drought on crop yields, a long-term perspective was taken. Crop yields for major crops were collected for the 1954-2004 period. However, data for this period was limited to major crops only. For other crops, data were collected for the more recent, but shorter period.

Rural Municipality of Saskatchewan Landing: Figure 4.1 charts illustrate yield for major crops over this period for the RM # No. 167. Production varies from year to year, however, 2001 and 2002 have depressed yields among all crops.

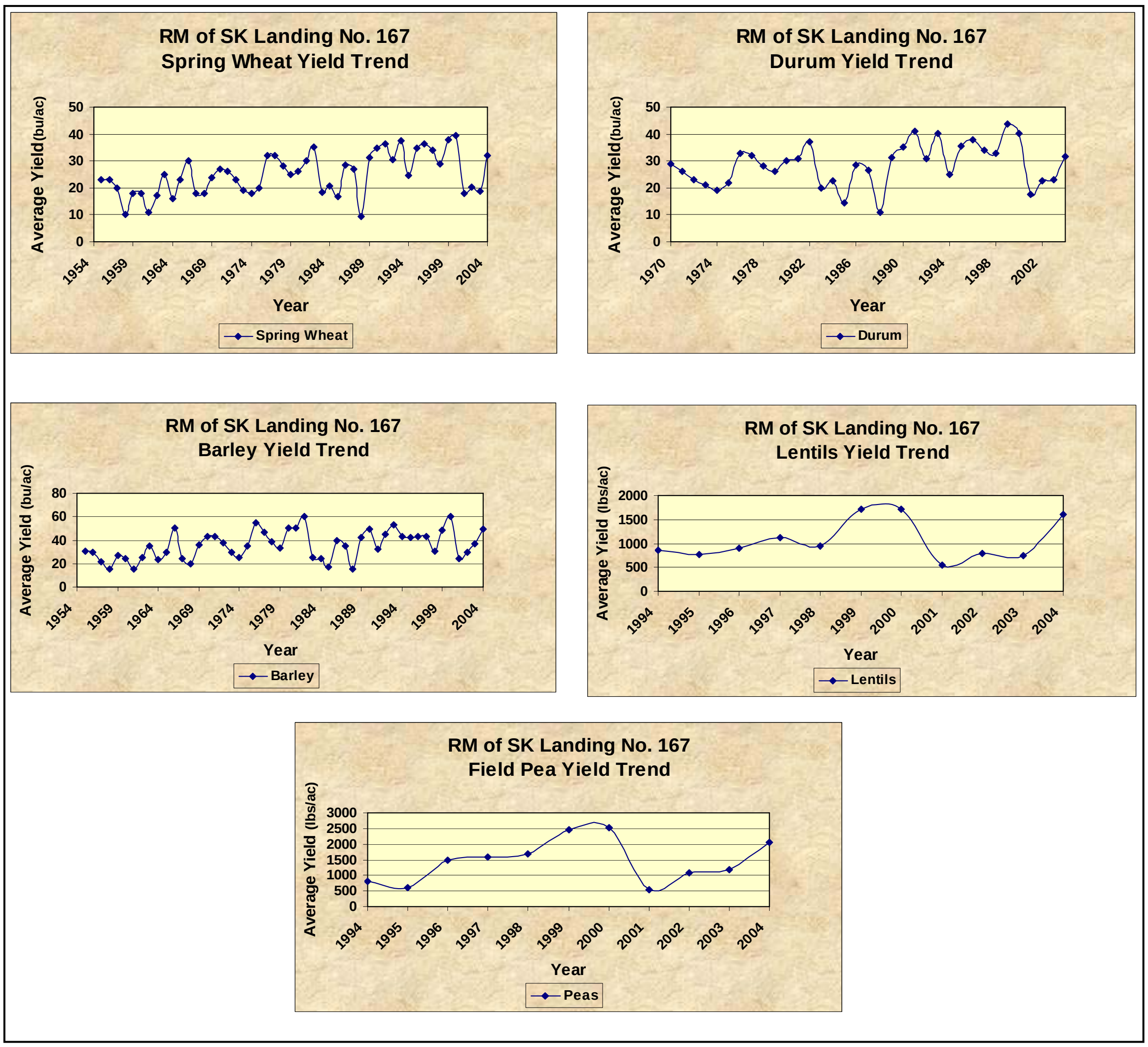

Figure 4.1 Trend in Yield of Major Crops in the RM of Saskatchewan Landing No. 167

Spring Wheat yielded an average of 39.4 bu/ac in 2000 and fell to 17.8 bu/ac in 2001. The average yield rose slightly in 2002 to 20.3 bu/ac and again slightly fell to 18.7 bu/ac in 2003. Yields were up in 2004 to 32.2 bu/ac. Thus, for this crop, drought effects were noticed for 2001 to 2003 period. It should be noted that this period was better than the record low crop yield which were recorded for the year 1988 when the average spring wheat yield was 9.3 bu/ac.

Durum yields plummeted from a high of 40.4 bu/ac in 2000 to 17.7 bu/ac in 2001. In 2002 the average yield slightly rose to 22.6 bu/ac and again in 2003 to 23 bu/ac. Finally, in 2004 yields climbed back up to 31.7 bu/ac. The lowest average yield in this trend was 11 bu/ac in 1988 and 14.5 bu/ac in 1985. Durum was introduced to this RM in 1970 and initially produced an average yield of 29 bu/ac.

Barley yields were lower in 2001 and 2002 averaging 24.5 & 29.8 bu/ac. This was significantly lower than the 2000 average of 59.8 bu/ac and the 2004 average of 49 bu/ac. The 2003 average yield was only slightly higher than that in the previous years, averaging about 36.6 bu/ac.

Field Peas were introduced in this RM in 1992 and had an initial average yield of 1,000 lbs/ac. The highest yield in this trend was in 2000 at 2,531.6 lbs/ac and the lowest yield followed in 2001 crashing to 531 bu/ac. At a test weight of 50 lbs/bu the volume-based yield is down 50 to 10 bu/ac. In 2002 the average yield rose to 1,081 lbs/ac and again in 2003 to 1196 lbs/ac. In 2004, the average yield climbed further to 2,056 lbs/ac.

Lentils were also introduced into this RM in 1992 and had an initial average yield of 1,200 lbs/ac. The highest yield in this trend was in 1999 at 1,714.4 lbs/ac and the second highest yield was seven pounds lower at 1,707.3 lbs/ac in 2000. The drought in 2001 was reflected by the lowest recorded yield of 559 lbs/ac. In 2002 the average yield rose slightly to 785 lbs/ac but fell again in 2003 to 737 lbs/ac. Finally yields rebounded in 2004 to an average of 1,614 lbs/ac.

Rural Municipality of Riverside: Figure 4.2 illustrates common crop yields as far back as 50yrs for the Rural Municipality of Riverside (No. 168). Production varies from year to year; however, 2001 and 2002 did have depressed yields for all crops.

Spring Wheat averaged 31.9 bu/ac in 2000, which decreased to 24.9 bu/ac in 2001. In 2002 yields dropped further to 17.2 bu/ac and even further in 2003 to 12.7 bu/ac. Finally in 2004 yields bounced back to 32.8 bu/ac. Like the neighboring municipality of Saskatchewan Landing, the most significant drop in yield occurred in 1988 when the municipal average dropped to 7.7 bu/ac.

Pattern of durum wheat yields was almost identical to that for the spring wheat. Yields were strong in 2000 at 35.3 bu/ac and then began to fall in 2001 to 21.7 bu/ac. In 2002, yields fell again to 19.1 bu/ac but rose slightly in 2003 to 23.1 bu/ac. The year 2004 noticed healthy yields again at 38.4 bu/ac. The lowest recoded yield during this 50-year period was 7.8 bu/ac in 1988.

Barley production averaged at 45.8 bu/ac in 2000 then declined to 38 bu/ac in 2001 and finally 26.4 bu/ac in 2002. In 2003, yields fell further to 24.7 bu/ac and then jumped to its highest value in this fifty year trend at 54.1 bu/ac in 2004. The 1988 crop year experienced the worst recorded yields at an average of 17.2 bu/ac.

Field Peas are new to this municipality as they were introduced in 1992 and yielded and average of 500 lbs/ac. The highest yielding years were 1999 -- at an average of 2,879.1 lbs/ac and 2000 -- at an average of 2,479.2 lbs/ac. The year 2001 witnessed a severe decrease in the pea yield to 533 lbs/ac, but then in 2002 the average yield rebounded to 1,484 lbs/ac. In 2003 the average yield decreased again to 1,138 lbs/ac and, finally, 2004 experienced the third highest average yield at 2,461 lbs/ac.

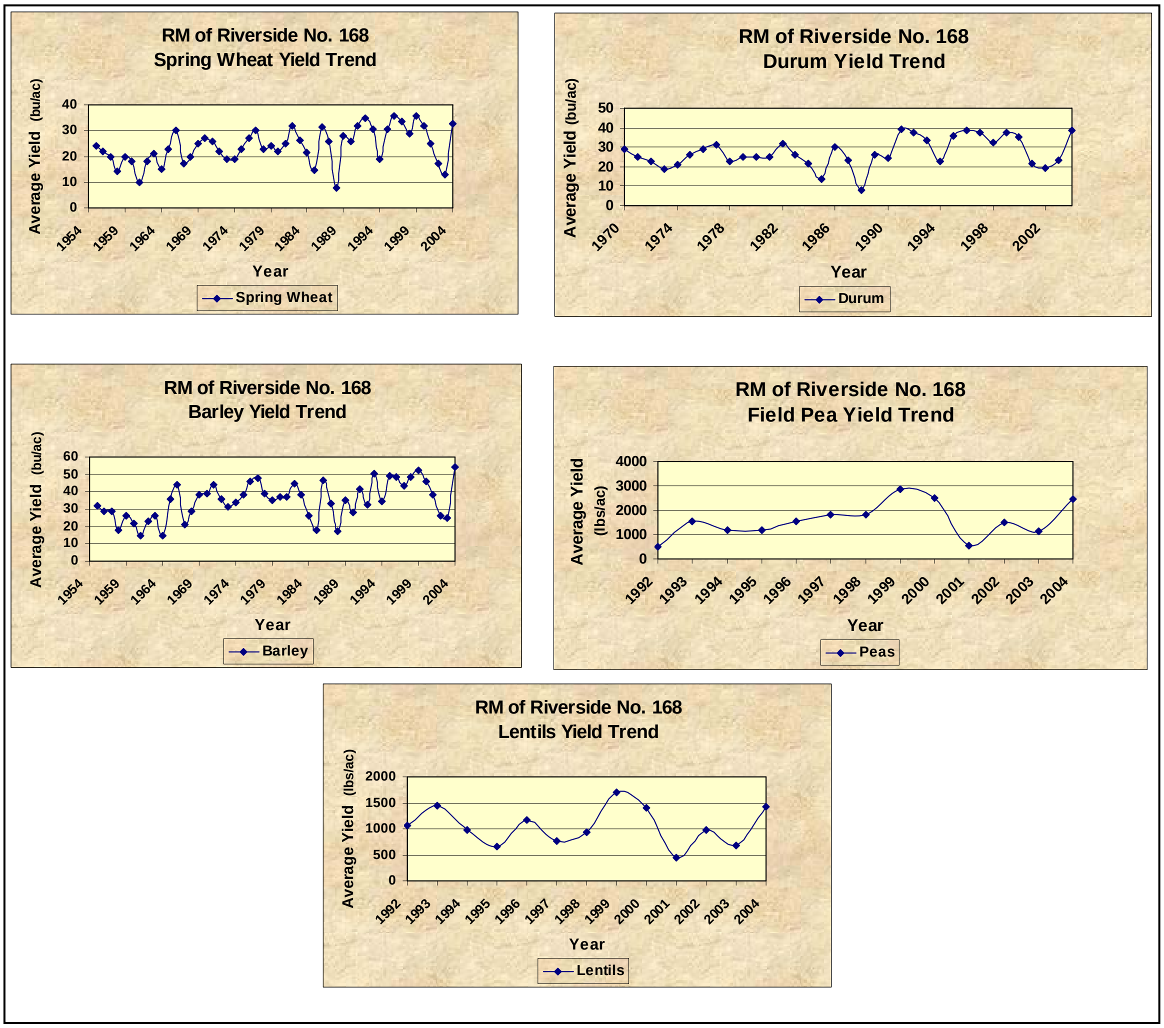

Figure 4.2 RM of Riverside No. 168; Yield Trends

Like peas, lentils are also a relatively new crop to this municipality as they were introduced in 1992 and yielded an average of 1,064 lbs/ac. This trend is indeed very similar to that of field peas. The greatest yielding years were 1999 at an average of 1,695.8 bu/ac and 2000 at an average of 1,409.3 lbs/ac. The year 2001 saw a severe decrease to 439 lbs/ac and then in 2002 the average yield bounced back slightly to 977 lbs/ac. In 2003, the average yield was down again to 672 lbs/ac only to spike back in 2004 to 1,425 lbs/ac.

4.2.2 Economic Impact on Crop Production

The economic impact of the droughts on agricultural producers was measured as a change in producer surplus during a drought year relative to some normal (base) period. Producer surplus is the difference between gross returns from agricultural production and respective cost of producing the same goods. Total gross return from agricultural crop production is simply a weighted product of area under a crop and its respective yield. These two variables have been discussed above. The cost of production in a drought year required primary data collection. However, this was assumed to be beyond the resources available for this study. Review of standard cost of production budgets was undertaken and used for the study. A review of various studies was also undertaken to arrive at some evidence of change in cost of production during a drought year. However, not many studies for the Canadian Prairie provinces have addressed this issue. The only study that has reported on this aspect was that by Kulshreshtha and Marleau (2005), which reported that cost of production during a drought year does not change significantly unless drought conditions are predicted well in advance of seeding the crops. In this study, it was assumed that cost of production for various crops in the two study RMs will not change on account of the drought conditions. Thus, change in the producer surplus during a drought year is simply a change in the gross revenue from crop production, although in this study it was estimated as a net return to producers.

Change in the producer surplus was estimated using major crops in each of the RMs. Approximately 93% of the total crop land in the RM of Saskatchewan Landing No. 167 and 87% in the RM of Riverside No. 168 were represented by crops shown in Tables 4.2 and 4.4, respectively. Therefore the following analysis may result in a slight underestimated impact of the drought.

The base period for this analysis was assumed to be 1998-2000 period. The costs of production and prices for each year were derived from the Saskatchewan Agriculture and Food crop planning guides. Yield data were inputted into the crop planning guides specific to each year. Total costs excluding labor and management were used. These costs included variable costs, such as input costs, and fixed costs such as depreciation, taxes and investments. From this, a net revenue/acre value was calculated for specific crops. Next the Statistics Canada Census 2001 crop acreage data provided the acreage of those specific crops within each RM. Calculations were done for each crop in each RM and summed to show the total impact. These results are shown in Table 4.5.

The 2001 and 2002 droughts brought about a net economic loss to the producers in the two rural municipalities. This decrease was primarily a result of decreased yield of various crops. There was a loss of $ 14.3 million in 2001 and another $7.3 million in 2002 relative to the 1998-00 average net returns. The 2002 drought year was not as severe. However, producers’ net returns were still negative when all production inputs were accounted for. The economic situation improved in 2003 but was still grim as it resulted in a loss of $4 million (relative to base period). Total impact of the drought in the two RMs during 2001 to 2003 was estimated to be $25.8 million.

Table 4.5 Economic Impact of Drought on Crop Production

Particulars	Total Net Revenues from Crop Production ($000) during				
	98-00 AVG	2001	2002	2003	2004
RM of Saskatchewan Landing No. 167, 93% Representation	$2,328.84	($3,219.83)	($359.57)	$1.419.51	$1,154.96
RM of Riverside No. 168, 87% Representation	$3,120.49	($5,637.54)	($1,476.96)	($175.18)	$6,923.64
Total RM Crop Impacts	**$5,449.33**	**($8,857.37)**	**($1,836.53)**	**$1,244.33**	**$8,078.60**
Economic impact of the drought		**($14,306.70)**	**($7,285.86)**	**($4,205.00)**	

From this economic analysis, simply stated, the crop production sector is very vulnerable to drought. The trend towards diminishing returns, due to the increasing cost of production and bearish markets, requires consistent yields and results in significant vulnerability to drought.

4.2.3 Impact of the Drought on Livestock production

The livestock sector within the rural municipalities of Riverside and Saskatchewan Landing consists primarily of cow-calf and on-farm feeder operations. This sector of the local agriculture industry is supported by forage production on farms. According to the 2001 Agricultural Census (Statistics Canada 2003), 22.98% of Riverside's and 19.89% of Saskatchewan Landing's total farm area was in pasture for grazing. There is no significant value-added agribusiness within this area. Therefore, the livestock industry consists mostly of primary production. Tables 4.6 and 4.7 provide historical data on the total number of cattle within these Rural Municipalities. Both Rural Municipalities have experienced an increasing trend in cattle inventory that reached a relative plateau between the 1991 and 2001 Agricultural Census years.

Table 4.6 Historical Cattle Inventories in the RM of Saskatchewan Landing (No. 167), 1981 – 2001

Year	Total Cattle and Calves	Total Cows	Total Heifers >1yr	Calves <1yr
1981	4,597	2,094	444	1,716
1986	3,487	1,434	530	1,242
1991	6,022	2,226	1,488	1,403
1996	5,160	2,232	637	1,815
2001	6,410	2,497	726	2,340

Table 4.7 Historical Cattle Inventories in the RM of Riverside (No. 168), 1981 – 2001

Year	Total Cattle and Calves	Total Cows	Total Heifers >1yr	Calves <1yr
1981	6,382	2,849	773	2,230
1986	5,952	2,216	1,183	1,828
1991	9,891	2,330	1,222	2,052
1996	8,224	3,269	655	3,330
2001	9,277	4,055	885	4,023

According to these data, the Rural Municipality of Riverside produced more Cattle than the RM of Saskatchewan Landing. However, a part explanation for this the relative size differences between the two RMs. Adjusting for these, RM of Riverside has a cattle density of 34.8 cattle per acre (farm area) as against 32.2 cattle per acre for the RM of Saskatchewan Landing.

Estimation of drought impact on livestock production concentrated mainly on cattle production. This is because of high dependence of this production of availability of good quality forage and range condition, which are affected by drought conditions. Data availability is a major constraint to estimation of exact drought impacts at the rural municipality level. This is because yearly inventories of cattle are not available. No farm surveys were exercised on account of resource availability. As a crude substitute, data for the Census Agricultural Region Level (CAR) 3BN were used.

When a drought hits there are many production decisions that need to be made. Since cash flow and financing is usually dismal, most of the important decisions are done under this budget constraint. Unfortunately, one of the most immediate decisions producers must make during a drought is to sell off part of their cattle herd numbers to meet feed and water supplies. This is recognized usually by the culling (sale or disposition) of cows, decreased retention of replacement heifers, and selling feeder cattle at lighter weights. Of these actions, the culling of cows and the reduced retention of replacement heifers results in the most negative drought impacts in the short and long term.

In the short term, these sales and dispositions cause an increase in income but decrease their production for several years after the drought. Most importantly, if producers did sell off their cattle herd, the impact of the drought would be compounded long after the drought period, i.e., until their breeding stock returned to the pre-drought period size. Even when the herds return to their previous size, there is still an opportunity cost in the herd number growth lost during those recovery years. Therefore, to measure the economic impact of drought on cattle production, a poly-periodic analysis is needed. This was considered beyond the resources available for this project. As a substitute, emphasis was placed on change in the number of cows and replacements in the CAR 3BN.

Total cattle and calve numbers for CAR 3BN in 2001 peaked at 149,062 but began declining in 2002 to 136,000 and 128,356 in 2003 (Table 4.8). However, on May 20, 2003 export ban was confirmed after the discovery of Bovine Spongiform Encephalopathy (BSE), resulting in an explosion of total cattle and calve numbers to 215,600. These data support the argument that dispositions of cattle and calves were a result of the 2001 and 2002 droughts. These droughts created a need to liquidate herd numbers either to offset other low farm income or to meet feed and water supplies. The impact of the drought on herd numbers did not have a compounding effect in the years following because of the BSE crisis in 2003. This argument is further supported by the data for beef cows. Beef cow numbers dropped from 62,506 in 2001 to 59,000 in 2002. If there were not enough resources (feed and water) for the 2002/03 winter, producers would have sold a part of their herd as cow/calf pairs or as culled cows. This was noticed in 2003 as numbers dropped to 54,197. This indicates that the drought created a long term impact. However, as mentioned above, the BSE crisis in 2003 offset the cattle number impacts as herd numbers increased in 2004 to 93,700.

Table 4.8 Cattle on Farms by Crop District (CAR 3BN), 1986 – 2004

Year	Date	Calves	Steers	Slaughter Heifers	Beef Replacement Heifers	Milk Heifers	Beef Cows	Milk Cows	Bulls	Total Cattle & Calves
1986	3-Jun	31,981	5,970	3,613	7,762	1,320	34,470	3,204	2,083	90,403
1991	4-Jun	39,630	9,676	4,558	8,627	1,081	42,937	2,899	2,579	111,987
1996	14-May	50,370	7,547	n.a	n.a.	n.a.	56,771	1,698	3,353	132,740
1997	1-Jul	54,200	4,300	3,800	10,000	900	57,100	1,900	3,300	135,500
1998	1-Jul	52,310	4,833	6,828	8,870	387	55,932	1,341	2,552	130,823
1999	1-Jul	52,700	2,600	5,400	10,500	200	52,600	675	2,500	127,175
2000	1-Jul	57,800	8,400	3,700	14,500	260	57,700	640	3,000	146,000
2001	15-May	59,562	5,083	5,490	11,506	446	62,506	1,288	3,181	149,062
2002	1-Jul	56,400	7,000	500	9,300	670	59,000	640	3,400	136,910
2003	1-Jul	51,297	4,923	4,110	10,054	544	54,197	758	3,358	128,356
2004	1-Jul	86,700	9,900	5,900	12,700	800	93,700	n.a.	n.a.	215,600

Source: Statistics Canada, Census of Agriculture, and Saskatchewan Agriculture and Food

To further investigate the drought impacts, beef replacement heifer numbers in CAR 3BN were studied. Previous to the drought years, 2000 beef replacement heifer numbers totalled 14,500, the highest number during the 1986 to 2004 period. In 2001, the total beef replacement heifers decreased to 11,506 and even more in 2002 to 9,300 (Table 4.8). This signifies that these droughts had an impact on beef replacement numbers in the short term. They rebounded slightly in 2003 to 10,054 and again in 2004 to 12,700. The total number of beef replacement heifers did not return to the highest level (as seen for 2000) but did approach normal relative to the historical trend.

To further understand the economic impacts of the drought, cattle and calves prices were studied. Cattle and calves prices were strong prior to the drought years, while being the highest in the year 2000. However, the drought brought about a decrease in cattle prices, partly due to increased cattle available for sale. Cattle prices in 2000 peaked at $113.65 per cwt and dropped to $112.91 in 2001 and $102.62 in 2002 per cwt (hundredweight), as shown in Table 4.9. These were the three highest years between 1995 and 2004. Calf prices were the highest in 2000 at $171.50 per cwt and dropped to $164.78 in 2001 and $134.66 in 2002 per cwt. However, production costs would have been higher as water, pasture, and feed needed to be procured from further distances at greater costs (Saskatchewan Agriculture and Food 2004).

In summary, the drought years of 2001 and 2002 created a need to sell-off cattle and calves to meet feed and water resources. This is supported by a decreasing trend in the number of cattle in 2002 and 2003, and increased marketings of cows during 2001 and 2002 (Table 4.10). A plot of inventories and marketings in the CAR is shown in Figure 4.3. Prices were high during those years which resulted in higher income if procurement costs of feed and water resources were low this is subject to further empirical scrutiny).

Table 4.9 Average Cattle and Calve Prices, Saskatchewan, $/cwt, Cattle and Calves, 1995-2004

Year	Cattle	Calves
1995	$80.28	$100.16
1996	$68.90	$83.39
1997	$85.58	$114.41
1998	$90.78	$123.87
1999	$100.57	$147.37
2000	$113.65	$171.50
2001	$112.91	$164.78
2002	$102.62	$134.66
2003	$99.48	$126.52
2004	$79.35	$105.02

Table 4.10 Cattle Marketings by Crop District (CAR 3BN)

Year	Steers	Heifers	Cows	Bulls	Calves	Total Cattle and Calves
1995	22,510	16,500	5,990	1,440	8,060	54,500
1996	21,690	17,300	7,850	1,470	11,820	60,130
1997	29,880	24,170	10,880	1,660	4,830	71,420
1998	22,030	19,850	9,010	1,310	12,600	61,730
1999	22,740	19,550	7,500	1,210	16,850	68,580
2000	25,400	23,480	7,640	1,090	15,790	73,400
2001	24,620	26,470	9,680	1,430	12,770	74,970
2002	24,960	22,590	10,080	1,230	11,240	70,100
2003	23,780	26,600	4,380	720	15,990	71,470
2004	31,870	26,780	4,360	830	9,390	73,230

Source: Saskatchewan Agriculture and Food- Cattle Marketing

In 2003 cattle and calf numbers continued to decrease but reached record highs in 2004 due to BSE in the previous year. Although cattle numbers were not as affected in the long term the situation became worse especially if debt was incurred because of the drought years. This is because cattle prices plummeted from the initial drought year in 2001 at $112.91 to $79.35 per cwt in 2004. If producers did not recover immediately then they were injected into a fragile economic situation. The high cattle numbers after the drought years are non-drought related and are the opposite effect of the long term drought impacts. The high cattle numbers after the drought were a result of BSE.

Financial support whether from government, private investment and/or farm equity would have been required during the drought years and immediately after. In a normal drought situation the best way to economically offset the impacts would be to increase the herd size as soon as water and feed resources returned to normal levels. If the replenishment of these resources became lengthy, then support is required to adjust the herd size to an unaffected level.

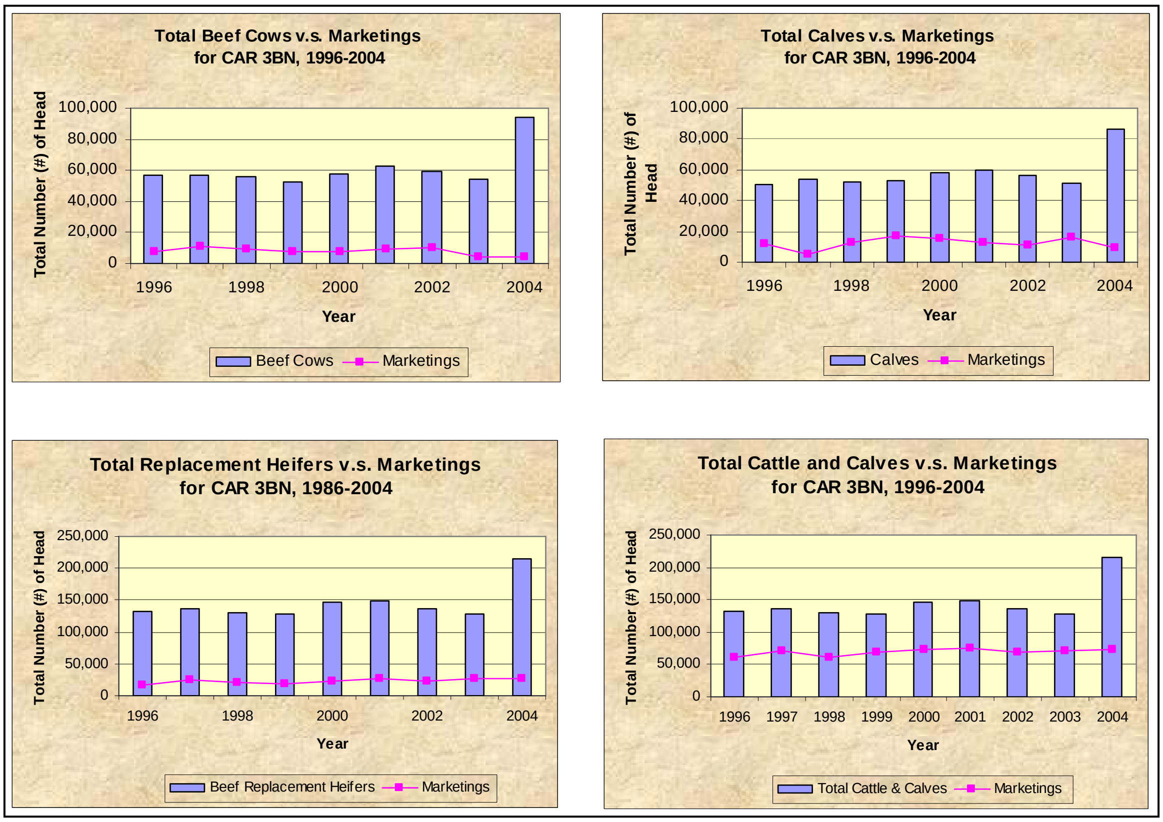

Figure 4.3 Cattle and Calves Inventories and Marketings, CAR 3BN, Saskatchewan, 1996-2004

The repercussions of BSE complicated the matter for cattle producers and especially mixed farms. The long term effects of drought are not recognized in this analysis due to the BSE occurrence the following year in 2003. However, this provides evidence that the drought years of 2001 and 2002 created a negative impact on cattle production. An exact magnitude of this impact remains to be estimated using primary data.

5. RESULTS OF FOCUS GROUPS AND OTHER INTERVIEWS

A series of interviews and focus group meetings with residents of Cabri, Stewart Valley and the region directly surrounding these two communities were conducted by Stephanie Jeannes and Erin Knuttila during the summer of 2005. Interviewees were asked a series of questions dealing with current risks such as environmental, economic, adaptive strategies to these risks, possible future risks and their potential adaptive strategies and their understanding of climate change.

There was a Drought Focus Group Meeting held in Cabri, November 22, 2006. It was led by Dr. Harry Diaz, Stephanie Jeannes and Erin Knuttila (Diaz et al. pers. comm. 2006). Several questions were addressed:

- How did the drought of 2001-2002 affect the communities of Cabri and Stewart Valley? What type of water problems occurred during the droughts?

- How did the drought affect you and your family? Your business? How did the drought affect the community? How did these water problems affect you and your family? Your business? How did these problems affect the community?

- How did you and your family manage the drought? How did you and your family manage these water problems? Why did you (your family) choose this particular approach? Did you get help from other people, such as relatives and/or friends?

- How did the community deal with the problem(s)? What was the role of the local government in dealing with these problems? Did the community receive help from public institutions such as the Saskatchewan Watershed Authority? How did people help each other in dealing with these problems?

- If things were drier in this region, how would it affect you? What would you do about it? How much of a change in moisture can you cope with? Why? What else might be done? If river flow decreased, how would this affect you? What would you do if there was less water in the river?

- What kind of changes in water (quality, quantity, availability) would pose problems for you? Why? How? What are the implications for your livelihood? How would you manage these changes?

- Are there organizations/institutions that you think may be able to help in the future? How? Why? Do the organizations you currently use need to change if climate and water dynamics change? How? Are there institutions that currently do not exist here that would help?

5.1 Responses from Cabri Interviews

Responses from Cabri residents and people in the surrounding region are summarized below. The responses often include a combination of drought impacts along with the adaptation measures taken to deal with the impacts.

- Many of these respondents, especially in the Cabri region, said that low water levels and lack of precipitation were an issue when the 2001/2002 drought occurred. Low water levels made an impression on the people because it affected water available for cattle, irrigation, personal usage as well as for town usage.

- The low precipitation levels reduced crop production levels with crop quality being variable. Farmers offset this by accessing government programs such as crop insurance and the National Income Stabilization Program. However, many of the farmers found that crop insurance barely covered operating costs.

- Farmers also found that grasshoppers were a problem during the drought years. The result was many farmers sprayed.

- Farmers required more water for spraying than they did years ago. Farmers now spray five to six times per year as compared to once per year in the past. Farmers obtain much of the water they require for spraying from municipal wells in both the Cabri and Stewart Valley regions. The farmers also stated that the water quality is not as good as it was when they were able to access Cabri potable water.

- Grain farmers also seeded earlier in the growing season to try to take advantage of the available soil moisture.

- Livestock producers had various issues due to drought conditions including lack of available water for cattle and a decrease in hay yields. The producers hauled water from RM wells for livestock consumption. Where it was an option, livestock producers irrigated as much as they could to attain a hay crop.

- The farmers along the Cabri pipeline have access to the water to fill dugouts located on their land.

- The town of Cabri imposed strict water conservation measures. The result was farmers were no longer allowed to use town water for spraying, town residents were permitted to water every other day and water was pumped from the South Saskatchewan River to fill the car wash. Also, businesses were affected such as the town car wash was not allowed to operate.

- The town attempted to find groundwater close by but was unsuccessful. Management strategies have changed so that when the town water reservoir can hold more water, it will be pumped from the river instead of waiting until water levels are critical.

- Cabri residents had to adapt to water shortages in various ways including hauling water from municipal wells to water trees, installing rain barrels to catch water from the eves, collecting residential grey water and using it on the gardens and washing their vehicles in a different community. Most residents complied with the water restriction order.

5.2 Responses from Stewart Valley Interviews

Like Cabri, residents of Stewart Valley as well as farmers in the surrounding region were interviewed. Their responses are summarized below:

- In the Stewart Valley region, the 2001/2002 drought was not considered to be as problematic as in the Cabri region. The Stewart Valley region had average to little below average crop yields. Many of the grain producers had crop insurance but were unable to collect because their yields were above the cut-off collection line. Minimum tillage is used in the region which appears to help manage soil moisture better than conventional tillage farming.

- The economic impact varied among these communities. For the most part it was negative as crop yields decreased and management costs increased.

- Livestock producers had reduced income because of the increase in cost of the management of resources. Feed and water became sparse and therefore the associated procurement costs decreased their income. Producers did not indicate any dispositions as a result of resource shortages; therefore long term impacts as a result of a decrease in herd stock cannot be determined.

- Crop producers experienced a decrease of income directly in relation to yield loss. They indicated that their input costs, which are relatively beyond their control, have narrowed their profit margin so significantly that there is no room for yield loss. In other words, their break-even yield has increased and as a result the impacts on crop yield during 2001 and 2002 left them with very low to negative income returns. There was also an increase in input costs for grain producers associated with the drought.

- Insecticide costs increased due to the need to spray for grasshoppers and spraying costs in general increased as water was limiting in quality and quantity. No effect on spraying operations or re-spraying was noted on account of water quality, but such impacts may be present from the water quality available during this period.

- Since these communities are dependent on the primary agriculture sector, the impacts of the droughts spilled onto the urban business financial statements. Producers had less money and therefore spent less. The restaurants experienced less business as the community “ate out” less frequently. Retail outlets experienced a decrease in sales as less was spent on items that were not a necessity. For every business that was affected, they in turn made the same decisions as primary producers. They cut costs in their everyday lives and spent less at other businesses within the town.

- Where there was depression in the economic state of agriculture there was a renewed prosperity in oil and gas. The value that the oil and gas industry generated helped support most of the community businesses throughout the drought period and also provided an option of secondary employment for producers and other people directly reliant on agriculture.

- The tourism industry proved to be exceptionally vulnerable during the drought. The local Cabri regional park experienced less business as water levels were low. This meant that fewer people were attracted to Cabri which affected retail, food, and accommodation businesses the most. Also, there is usually a strong tourism industry for sportsman hunting waterfowl. Low water levels decreased the amount of waterfowl in the area and therefore fewer sportsmen were attracted. The retail, food, and accommodation businesses were again affected the most by this.

5.3 Summary

Overall, individuals and families simply tightened their belts and spent less. People involved in the agriculture or tourism industries and water sector were affected the most. Community businesses achieved less success then other years but no receiverships were reported. The oil and gas industry contributed greatly to the survival of these communities, especially Cabri. The effects of the drought were more prominent in Cabri and surrounding area than Stewart Valley. Most people signified that the economic state of their communities has been complicated by uncontrollable external factors especially those involved in agriculture. However, the 2001 and 2002 droughts are remembered by all as being far from prosperous times.

More details on various categories of impacts of and adaptation to the droughts are summarized in Table 5.1 for Cabri residents and Table 5.2 for Stewart Valley residents.

Table 5.1 Drought Impacts and Adaptations of Cabri and Area Residents

Type of respondents	Impacts				Adaptations		
	Physical	**Biological**	**Economic**	**Social**	**Successful**	**Not Successful**	**Reason**
The Community	-Drinking /personal water now came from well reserves -NOT enough water to meet the communities demand (water quantity) -Noticing extreme weather fluctuations and the ease of experiencing sunburn -Notice less snow throughout the winter	-Garden (quantity and quality)	-Most do not drink town water -Increased the demand for bottled water -Get less work done due to the weather extremes	-Could not Garden and a garden is important to their livelihood -Panic stricken and stressed -People experienced discomfort due to bathing with well water (minerals in water react with soap and produce a crawling feeling) -Social stigma of wasting water -prayed for rain -people worked together	-Water conservation strategies in households Hauled water form municipal wells to water trees Installed rain barrels under eves Collect grey water and use on garden Washed car in Swift Current Purchased bottled water -People worked together to conserve water when it was most required		-Development of a personal water reserve to assure a water supply during drought -Also in an effort to prevent further depletion of a limited water supply and manage temperate weather extremes

Type of respondents	Impacts				Adaptations		
	Physical	**Biological**	**Economic**	**Social**	**Successful**	**Not Successful**	**Reason**
Local Businesses	-Climate change has been recognized: "a hotter sun" "people are more prone to sunburn"		-Restricted water reserves almost prevented food and accommodation businesses from operating due to the inability to provide water for showering, laundry, and dishes -Experienced less business due to farmers having no money -Less water = less recreation activity = less money spent in pub, cafés, and retail outlets. -Car wash shut down to save water creating an opportunity cost -Cut Staff	-Reduced income resulted in a poorer standard of living -Cannot drink town water -Experienced constraints of water rationing	-Utilized available water sparingly -Recycled bath water for her garden -Purchases bottled water -Waited until the water levels returned to normal before reopening the car wash	-Manage water used by other people staying at the hotel -Increasing sales volume	-Conserve limited water resources to maintain businesses

Type of respondents	Impacts				Adaptations		
	Physical	**Biological**	**Economic**	**Social**	**Successful**	**Not Successful**	**Reason**
Water Utility	-Water supplies reached dangerously low levels -Evaporation rates from the reservoir were almost equal to that of the water added from the secondary source -Has high levels of manganese	-Had spill-over (human error in 2002) that caused a boil water advisory for the following two years due to a bacteria concern	-System is designed for 'soft-water' therefore it cannot treat well water -System production cannot meet the local demand -Cost of pumping water into reservoir vs. the cost of a water shortage -Rate=7500 gallons in three months for $60	-Workers stressed because they start at 7 and some stay till 3 am	-Pumped water into reservoir from the river - Town foreman takes weekly water samples and sends them to the provincial lab -Water users are advised to not put bleach into their water due to the high manganese content	-Drilled holes outside the community to tap into the "Judith Aquifer" but were not successful	-All in attempt to alleviate water shortage caused by drought
Tourism Industry	-Local lake levels -Waterfowl decreased in #'s	-The taste of local drinking water is not attractable	-Less visitors at local park due to no water -Less hunters -"Word of Mouth" led to Cabri being recognized as a dry area that is not attractable to tourists	-Could not provide a social experience for tourists due to lack of water	-Water was transported from Municipal Well to the local pool	-Sustaining the tourism business	-Keep hunters in the area and tourists visiting the park

Type of respondents	Impacts				Adaptations		
	Physical	**Biological**	**Economic**	**Social**	**Successful**	**Not Successful**	**Reason**
Livestock Producers	-No dry land Hay -No water for cattle in some pastures -Water quantity	-Water sources became unusable due to algal bloom caused by highly concentrated water -Poor forage yields	-Added costs of transporting hay and cattle to and from areas with adequate moisture -decreasing feedlot due to water shortages	-Added stress	-Transported hay form Northern Alberta - Cattle were relocated to pastures with water -Hauled potable water from town -Irrigation		-All an attempt to keep their herd physically alive
Grain Producers	-No water available for spraying -Poor water quality from secondary sources -Low water quality	-Noticed an increased grasshopper population -Reduced crop quality and quantity	-Added costs of transporting water -Added cost from the disadvantages of spraying with ground water -Lower yield from less fertilizer being applied after a dry year	-Added personal danger with spraying due to nozzle and filter maintenance	-Scavenged for water in dugouts and secondary sources such as municipal wells -Crop insurance (hail insurance NISA, CAIS) -Southwest conservation Association puts on field days to give farmers ideas of how to conserve water and which crops require less water -Farmers along the SSR/Cabri pipeline fill their dugouts with water from that pipeline -Hauled potable water from town -Sprayed for grasshoppers -Continuous cropping appears to have helped the potential impact of soil erosion -Seed earlier to advantage from available moisture	-Crop insurance did barely covered the cost of production which left them with no income	-Solve water shortage -Crop insurance doesn't cover all the costs of farming and pay back is decreasing -NISA/CAIS takes a long times to get payment

Type of respondents	**Impacts**				**Adaptations**		
	Physical	**Biological**	**Economic**	**Social**	**Successful**	**Not Successful**	**Reason**
Mixed Farms (same as livestock and grain)	-Water level at irrigation source was 6' above the intake and 2.5' are required -Low water quantity -Less snow throughout the winter	- Noticed an increased grasshopper population	-Could not irrigate therefore less hay was produced -More time was spent irrigating -More crop and forage loss due to grass hoppers	-Increased stress created personal household conflict -More management required	-Irrigated less but at optimal times -Hauled potable water from town -Communicated the issues of concern within the household -Cut fertilizer input costs	-Complete control of the grasshoppers	-Utilize water resource available -Prevent further crop and forage loss -Sustain the farm business economically
Local Governments	-Low water quantity				-water conservation measures implemented Lawn watering restrictions Farmers not allowed to use town water for spraying only household use -town rigged a pump to extend to the river to access more water to fill reservoir -extended intake float into the SSR so are able to access a more stable supply of water -in 2001/02 there was some policing of water usage -shut down car wash -sent out informational packages on water conservation strategies	-tried to find groundwater but was unsuccessful (even if groundwater was found the water treatment plant is set up for surface water. Costs for conversion are great.)	Lessons learned ➔ need to manage water better ➔ when the river is full & can pump & we've got a place to put it then pump it

Table 5.2 Drought Impacts and Adaptations of Stewart Valley and Area Residents

Type of respondents	Impacts				Adaptations		
	Physical	**Biological**	**Economic**	**Social**	**Successful**	**Not Successful**	**Reason**
Local Businesses	-Drought was not a major issue except for 1988 -2001/02 years were referred to as crop insurance years that were poor but not devastating - More violent and unpredictable weather -Good water source just outside of town that is heavily drawn upon for human consumption, spraying, washing cloths, etc -Town water is supplied by two town wells	-Increase in pests, especially large game	-95% of the Co-ops income is from primary agriculture therefore its performance is affected negatively in a dry year -less yield=poor bottom line	- Added Stress	-Crop Insurance -Hail Insurance		
Grain Producers	-Did not experience severe hardships from the drought of 2001/02 -Did not have water issues -Have an abundance of good quality groundwater.	-Increase in "sawfly" (may have been initiated by the drought year and is just becoming present now -2 to 3 years ago had an average to a little below average crop quantity year	-Commodity prices are too low -Input prices are too high	-Stress of having no income from poor crops not supported by commodity prices and produced with costly inputs	-Crop Insurance -Hail Insurance -Zero till helps manage moisture in fields	Couldn't collect crop insurance because yield was too high	

6. SUMMARY AND CONCLUSIONS

6.1 Summary

The major objective of this study was to investigate the impacts of 2001 and 2002 droughts on the rural communities of Cabri and Stewart Valley in Saskatchewan with emphasis on water resources. These impacts were studied in the context of the communities, as well as in the context of the larger region – Rural Municipality of Riverside (No. 168 housing the community of Cabri) and Rural Municipality of Saskatchewan Landing (No. 167 housing the community of Steward Valley). Drought impacts were assessed in terms of bio-physical changes as well as economic changes observed during the drought years.

The community of Cabri is dependent on the South Saskatchewan River for its water needs, both for domestic as well as irrigation purposes. Stewart Valley depends on groundwater sources for meeting its water use. With the exception of the Miry Creek irrigation project, most of the agricultural production is under dryland production systems. Both the communities are predominantly rural, with a population of 483 and 101 people in 2001 for Cabri and Stewart Valley, respectively. In addition, like other smaller rural communities in the Prairies, both of these communities have exhibited a declining population trend and an increased elderly population.

Agriculture is main driving force for the two communities. Most businesses in these communities are related to agricultural production. Oil and gas industry is the second most important industry in the region. Some tourism activities are also present, particularly in the Cabri and surrounding region.

Both the regions experienced the droughts of 2001 and 2002, although the degree of their exposure was different for the two communities and the surrounding regions. Stewart Valley received more precipitation compared to Cabri during these periods.

Among various bio-physical impacts of the drought were decreased stream flow, minimal recharge to groundwater, and only one-quarter full dugouts. However, the community of Steward Valley had a more reliable source of water than Cabri.

Crop production in the surrounding region is dominated by the production of durum wheat, spring wheat, and lentil and dry beans, although other crops are also grown in the region. Yields of all major crops were lower during the droughts.

6.2 Major Conclusions

The communities of Stewart Valley and Cabri and surrounding communities provided a valuable contrast for an examination of adaptation and vulnerability to drought. The communities had different exposures as Cabri had more severe drought intensities. Cabri also had more severe impacts especially on the town's water supply. Cabri uses a reservoir which was susceptible to water loss through evaporation and decreased river flow. Cabri therefore undertook more adaptation measures, several of which were successful. Stewart Valley's water source is groundwater was more reliable, considering its smaller population and conservation measures.

- Droughts were experienced in both Cabri and Stewart Valley regions. They were less severe in 2002 and less severe in the Stewart Valley area.
- Total crop revenues in both the rural municipalities were negative during 2001 and 2002 drought years, although the impact of the drought in 2002 compared to 2001 was less severe in both the municipalities.
- Cattle marketings were slightly higher in 2001 and 2002 but their economic impacts could not be assessed due to lack of data.
- Cabri residents had to adapt to water shortages in various ways including hauling water from municipal wells, but in the Stewart Valley this was not a major issue because of the groundwater sources primarily.
- Producers had less income due to poor crop yields, and relatively unchanged input costs. Non-agricultural businesses also suffered since farmers had less money to spend.

6.3 Recommendations for Further Studies

The investigation results presented in this report are indicative of the economic costs to society from occurrence of droughts. Such investigations need to be extended to other communities in the South Saskatchewan River Basin as well as in Chile.

6.3.1 Work Plan for Alberta Communities

At the time of writing this report, the Blood Indian Reserve has been selected for ethnographic work. Work plan for this community would include: (1) Study of the economic bases of the reserve; (2) Socio-economic profile of the members and their occupation; (3) Assessment of drought nature; (4) Assessment of bio-physical impacts of the 2001 and 2002 droughts; and (5) Translating the bio-physical drought impacts into socio-economic impacts. This type of work can be extended to other communities, if selected for further studies.

6.3.2 Work Plan for Saskatchewan Communities

At the time of writing this report, the community of Outlook has been selected for further ethnographic work. Work plan for this community would be similar in nature to the Alberta communities. These may include: (1) Study of the economic bases of the reserve; (2) Socio-economic profile of the members and their occupation; (3) Assessment of drought nature; (4) Assessment of bio-physical impacts of the 2001 and 2002 droughts; (5) Translating the bio-physical drought impacts into crop production impacts both on dryland and irrigated farms; (6) Assessment of economic costs of the droughts on livestock farms; and (7) Translating the above changes into socio-economic impacts.

7. ACKNOWLEDGEMENTS

Funding was provided by the University of Regina through the Social Sciences and Humanities Research Council of Canada's (SSHRC) Major Collaborative Research Initiatives (MCRI). This project was a part of the Institutional Adaptation to Climate Change Project. In-kind funding was provided by the Saskatchewan Research Council and the University of Saskatchewan. We thank Dr. Harry Diaz, Stephanie Jeannes and Erin Knuttila for allowing us to use the information from the community interviews and focus groups. We thank all the organizations and their personnel who assisted with locating information and provided advice. L. Crone and C. Hudym, SRC, accomplished the word processing.

8. REFERENCES

Anderson, D.F., 2006. Personal Communication. Mr. Anderson is a Senior Technologist with the Regulatory Coordination, Operations Division of the Saskatchewan Watershed Authority, Moose Jaw, Saskatchewan.

Bell, G. 2002a. Personal Communication. Mr. Bell is a hydrologist with Agriculture and Agri-Food Canada, Prairie Farm Rehabilitation Administration, Saskatoon, Saskatchewan. In: Wittrock, V. 2005. Canadian Droughts of 2001 and 2002: Water Resource Conditions in Western Canada: Impacts and Adaptations. In: Wheaton, E., S. Kulshreshtha and V. Wittrock (Editors) 2005.

Bell, G. 2002b. Personal Communication. Mr. Bell is a hydrologist with Agriculture and Agri-Food Canada, Prairie Farm Rehabilitation Administration, Saskatoon, Saskatchewan. Data received from L. Campbell, Operations and Planning Engineer, Department of Highways and Transportation, Saskatoon, Saskatchewan. In: Wheaton, E. 2005. Canadian Droughts of 2001 and 2002: Wind Erosion in Western Canada: Impacts and Adaptations. In: Wheaton, E., S. Kulshreshtha and V. Wittrock (Editors) 2005.

Bonsal, B. Personal Communication. 2006. Mr. Bonsal is a Research Scientist, Climate Impacts on Hydrology and Aquatic Ecosystems, Environment Canada, Saskatoon, Saskatchewan.

Cabri Community Development Council, History Committee. 1963. History of Cabri and District, 1912-1963: its Pioneers, Organizations, and General Developments. Cabri Community Development Council, Cabri, Saskatchewan.

Calpas, J. and D. Johnson. 2003. Grasshopper Management. Agri-Facts: Practical Information for Alberta's Agriculture Industry. Alberta Agriculture, Food and Rural Development and Agriculture and Agri-Food Canada. 11 pp. Available at: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex6463/$file/622-27.pdf?OpenElement

Diaz, H., D. Gauthier, and D. Sauchyn. 2003. Institutional Adaptations to Climate Change – Comparative Study of Dryland River Basins in Canada and Chile. University of Regina, Regina, Saskatchewan. Grant Application to Social Sciences and Humanities Research Council of Canada.

Diaz, H., S. Jeannes, and E. Knutilla. Personal Communication. H. Diaz is a Professor in the Department of Sociology and Social Studies at the University of Regina, Regina, Saskatchewan. S. Jeannes and E. Knutilla are Dr Diaz's graduate students.

Environment Canada. 2006a. Canadian Climate Data [Web Page]. Accessed January 2006. Available at: http://www.climate.weatheroffice.ec.gc.ca/advanceSearch/searchHistoricDataStations_e.html.

Environment Canada, Water Survey of Canada. 2006b. Water Data [Web Page]. Accessed January and March 2006. Available at: www.wsc.ec.gc.ca/staflo.html.

Ford, J. Personal Communication. 2006. J. Ford is a Technician in Ground Water Approvals, Ground Water Management, Saskatchewan Watershed Authority, Moose Jaw, Saskatchewan.

Google, Inc. 2006 Google Earth [Web Page]. Accessed January 2006. Available at http://earth.google.com.

Hagen, G. Personal Communication. 2006. G. Hagen is a Senior Technologist of Regional Operation, Saskatchewan Watershed Authority, Swift Current, Saskatchewan.

Hartley, S. Personal Communication. 2006. S. Hartley is an Insect/Vertebrate Pest Management Specialist, Crop Development Branch, Saskatchewan Agriculture and Food, Regina, Saskatchewan.

Hopkinson, R. 2000. Note to Users of Environment Canada's PDI Products. Environment Canada, Regina, Saskatchewan. 4 pp.

Johnson, D. and J. Calpas. 2003. 2003 Grasshopper forecast for Alberta and adjoining regions of Saskatchewan [Web Page]. Available at: http://www.sidney.ars.usda.gov/grasshopper/Extras/cafrst03.htm

Johnson, D., J. Calpas, and G. Coulter. 2002. Lethbridge Research Centre Report: 2002 Grasshopper Forecast for the Canadian Prairies: Average Risk up 50 Percent [Web Page]. Accessed March 14, 2006. Available at: http://res2.agr.ca/lethbridge/rep2002/rep0220_e.htm.

Johnson, D. Personal Communication. 2006. D. Johnson is a Professor of Environmental Science, Canada Research Chair in Sustainable Grassland Ecosystems, Department of Geography, University of Lethbridge, Lethbridge, Alberta.

Judisch D. and H. Cutforth. 2003. 2002: A Year of Weather Extremes. Research Newsletter No 1. Semiarid Prairie Agriculture Research Centre, Swift Current, Saskatchewan.

Karrenbrock, J.D. 1989. The 1988 Drought: Its Impact on District Agriculture. Federal Reserve Bank of St. Louis; May/Jun 1989; 71, 3; ABI/INFORM Global

Kulshreshtha, S. and R. Marleau. 2005. Canadian Droughts of 2001 and 2002: Economic Impacts on Crop Production in Western Canada. SRC Publication No. 11602-13E03. In: E. Wheaton, S. Kulshreshtha and V. Wittrock (Editors), Canadian Droughts of 2001 and 2002: Climatology, Impacts and Adaptations. Volume II. SRC Publication No. 11602-1E03. Saskatchewan Research Council, Saskatoon, Saskatchewan.

Lundqvist, O. 1999. Agroclimate. *In*: Fung, K. (Director and Editor), Atlas of Saskatchewan, Saskatoon, Saskatchewan. 336+ pp.

Maathuis, H., E.J. Jawaorski, and D.A. Zlipko. 2001. Groundwater Observation Well Network in Saskatchewan, Canada. Saskatchewan Research Council (SRC), Saskatoon, Saskatchewan. SRC Publication No. 10419-2E01.

Natural Resources Canada. 2006. The Atlas of Canada [Web Page]. Accessed February 8, 2006. Available at: http://atlas.nrcan.gc.ca/site/english/maps/topo/

Olfert, O., S. Hartley, J. Gavloski, L-A. Kaminski, and D. Giffen. 2003. The 2001 Saskatchewan and Manitoba Grasshopper Forecast [Web Page]. Accessed January 9, 2006. Available at: http://res2.agr.ca/saskatoon/result/grasshopper2001-sauterelle2001_e.htm.

Palmer, W.C. 1965. Meteorological Drought. United States Department of Commerce, Washington, District of Columbia. Research Paper No. 45. 58 pp.

Paul, A.H. 1991. Studies of Long-Lived Hailstorms in Saskatchewan, Canada From Crop Insurance Data. *Natural Hazar*ds **4**:345-352.

Paul, A. Personal Communication. 2006. A. Paul is a Professor of Geography, Department of Geography, University of Regina, Regina, Saskatchewan.

Prairie Farm Rehabilitation Administration – Agriculture and Agri-Food Canada, Rural Water Development Program, (PFRA, RWDP) Historical Records. 2006. RM of Saskatchewan Landing (167) and Riverside (168) Historical Dugout Locations. Agriculture and Agri-Food Canada, Regina, Saskatchewan.

Prairie Farm Rehabilitation Administration – Agriculture and Agri-Food Canada. 1988. Cabri's Potable Water Reservoir Capacity Curves. Agriculture and Agri-Food Canada, Regina, Saskatchewan.

Prairie Farm Rehabilitation Administration – Agriculture and Agri-Food Canada. 2006. Drought Watch [Web Page]. Available at: http://www.agr.gc.ca/pfra/drought/archives_e.htm.

Rosine, J. and N. Walraven. 1989. Drought, Agriculture and the Economy. 1989 Board of Governors of the Federal Reserve System.

Ryback, D. 2003. Personal Communication. Palmer Drought Severity Index Map Series, Prairie Province. D. Ryback, Meteorological Service of Canada, Environment Canada, Saskatoon, Saskatchewan.

Ryback, D. 2002. Personal Communication. Palmer Drought Severity Index Map Series, Prairie Province. D. Ryback, Meteorological Service of Canada, Environment Canada, Saskatoon, Saskatchewan.

Ryback, D. 2001. Personal Communication. Palmer Drought Severity Index Map Series, Prairie Province. D. Ryback, Meteorological Service of Canada, Environment Canada, Saskatoon, Saskatchewan.

Ryback, D. 2000. Personal Communication. Palmer Drought Severity Index Map Series, Prairie Province. D. Ryback, Meteorological Service of Canada, Environment Canada, Saskatoon, Saskatchewan.

Saskatchewan Agriculture and Food. 2004. Statistics Handbook [Web Page]. Available at: http://www.agr.gov.sk.ca/.

Saskatchewan Agriculture and Food. 2002. 2003 Grasshopper Forecast [Web Page]. Available at: http://www.agr.gov.sk.ca/.

Saskatchewan Agriculture and Food. 2001. 2002 Grasshopper Forecast [Web Page]. Available at: http://www.agr.gov.sk.ca/.

Saskatchewan Agriculture and Food Cattle Marketing. Accessed March 2006. Available at: http://www.agr.gov.sk.ca/Livestock/beef.asp?firstPick=Livestock&secondpick=Beef&thirdpick=Marketing&selection=Marketing.

Saskatchewan Agriculture and Food. 2000. Grasshoppers [Web Page]. Accessed March 14, 2006. Available at: http://www.agr.gov.sk.ca/OCS/crops/integrated_pest_management/insects/grasshopperff.asp?firstPick=Crops&secondpick=Integrated%20Pest%20Management&thirdpick=Insects.

Saskatchewan Watershed Authority. 2006. Groundwater Observation Wells [Web Page]. Accessed January 2006. Available at: www.swa.ca/WaterManagement/Groundwater.asp?type=observationwells.

Southwest Regional Economic Development Authority. 2006. Southwest Regional Economic Development Authority [Web Page]. Available at: www.southwestreda.ca.

Statistics Canada. Census of Agriculture, 1961-2001. Obtained from the University of Saskatchewan Data Library Services [Web Page]. Accessed March 2006. Available at: http://library.usask.ca/data

Statistics Canada. 1986-2001. Community Profiles. Statistics Canada, Ottawa, Ontario.

Stehlik, D., I. Gray and G. Lawrence. 1999. Drought in the 1990s - Australian Farm Families' Experiences. Publication No. 99/14 Project No. UCQ-5A. Rural Industries Research and Development Corporation.

Warren, R.T. Personal Communication. 2006. Mr Warren is an Agroclimate Applications Technician with the Climate Monitoring and Forecasting Group of the Prairie Farm Rehabilitation Administration, Agriculture and Agri-Food Canada.

Wheaton, E. 2005. Canadian Droughts of 2001 and 2002: Wind Erosion in Western Canada: Impacts and Adaptations. In: Wheaton, E., S. Kulshreshtha and V. Wittrock (Editors) 2005

Wheaton, E. 1992. Prairie Dust Storms – A Neglected Hazard. *Natural Hazards* **5**:53-63.

Wheaton, E. and V. Wittrock. 2005. Canadian Droughts of 2001 and 2002: Climatological Description of the Droughts in Western Canada. In: Wheaton, E., S. Kulshreshtha and V. Wittrock (editors). 2005. Climatology, Impacts and Adaptations. Volume II. SRC Publication No. 11602-1E03. Saskatoon: Saskatchewan Research Council.

Wheaton, E., S. Kulshreshtha and V. Wittrock (Editors). 2005. Climatology, Impacts and Adaptations. Volume II. Saskatchewan Research Council (SRC), Saskatoon, Saskatchewan. SRC Publication No. 11602-1E03.

APPENDIX A

BIO-PHYSICAL FIGURES

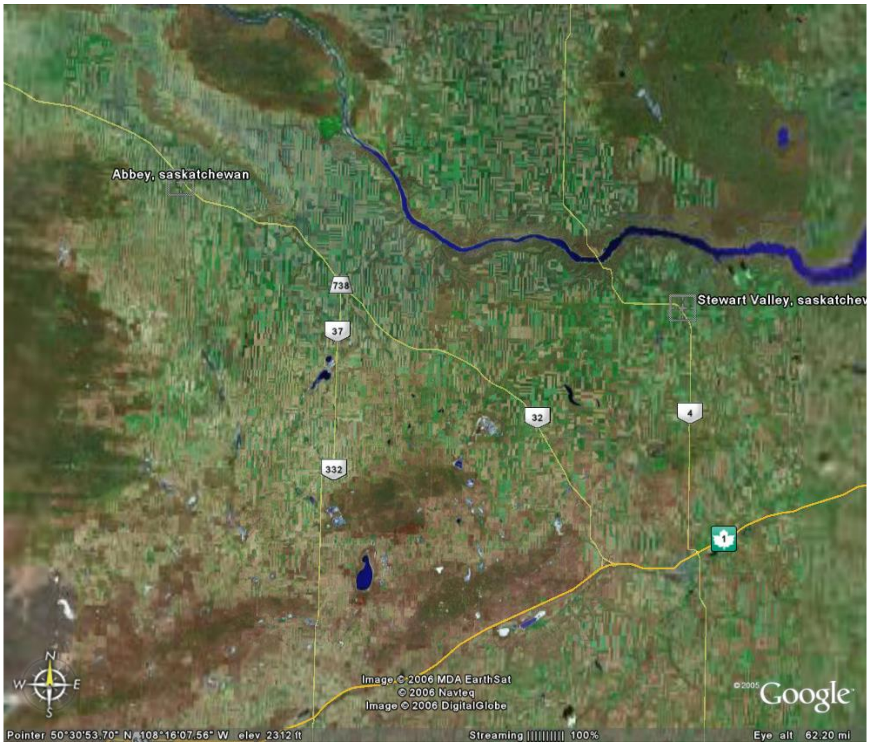

Figure A.1 Selected Climate Stations in the Study Area (Google 2006)

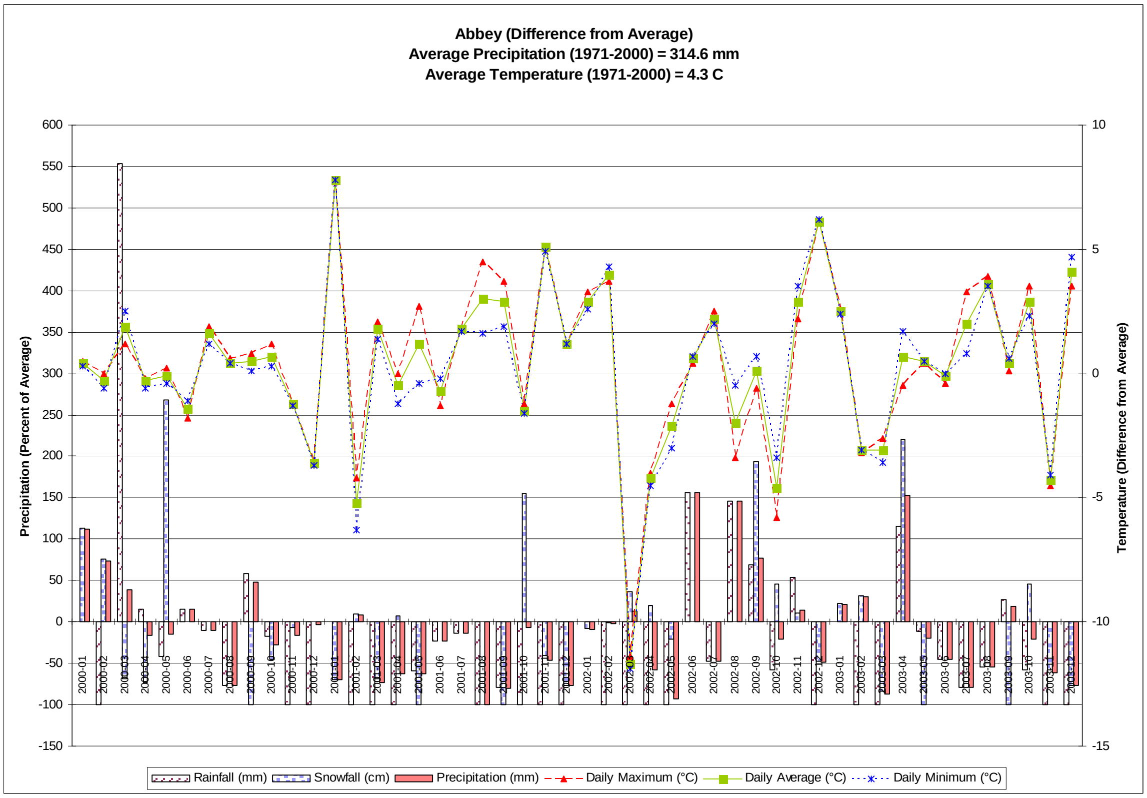

Figure A.2 Abbey's Climate for 2000 to 2003 (Data Source: Environment Canada 2006a)

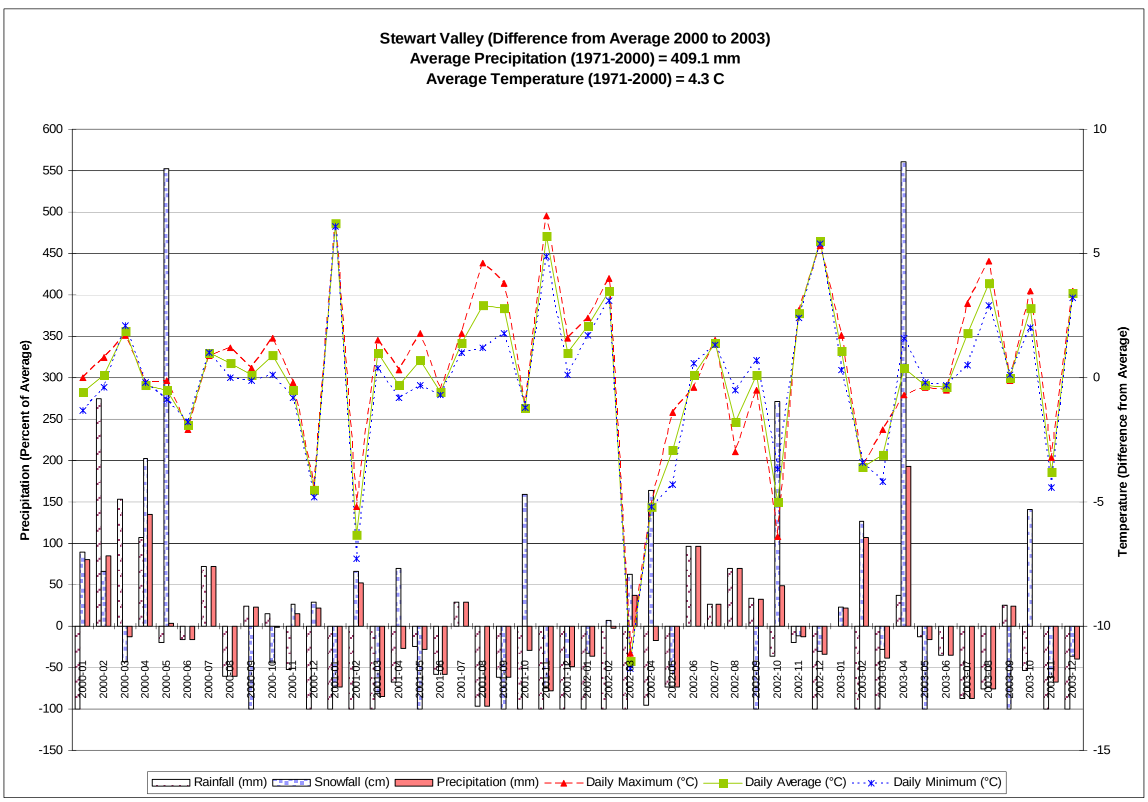

Figure A.3 Stewart Valley's Climate for 2000 to 2003 (Data Source: Environment Canada 2006a)

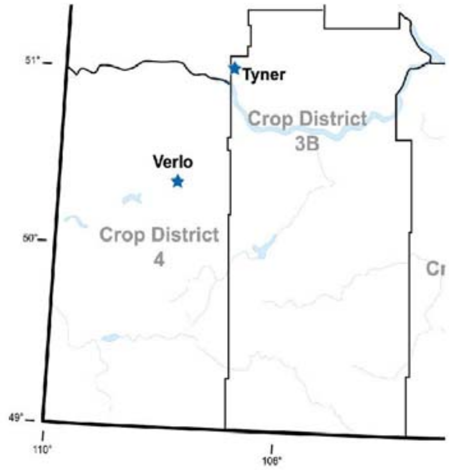

Figure A.4 Selected Groundwater Observation Wells (Saskatchewan Watershed Authority 2006)

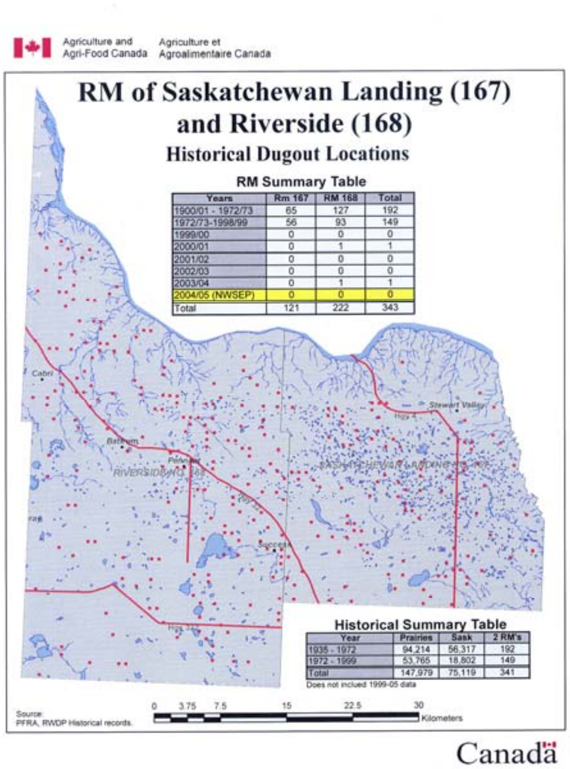

Figure A.5 Historical Dugout Locations in the RMs of Saskatchewan Landing and Riverside (PFRA – Agriculture and Agri-Food Canada 2006)

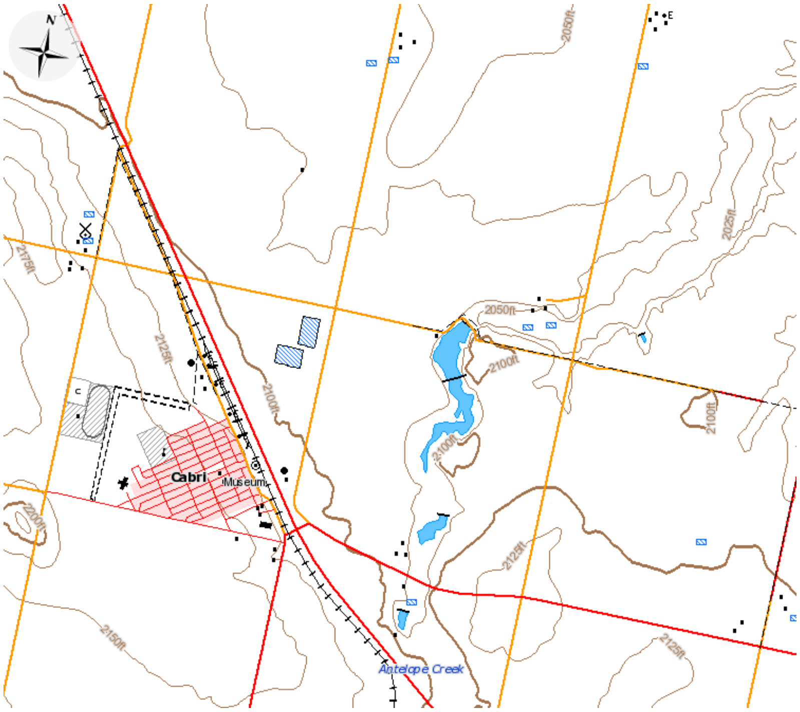

Figure A.6 Cabri and Potable Water Reservoir (Natural Resources Canada 2006)

Figure A.7 Cabri's Potable Water Reservoir Nov 22, 2005 (Photo: E. Wheaton, Saskatchewan Research Council)

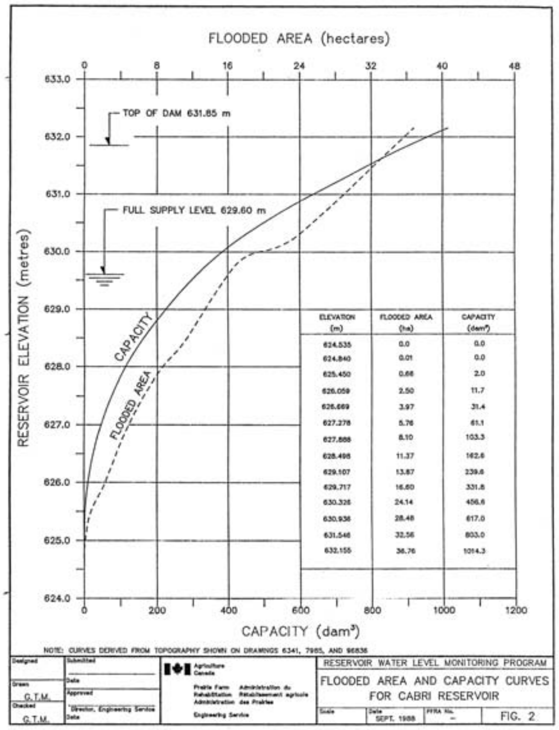

Figure A.8 Cabri's Potable Water Reservoir Capacity Curves (PFRA – Agriculture Canada 1988)

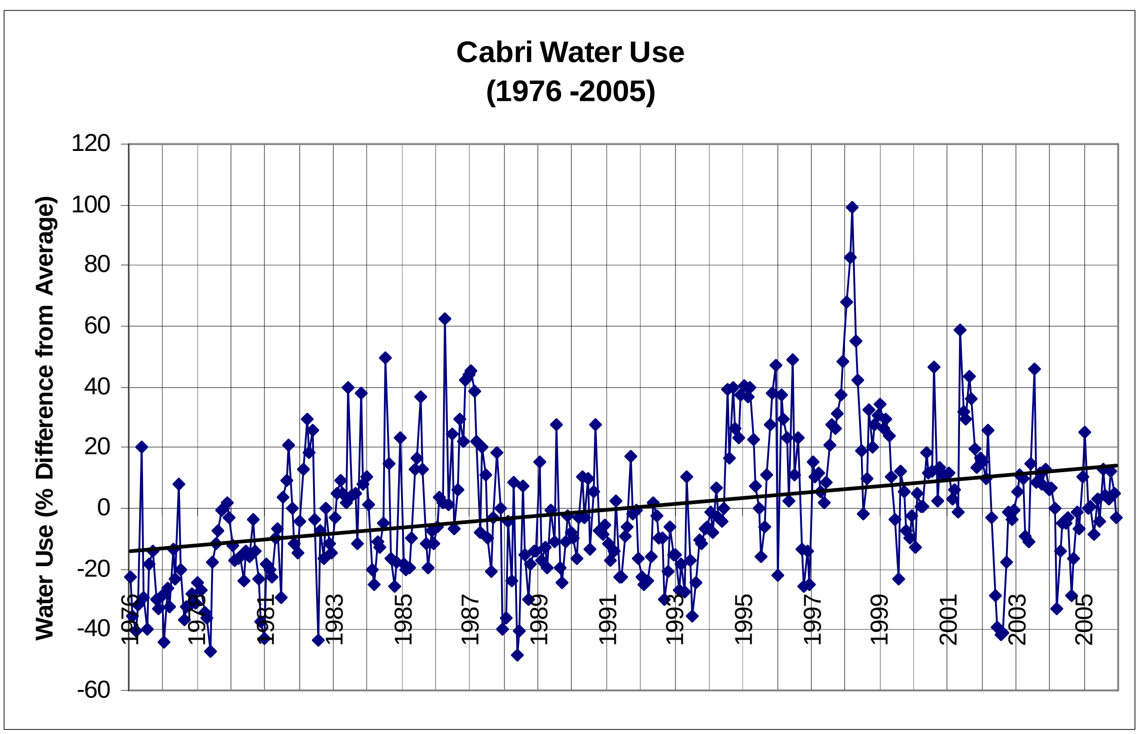

Figure A.9 Cabri Potable Monthly Water Consumption (1976-2005) (Data: Anderson 2006)

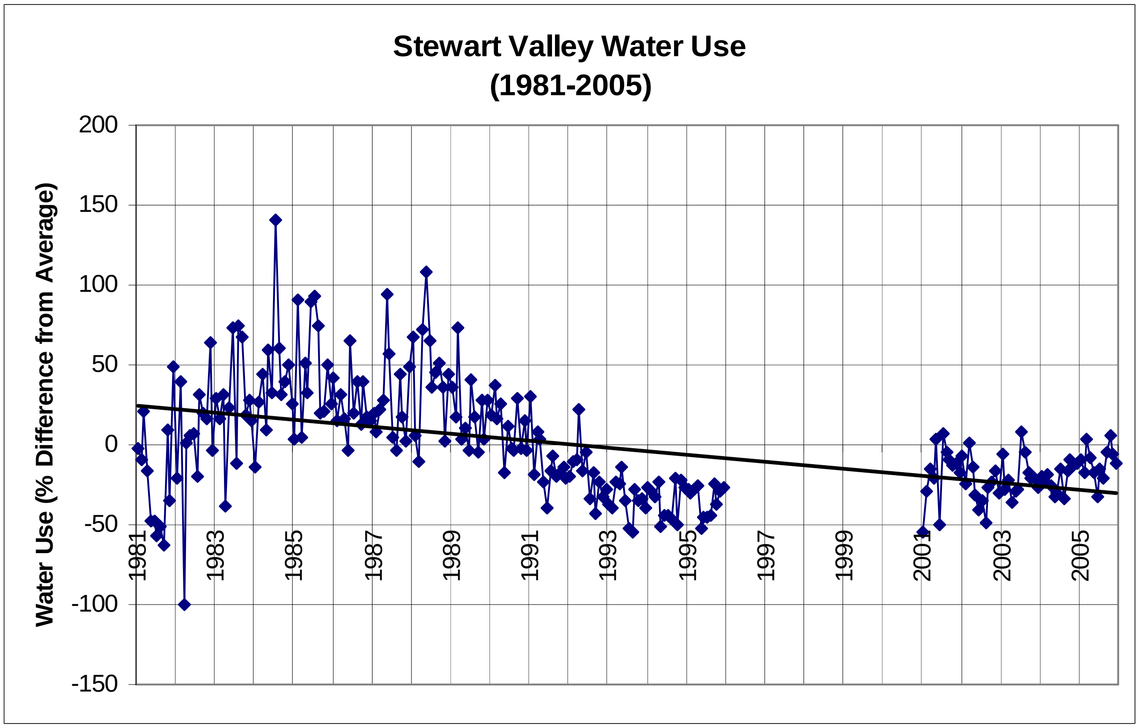

Figure A.10 Stewart Valley Monthly Potable Water Consumption (1981-2005) (Data: Anderson 2006)

Figure A.11 Selected Potential Evapo-Transpiration Sites (Google Earth 2006)

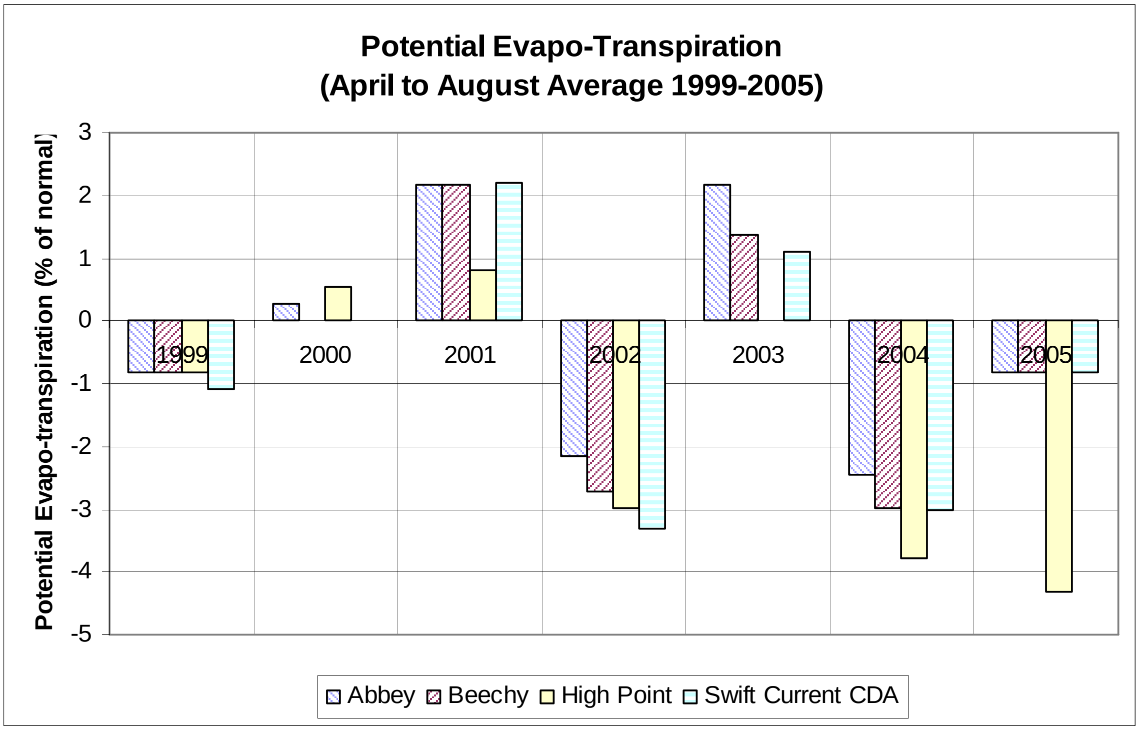

Figure A.12 Potential Evapo-Transpiration for the April to August 1999-2005 period for Abbey, Beechy, High Point and Swift Current CDA (Data Source: PFRA – Agriculture and Agri-Food Canada 2006)

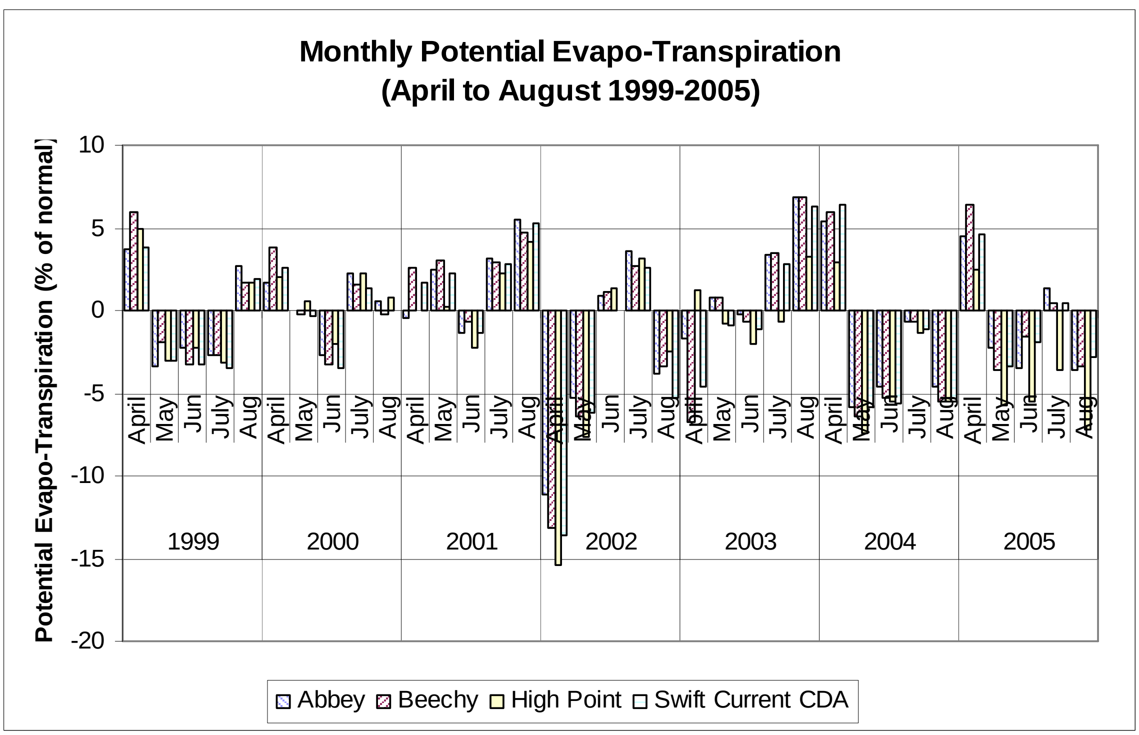

Figure A.13 Monthly Potential Evapo-Transpiration for the April to August 1999 – 2005 Period for Abbey, Beechy, High Point and Swift Current CDA (Data Source: PFRA – Agriculture and Agri-Food Canada 2006).

Palmer Drought Severity Index Maps (Fall 2000 to Spring 2003)

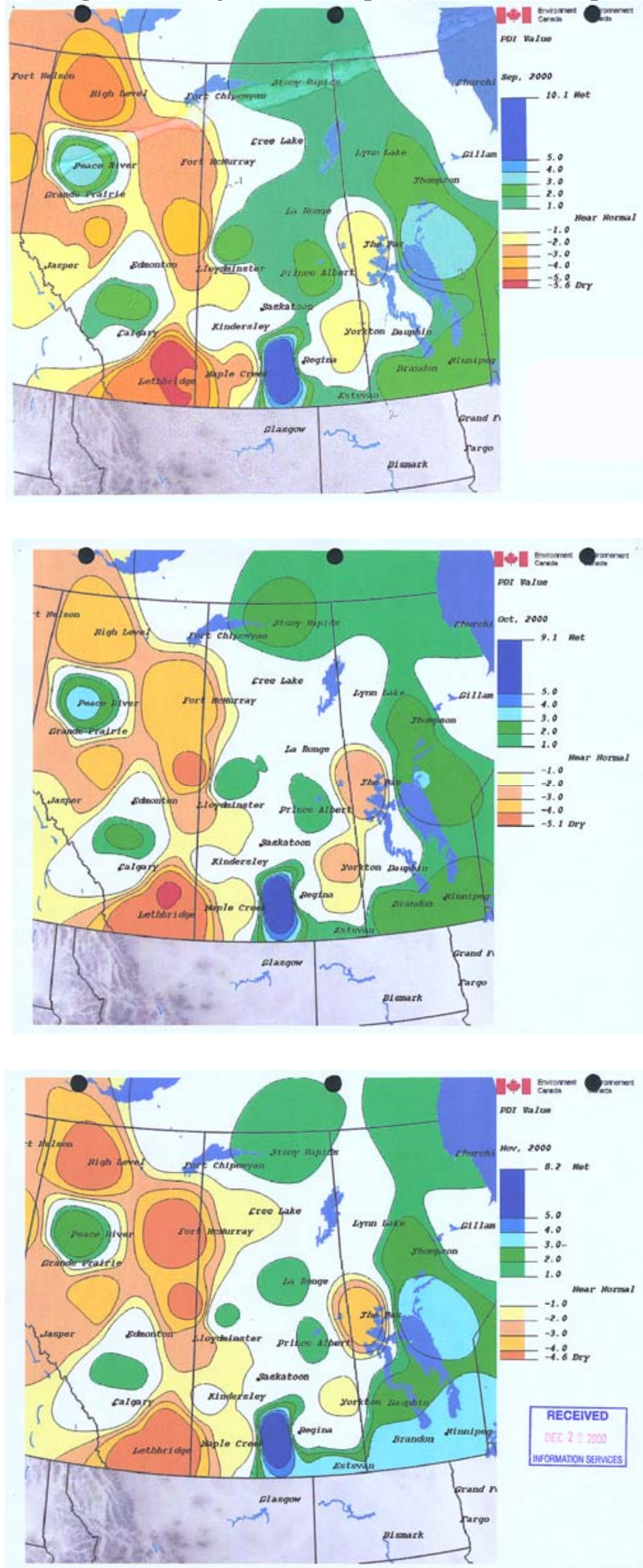

Figure A.14 Palmer Drought Severity Index for the Canadian Prairie Provinces, Fall (September, October, November) 2000 (Ryback, pers. comm. 2001)

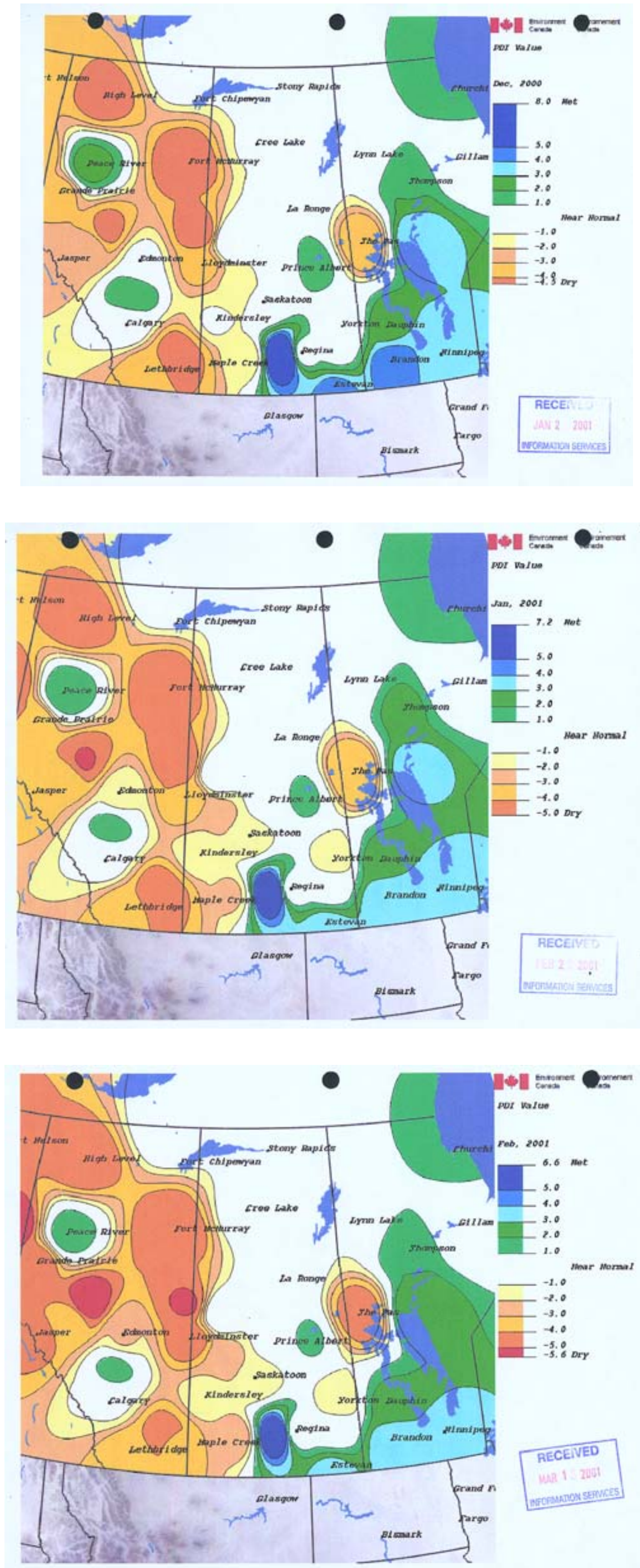

Figure A.15 Palmer Drought Severity Index for the Canadian Prairie Provinces, Fall (December, January, February) 2000/2001 (Ryback, pers. comm. 2001)

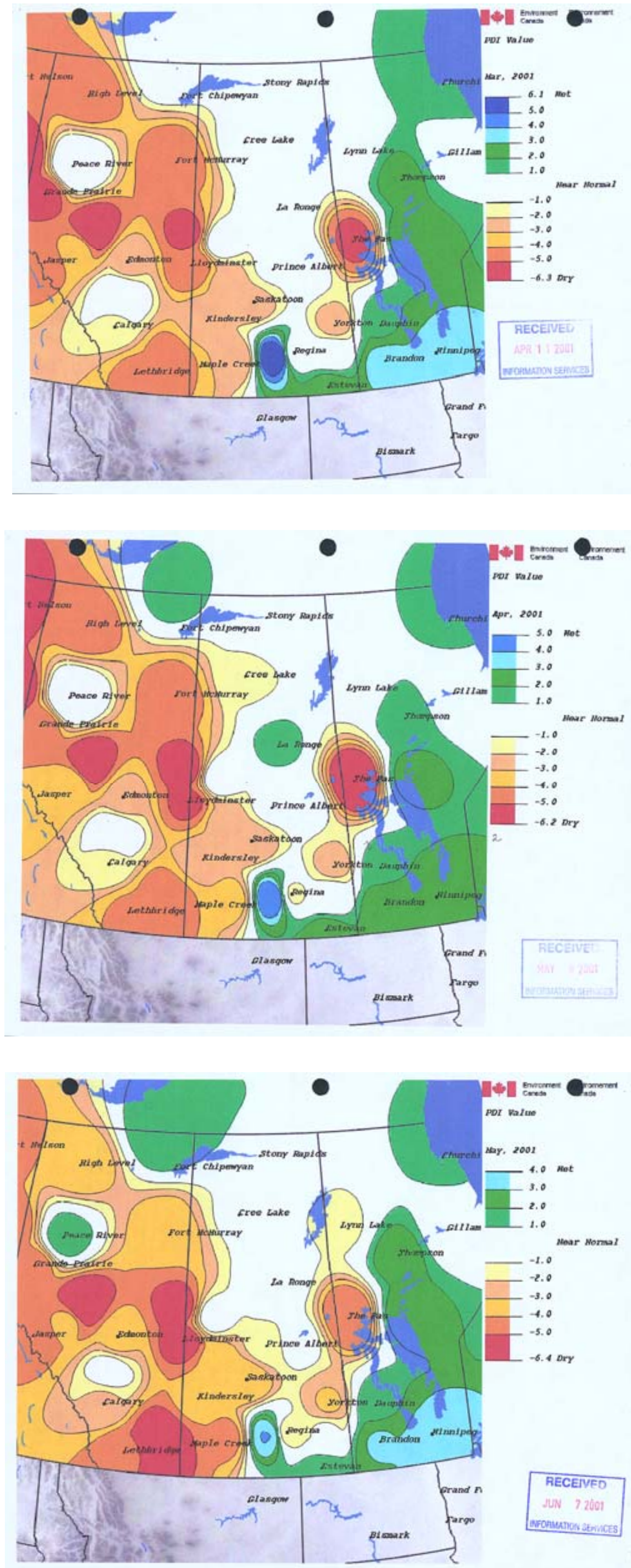

Figure A.16 Palmer Drought Severity Index for the Canadian Prairie Provinces, Spring (March, April, May) 2001 (Ryback, pers. comm. 2001)

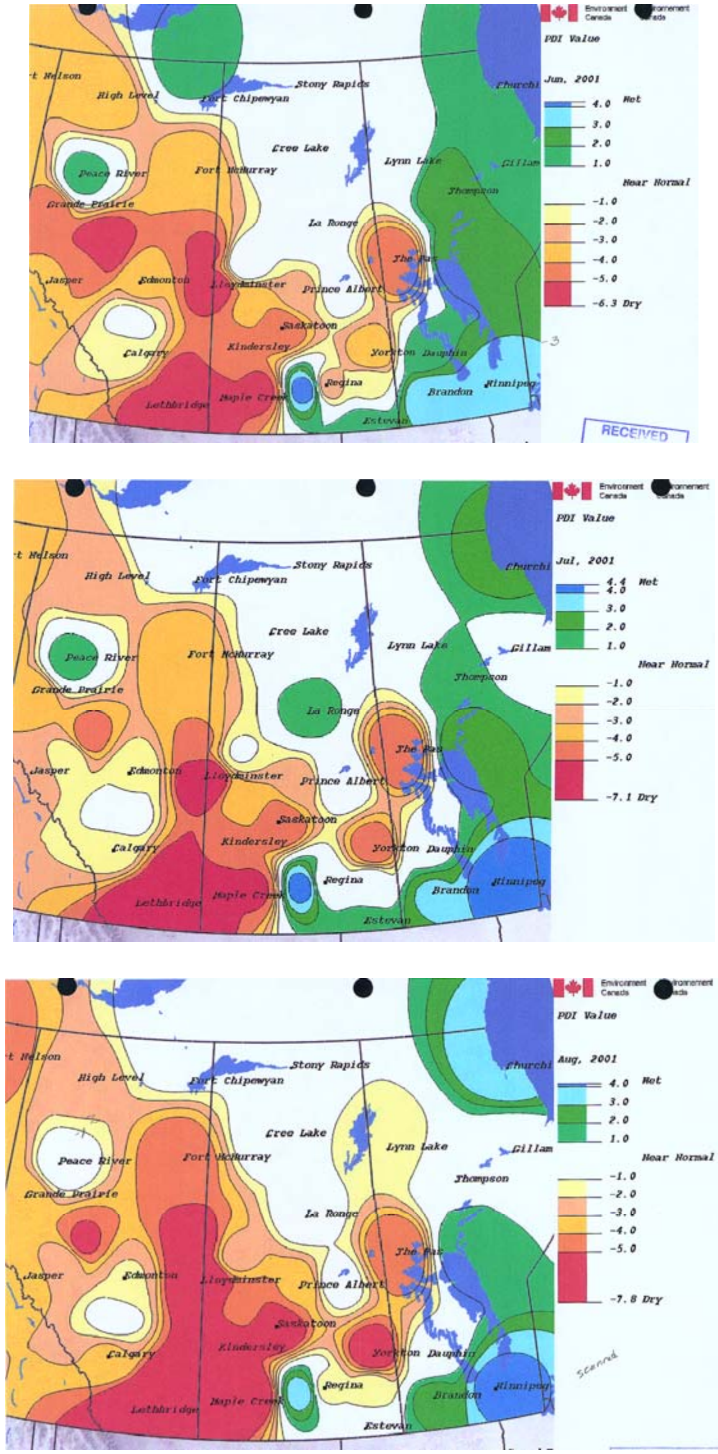

Figure A.17 Palmer Drought Severity Index for the Canadian Prairie Provinces, Summer (June, July, August) 2001 (Ryback, pers. comm. 2001)

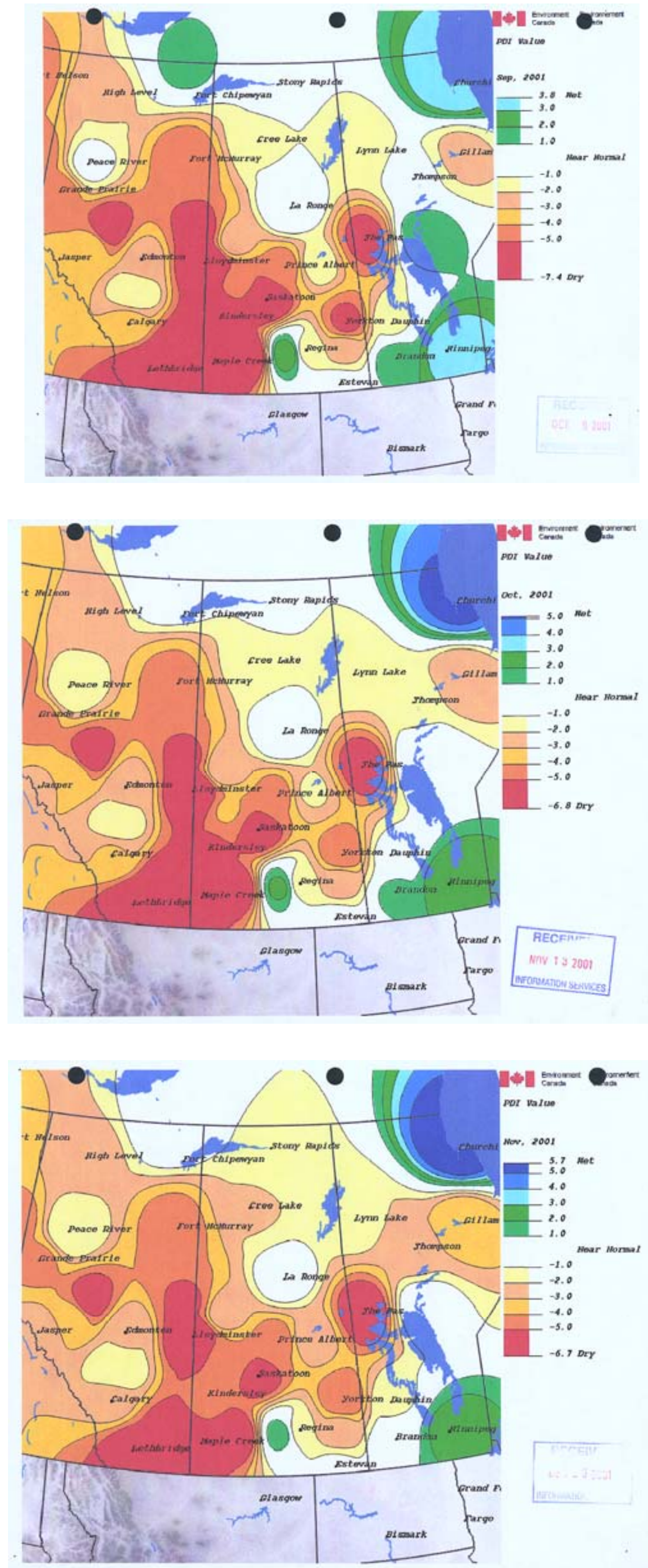

Figure A.18 Palmer Drought Severity Index for the Canadian Prairie Provinces, Fall (September, October, November) 2001 (Ryback, pers. comm. 2001)

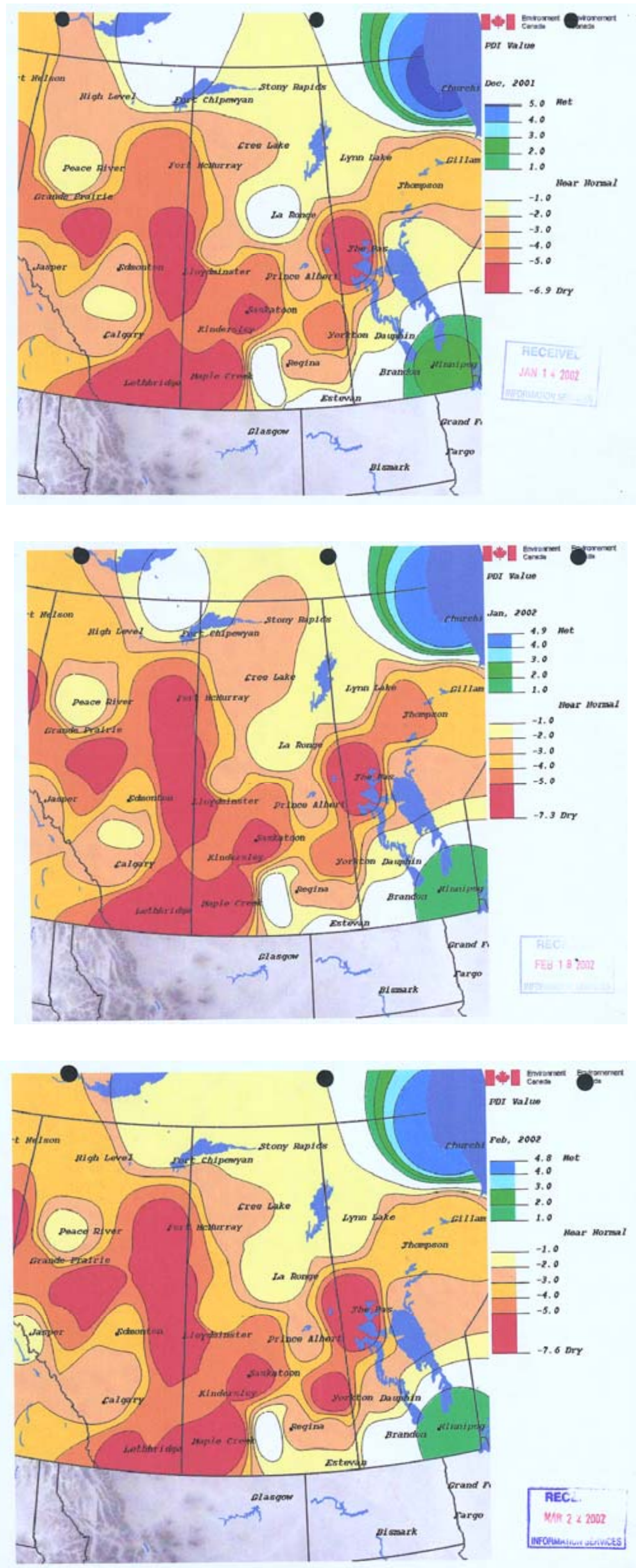

Figure A.19 Palmer Drought Severity Index for the Canadian Prairie Provinces, Winter (December, January, February) 2001/2002 (Ryback, pers. comm. 2002)

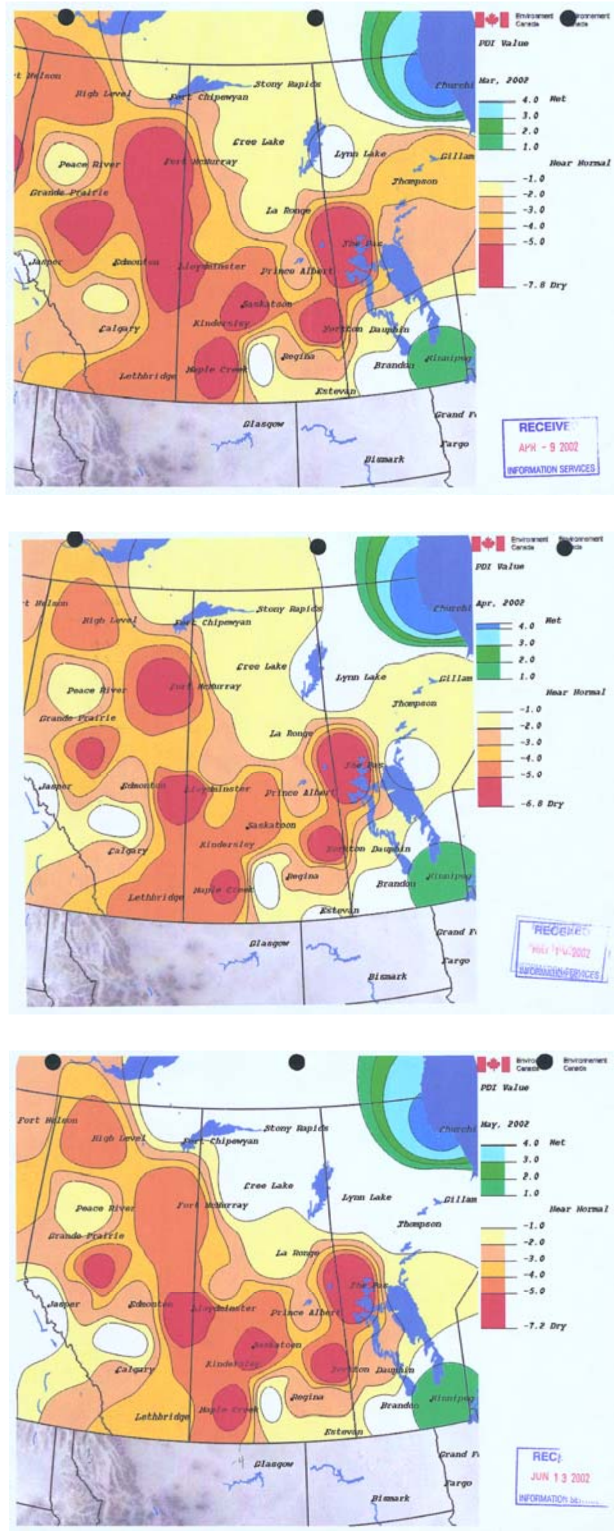

Figure A.20 Palmer Drought Severity Index for the Canadian Prairie Provinces, Spring (March, April, May) 2002 (Ryback, pers. comm. 2002)

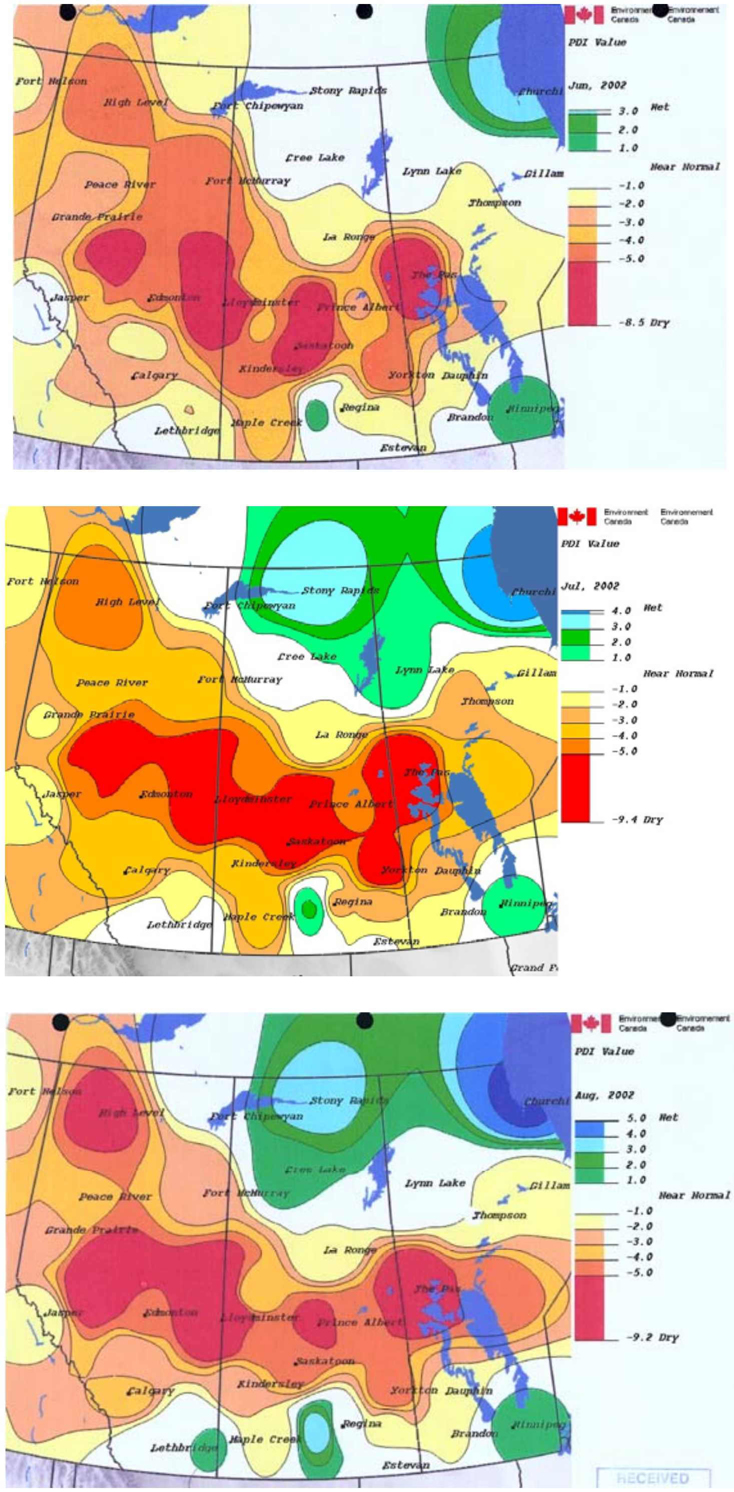

Figure A.21 Palmer Drought Severity Index for the Canadian Prairie Provinces, Summer (June, July, August) 2002 (Ryback, pers. comm. 2002)

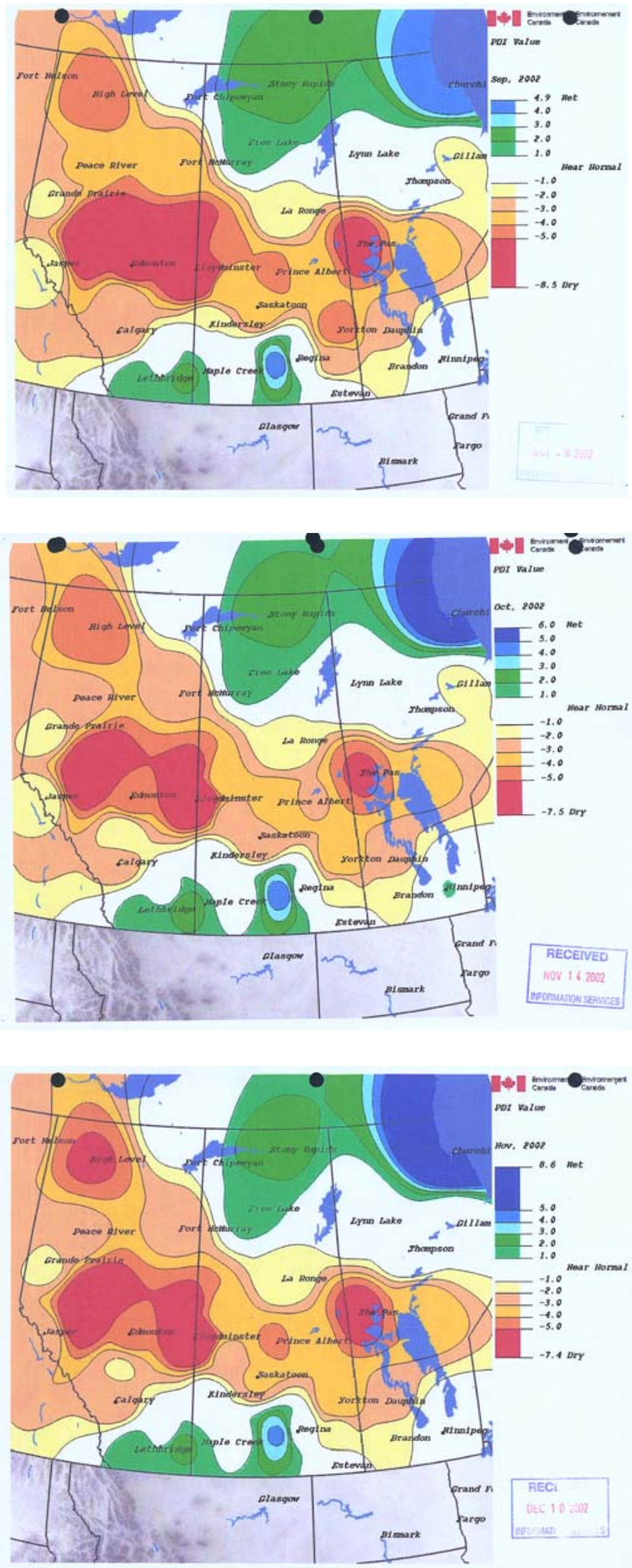

Figure A.22 Palmer Drought Severity Index for the Canadian Prairie Provinces, Fall (September, October, November) 2002 (Ryback, pers. comm. 2002)

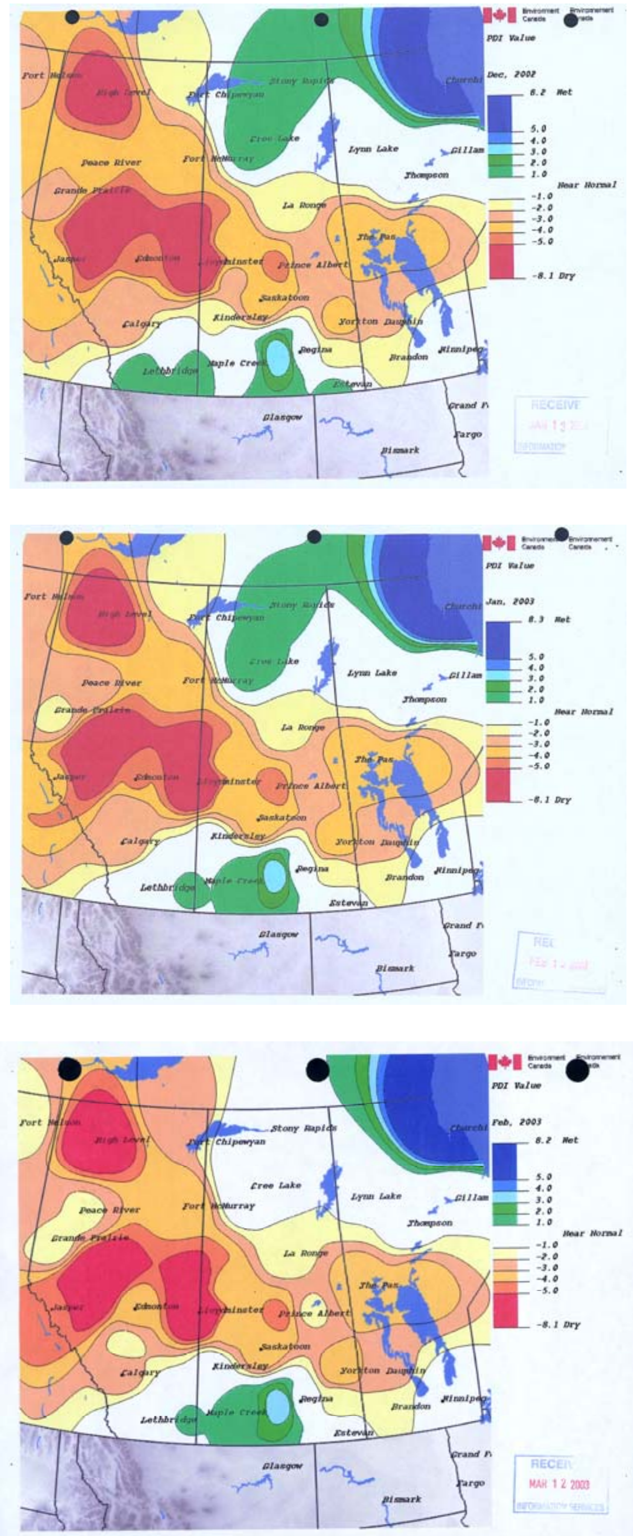

Figure A.23 Palmer Drought Severity Index for the Canadian Prairie Provinces, Winter (December, January, February) 2002 (Ryback, pers. comm. 2003)

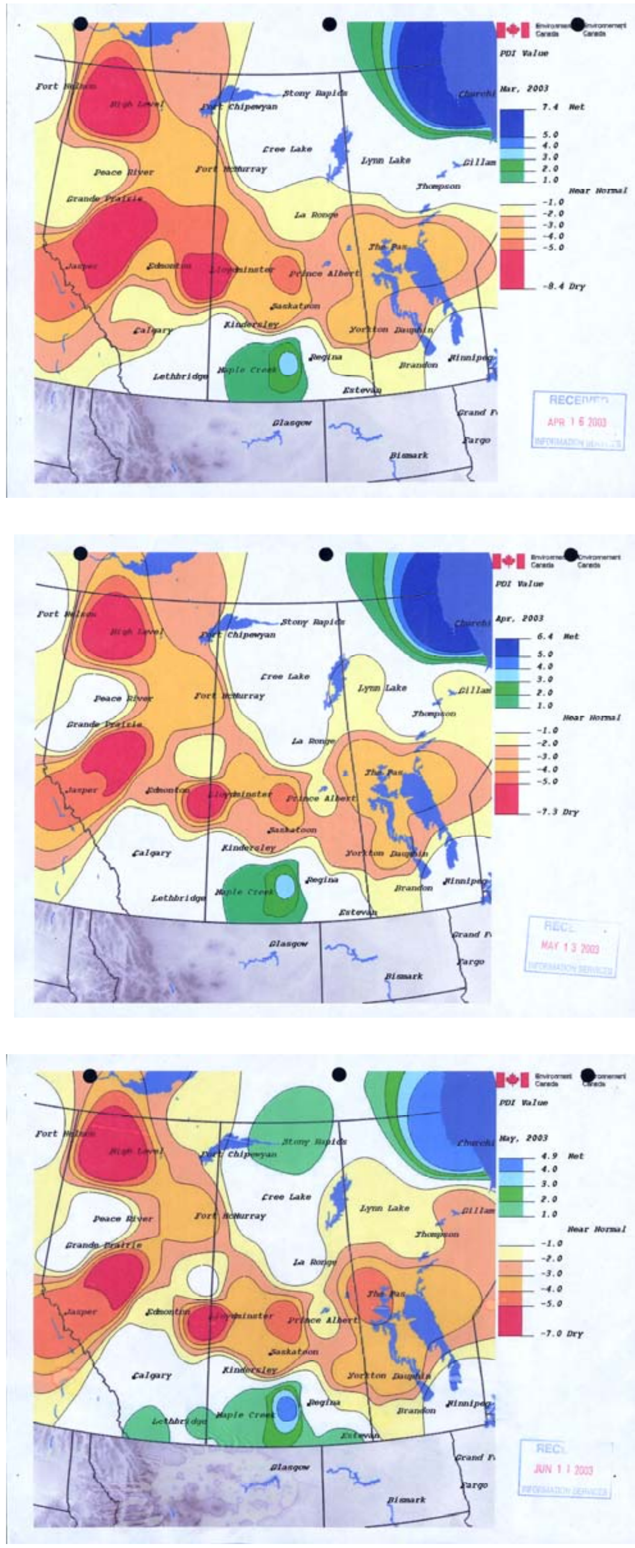

Figure A.24 Palmer Drought Severity Index for the Canadian Prairie Provinces, Spring (March, April, May) 2003 (Ryback, pers. comm. 2003)

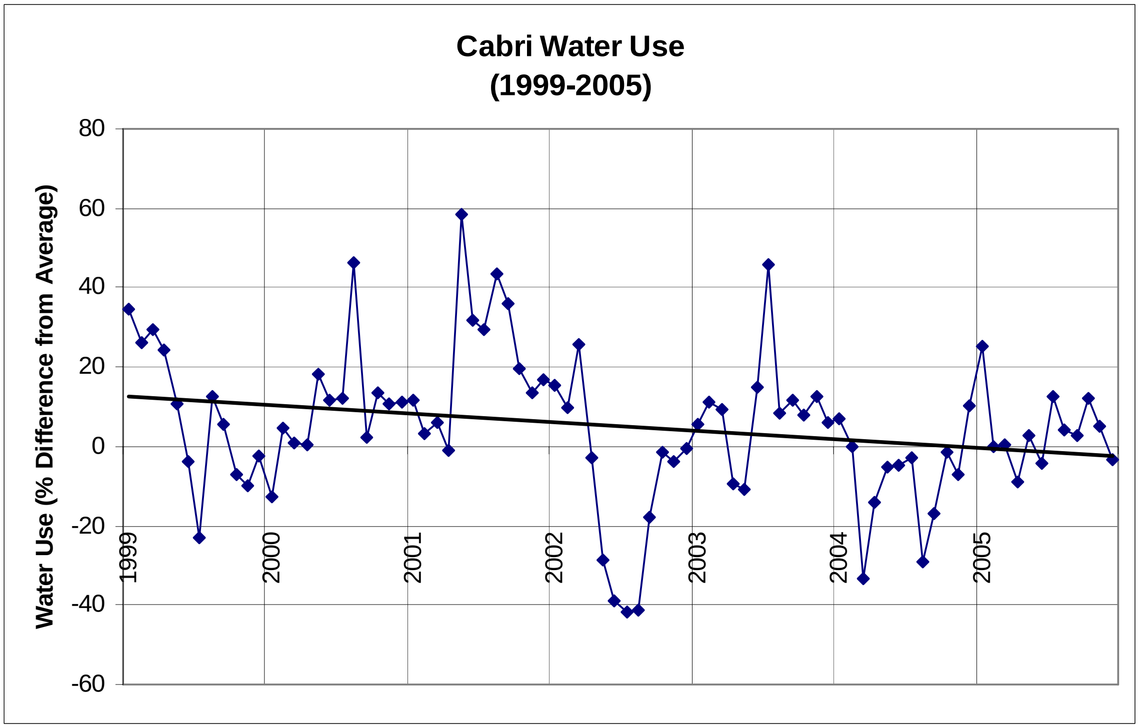

Figure A.25 Cabri Potable Monthly Water Consumption (1999-2005) (Data: Anderson 2006)

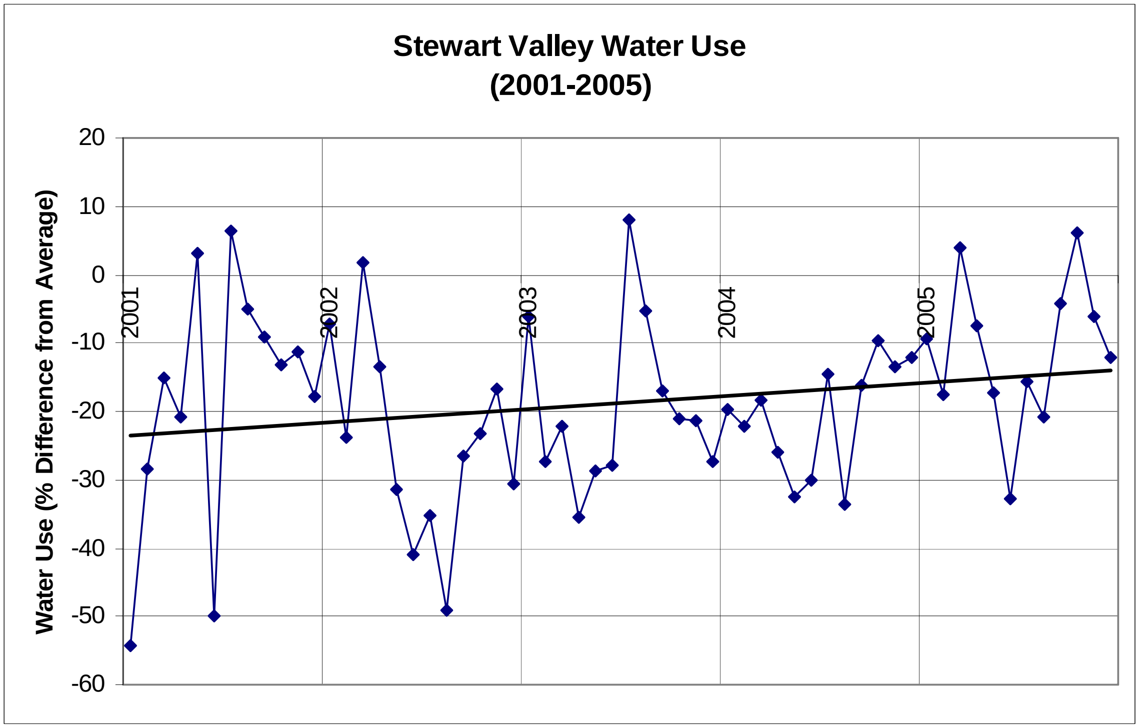

Figure A.26 Stewart Valley Monthly Potable Water Consumption (2001-2005) (Data: Anderson 2006)

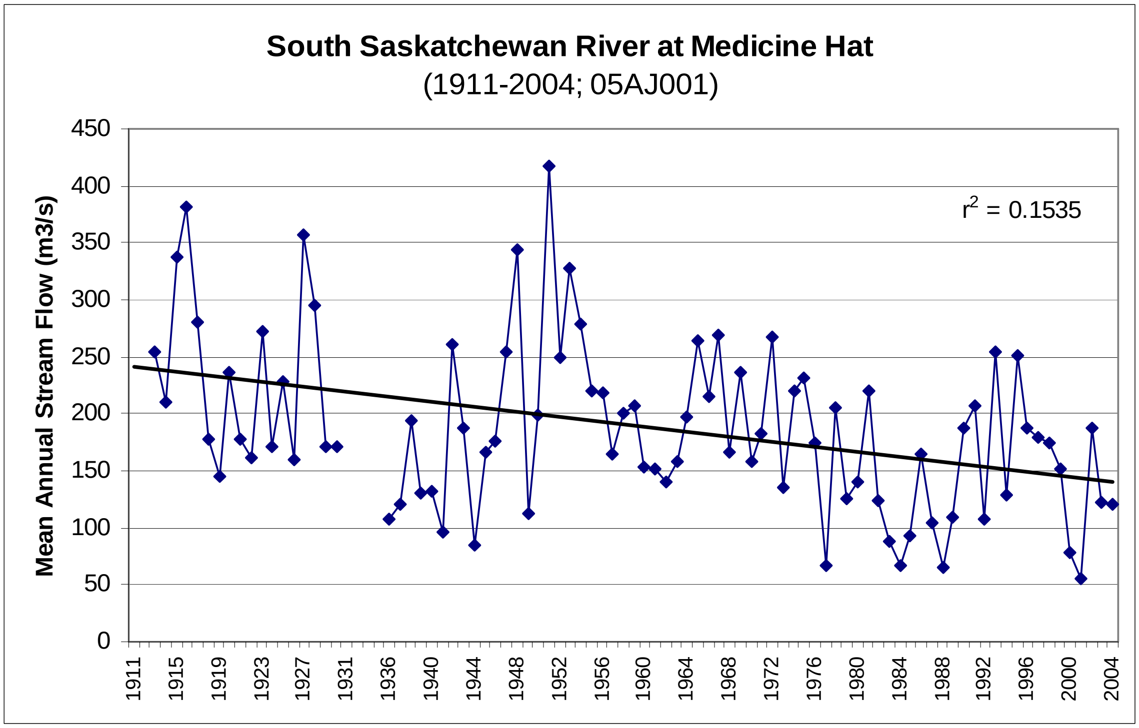

Figure A.27 South Saskatchewan River Mean Annual Discharge at Medicine Hat (1911-2004) (Data Source: Environment Canada 2006b)

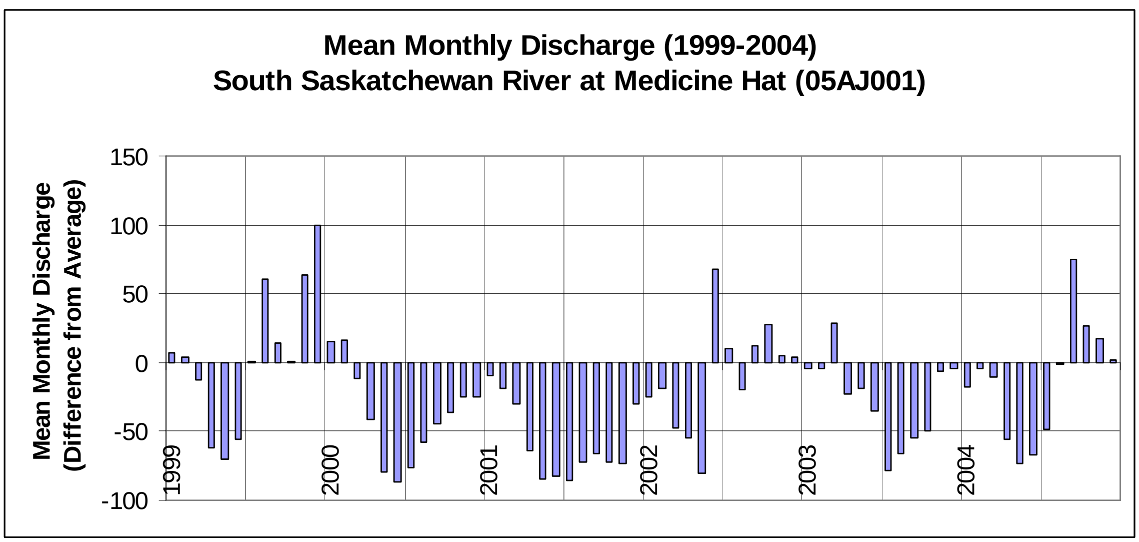

Figure A.28 South Saskatchewan River at Medicine Hat Mean Monthly Discharge 1999-2004 (Percent Difference from Average) (Data Source: Environment Canada 2006b)

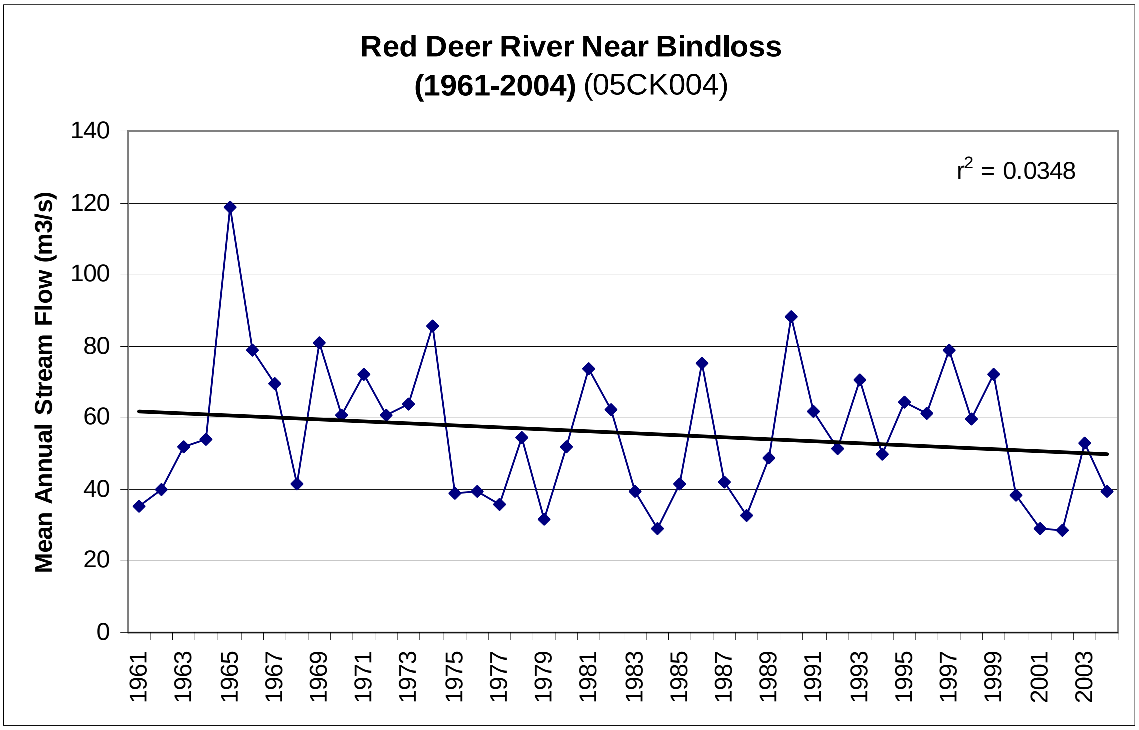

Figure A.29 Red Deer River Mean Annual Discharge near Bindloss (1961-2004) (Data Source: Environment Canada 2006b)

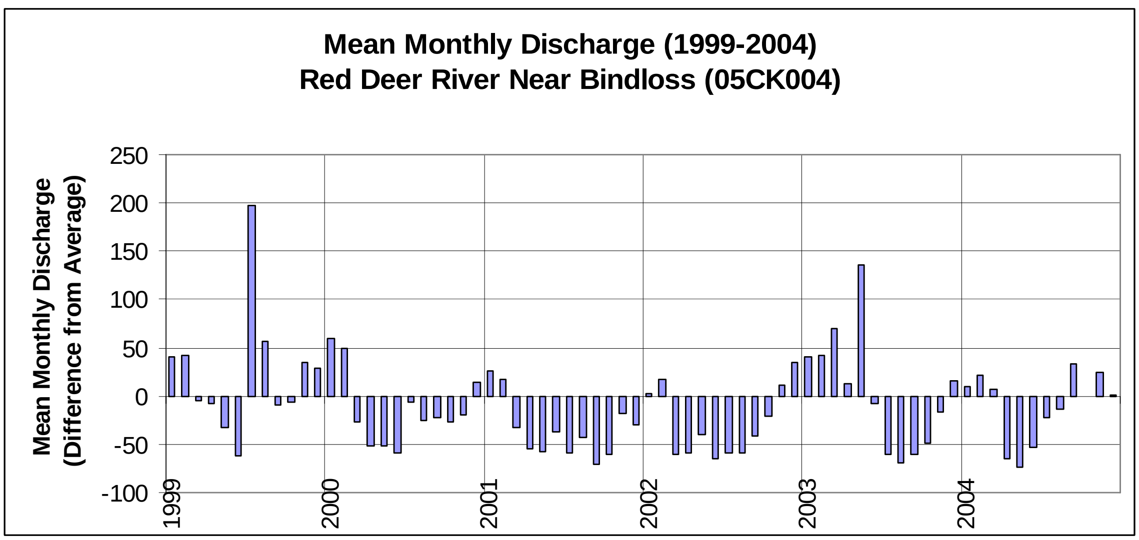

Figure A.30 Red Deer River Near Bindloss Mean Monthly Discharge 1999-2004 (Percent Difference from Average) (Data Source: Environment Canada 2006b)

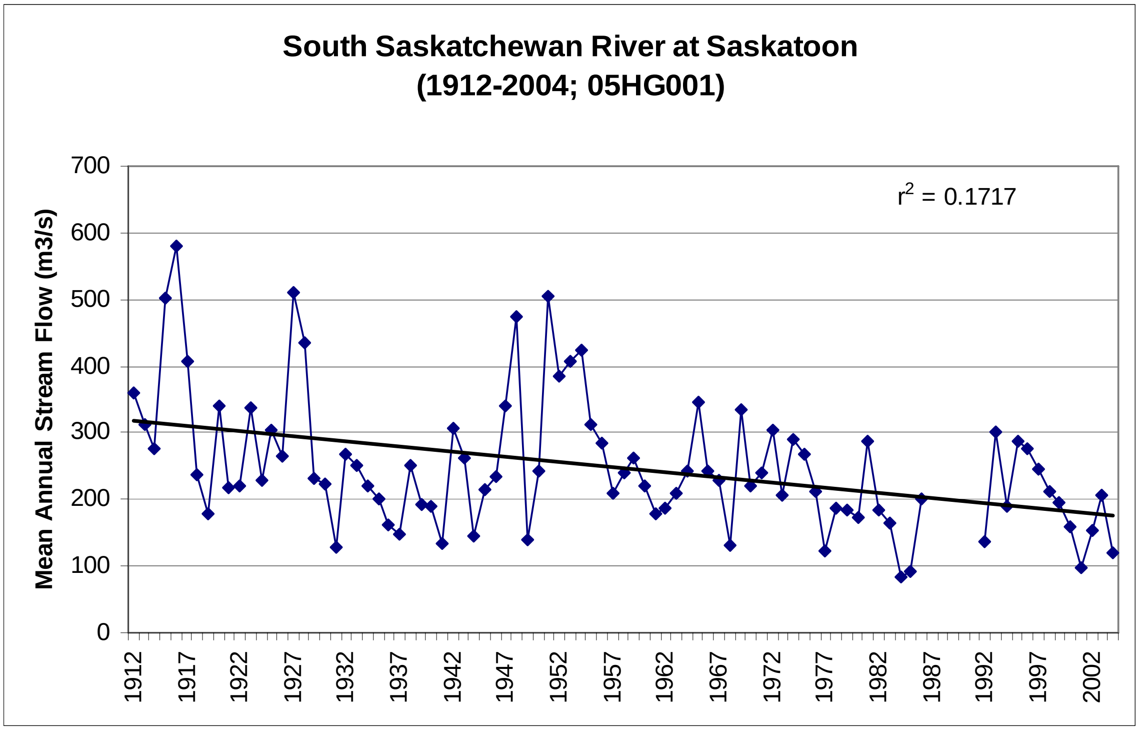

Figure A.31 South Saskatchewan River Mean Annual Discharge at Saskatoon (1912 – 2004) (Data Source: Environment Canada 2006b)

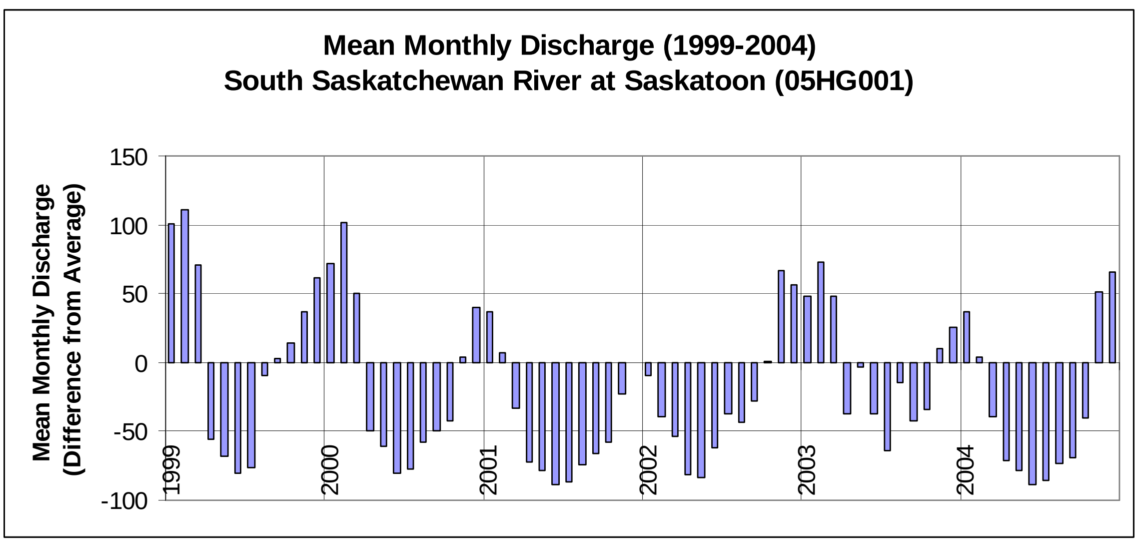

Figure A.32 South Saskatchewan River at Saskatoon Mean Monthly Discharge 1999-2004 (Percent Difference from Average) (Data Source: Environment Canada 2006b)

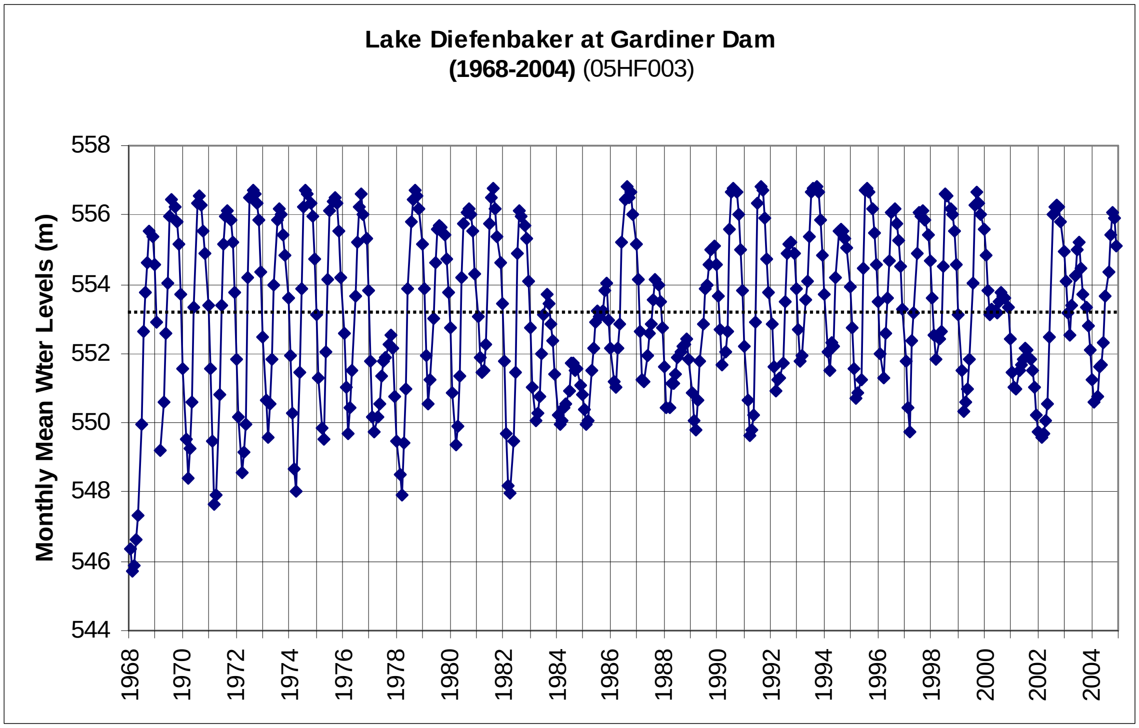

Figure A.33 Monthly Mean Water Levels at Lake Diefenbaker (Data Source: Environment Canada 2006b)

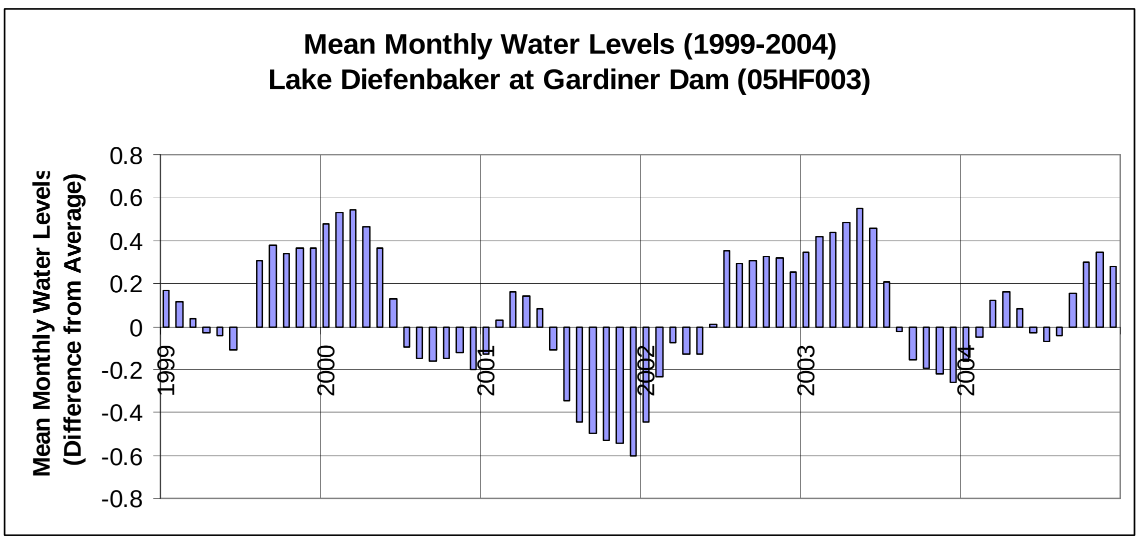

Figure A.34 Lake Diefenbaker at Gardiner Dam Mean Monthly Water Levels 1999-2004 (Percent Difference from Average) (Data Source: Environment Canada 2006b).

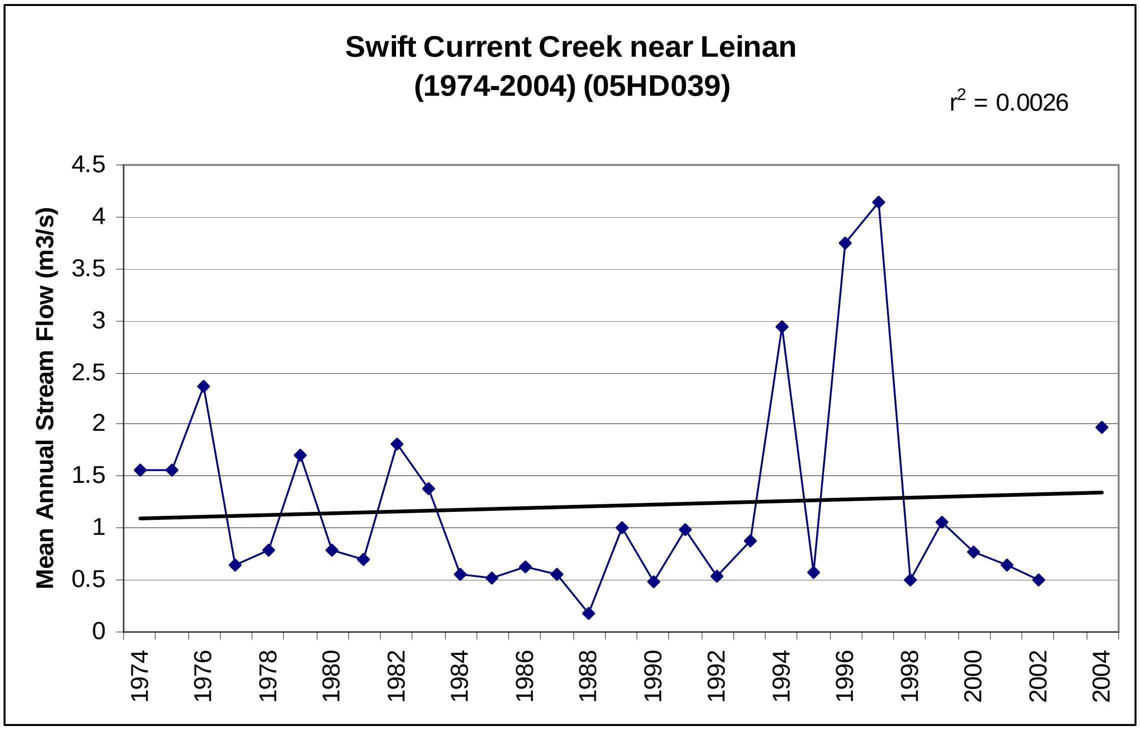

Figure A.35 Swift Current Creek Mean Annual Discharge near Leinan (1974-2004) (Data Source: Environment Canada 2006b)

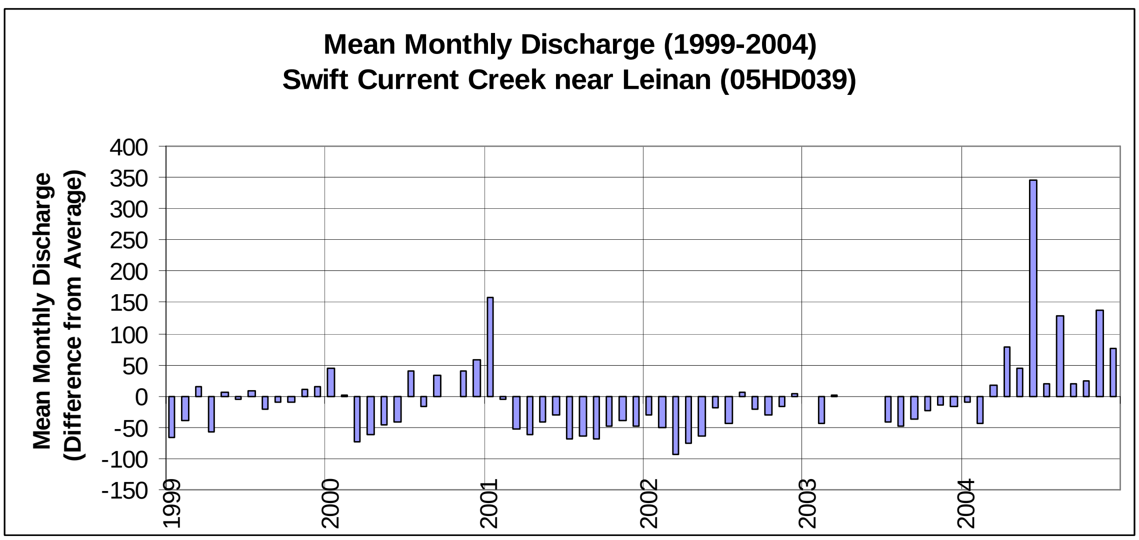

Figure A.36 Swift Current Creek near Leinan Mean Monthly Discharge 1999-2004 (Percent Difference from Average) (Data Source: Environment Canada 2006b)

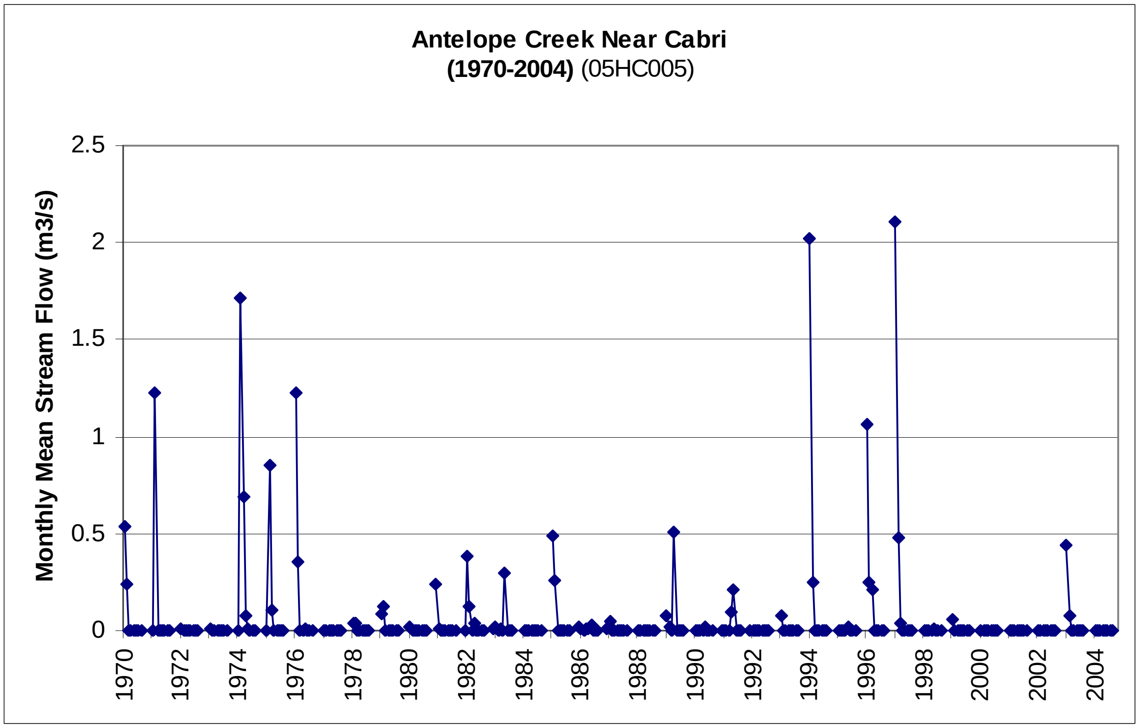

Figure A.37 Antelope Creek Mean Monthly Discharge near Cabri (1970-2004) (Data Source: Environment Canada 2006b)

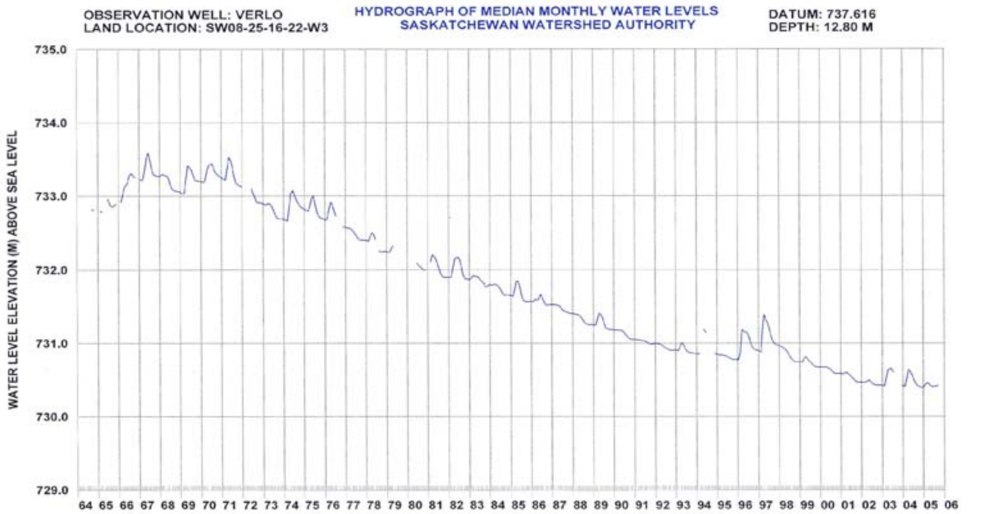

Figure A.38 Hydrograph of Median Monthly Water Levels, Verlo (Saskatchewan Watershed Authority 2006)

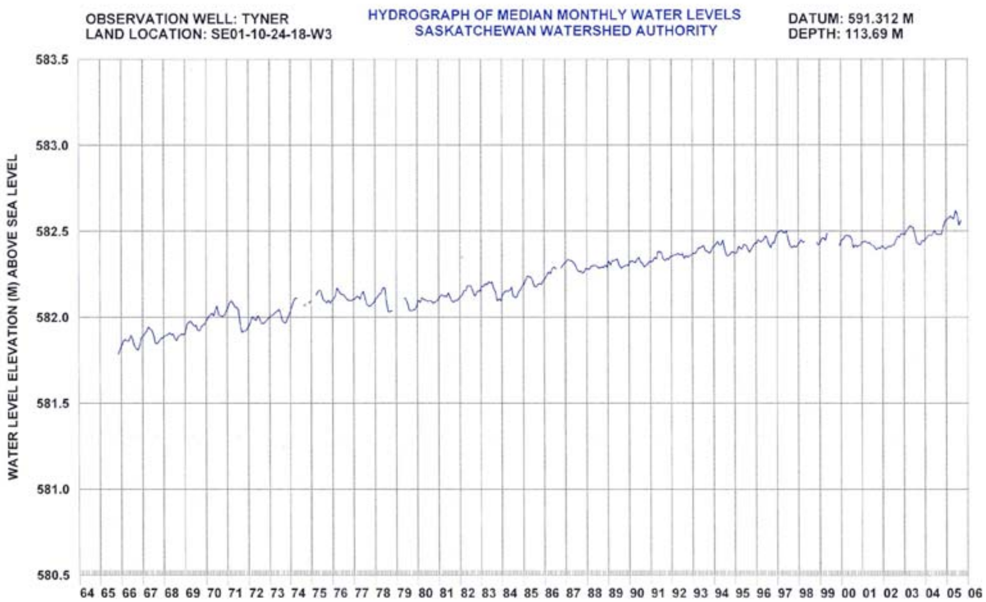

Figure A.39 Hydrograph of Median Monthly Water Levels, Tyner (Saskatchewan Watershed Authority 2006)

Dugout Levels on the Canadian Prairies for 2000 to 2003

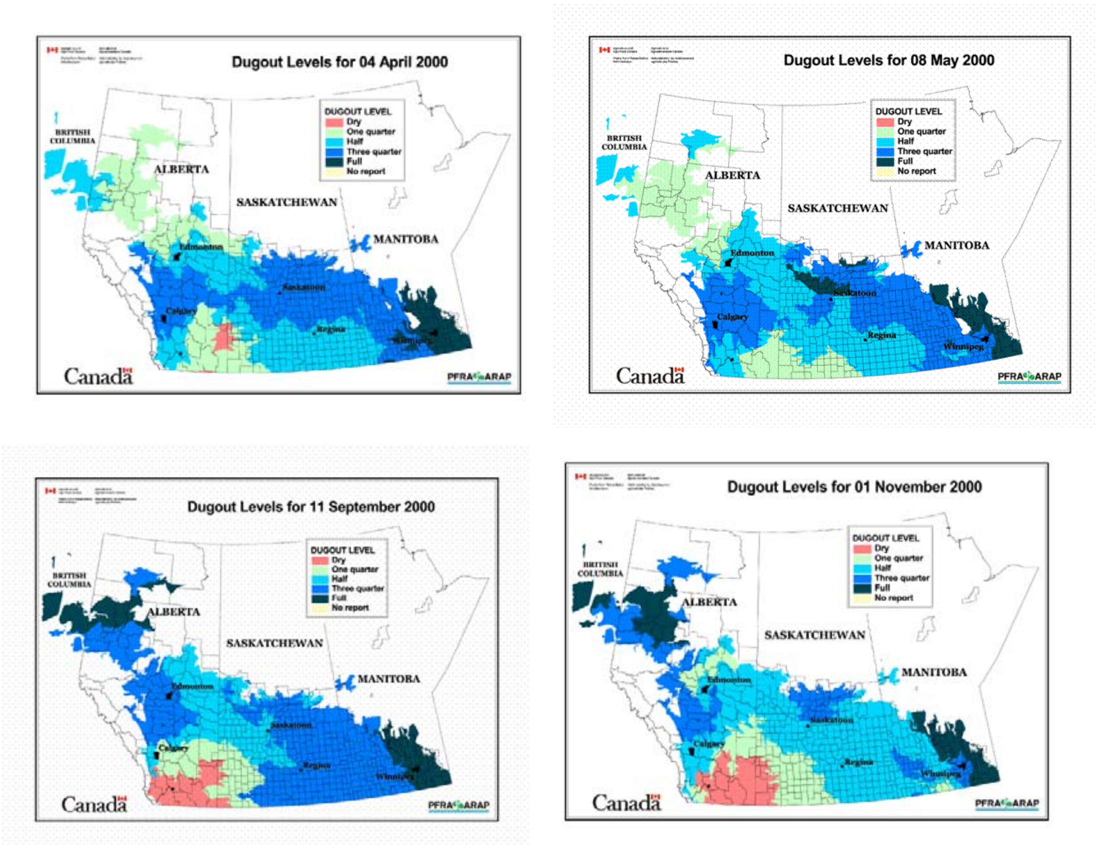

Figure A.40 Dugout Levels across Canadian Prairies 2000 (PFRA - Agriculture and Agri-Food Canada 2006)

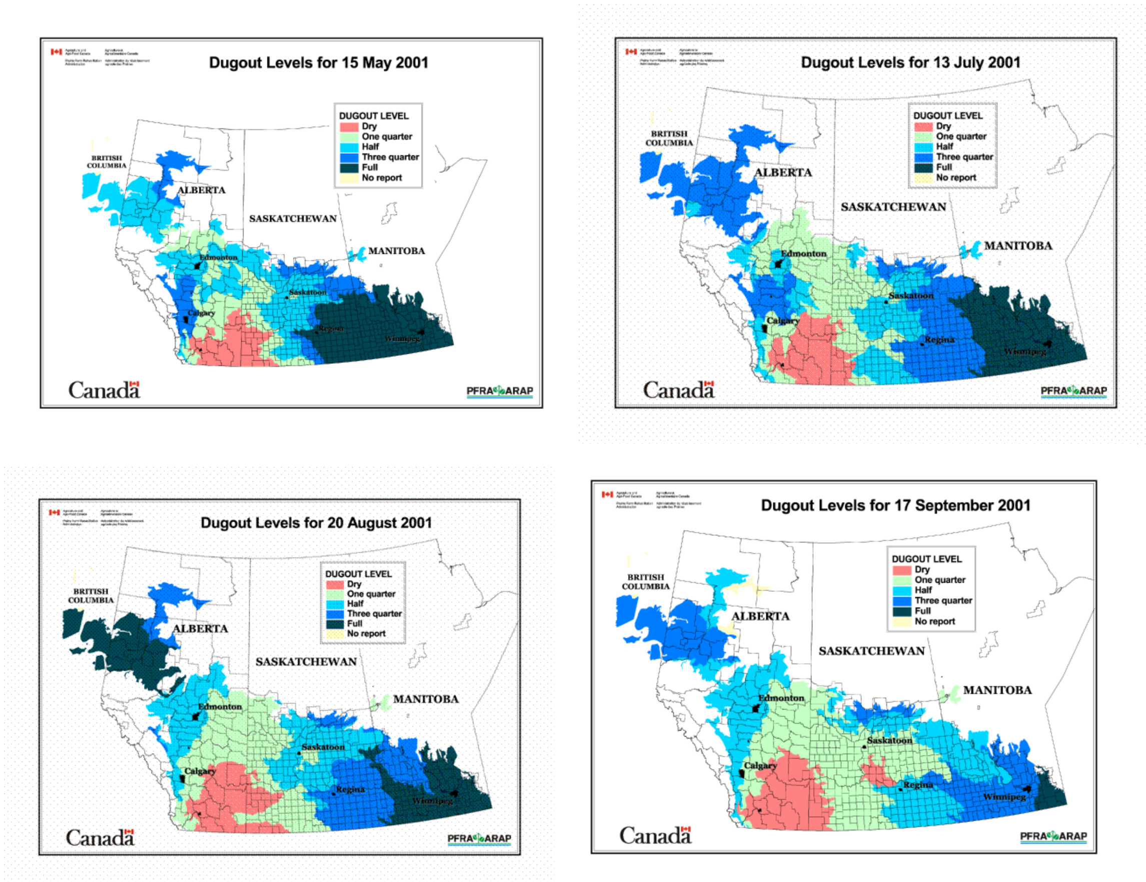

Figure A.41 Dugout Levels across Canadian Prairies 2001 (PFRA - Agriculture and Agri-Food Canada 2006)

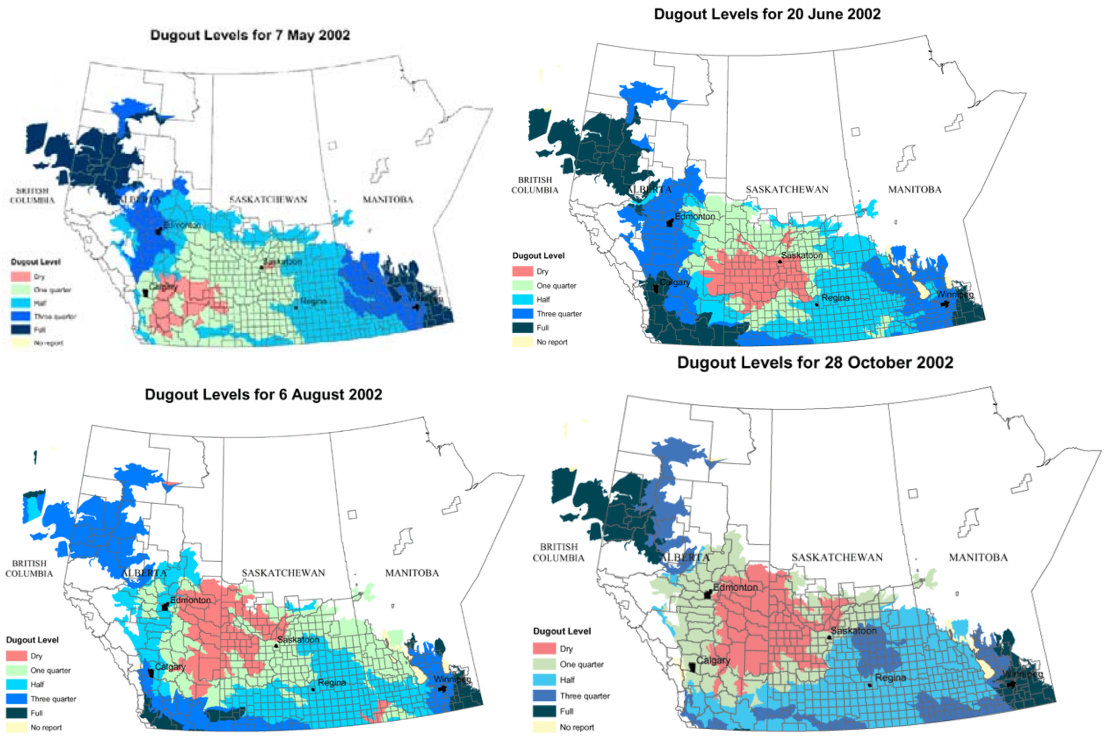

Figure A.42 Dugout Levels across Canadian Prairies 2002 (PFRA - Agriculture and Agri-Food Canada 2006)

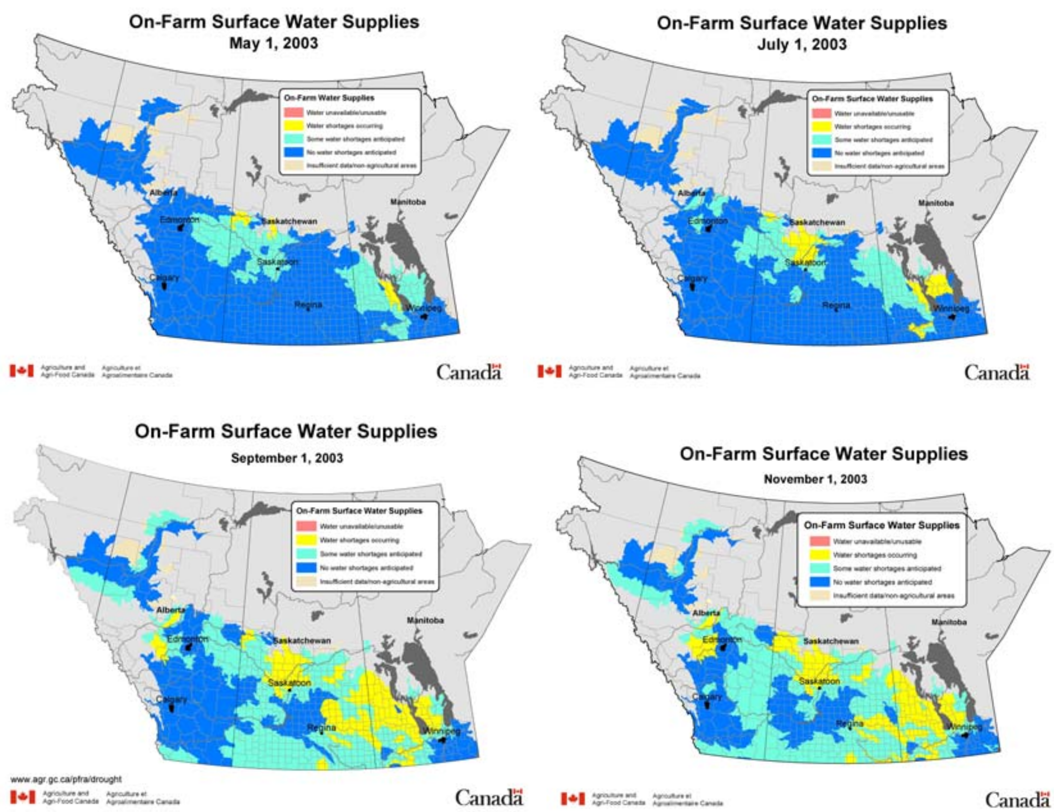

Figure A.43 On-Farm Surface Water Supplies across Canadian Prairies 2003 (PFRA - Agriculture and Agri-Food Canada 2006)

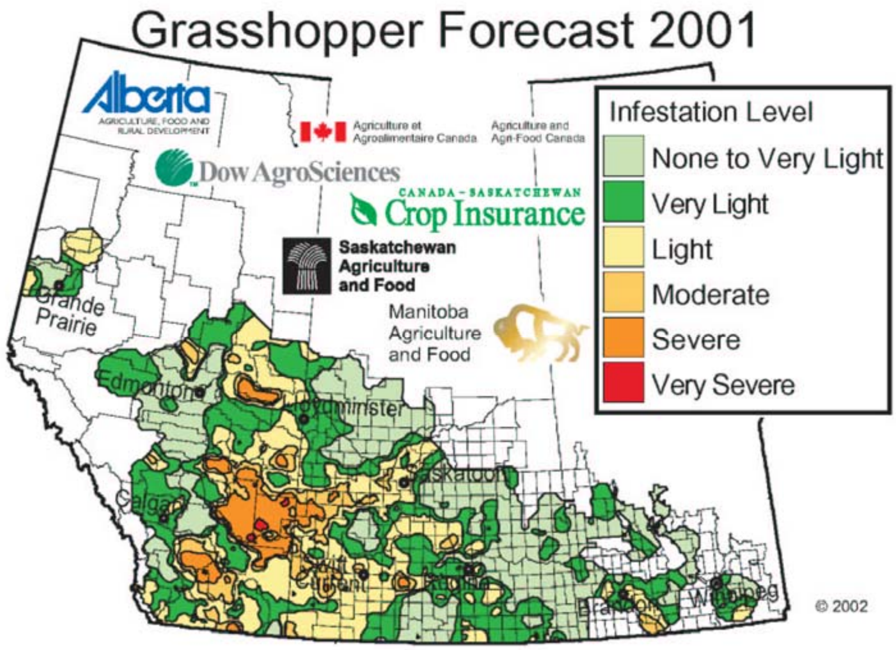

Figure A.44 Grasshopper Forecast 2001 (Olfert et al. 2003)

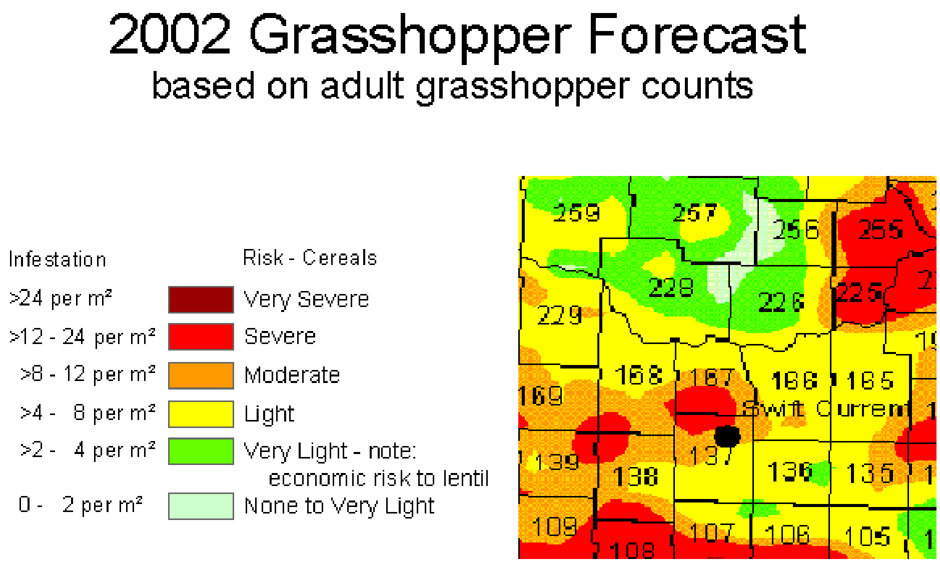

Figure A.45 Grasshopper Forecast 2002 (Saskatchewan Agriculture and Food 2001)

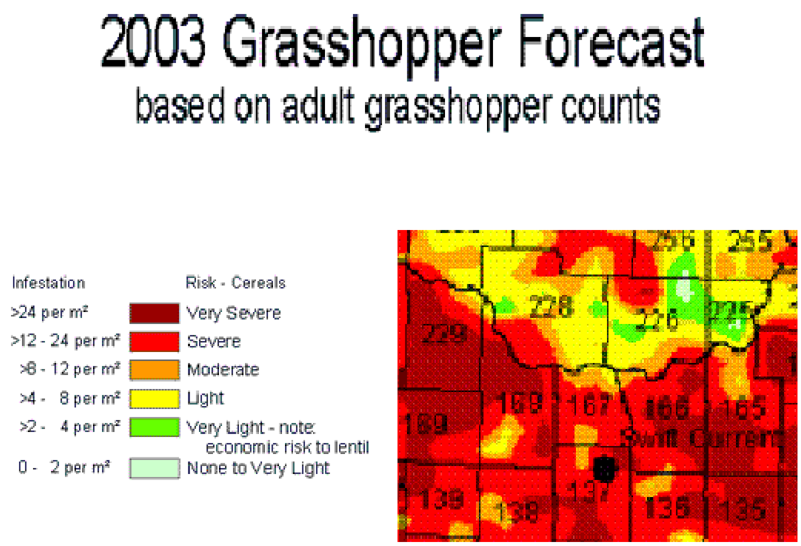

Figure A.46 Grasshopper Forecast 2003 (Saskatchewan Agriculture and Food 2002)

APPENDIX B

REVIEW OF LITERATURE

In the initial stages of the Case study of Cabri and Stewart Valley a literature review of journal articles focusing on farm-level impacts of drought was completed. This research focused on agricultural communities in Western Canada. Later on this search was widened to any relevant study. The purpose of this literature review was to confirm and study any similar projects with respect to farm-level drought impacts. This research revealed a small number of publications mostly focusing on the 1988 Drought of the United States and the Australian Drought of the 1990s. However, with the exception of the Australian Farm Families Report, most of these publications were not farm-level specific but concentrated on the national economy as a whole.

The most comprehensive and useful publication was one in Australia was by Stehlik et al. (1999). This study focused on two very different agricultural areas within Australia -- Central Queensland and Western Riverina. Central Queensland is a beef producing area and Western Riverina is a sheep/wheat producing area. Unfortunately these two areas were affected by drought from 1989 until 1996 which is a ghastly period of drought. (Stehlik et al. 1999)

The Australian drought literature focused mostly on social issues; however, a few adaptation methods were revealed. Farmers compensated their low income by finding off-farm work, used their machinery to generate off-farm income, and set aside land for cropping if precipitation occurred. A few on-farm management options were to supplement the feeding of livestock, agistment, sell livestock, clear vegetation to increase grazing area, and or move to the coast (Stehlik et al. 1999). These are similar key issues that Cabri and Stewart Valley were combed for. It appears that in Australia, under very adverse drought conditions, producers made similar management decisions as producers in Cabri and Stewart Valley.

Lack of water during drought period is also discussed in the Australian literature in terms of management. Producers in Australia were forced to invest in pipelines, drill wells, and manipulate reservoirs. All these measures require extensive amounts of labor and money that producers were short of. Producers discussed how cash flow did not exist but they needed to invest in equipment to procure water and did not regret the decision as they rationalized the existence of their herd. Therefore they incurred financial debt which became a long term drought impact. (Stehlik et al. 1999)

Moving onto the literature centered on the 1988 drought in the United States the focus transitions from the farm level to the national level. At the farm-level drought effects were recognized as dramatic and uneven. Producers with inventories and sufficient yields benefited greatly from increased crop prices. However, producers that experienced yield losses may not have benefited from insurance indemnities or federal disaster payments. (Rosine and Walraven 1989)

Rosine and Walraven (1989) studied the livestock sector. Cattle herds in the United States are recognized as capital assets and their value is determined by the number of marketable animals and the income those assets are expected to generate. Therefore the long term impact created by herd dispositions is recognized. The theory applied examined whether or not increased feed and resource costs associated with the drought created a need to extensively liquidate herd numbers. In theory, an extensive liquidation of herd numbers would increase meat supplies on the market causing lower prices in the short term and increasing future prices because of reduced supplies. If a cattle producer can financially survive a drought they will then benefit in the long term from an increase in price. Cattle producers in the United States did not follow through with dispositions as expected in the middle of summer in 1988. In the United States, there is policy in place that provides subsidies to help producers maintain there herd numbers in drought years. Those subsidies offset the long term impacts of drought but also dampened the market fluctuations stirred by drought conditions. (Rosine and Walraven 1989)

In “The 1988 Drought: Its Impact on District Agriculture” by Karrenbrock (1989), impacts of the 1988 drought in the United States was studied. This literature outlined several government support programs that assisted producers during the drought. The most popular government program was the Conservation Reserve Program (CRP). The CRP allowed producers to take land out agricultural production for 10 years in return for annual payments to the land owner. The CRP helped American producers by providing a way to manage risk. Livestock producers were supported and encouraged to maintain there herd numbers. Producers were partially reimbursed for the costs of purchasing feed and additional transportation expenses. There were also low interest loans available if debt needed to be incurred. (Karrenbrock 1989)

This literature Review provided some level of experienced theory as to the research process for the Cabri and Stewart Valley Case Study. However, this literature review did not reveal a large quantity of research which supports the need for further research as to the farm-level impacts of drought. Although, these literature pieces were very useful and most importantly they revealed similarities between Western Canada, Australia, and the United States. They support the common susceptibility that farmers around the world share in times of drought.

APPENDIX C

DETAILED DATA TABLED FOR FARM ECONOMIC ANALYSIS

Table C.1 Yield of Major Crops, RM of Saskatchewan Landing No. 167, 1955-2004

Year	Spring Wheat (bu/ac)	Durum (bu/ac)	Barley (bu/ac)	Year	Spring Wheat (bu/ac)	Durum (bu/ac)	Barley (bu/ac)	Lentils (lbs/ac)	Peas (lbs/ac)
1955	23.0	N/A	31.0	1980	26.0	30.0	50.0	N/A	N/A
1956	23.0	N/A	30.0	1981	30.0	31.0	50.0	N/A	N/A
1957	20.0	N/A	22.0	1982	35.0	37.0	60.0	N/A	N/A
1958	10.0	N/A	15.0	1983	18.5	20.1	25.0	N/A	N/A
1959	18.0	N/A	27.0	1984	20.8	22.5	24.0	N/A	N/A
1960	18.0	N/A	24.0	1985	16.9	14.5	17.2	N/A	N/A
1961	11.0	N/A	15.0	1986	28.5	28.7	39.6	N/A	N/A
1962	17.0	N/A	25.0	1987	27.1	26.6	35.0	N/A	N/A
1963	25.0	N/A	35.0	1988	9.3	11.0	15.0	N/A	N/A
1964	16.0	N/A	23.0	1989	31.3	31.2	42.3	N/A	N/A
1965	23.0	N/A	30.0	1990	34.6	35.3	49.8	N/A	N/A
1966	30.0	N/A	50.0	1991	36.5	41.2	32.2	N/A	N/A
1967	18.0	N/A	24.0	1992	30.6	30.9	45.0	1,200.0	1,000.0
1968	18.0	N/A	20.0	1993	37.5	40.2	53.0	830.0	N/A
1969	24.0	N/A	36.0	1994	24.7	25.1	43.1	854.0	800.0
1970	27.0	29.0	43.0	1995	34.7	35.7	41.9	778.0	600.0
1971	26.0	26.0	43.0	1996	36.4	37.8	43.0	911.0	1,500.0
1972	23.0	23.0	38.0	1997	33.9	34.0	43.0	1114.2	1,567.5
1973	19.0	21.0	30.0	1998	28.9	32.9	30.2	935.9	1,683.6
1974	18.0	19.0	25.0	1999	37.7	43.8	48.9	1714.4	2,457.5
1975	20.0	22.0	35.0	2000	39.4	40.4	59.8	1707.3	2,531.6
1976	32.0	33.0	55.0	2001	17.8	17.7	24.5	559.0	531.0
1977	32.0	32.0	47.0	2002	20.3	22.6	29.8	785.0	1,081.0
1978	28.0	28.0	39.0	2003	18.7	23.0	36.6	737.0	1,196.0
1979	25.0	26.0	33.0	2004	32.2	31.7	49.0	1,614.0	2,056.0

Table C.2 Yield of Major Crops, RM of Riverside No. 168, 1955-2004

Year	Spring Wheat (bu/ac)	Durum (bu/ac)	Barley (bu/ac)	Year	Spring Wheat (bu/ac)	Durum (bu/ac)	Barley (bu/ac)	Lentils (lbs/ac)	Peas (lbs/ac)
1956	22.0	N/A	29.0	1981	25.0	25.0	37.0	N/A	N/A
1957	20.0	N/A	29.0	1982	32.0	32.0	45.0	N/A	N/A
1958	14.0	N/A	18.0	1983	26.2	26.2	38.6	N/A	N/A
1959	20.0	N/A	26.0	1984	21.3	21.6	26.2	N/A	N/A
1960	18.0	N/A	22.0	1985	14.6	13.4	17.9	N/A	N/A
1961	10.0	N/A	15.0	1986	31.5	30.1	46.7	N/A	N/A
1962	18.0	N/A	23.0	1987	25.8	23.1	33.4	N/A	N/A
1963	21.0	N/A	26.0	1988	7.7	7.8	17.2	N/A	N/A
1964	15.0	N/A	15.0	1989	27.9	26.3	34.9	N/A	N/A
1965	23.0	N/A	36.0	1990	25.9	24.2	28.3	N/A	N/A
1966	30.0	N/A	44.0	1991	31.9	39.2	41.4	N/A	N/A
1967	17.0	N/A	21.0	1992	34.7	37.3	32.7	1,064.0	500.0
1968	20.0	N/A	29.0	1993	30.7	33.4	50.4	1,457.0	1,533.0
1969	25.0	N/A	38.0	1994	18.8	22.7	34.7	978.0	1,189.0
1970	27.0	29.0	39.0	1995	30.7	35.9	49.0	661.0	1,200.0
1971	26.0	25.0	44.0	1996	35.9	38.4	48.8	1,176.0	1,556.0
1972	22.0	23.0	36.0	1997	33.5	37.7	43.3	768.5	1,825.1
1973	19.0	19.0	31.0	1998	29.0	32.5	48.6	925.8	1,817.7
1974	19.0	21.0	34.0	1999	35.6	37.3	52.1	1,695.8	2879.1
1975	23.0	26.0	38.0	2000	31.9	35.3	45.8	1,409.3	2,479.2
1976	27.0	29.0	46.0	2001	24.9	21.7	38.0	439.0	533.0
1977	30.0	31.0	48.0	2002	17.2	19.1	26.4	977.0	1,484.0
1978	23.0	23.0	39.0	2003	12.7	23.1	24.7	672.0	1,138.0
1979	24.0	25.0	35.0	2004	32.8	38.4	54.1	1,425.0	2,461.0

APPENDIX D

ECONOMIC IMPACT ON CROP PRODUCTION SAMPLE DATA AND CALCULATIONS: RM OF SASKATCHEWAN LANDING NO. 167

Table D.1 Estimated Economic Impact on Durum Production in RM No. 167, $ per Acre, 2001-2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (bu/ac)	39.03	17.7	22.6	23	31.7
Price ($/bu)	$3.88	4.25	4.79	5.73	4.25
Gross Revenue/acre	$151.45	$75.23	$108.25	$131.79	$134.73
Cost of Production/acre	$107.84	$108.37	$101.89	$112.93	$119.09
Net Revenue/acre*	$43.61	($33.15)	$6.36	$18.86	$15.64
RM Crop Acres	46,717	46,717	46,717	46,717	46,717
Percent of Total RM Crop Acres	37.27%	37.27%	37.27%	37.27%	37.27%
RM Revenue ($ 000)	$2,037.14	($1,548.43)	$297. 31	$881.08	$730.42

* Figures in parentheses are negative values

Table D.2 Estimation of Economic Impact of Droughts on Spring Wheat Production in RM No. 167, 2001 to 2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (bu/ac)	35.33	17.8	20.3	18.7	32.2
Price ($/bu)	$3.53	4.25	4.70	5.55	4.00
Gross Revenue/acre	$124.61	$75.65	$95.41	$103.79	$128.80
Cost of Production/acre	$104.68	106.43	99.39	111.10	116.37
Net Revenue/acre*	$19.93	($30.78)	($3.98)	($7.32)	$12.43
RM Crop Acres	14,305	14,305	14,305	14,305	14,305
Percent of Total RM Crop Acres	11.41%	11.41%	11.41%	11.41%	11.41%
RM Revenue ($ 000)	$285.08	($440.31)	($56.93)	($104.64)	$177.81

* Figures in parentheses are negative values

Table D.3 Estimation of Economic Impact of Droughts on Barley Production in RM No. 167, 2001-2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (lbs/ac)	1452.53	559	785	737	1614
Price ($/lb)	$0.16	0.16	0.17	0.2	0.18
Gross Revenue/acre	$237.25	$89.44	$133.45	$147.40	$290.52
Cost of Production/acre	$150.89	$138.63	$136.62	$161.65	$164.05
Net Revenue/acre*	$86.36	($49.19)	($3.17)	($14.25)	$126.47
RM Crop Acres	16,077	16,077	16,077	16,077	16,077
Percent of Total RM Crop Acres	12.83%	12.83%	12.83%	12.83%	12.83%
RM Revenue ($ 000)	$13.03	($6.82)	($0.43)	($2.30)	$20.76

* Figures in parentheses are negative values

Table D.4 Estimation of Economic Impact of Droughts on Barley Production in RM No. 167, 2001 – 2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (bu/ac)	46.30	24.5	29.8	36.6	49
Price ($/bu)*	$1.88	2.00	2.31	2.93	2.40
Gross Revenue/acre	$87.04	$49.00	$68.84	$107.24	$117.60
Cost of Production/acre	$103.11	$103.76	$97.68	$107.05	$115.73
Net Revenue/acre**	($16.07)	($54.76)	($28.84)	$0.19	$1.87
RM Crop Acres	5,810	5,810	5,810	5,810	5,810
Percent of Total RM Crop Acres	4.64%	4.64%	4.64%	4.64%	4.64%
RM Revenue ($ 000)	($93.34)	($318.16)	($167.57)	$1.09	$10.86

* Feed Barley Prices
** Figures in parentheses are negative values

Table D.5 Estimation of Economic Impact of Droughts on Oat production in RM No. 167, 2001 – 2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (lbs/ac)	56.43	N/A	35.9	N/A	48.4
Price ($/lb)	$1.43	1.50	1.89	2.50	1.65
Gross Revenue/acre	$80.51	N/A	$67.85	N/A	$79.86
Cost of Production/acre	$99.70	$99.25	$95.12	$104.42	$110.91
Net Revenue/acre*	($19.20)	N/A	($27.27)	N/A	($31.05)
RM Crop Acres	2,876	2,876	2,876	2,876	2,876
Percent of Total RM Crop Acres	2.29%	2.29%	2.29%	2.29%	2.29%
RM Revenue ($ 000)	($55.21)	N/A	($78.43)	N/A	($89.30)

* Figures in parentheses are negative values

Table D.6 Estimation of Economic Impact of Droughts on Canary Seed Production in RM No. 167, 2002-2004 and Base

Particulars	1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (lbs/ac)*	741.33	501.00	599.00	4,161.00	903.00
Price($/lb)	$0.12	0.11	0.16	0.20	0.15
Gross Revenue/acre	$91.43	$55.11	$95.84	$832.20	$135.45
Cost of Production/acre	$111.41	$105.26	$104.34	$116.87	$119.06
Net Revenue/acre**	($19.98)	($50.15)	($8.50)	$715.33	$16.39
RM Crop Acres	1,165	1,165	1,165	1,165	1,165
Percent of Total RM Crop Acres	0.93%	0.93%	0.93%	0.93%	0.93%
RM Revenue ($ 000)	($23.27)	($58.42)	($9.90)	$833.31	$19.09

* At the CAR level
** Figures in parentheses are negative values

Table D.7 Estimation of Economic Impact of Droughts on Field Pea Production in RM No. 167, 2000 – 2004

Particulars	2000	2001 Drought	2002 Drought	2003	2004
Yield (lbs/ac)	2531.6	531.0	1,081.0	1,196.0	2,056.0
Price ($/lb)	0.07	0.07	0.10	0.12	0.10
Gross Revenue/acre	$164.55	$34.52	$104.86	$141.61	$195.32
Cost of Production/acre	$145.00	$145.00	$148.00	$167.32	$159.72
Net Revenue/acre*	$19.55	($110.49)	($43.14)	($25.71)	$35.60
RM Crop Acres	7,452	7,452	7,452	7,452	7,452
Percent of Total RM Crop Acres	5.95%	5.95%	5.95%	5.95%	5.95%
RM Revenue ($ 000)	$145.72	($823.33)	($321.50)	($191.62)	$265.29

* Figures in parentheses are negative values

Table D.8 Estimation of Economic Impact of Droughts on Mustard Production in RM No. 167, 2001-2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield* (lbs/ac)*	881	628	458	598	970
Price* ($/lb)*	$0.16	0.12	0.17	0.20	0.16
Gross Revenue/acre	$140.96	$75.36	$77.86	$119.60	$155.20
Cost of Production/acre	$115.65	$106.66	$106.28	$116.34	$129.45
Net Revenue/acre**	$25.31	($31.30)	($28.42)	$3.26	$25.75
RM Crop Acres	778	778	778	778	778
Percent of Total RM Crop Acres	0.62%	0.62%	0.62%	0.62%	0.62%
RM Revenue ($ 000)	$19.69	($24.35)	($22.11)	$2.54	$20.03

* CAR level data
** Figures in parentheses are negative values

Table D.9 Total Economic Impacts on Crop Production for RM No. 167, 2000 – 2004

Year	Gross Revenue in Thousand Dollars*
2000	$2,328.84
2001	($3,219.83)
2002	($359.57)
2003	$1,419.51
2004	$1,154.96

* Figures in parentheses are negative values

APPENDIX E

ECONOMIC IMPACT ON CROP PRODUCTION SAMPLE DATA AND CALCULATIONS: RM OF RIVERSIDE NO. 168

Table E.1 Estimation of Economic Impact of Droughts on Durum Production in RM No. 168, 2001 – 2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (bu/ac)	35.03	21.7	19.1	23.1	38.4
Price ($/bu)	$3.88	$4.25	$4.79	$5.73	$4.25
Gross Revenue/acre	$135.93	$92.23	$91.49	$132.36	$163.20
Cost of Production/acre	$107.84	$108.37	$101.89	$112.93	$119.09
Net Revenue/acre*	$28.09	($16.15)	($10.40)	$19.43	$44.11
RM Crop Acres	85,476	85,476	85,476	85,476	85,476
Percent of Total RM Crop Acres	47.88%	47.88%	47.88%	47.88%	47.88%
RM Revenue ($ 000)	$2,400.68	($1,380.01)	($889.04)	$1,661.06	$3,770.35

* Figures in parentheses are negative values

Table E.2 Estimation of Economic Impact of Droughts on Lentil Production for RM No. 168, 2001 – 2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (bu/ac)	1343.63	439	977	672	1425
Price ($/bu)	$0.16	$0.16	$0.17	$0.20	$0.18
Gross Revenue/acre	$219.46	$70.24	$166.09	$134.40	$256.50
Cost of Production/acre	$150.89	$138.63	$136.62	$161.65	$164.05
Net Revenue/acre*	$68.57	($68.39)	$29.47	($27.25)	$92.45
RM Crop Acres	11,711	11,711	11,711	11,711	11,711
Percent of Total RM Crop Acres	6.56%	6.56%	6.56%	6.56%	6.56%
RM Revenue ($ 000)	$803.02	($800.92)	$345.12	($319.12)	$1,082.68

* Figures in parentheses are negative values

Table E.3 Estimation of Economic Impact of Droughts on Spring Wheat Production in RM No. 168, 2001-2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (bu/ac)	32.17	24.9	17.2	12.7	32.8
Price ($/bu)	$3.53	$4.25	$4.70	$5.55	$4.00
Gross Revenue/acre	$113.44	$105.83	$80.84	$70.49	$131.20
Cost of Production/acre	$104.68	$106.43	$99.39	$111.10	$116.37
Net Revenue/acre*	$8.76	($0.61)	($18.55)	($40.62)	$14.83
RM Crop Acres	11,370	11,370	11,370	11,370	11,370
Percent of Total RM Crop Acres	6.37%	6.37%	6.37%	6.37%	6.37%
RM Revenue ($ 000)	$99.61	($6.89)	($210.91)	($461.79)	$168.62

* Figures in parentheses are negative values

Table E.4 Estimation of Economic Impact of Droughts on Barley Production in RM No. 168, 2001 – 2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (bu/ac)	48.83	38.00	26.40	24.70	54.10
Price ($/bu)	$1.88	$2.00	$2.31	$2.93	$2.40
Gross Revenue/acre	$91.81	$76.00	$60.98	$72.37	$129.84
Cost of Production/acre	$103.11	$103.76	$97.68	$107.05	$115.73
Net Revenue/acre*	($11.30)	($27.76)	($36.70)	($34.68)	$14.11
RM Crop Acres	9,061	9,061	9,061	9,061	9,061
Percent of Total RM Crop Acres	5.08%	5.08%	5.08%	5.08%	5.08%
RM Revenue ($ 000)	($102.42)	($251.53)	($332.50)	($314.23)	$127.85

* Figures in parentheses are negative values

Table E.5 Estimation of Economic Impact of Droughts on Field Pea Production in RM No. 168, 2000 – 2004

Particulars	2000	2001 Drought	2002 Drought	2003	2004
Yield (bu/ac)	2,479.2	533.0	1,484.0	1,138.0	2,461.0
Price ($/bu)	$0.05	$0.05	$0.08	$0.10	$0.08
Gross Revenue/acre	$134.29	$28.87	$119.96	$112.28	$194.83
Cost of Production/acre	$145.00	$145.00	$148.00	$167.32	$159.72
Net Revenue/acre*	($10.71)	($116.13)	($28.04)	($55.04)	$35.11
RM Crop Acres	17,172	17,172	17,172	17,172	17,172
Percent of Total RM Crop Acres	9.62%	9.62%	9.62%	9.62%	9.62%
RM Revenue ($ 000)	($183.91)	($1,994.17)	($481.56)	($945.10)	$602.95

* Figures in parentheses are negative values

Table E.6 Estimation of Economic Impact of Droughts on Oat Production in RM No. 168, 2001 – 2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (bu/ac)	49.73	39.00	34.60	23.50	56.50
Price ($/bu)	$1.43	$1.50	$1.89	$2.50	$1.65
Gross Revenue/acre	$70.95	$58.50	$65.39	$58.75	$93.23
Cost of Production/acre	$99.70	$99.25	$95.12	$104.42	$110.91
Net Revenue/acre*	($28.76)	($40.75)	($29.73)	($45.67)	($17.69)
RM Crop Acres	1,949	1,949	1,949	1,949	1,949
Percent of Total RM Crop Acres	1.09%	1.09%	1.09%	1.09%	1.09%
RM Revenue ($ 000)	($56.04)	($79.42)	($57.93)	($89.01)	($34.47)

* Figures in parentheses are negative values

Table E.7 Estimation of Economic Impact of Droughts on Mustard Production in RM No. 168, 2001 – 2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (lbs/ac)	1,029.83	570.00	716.00	570.00	698.00
Price ($/lb)	$0.16	$0.12	$0.17	$0.20	$0.16
Gross Revenue/acre	$162.23	$68.40	$121.72	$114.00	$111.68
Cost of Production/acre	$115.65	$106.66	$106.28	$116.34	$129.45
Net Revenue/acre*	$46.58	($38.26)	$15.44	($2.34)	($17.77)
RM Crop Acres	2,009	2,009	2,009	2,009	2,009
Percent of Total RM Crop Acres	1.13%	1.13%	1.13%	1.13%	1.13%
RM Revenue ($ 000)	$93.58	($76.86)	$31.02	($4.70)	($35.70)

* Figures in parentheses are negative values

Table E.8 Estimation of Economic Impact of Droughts on Chick Pea Production in RM No. 168, 2001 – 2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (lbs/ac)	x	719	x	881	1,20
Price ($/lb)	$0.25	$0.22	$0.22	$0.22	$0.22
Gross Revenue/acre	N/A	$158.18	N/A	$193.82	$224.40
Cost of Production/acre	$198.35	$198.35	$186.17	$184.35	$179.95
Net Revenue/acre*	--	($40.17)	--	$9.47	$44.45
RM Crop Acres	25,751	25,751	25,751	25,751	25,751
Percent of Total RM Crop Acres	14.42%	14.42%	14.42%	14.42%	14.42%
RM Revenue ($ 000)	N/A	($1,034.42)	N/A	$243.86	$1,144.63

* Figures in parentheses are negative values

Table E.9 Estimation of Economic Impact of Droughts on Canary Seed Production in RM No 168, 2001 – 2004 and Base

Particulars	Base 1998-2000 Average	2001 Drought	2002 Drought	2003	2004
Yield (lbs/ac)	1,158.86	899.00	1,007.00	713.00	1,102.00
Price ($/lb)	$0.12	0.11	0.16	0.20	0.15
Gross Revenue/acre	$142.93	$98.89	$161.12	$142.60	$165.30
Cost of Production/acre	$111.41	$105.26	$104.34	$116.87	$119.06
Net Revenue/acre*	$31.52	($6.37)	$56.78	$25.73	$46.24
RM Crop Acres	2,093	2,093	2,093	2,093	2,093
Percent of Total RM Crop Acres	1.17%	1.17%	1.17%	1.17%	1.17%
RM Revenue ($ 000)	$65.97	($13.33)	$118.84	$53.85	$96.78

* Figures in parentheses are negative values

Table E.10 Total Economic impact on Crop Production in RM No. 168

Year	Gross Revenue in Thousand Dollars
2000	$3,120.49
2001	($5,637.54)
2002	($1,476.96)
2003	($175.18)
2004	$6,923.64

* Figures in parentheses are negative values