Watershed Management Plan:
Water Quantity Component

BATTLE RIVER
WATERSHED ALLIANCE

Understanding the Policy Context for Drought Management in the Battle River and Sounding Creek Watersheds

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Executive Summary

As part of the Battle River Watershed Alliance's dedication to the development of the Watershed Management Plan (WMP), policy research and development will be undertaken for each of the main watershed management components. This report is the background policy research for the drought component of the WMP.

To develop effective policies and guidelines encouraging compliance on a voluntary basis, knowledge of the policies, guidelines, and monitoring resources that exist as potential support and mitigation & adaptation measures is crucial for development of effective. Policies and guidelines set out by various sectors impacted by drought from the international to the local level have been are outlined and discussed. Though many policies pertain to financial assistance for the agricultural sector, addressing importance of economic, environmental, and health support in times of drought is paramount.

Using a media scan to initiate the policy research process, ad hoc and official drought policies and management plans at play at the international, national, provincial, regional, and municipal levels that address economic, social, and environmental implications of drought were investigated. Such information and context will be essential to determine actors involved in the policy issues and for development of effective policy and guidelines for the Battle River Watershed as part of the Watershed Management Plan.

Currently, most municipalities in the Battle River Watershed do not have drought adaptation or management plans. Most programs and policies surrounding drought occur at the provincial and federal level through several different ministries. The majority of these plans and policies focus on agricultural assistance, with few addressing other economic, social, or environmental issues associated with drought.

Some international agencies and governments have developed polices and recommendations regarding development of effective drought management policies, plans, and methods of adaptation. In the context a changing global climate, issues surrounding drought and water scarcity is not limited to Canada. As such, these can be used to create policy recommendations specific to the Battle River Watershed.

Drought adaptation is not a new concept, especially to agricultural producers who have had to deal with such challenges in the past. However, with a changing climate comes increased uncertainty as well as increasingly extreme weather. Though mitigation of the effects of increasingly severe and length of droughts is needed through water management and conservation, adaptation will be the primary course of action for most areas affected by drought. Selecting regionally appropriate adaptation methods and monitoring effectiveness of those methods through the adaptive management process is the most effective way to promote implementation.

Acknowledgements

Thanks to Bettina Alder and Natasha Agar for conducting the media scan. Thank you to the members of the Battle River Watershed Alliance and the Policy Committee for your collaborative effort and input. Thank you to those from Alberta Agriculture and Rural Development, Alberta Environment and Sustainable Resource Development, City of Camrose, Camrose County, ATCO, and Ontario Ministry of Agriculture, Food, and Rural Affairs for all the information and in-kind support they provided for this report.

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1.0 Introduction

1.1 Overview

The purpose of this report is to highlight the drought policies and management plans that are currently in place locally, regionally, provincially, federally, and internationally that will support and contribute to the development of policy recommendations as they pertain to the management of drought in the Battle River Watershed Alliance planning area. This report also outlines recommendations and potential adaptation measures that could be used to develop drought management guidelines for the Battle River and Sounding Creek Watersheds.

1.2 Battle River Watershed Alliance

The Battle River Watershed Alliance (BRWA) was created in 2006 as a non-profit society. Shortly after formation, the BRWA was selected by Alberta Environment and Sustainable Resource Development (then Alberta Environment), under the Water for Life: Alberta's Strategy for Sustainability as the designated Watershed Planning and Advisory Council (WPAC) for the Battle River watershed (Figure 1).

The BRWA works in partnership with communities, watershed stewardship groups, four orders of government (first nations, municipal, provincial, federal), industry, non-governmental organizations and residents, to improve the health of the Battle River and Sounding Creek watersheds using the best science and social science available.

The interplay of interests and pressures to and from governments, and the many layers of negotiation involved in instances of policy making are of interest to the BRWA. Interests and pressure include external influences that exist in all aspects of policy making and regulation, including those from industry, four orders of government that exist in Canada (First Nation, Federal, Provincial, Municipal), other governments, and public groups of various forms.

The BRWA uses a policy community approach to examine the interplay of interests and pressures to and from governments, and layers of negotiation involved in instances of policy making (Atkinson & Coleman, 1992; Coleman and Skogstad, 1990;

Skogstad, 2005). In this way, we define policy making as a series of decisions made before, during and after where policies take shape.

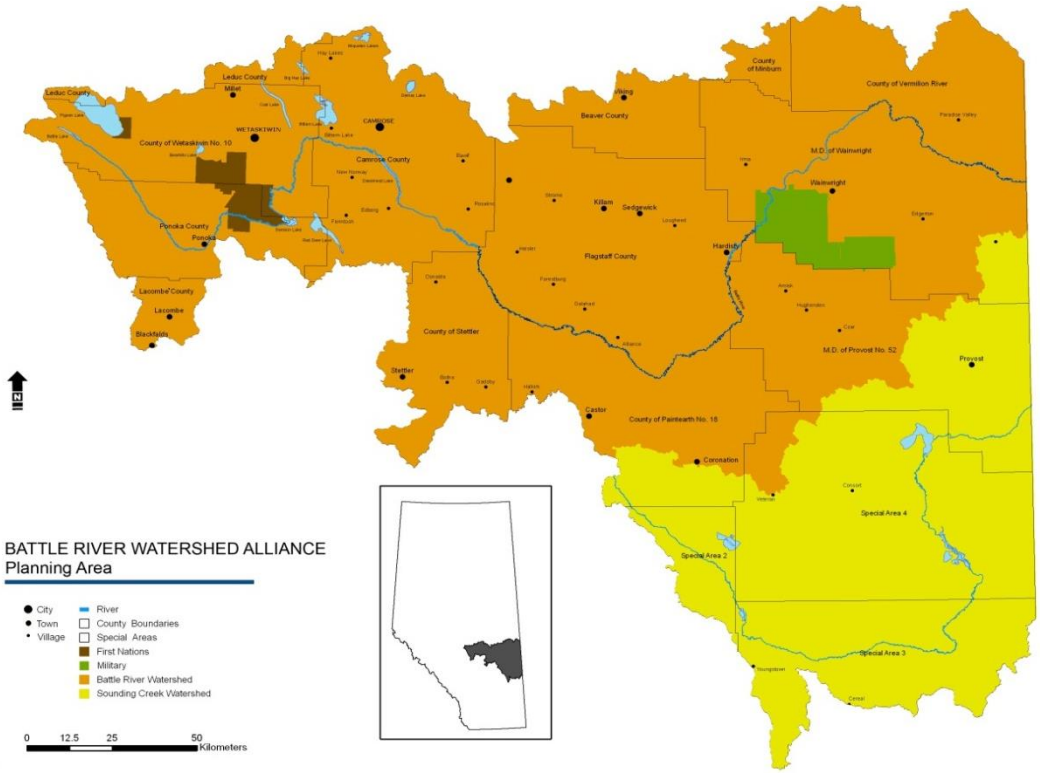

Figure 1. Battle River Watershed Alliance planning area (Battle River Watershed Alliance (BRWA), 2012a).

The Watershed Management Plan (BRWA, 2012a) is comprised of four general topic areas: water quality, water quantity, land management, and biodiversity. Drought is one component under water quantity, but has implications for all areas (Figure 2).

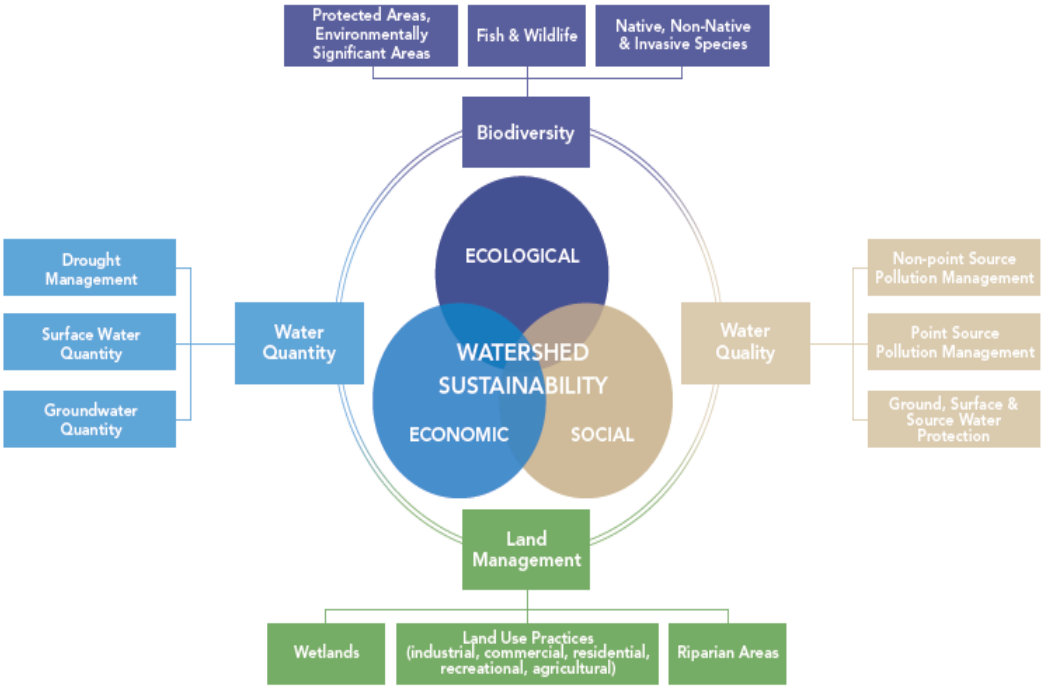

Figure 2. Framework for watershed management planning components in the Battle River and Sounding Creek watersheds.

Adaptive management is an approach to natural resource policy that embodies a simple imperative: policies are experiments that, over the course of the adaptive management planning cycle (Figure 3), may prove inappropriate (Lee, 1993). Adaptive management learns from these experiments in a manner that links science with social and economic values found within the watershed (Mitchell, 1997; Sauchyn et al., 2010). By adopting an adaptive management approach for watershed management planning, the BRWA acknowledges that the natural and social systems functioning within the watershed is not completely understood. Both the natural and social systems will, in the course of time, present surprises that will test the adaptive management approach. The BRWA and its partners must approach watershed management planning with the expectation that some policies and actions identified during the planning process may well be inappropriate, but that the experiences and lessons learned allow us to collectively improve watershed management approaches over time. These stages of adaptive management for watershed management planning described in *Water for Life: Alberta's Strategy for Sustainability* (Government of Alberta, 2003).

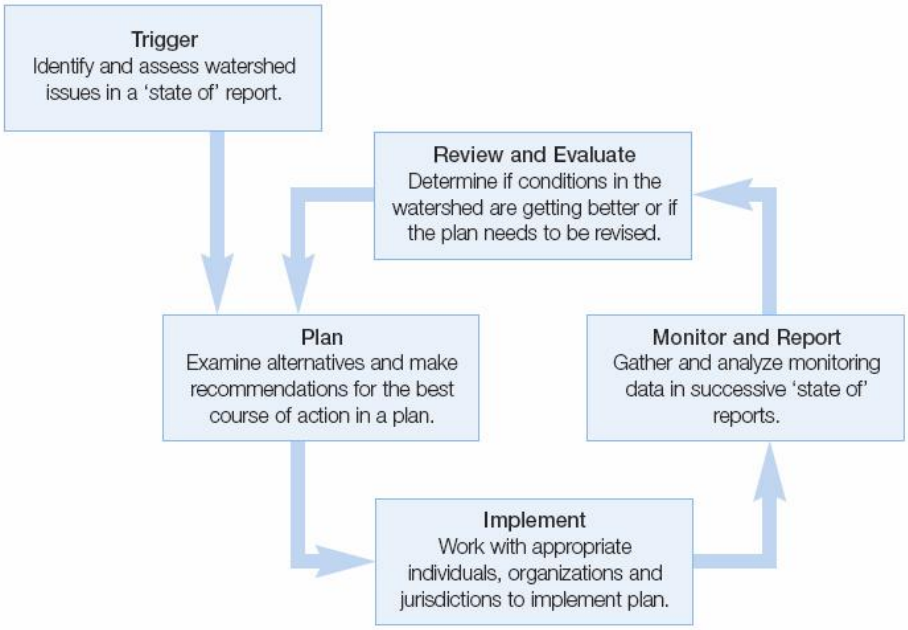

Figure 3. Adaptive management planning cycle for watershed management planning in the Battle River and Sounding Creek watersheds (Government of Alberta, 2003).

Policy background research, policy recommendations, and guidelines will be developed for each watershed management component for each sub-watershed throughout the watershed management plan development (Figure 4). Policies examined should incorporate formal and informal (*ad hoc*) policies, and address economic, social, and environmental impacts of topic. Examples of short term (i.e. during the current crop year) and longer term (longer than the current crop year) adaptations were presented by topic area.

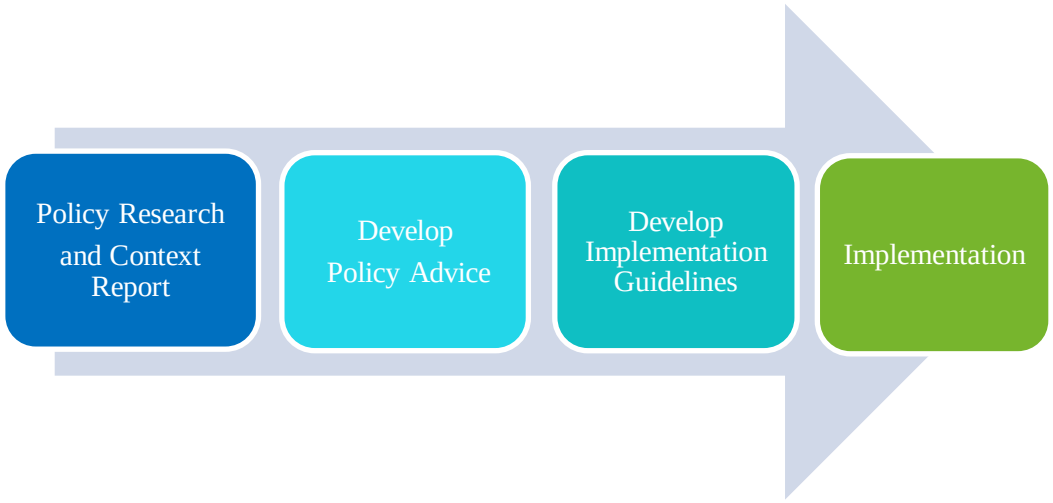

Figure 4. Policy research and development process.

The purpose of this report is to explore the policy context within which the management of drought occurs in the planning areas of the Battle River Watershed Alliance. From this report and in accordance with the watershed management plan, policy recommendations and implementation guidelines will be developed by the Battle River Watershed Alliance.

1.3 Drought and Definitions

Drought is commonly defined "as an extended period of below-normal precipitation resulting in decreased soil and subsoil moisture levels and diminished surface water supplies" (ARD, 2010b, p. 4). In the discussion about drought, sub-characteristics have arisen to address different aspects and implications of drought. The most common four are *meteorological, hydrological, agricultural, and socio-economic* drought. ***Meteorological drought*** is defined by below-average precipitation in a particular place and at a particular time. ***Hydrological drought*** is associated with the effect of low precipitation on water levels in rivers, reservoirs, lakes and aquifers. Hydrological droughts are usually temporally delayed and are noticed some time after meteorological droughts. ***Agricultural drought*** links the characteristics of meteorological or hydrological drought to impact on agricultural activities, such as crop growth or livestock maintenance (Wilhite & Glantz, 1985). This depends only on the

amount of precipitation, but also on the correct use of water. (econnics, 2010). Lastly, ***socio-economic drought*** occurs when the demand for an economic good exceeds supply of water resources as a result of a weather-related shortfall in water supply. Severity and impact are affected by water demand, the extent of water use efficiency measures, and the ability to bring new supplies on-line (econnics, 2010). Though there is no official definition of ***groundwater drought***, Rutulis (as cited in Maathuis & Thorleifson, 2000) describes it as "a natural decline in groundwater level that results in dewatering of an aquifer or part of it, completely or to the point where it would cause water supply problems, i.e. where it is practically dry" (p.29).

Drought is distinct from water scarcity. Drought is a natural and often a cyclical climate phenomenon defined by sustained and extensive below-average water availability. Water scarcity occurs as a result of overexploitation of water resources by a range of consumers, with demand often exceeding availability. Symptoms of water scarcity include reduced river flows, as well as low lake and groundwater levels. The impacts of water scarcity are often exacerbated as the frequency and severity of droughts, driven by climate change, are predicted to increases (European Environment Agency (EEA), 2009).

1.4 Key Concepts

Several key elements that relate to dealing with drought and other results of climate variability are discussed in drought management literature. Though the concepts of adaptation, vulnerability, adaptive capacity, and resilience are applicable to many issues, the specific application of these definitions as they pertain to the issue of drought needs to be understood to understand policy context.

1.4.1 Adaptation

Adaptation refers to any action that reduces negative impacts of drought and/or positions us to take advantage of new opportunities that may be presented. The role of adaptation is to alleviate any current impacts (Füssel & Klein, 2006), to reduce sensitivity and exposure to hazards, and to increase resiliency to stressors. The purpose is not to be

able to eliminate all negative impacts but to lessen the severity. Adaptation can be anticipatory or reactive. Both anticipatory and reactive adaptation can be planned, but reactive adaptation can also be ad hoc (spontaneous, without planning). Planned anticipatory adaptations tend to be more effective and have lower long-term costs (Warren & Egginton, 2008).

1.4.1.1 Adaptive capacity

Adaptive capacity is the "potential, capability or ability of a system to adapt" (IPCC, 2001). This would apply to drought and its effects and impacts. Two key questions must be considered to address adaptive capacity: "Adaptive capacity of what?" and "Adaptive capacity to what?" (Smit et al., 1999).

Canada's highly variable climate has increased the capacity of Canadians to adapt to climate change and other climatic events like drought. All experiences, past and future, can influence adaptive capacity positively and negatively (Smit et al., 2001).

Adaptation and adaptive capacity are linked. Adaptation methods that enhance adaptive capacity are more effective ways of taking action, regardless of uncertainty about climate issues (Smit & Pilifosova, 2003). As adaptive capacity increases, vulnerability decreases (Warren & Egginton, 2008).

Adaptive capacity is determined through several location-specific factors (ie. access to information, social capital, economic wealth, knowledge & skills, access to technologies, infrastructure, and institutions) that depend upon social, economic, and institutional conditions and the region being studied (Figure 5) (Smit et al., 2001, Warren & Egginton, 2008). As adaptive capacity is difficult to measure, proxy indicators, such as per capita income, education level, and population density, can be used (Yohe & Tol, 2002).

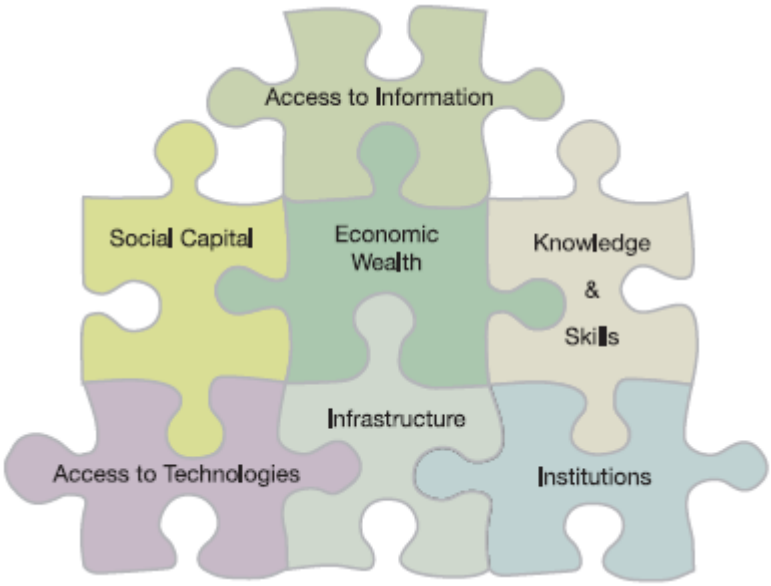

Figure 5. Contributing factors of adaptive capacity (Warren & Egginton, 2008, adapted from Smit et al., 2001).

As adaptive capacity is difficult to measure, proxy indicators, such as per capita income, education level, and population density, can be used (Yohe & Tol, 2002).

1.4.2 Mitigation

Mitigation refers to "anthropogenic interventions" (IPCC, 2001) necessary to reduce the severity and magnitude of drought events, while adaptation is essential to reduce the damages from drought that cannot be avoided (Intergovernmental Panel on Climate Change (IPCC), 2007a; Klein et al., 2007). Mitigation affects the demand for and potential feasibility and success of adaptation (Warren & Egginton, 2008). Both mitigation and adaptation are essential and complementary policy responses to the challenges presented by drought.

Though climate cycles are primarily responsible for drought, overuse, misuse, and allocation of water resources can compound drought (European Commission (EC), 2012; EEA, 2009; Gómez Gómez & Pérez Blanco, 2012; Kampragou, et al., 2011). As such, mitigation *and* adaptation should be included in any drought management policy.

1.4.3 Vulnerability

Vulnerability refers to the degree to which a system is susceptible to, and unable to cope with, extreme events such as drought and its impacts. Vulnerability of a system is determined as a function of the character, magnitude, and rate of progression of event, and how those relate to the system sensitivity and adaptive capacity (IPCC, 2001). Thus, assessing vulnerability must consider the main stressors on a system (climatic and non-climatic), as well as socioeconomic influences on adaptive capacity (Adger & Kelly, 1999; Füssel & Klein, 2006; Warren & Egginton, 2008).

1.4.4 Resilience

Resilience is the "amount of change a system can undergo without changing" (IPCC, 2001, p. 383). Though often used often used synonymously with adaptive capacity, resilience suggests the ability of "systems to remain at their current state and to provide the same function and structure" (Warren & Egginton, 2008, p. 33; see also Walker et al., 2004), but does not align with the goal or purpose of adaptation as change is often necessary for adaptation.

Resilience presents the concepts of coping ranges and thresholds, both important in adaptation. The coping range is the variation that a system can absorb without sustaining significant impacts. Adaptation measures will change the coping range of a system, increasing a system's resilience and decreasing vulnerability. The threshold is the "point at which significant impacts are incurred…or the system undergoes a state of change" (Warren & Egginton, 2008, p. 33). When the threshold is past, the coping range is exceeded, and/or resilience is overpowered. Though determining thresholds is critical to guide adaptation decisions, thresholds are rarely able to be determined beforehand (International Scientific Steering Committee, 2005; Warren & Egginton, 2008). In drought terms, this suggests that to a certain degree, environmental, social, and economic systems can withstand pressure created by an environmental stressor before major impacts affect the system's ability to function. For example, most farmers may be able to make it through a two or three-year drought, though perhaps by a slim margin. However, a prolonged drought could dry up surface water sources (ie. wetlands, streams), leading

to a lower water table. Trouble accessing water for cattle could cause force some farmers into bankruptcy, and as a result, move in with family in a different community. If this were to occur throughout an area, there would be a significant loss of social capital and business in the community.

1.4.5 Risk Management

With increased global vulnerability to drought, greater attention has been directed to reducing risks associated with drought through planning to improve operational capabilities (i.e. precipitation and moisture monitoring, reinforcing institutional capacity) and mitigation and adaptation measures to reducing drought impacts. Mitigating the effects of drought requires the use of all components of the cycle of disaster management (Figure 6) rather than only the crisis management portion of this cycle. When a natural

Figure 6. Cycle of disaster management (Wilhite et al., 2005).

hazard event and resulting disaster occurs, governments and donors typically follow with impact assessment, response, recovery, and reconstruction activities to return the region or locality to a pre-disaster state. Historically, less emphasis has been given to preparedness, mitigation, and prediction or early warning actions (i.e., risk management)

that would reduce severity of future drought impacts and lessen the need for government intervention in the future. This emphasis on crisis management has forced society to move from one disaster to another with little, if any, reduction in risk. In drought-prone regions, drought often reoccurs before the region fully recovers from the last drought (Wilhite et al., 2005).

2.0 Background

The planning area for the watershed management planning process includes the Alberta portions of both the Battle River and Sounding Creek watersheds. In this section, the geographic context for each watershed is provided.

2.1 Battle River Watershed

2.1.1 Location

The planning area for the Battle River Watershed Alliance begins just west of Highway 2 at Battle Lake, and continues east to the Alberta-Saskatchewan border (Figure 7). The planning area boundary is defined as the portion of the Battle River watershed that lies within Alberta. Topography defines the entire watershed, as it shapes the course and speed of water moving through the area. The boundaries of the watershed are known as drainage divides (i.e. the height of land between adjoining watersheds). Within the Battle River watershed there are five sub-watersheds: Bigstone, Iron Creek, Paintearth, Blackfoot, and Ribstone. Sounding Creek watershed to the southeast is also part of the BRWA planning area, and incorporates Alberta's Special Areas (BRWA, 2012a).

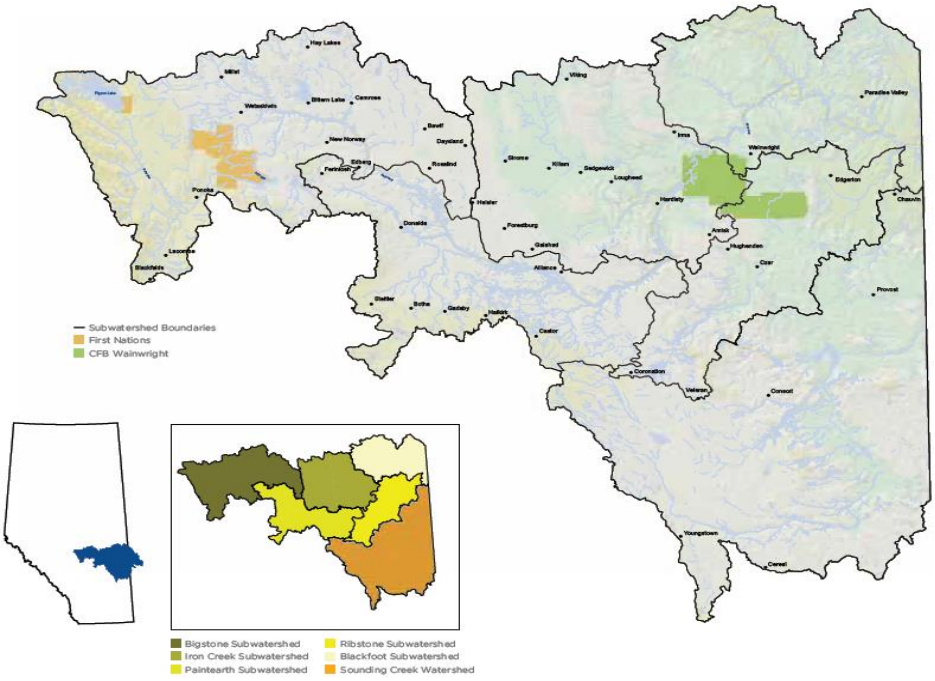

Figure 7. Battle River Watershed and Sounding Creek Watershed.

2.1.2 Natural Landscape

The Alberta portion of the Battle River watershed is located entirely within the province's settled "White Zone", and takes in portions of the Lower Foothills, Central Mixedwood, Dry Mixedwood, Central Parkland and Northern Fescue Natural Sub-Regions (BRWA, 2012a).

The Battle River watershed is a sub-watershed of the greater North Saskatchewan River Basin, draining approximately 40 per cent of the land base of this watershed. However, the Battle River only contributes approximately 3 per cent of the water that flows in the North Saskatchewan River. There are two primary reasons for this: (1) the headwaters of the Battle River originate in the Western Plains at Battle Lake. This means water flowing in the Battle River originates as groundwater and surface water runoff from local snow melt and rains, rather than from mountain and foothills snowpack runoff; (2) The topography of the Battle River Watershed is predominantly flat (the river's average gradient is less than 0.4 m/km) with large tracts of land that are considered non-contributing, either naturally or due to human influence (e.g. ditching and draining practices). Non-contributing means that water falling as snow or rain collects in

small lakes and wetlands, where the water will eventually either infiltrate into the ground or evaporate before it ever reaches the Battle River. All of this results in very low flows in the Battle River, except for a short period of time annually in April and May and periodically in summer months during major rain storm events (BRWA, 2012a).

2.2 Sounding Creek Watershed

2.2.1 Location

The planning area for the Sounding Creek watershed begins just east of Sullivan Lake near Highway 36 and continues east to the Alberta-Saskatchewan border (Figure 1). The planning area boundary is defined as the portion of the Sounding Creek watershed that lies within Alberta (BRWA, 2012a).

2.2.2 Natural Landscape

The Alberta portion of the Sounding Creek watershed is entirely within the province's settled "White Zone", and takes in portions of the Central Parkland, Northern Fescue and Dry Mixed Grass Natural Sub-Regions (BRWA, 2012a).

The Sounding Creek watershed is considered dead drainage. Sounding Creek begins near Hanna, Alberta and flows into Sounding Lake. The outlet from Sounding Lake is Eyehill Creek, which flows into Saskatchewan and culminates in Manito Lake. There is no outlet from Manito Lake. As outflows from Sounding Lake are believed to have only occurred one or two times in the last fifty years, the area upstream of Sounding Lake is generally considered a non-contributing area. Despite being a non-contributing watershed, it is classified by PFRA as a sub-watershed of the greater North Saskatchewan River Basin (BRWA, 2012a).

2.3 Drought, weather, and climate

Since the 1970s, more intense and longer droughts have been increasing experienced. Increased drying linked with higher temperatures and decreased precipitation has contributed to changes in drought. Changes in sea surface temperatures, wind patterns and decreased snowpack and snow cover have also been linked to droughts

(IPCC, 2007b). More extreme events, droughts and heavy rainfall, are increasingly likely to occur, even within the same growing season (Tebali et al, 2006).

Not only will less precipitation occur, but with increasing temperatures a smaller proportion of precipitation may fall as snow and more as rain (Arnell et al., 2001). This will alter the timing of peak streamflows which has implications for agricultural water needs. Aquifers generally are replenished by rainfall, rivers, wetlands, and lakes. A change in the amount of effective rainfall will alter recharge, but so will also change the duration of the recharge season (Arnell et al., 2001). Potential changes in rainfall with also affect the ability of rivers, wetland and lakes to recharge aquifers (Kundzewicz et al., 2007). The susceptibility of aquifers to drought and other changes in climate decreases with depth of the aquifer (Maathuis & Thorleifson, 2000). Groundwater in general responds more slowly to climate change than surface water. Groundwater levels are more closely correlated with precipitation than with temperature, but temperature becomes a factor for shallow aquifers (Kundzewicz et al., 2007).

Apart from the potential of changes in the type and amount of precipitation, agricultural practices face the additional problems related to increased heat. Higher temperatures will lead to significantly greater rates of evaporation causing substantial loss of soil moisture from what precipitation does accumulate (Kulshreshtha, 2011; Sauchyn & Kulshreshtha, 2008).

Hydrological changes cannot yet be forecast reliably at the watershed scale. There is some evidence that the intensity of rainfall events may increase under global warming, as a result of an increase in the water content of the atmosphere, which could potentially cause flooding, or increased soil erosion. For most of Alberta, it is more likely that there will be decreasing annual streamflow, and increasing likelihood of severe droughts, thus increasing irrigation demands (Cohen et al., 2001).

Climate change exaggerates current pressures in water management, adding to the debate on sound management strategies. As well, climate change moves climactic conditions and related extremes out of the historical coping range (Sauchyn, 2012; Sauchyn et al., 2007; Tebali et al, 2006). It also adds a new component relating to

uncertainty in climate change: How can water management efficiently adapt to climate change, given that the magnitude (or possibly even the direction) of change is not known (Arnell et al., 2001)?

Climate change and its effects on drought frequency and duration have the potential to significantly impact many sectors of the Canadian economy. Though agriculture would be greatly impacted, tourism and transportation, among others, would also be adversely impacted. The sensitivity of activities to climate change will likely increase and expand as drought and other severe and extreme weather increase in frequency and intensity (Field et al., 2007).

The Government of Canada is working toward adaptation to climate change through the Climate Change Impacts and Adaptation Program. The goal of the program in to reduce Canada's vulnerability to climate change by supporting cost shared research to address data gaps about our vulnerability, and to provide information for adaptation decision-making (Lemmen & Warren, 2004; Warren et al., 2008). The Climate Change Impacts and Adaptation Program supports the Climate Change Impacts and Adaptation Research Network (C-CIARN). The role of the network is to facilitate connections between stakeholders and researchers, and "promotes new research techniques and methodologies, disseminates information, and provides a voice for an emerging impacts and adaptation research community" (Lemmen & Warren, 2004).

2.3.1 Weather and Climate in the Battle River Watershed

Weather and climate conditions in Alberta are influenced primarily by the general movement of warm air traveling north from the equator. As this warm continental air mass migrates north, it gets deflected eastward by the rotation of the earth, called the Coriolis Effect. The resulting winds, known as Westerly Winds, have a controlling influence over temperature, precipitation, radiation and growing degree days observed in Alberta. Three major climatic regimes have been identified as occurring in Alberta, including: Cordilleran, Boreal and Grassland (Strong & Leggat, 1992). Because of its geographic setting in east central Alberta, the weather and climate of the Battle River Watershed falls under the influence of the Boreal and Grassland climatic regimes.

2.3.1.1 Temperature

Using data from eight stations across the Battle River Watershed the mean annual temperature for the entire Battle River Watershed is 2.35°C. Moving from North to South across the watershed there is an increase in mean annual temperature with Vermillion on the northern edge of the watershed records the coolest mean annual temperature at 1.1°C, while Stettler recorded mean annual temperatures 3.0°C. Similarly, moving from West to East across the watershed there is a slight increase in mean annual temperature with Lacombe at 2.4°C. In the central portion of the watershed Wetaskiwin and Camrose recorded mean annual temperatures of 2.4°C and 2.7°C respectively, while Wainwright records a mean annual temperature of 2.6°C. The spatial temperature variation in the Battle River Watershed for the coldest (January) and warmest (July) months of the year respectively are presented in the following couple figures. The average January temperature varies from -10°C to -21°C (Figure 8). The Battle River Watershed average July temperature varies from 7°C to 18°C (Figure 9).

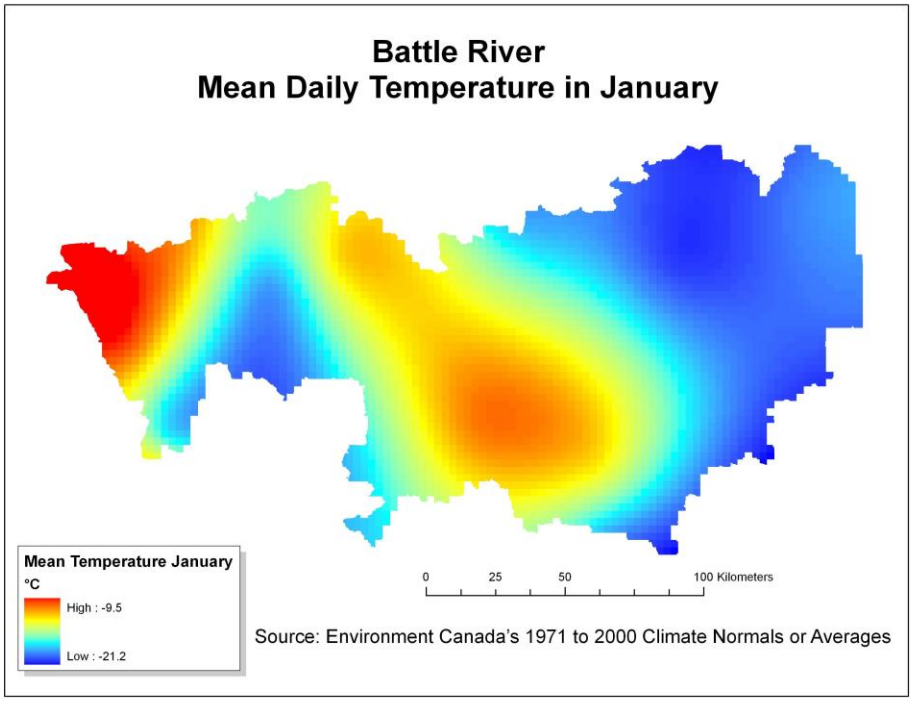

Figure 8. Battle River mean daily temperature in January.

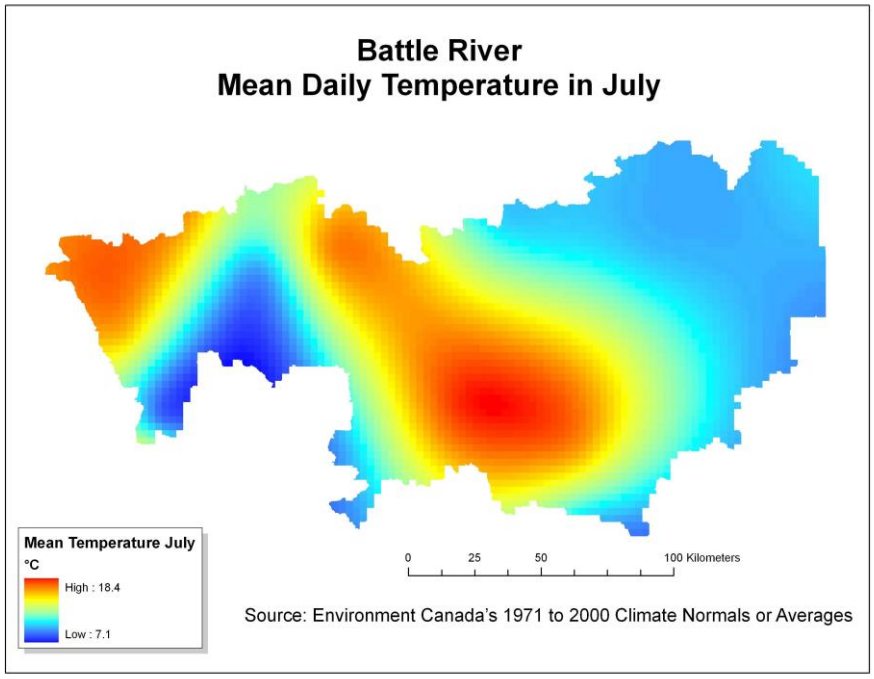

Figure 9. Battle River mean daily temperature in July.

2.3.1.2 Precipitation

There is considerable variability in precipitation spatially and seasonally across the Battle River Watershed. Mean annual precipitation for the entire Battle River Watershed is 440 mm, and decreases 87 mm from 499 mm in the west to 412 mm in east, based on analysis of data from eight stations across the Battle River Watershed. The mean annual, minimum and maximum precipitation for each sub-watershed is summarized in Table 1.

Table 1
Annual Precipitation for Battle River Watershed.

	Annual Precipitation (1970 - 2000)		
Sub-Basin	**Mean**	**Max**	**Min**
	(mm)	*(mm)*	*(mm)*
Bigstone	498.73	570.63	438.25
Blackfoot	412.37	436.49	391.33
Iron	432.06	443.47	415.17
Paintearth	443.12	491.78	408.33
Ribstone	411.41	440.22	389.85
Average	439.54	476.52	408.59

The mean annual precipitation distribution is presented in Figure 10. The greatest precipitation occurs in the western headwaters of the Battle River Watershed and decreases gradually downstream to less than 400 mm per year in the extreme eastern and southern portions of the watershed. The mean annual precipitation runoff depth is the net precipitation that contributes flow to the Battle River over the watershed area. The mean annual precipitation runoff depth varies from west to southeast from 50-75 mm to 2-5 mm.

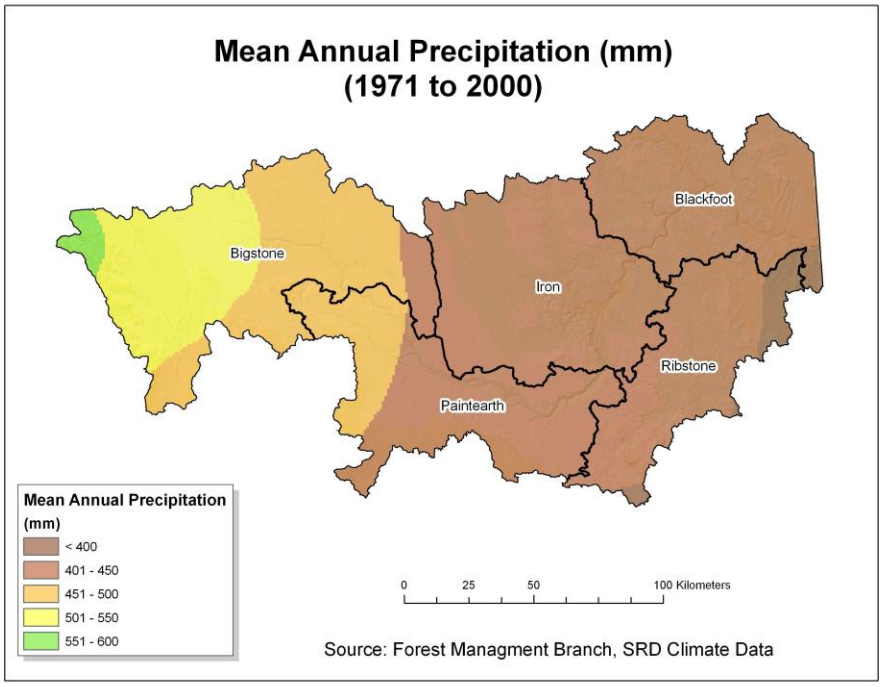

Figure 10. Distribution of mean annual precipitation over the Battle River Watershed.

The monthly average precipitation normals (1971-2001) are charted for two climate stations in Figure 11, representing the eastern and western regions of the watershed. There is considerable seasonal variability in precipitation in the Battle River Watershed, with approximately 70 percent of precipitation occurring in the summer months as rain during the height of the growing season in June, July and August (Figure 11).

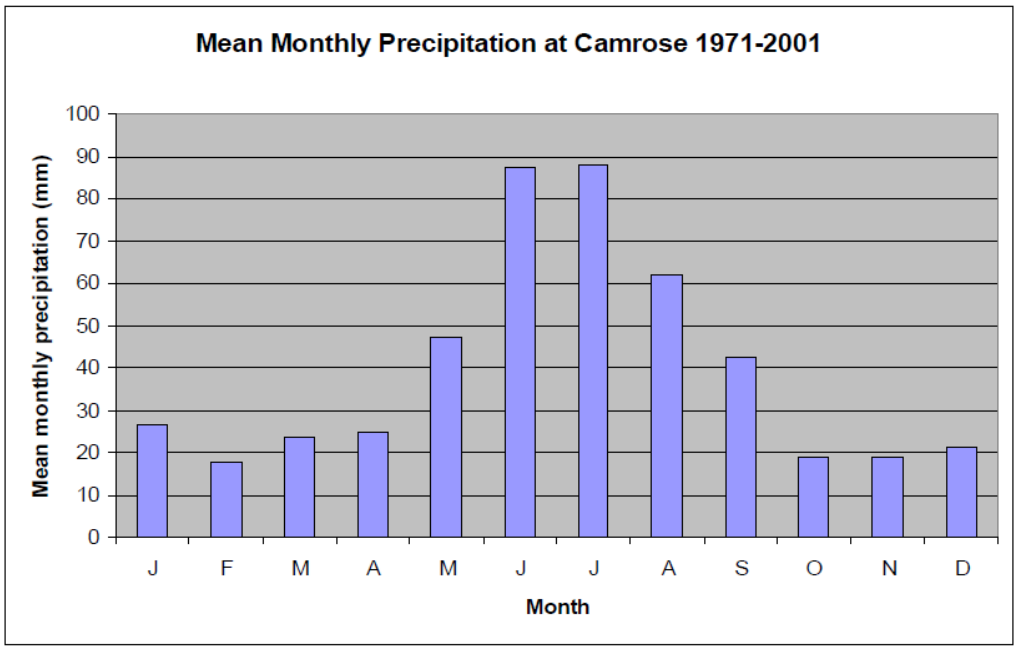

Figure 11. Mean monthly precipitation in Camrose 1971-2001.

2.3.1.3 Frost Free Days/Growing Degree Days:

Frost free days are calculated as the number of days from the last spring frost to the first fall frost. Records show that the average annual frost free period in the Battle River Watershed lasts approximately 135 days, with the last frost occurring in May and the first frost occurring in September.

The growing season for plants is measured by the difference between the mean daily temperature and the plant growth temperature, called Growing Degree Days (GDD). GDD are an indicator of total heat available for plants in the growing season. Although 10°C is the most common base for GDD calculations, the lifecycle of crops commonly found in the Battle River Watershed (wheat, barley, rye, oats, flaxseed, canola, lettuce, and asparagus) require a minimum of 5.5°C for their lifecycles to begin. For the purposes of estimating GDD in the Battle River Watershed, we used temperature values above 5°C. Between 1971 and 2001 Lacombe saw an average 1318.5 GDD, Stettler experienced an average 1430.3 GDD, and Camrose saw an average 1435.5 GDD. The trend in GDD correlates with observed precipitation and temperature patterns follow a southwest to northeast trend.

2.3.1.4 Climate of the Battle River Watershed

Using mean monthly temperature and precipitation data over a period of record spanning 30 years from 1971 -2001, we built a profile of the general climatic conditions of the Battle River Watershed using temperature and precipitation data from several locations across the watershed, called a climate diagram. Climate diagrams summarize a range of information, including seasonal variation in temperature and precipitation, the length and intensity of wet and dry seasons, and the portion of the year during which average minimum temperatures are above 0°C.

In general, the climate of the Battle River Watershed is characterized by warm summers and cool winters (Figure 12). The mean annual temperature for the entire Battle River Watershed is 2.35°C with maximum temperatures occurring in June. Mean annual precipitation for the entire Battle River Watershed is 440 mm, peaking in June and July with rain. Maximum snow accumulations occur in January.

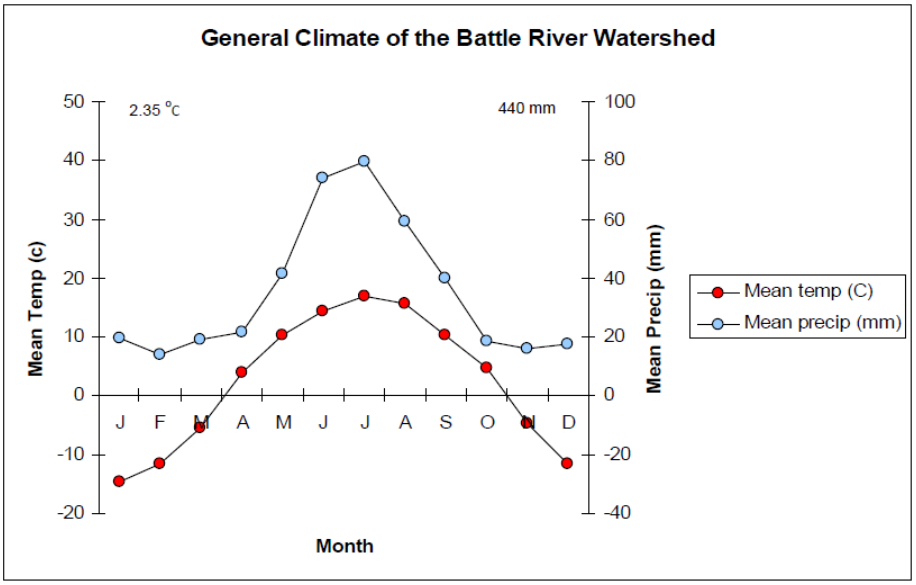

Figure 12. General climate of the Battle River Watershed.

Variations in climate from one location within the watershed to another have an influence on the vegetation types and distribution within the watershed. Travelling northwest to southeast, vegetation changes along a gradient beginning with the Boreal Forest region, then transitioning into Parkland, and eventually moving to Grassland regions.

Micro-climatic conditions often persist in river valleys and upland areas adjacent to larger water bodies like Pigeon Lake, Battle Lake and Red Deer Lake. Although climate data is not available to assess these sites, they tend to have cooler temperatures and greater available moisture then surrounding upland areas.

2.3.2 Climate Variability in the Battle River Watershed

2.3.2.1 Temperature:

Trends and variability were examined for annual minimum and maximum temperatures with emphasis on the extremes (Figure 13). For extreme maximum temperatures, the lowest observed temperature was 27°C while the highest maximum temperature was 36.7°C. No consistent trend is found for extreme maximum temperatures, suggesting there is little change in the frequency of extreme hot days. Extreme minimum temperatures were also examined for trends and variability. Extreme minimum temperatures of -47.8°C in 1947 and -47.2°C in 1950 were observed. Trend analysis yielded a moderate decrease in extreme minimum temperature over the period of record, suggesting there are fewer days with extreme low temperature during winter.

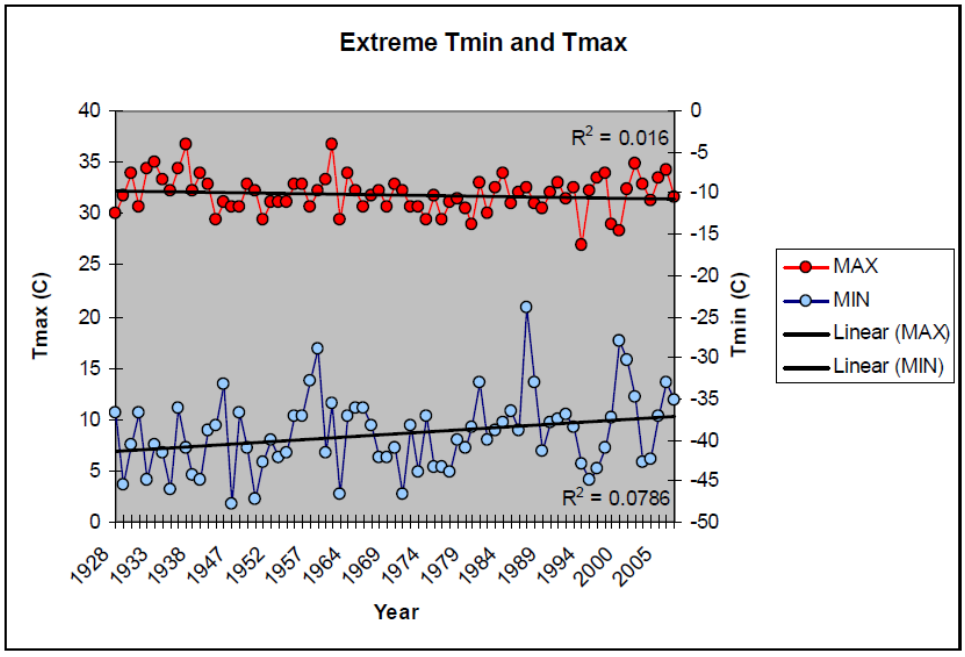

Figure 13. Extreme temperature maximum and minimum for the Battle River Watershed at Camrose.

2.3.2.2 Precipitation:

The headwaters of the Battle River originate in the Western Plains at Battle Lake, which limits flows in the river system to surface water runoff from local snow melt and rain events, as well as ground water contributions to base flow. Because the Battle River Watershed does not benefit from large annual mountain snowpack melts and glacier runoff, trends in precipitation measured as snow or rain becomes particularly important for water management.

There is considerable variability annually in overall precipitation (rain and snow) at locations across the watershed. For example, at Camrose peak precipitation occurred in 1973 and has shown a decreasing trend in annual precipitation (Figure 14).

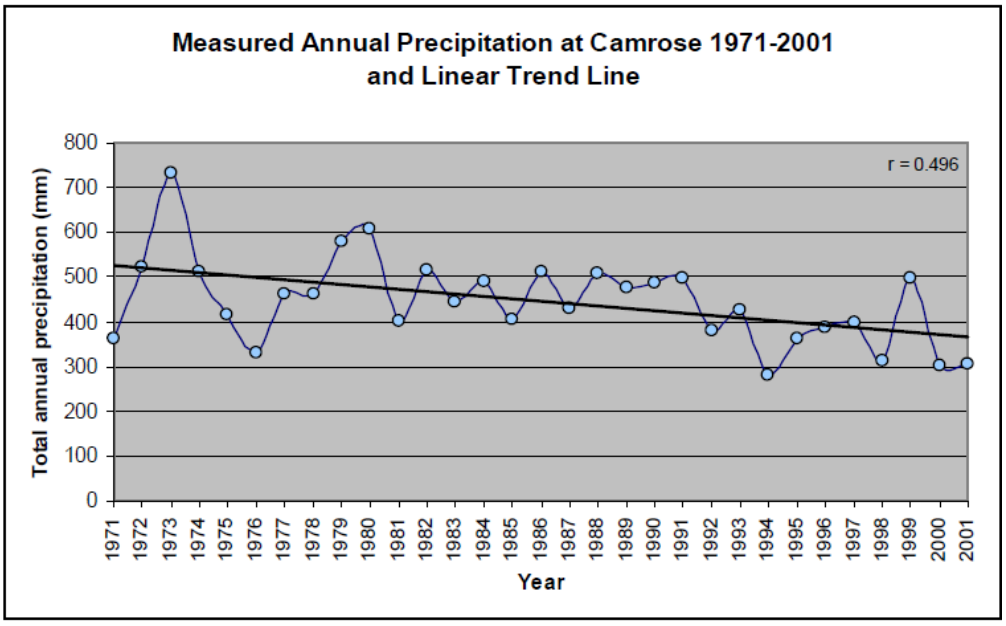

Figure 14. Measured annual precipitation at Camrose 1971 – 2001 and linear trend line.

Precipitation data is divided into rain and snow data to better track changes in precipitation seasonally over time (Figure 15 and 16, respectively). For both rain and snow, there is a decline in precipitation over time.

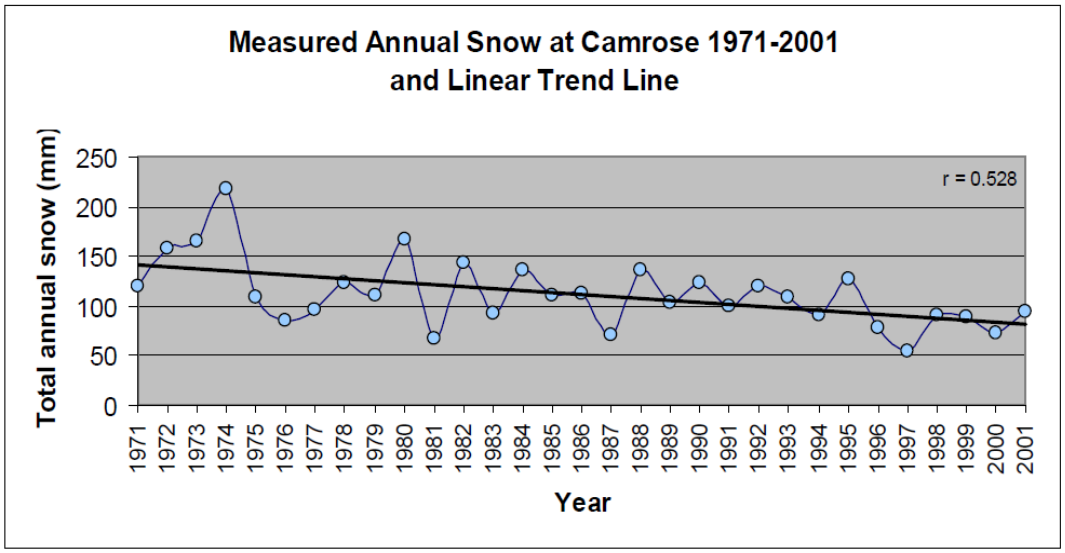

Figure 15. Measured annual snow at Camrose 1971 – 2001 and linear trend line.

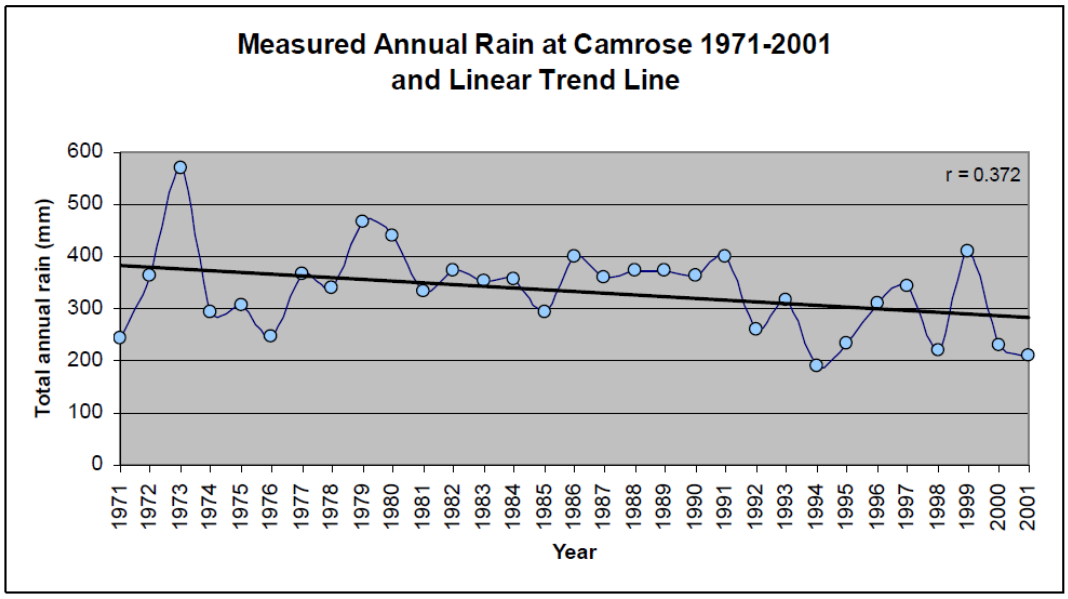

Figure 16. Measured annual rain at Camrose 1971 – 2001 and linear trend line.

2.3.2.3 Drought

Drought is a complex climatic event and its impact within the Battle River Watershed is of great importance. Because weather records for the Battle River Watershed are less than 100 years in length a longer perspective can be gained by examining soil moisture levels, tree ring patterns, and lake salinity levels across a broader area (Sauchyn et al., 2008). These data sets cover the larger Great Plains region of North

America, and show that an average drought on the prairies lasts approximately 12 years, although droughts lasting upwards of 40 years in duration are not uncommon (Figure 17) (Sauchyn et al., 2008). When these data are matched to weather records collected over the past 100 years, they indicate that the climate of the twentieth century was relatively favourable for settlement within the Great Plains (Zhang et al., 2000).

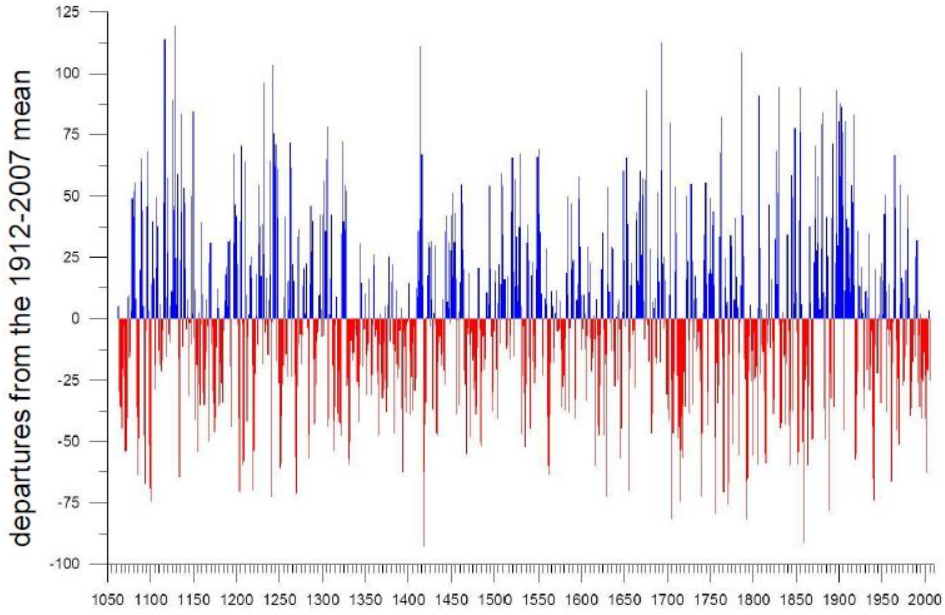

Figure 17. Full tree-ring reconstruction of mean annual flow (m3/s) of the North Saskatchewan River for the time period year 1063-2006. Proxy streamflow data are plotted as departures from the mean of the instrumental record (Sauchyn, 2012).

The Battle River Watershed, over the past century, has not experienced sustained droughts observed in preceding centuries. However, short duration droughts have occurred since the 1940s and may be better linked to multi-decadal climate variability than to climate change, which is expected to cause increased aridity and more frequent drought (Kharin & Zwiers, 2000; Wetherald & Manabe, 1999). For example, in 2009 climate data for the Battle River watershed at Camrose showed a water deficit period that began in late April and lasted until November.

2.3.3 Climate Adaptation in the Battle River Watershed

Global Climate Change Models (GCMs) are three-dimensional mathematical models that represent the physical processes of the atmosphere; ocean, cryosphere and

land surface that factor in feedback. GCMs play an important role in assessing vulnerability, impacts and adaptation studies over large geographic areas like the Great Plains. A key challenge is to translate climate changes at the global scale to climate changes at the local scale using GCMs. Although advances in computing technology have enabled large increases in the spatial and temporal resolution of GCMs, model results are still not sufficiently accurate at regional scales to be used directly in impact studies (Barrow et al., 2004). However, we can speculate on potential changes to climate in the future based on an assessment of existing GCMs. We compared five GCMs reviewed by Barrow & Yu (2005) with findings from Sauchyn et al. (2008). What follows provides a general picture of what the climate of the Battle River Watershed may look like in the future.

2.3.3.1 Temperature

There is an increasing body of observations that give a collective picture of a warming world. Specifically, Barrow & Yu (2005) found that annual mean temperature is projected to increase between 3°C and 5°C by 2050. During the period of instrumental record, there was an average increase in temperature of 1.6°C for 12 stations on the Prairies, most with data since 1895 (Sauchyn et al., 2008). The greatest upward trend during the period of record has occurred since the 1970s. Seasonally, spring shows the greatest warming, a trend that extends from Manitoba to northern British Columbia. It is concluded from this that shorter winters and longer drier summers will likely occur in the Battle River Watershed in the future.

2.3.3.2 Precipitation

As part of their GCM review, Barrow &Yu (2005) found annual precipitation changes from present day to be in the range of -10% to +15% by 2050, however by 2080, annual precipitation is projected to increase up to 15%. Precipitation data analyzed by Sauchyn et al. (2008) indicates an overall declining trend in precipitation during the months of November to February, with 30% of the monthly data from 37 stations showing a significant decrease during the period 1949-1989. These observations suggest

that shorter winters, wetter springs, and longer drier summers will likely be observed in the Battle River Watershed in the future.

2.3.3.3 Growing Degree Days

One outcome of general warming and of higher spring temperatures is a warmer and longer growing season. Growing Degree-days greater than 5°C are projected to increase by 30 to 50% by 2050. These increases are driven by a large increase in degree-day totals, rather than by large decreases in precipitation (Barrow & Yu, 2005). By 2050, much of Alberta is projected to experience degree-day totals similar to present degree day totals at Lethbridge (1772) and Medicine Hat (1962) (Barrow & Yu, 2005).

3.0 Methodology

3.1 Policy community approach

The Battle River Watershed Alliance policy committee strives to build a broad understanding of the 'policy context' in which our work occurs and work to anticipate potential issues in order to "provide policy advice in a place-based context and recommendations that minimize social, economic, and ecological trade-offs regarding watershed related issues" (BRWA, 2012b), utilizing the policy community approach (Atkinson & Coleman, 1992; Coleman & Skogstad, 1990; Skogstad, 2005) which allows the BRWA to systematically assess decisions made before, during and after the period where such 'policies' take shape.

The policy community approach is built on the premise that policy is created in decentralized and coordinated interactions between governing bodies and other societal actors. *Actors* are all the stakeholders and other people who are impacted by the policy issue. This approach examines the interplay of interests and pressures to and from governments and every layer of negotiation involved in policy making (Figure 18).

The *policy community* is made up of actors that form surrounding an issue area and/or common interest while working together to shape and influence the development

of policy. These include: corporate, government, public, and potentially (to a lesser extent) the scientific community and media (Skogstad, 2005).

A *policy network* is created when people are pulled in at certain times to influence specific decisions. It looks at the number and type of interactions between actors within the community. They often involve more numerous clusters of actors than in a policy community, each of which has an interest in the policy topic and the capacity to help determine policy (Skogstad, 2005).

The *policy map* tries to define the relationship between and among the actors or players in the policy community. Therefore it can be used to analyze the political environment that surrounds and affects the formation of policy.

To make policy work, each actor and party must participate, providing the information and knowledge they have surround the issue. Above all, cooperation is critical for policy to be effective (Skogstad, 2005)

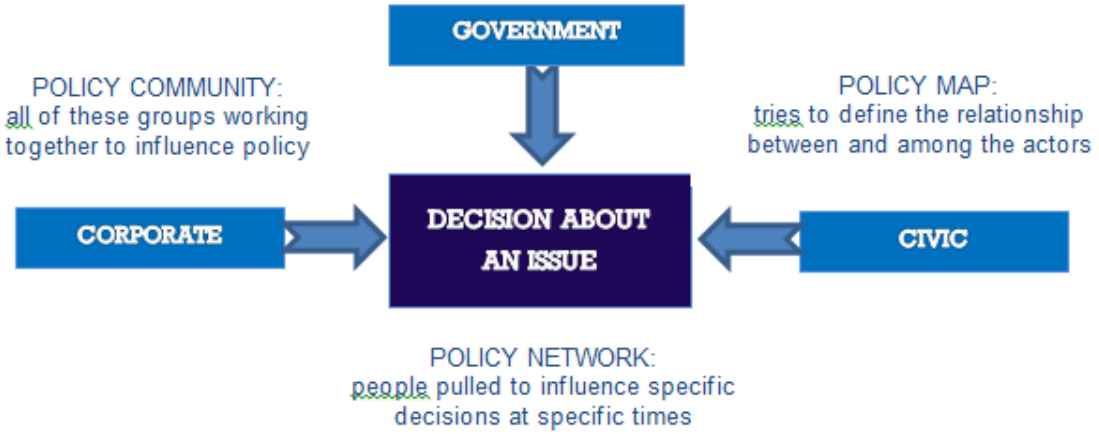

Figure 18. Policy community approach.

3.2 Policy Research

An eleven-step process to policy research was used. The steps in this research method included literature reviews, searches of media (e.g. newspapers and newsletters), research framework development and application, and the use of criteria to improve understanding of adaptation effectiveness. The steps of the process involve:

1. Media Scan – Identifying actors and themes surrounding an issue with local/regional focus, expanding to encompass provincial, national, and international media coverage of issue.
2. Actor files – Policies and other supporting documents of actors identified in media scan
3. Government documents – Four levels of government policies, guidelines, publications
4. Corporations – Corporate policies or documents
5. Legal documents – Government acts and legislation
6. International agencies – Any international agency or organization that is involved with the policy issue on an international scale.
7. Public – Includes any non-governmental organizations and similar entities working on or have spoken out about the policy issue.
8. Sandboxes – Conferences, etc.
9. Taking stock – Look for gaps in data
10. Literature – Peer-reviewed and other literature
11. Interviews – Used to supplement and cover gaps in data

3.3 Media Scan

There were two main methodologies used to develop a policy research database: 1) searches of various media sources 2) literature searches of formal and primary documents. The media searches were comprised of print media such as (e.g. Newspapers, newsletters, websites and magazines). This portion of the media scanning is similar to other media surveys conducted in the past by Strangberg (2005). Similarly media articles were organized by the themes, key words, and by geographical and timing identifiers.

The newspapers that were used ranged from local to provincial types which included some of the prominent local agricultural papers such as the County Market as well as papers like the Hanna Herald. Provincial and national news websites were also searched. Websites from organizations regarding drought were utilized, including:

Alberta Beef Producers, Agriculture and Agri-Food Canada (AAFC), as well as provincial and federal agricultural and environmental departments.

Media scanning was focused on the drought years ranging from 1998-2012, but focused mainly around the years 2002, 2003 and 2009 to take a deeper look into conditions leading up to and following drought events during those years as experienced in the Battle River and Sounding Creek watersheds. The geographical extent of the scan included the entire area of the Battle River Watershed as well as areas surrounding the watershed. A database was then developed and its more detailed steps are discussed below.

Steps in Media Scan:

- Newspapers that would be scanned were selected. A search method for articles relevant to the drought within each newspapers archives was conducted developed, beginning with selected key words;
- Electronic searching was the primary means to find articles;
- Articles were read, ensuring their relevancy. Title, article summary, date article was accessed, key words and actors were recorded in a database in Microsoft Excel/Access by the date the article was released; and
- A theme was also chosen for each article based on the content of the article

The themes that were chosen to start the search were: Drought and Agriculture, Drought and Agricultural Assistance, Drought and Municipalities, Drought and Environmental Stewardship, Drought and water quality, and Drought and Government, though many more emerged. These themes were chosen by reading through the articles and then deciding what type of theme the article would fit under best. Many articles dealt primarily with drought and agriculture but there were ones that fit under drought and agricultural assistance because aid was being given to suffering farmers. There were also articles that dealt with the municipalities and their issues with drought and water therefore that type would be classified under Drought and Municipalities. After searching through several different newspapers there was soon a point of saturation; the time when most articles found fit under themes that have already been made from past articles. The time of saturation was reached after finding articles from about two

newspapers. After searching through two newspapers there were no longer new themes appearing besides one or two exceptional ones such as Drought and Environmental Stewardship. Although a point of saturation was reached the rest of the newspapers chosen were searched through.

Different themes emerged over time as drought conditions worsened and as the drought came to an end. The same was true for key words that appeared in articles. Throughout the different stages of drought, different key words appeared more often, such as grasshopper near the end or the following year, whereas soil and moisture, and water were more at the beginning of drought events.

Actors and key words were identified along with themes that were identified for each article. Actors were chosen based on who the key players were in the article. For example, the Government of Canada may have provided funding to aid farmers. In this case the actor would be the Government of Canada. In other articles there may have been an Alberta Beef spokesperson commenting on the state of agriculture through the dry periods, in which case Alberta Beef would be the actor. There are also articles where there is no key actor but it may be a producer commenting on the state of the agricultural situation, in this case the producer would be the actor. Once the actors for each article are identified, searching for primary documents from each actor began. Each of these were filed and were be used in following steps in the policy research process.

For each article, key words were chosen that were relevant to drought. Key words were identified in each article based on which words were used the most often and specifically related to drought. Some articles only had one key word that appeared often and some articles had 4 or 5 words that emerged. All the key words that showed up most often would be underlined. Each time a key word occurred, it was underlined. The tally for each key word was recorded on the hard copy of the article, and recorded in the data base in Microsoft Access. Key words can then provide a filter for conducting further analysis during the development of policy advice.

3.3.1 Results and analysis from media scan

In the media scan, a total of 143 articles were found, with 24 themes identified (Table 2). In total, 24 media sources were used. 15 of these were regional newspapers and newsletters from regional organizations. The remainder consisted of national news agencies, international newspapers, and current events magazines.

Table 2
Number of articles with associated themes found in media scan

Theme	Number of articles
Agricultural Assistance	26
Agriculture	63
Agriculture Pests	6
Climate Change	1
Desertification	1
Drought Management	6
Economy	4
Ecosystems	2
Energy	1
Environmental Management	1
Environmental Stewardship	1
Government	3
Infrastructure	1
Landscaping	1
Livestock	13
Mental Health	1
Mitigation & Adaptation	1
Municipalities	10
Precipitation	16
Special Areas	3
Water Management	6
Water Quality	1
Water Restriction	1
Water Scarcity	1

Through the media scan, 53 actors were identified, though over half were mentioned in one article, while others were mentioned between 2 and 29 times (Table 3). All actors mentioned in media scan were included in actor files.

Where date on articles was given, articles were primarily published during and after problem periods (end of June – November). The exception would be concern about

the lack of snowfall that may contribute to drought, which was mentioned during the winter in early 2012.

From the media scan, actor files were set up to organize all the information gathered regarding the actor. Information was gathered from online sources, email correspondence, as well as personal contact.

Table 3
Actors mentioned in two or more articles

Actor	Number of articles
Agricultural Financial Services Corporation	8
Agriculture and Agri-Food Canada	6
Alberta Agriculture and Rural Development	29
Alberta Agriculture Information Centre	2
Alberta Beef Producers	5
Alberta Environment (now Alberta Environment and Sustainable Resource Development	4
Camrose County	8
Canadian Foodgrains Bank	3
Cattle Producer	4
City of Camrose	3
County of Wetaskiwin	5
Ducks Unlimited Canada DUC	2
Environment Canada	3
Government of Alberta	5
Government of Canada	5
Lacombe County	10
Leduc County	5
Local Business	3
Producers	16
Public	2

Following the eleven step research process, policy information was gathered and compiled. Though some actors do not have drought management policies (*ad hoc* or formal), many have identified drought as a significant reoccurring issue for life in rural Alberta and expressed the need for such measures to be in place. One of the most

prominent issues for the Battle River and Sounding Creek Watersheds are the impacts of drought on the agricultural sector and agricultural communities.

4.0 Drought and the Agricultural Community

Drought has and will continue to impact the agricultural communities because of the direct impact of drought on the landscape and the ability of plants and animals to survive. Though there are many official policies and programs developed by the various levels of government, the ancestors of the current programs were only developed in the 1940s (Swanson et al, 2009). Until then, people involved in agriculture had to rely on their own resources and the community to get through drought.

Adaptation to drought and its effects on agriculture can be characterized in a couple of ways. First, they can be seen as short-term and long-term adaptation measures. For example, Swanson et al. (2009) describes some of the adaptation measures and policy programs utilized by farmers in the areas around Coaldale and Foremost in southern Alberta during times of drought and extreme heat stress. Though many of the techniques used by the communities were similar, and applied equally well to drought as to extreme heat stress, variations did occur. Some of the short-term measures include: crop insurance (common in both regions), diverting water to high-value crops, increase irrigation (where possible), avoid fields to minimize damage and inputs needed, reduce movement on fields to minimize disturbance that could increase evaporation, efforts to reduce input costs, and become more financially sound, and waiting out the heat (Swanson et al., 2009). In the 2001-2002 drought, livestock operators transported hay, utilized feed types not normally used, and used available public and private lands and cropland that was not normally used (Wheaton et al., 2008).

Long-term measures targeted agricultural operations and techniques including: minimal and reduced tillage techniques, crop diversification, crop rotation, employ organic farming techniques, alteration of seeding and harvesting times to take advantage of early season moisture, selection of crops better suited to drought conditions, and use of government programs to help them cope with heat stress. Producers in the Coaldale area

were able to increase and shift their irrigation operations. However, those in the Foremost area participated in market research groups, employed the use of new technology to reduce disturbance of soil and moisture loss, shelterbelts, leaving trash on fields to retain snow increases soil moisture content, community water pipelines, and built a local knowledge network between famers to disseminate local knowledge. Drought situations also led to the development of SE Alberta Water Co-op (Swanson et al, 2009). Secondly, adaptation measures can be individual or collectively oriented. In the above examples, Coaldale area producers used a lot of adaptation measures that were individual in nature, while long-term measures used in the Foremost area were largely collectively oriented (Swanson et al, 2009).

Under the federal Greencover Canada (Agriculture and Agri-Food Canada (AAFC), 2007), Watershed Evaluation of Beneficial Management Practices (WEBs) program investigated and measured the economic and water quality impacts of several agricultural beneficial management practices (BMPs) in selected watersheds across Canada(AAFC, 2011g). Though it does not deal specifically with drought or water shortage issues, many of the BMPs studied dealt with agricultural land use practices that affect water retention and efficient water use such as: small reservoirs, irrigation efficiency, tillage and crop residue, wetland restoration, and runoff retention ponds (AAFC, 2011h).

As drought or periods of water shortage are common across many areas of the Canadian prairies, ensuring the security of water sources for agricultural and livestock production is paramount for rural areas. Preventing seepage or evaporation loss from dugouts by lining or covering the dugout may be needed. Group or community projects that can supply off-farm options are also a good back-up for times of water shortage. Projects such as community tank loading facilities, and canal or drainage systems are good ways for farmers to work together with municipalities (Agriculture and Rural Development (ARD), 2008).

5.0 Drought and Community Assistance

Drought has a tremendous impact on rural communities supported by agriculture. In the last section, drought adaptation practices implemented by the agricultural sector were discussed. Though the economic impacts on rural communities are more apparent and more heavily publicized, there are many impacts, direct and indirect, on rural citizens. Negative impacts to mental and physical health, as well as to social, cultural, and community dynamics within rural areas are overall more enduring and detrimental, but often less documented. In this section, impacts of drought on these elements are explores, as well as practices and organizations that address these issues in order to support community well-being.

5.1 Mental Health

5.1.1 Canada

Agriculture is one of the most stressful occupations in the Prairie Region of Canada (Roberston as referenced by Smoyer-Tomic et al., 2004) and drought conditions only exacerbate the stress (Smoyer-Tomic et al., 2004). Financial concerns are strongly associated with stress among farmers, especially family farmers that do not have the resources to buffer against agricultural losses (Smoyer-Tomic et al., 2004). Though financial concerns are perhaps the largest contributing factor to stress, other sources of pressure include uncontrollable natural forces (drought, flood, etc.), finance, farming bureaucracy, policy, market forces and time pressure (Smoyer-Tomic et al., 2004). With increasing frequency of drought, mental health issues including stress, depression, and anxiety, will become more of a concern in rural and agricultural communities (Bélanger et al., 2011; Kulshreshtha, 2011; Smoyer-Tomic et al., 2004). Furthermore, these issues can cause physical health concerns as well (Smoyer-Tomic et al., 2004). Suicide is highly correlated to depression caused by agricultural financial stress (Malmberg et al. as cited in Smoyer-Tomic et al., 2004) but has not been studied in relation to drought. However, suicide may increase during drought conditions or other extreme climate

conditions when farmers face a prolonged decrease in yields, greater financial pressures, and stress (Smoyer-Tomic et al., 2004).

In Canada, few mental health programs and initiatives have focused on rural communities and issues surrounding drought. Agriculture and Agri-Food Canada (AAFC) addresses the issue of farm stress, and their website provides national and provincial links to stress relief and help resources (AAFC, 2011b). The Canadian Mental Health Association (and its Alberta East Central Region division), is a charitable organization that aims to promote the mental health of all Canadians, and supports the resilience and the recovery of people experiencing mental illness. Such issues include stress and suicidal thoughts brought on by financial pressures.

5.1.2 Alberta

The Alberta Government recognizes the stress drought can cause for agricultural and rural citizens. Information pertaining to the identification of stress symptoms and advice for handling stress and preventing suicide is available through the Alberta Agriculture and Rural Development (ARD) website. ARD also provides information on Alberta Health Mental Health Services Mental Health Help Line and HEALTHLink Alberta, which provide assistance over the phone 24 hours a day. Alberta Community Mental Health Clinics provide voluntary clinical community-based mental health services in person and over the phone (ARD, 2004a, 2004b).

The Alberta Mental Health Board (AMHB), in 2002, disseminated several brochures still available on the Alberta Agriculture and Rural Development website. These include brochures on recognizing and managing stress (Alberta Mental Health Board (AMHB), 2002a), recognizing warning signs of suicide and how to seek help (AMHB, 2002b), and how to cope with crisis and increase resilience to adversity (AMHB, 2002c).

5.2 Public Health

Globally, drought and other extreme weather events associated with climate change are predicted to cause short-term and long-term problems related to human health.

The effects of drought on health include deaths, malnutrition, infectious and vector-borne diseases, and respiratory diseases (Menne & Bertollini, as cited in Confalonieri et al., 2007). Confalonieri et al. (2007) suggested several possible ways by which climate change and associated drought could impact human health: temperature-related illnesses and mortality, air pollution, effects of extreme weather events (and drought), and water and food borne disease.

An increase in the occurrence and duration of extreme high temperatures that accompanies climate change-induced drought can directly affect human health. Anticipated climate change-related increases in duration, intensity, and frequency of heat waves during droughts is expected to have an impact on mortality, and other heat-related symptoms such as heat cramps, fainting, heat exhaustion, heat stroke, and dehydration (Henry, 2002).

Specifically, Prairie regions in Canada will likely experience several other negative health consequences of climate change such as food-borne diseases, exacerbation of acute and chronic physical health conditions, and even mortality due to heatstroke (Kulshreshtha, 2011). Albertans may have a lower risk of suffering from heat-related symptoms and mortality because the dry, hot air masses characteristic of the province are not as significantly related to adverse health outcomes (Kalkstein & Smoyer, 1993). However, those in areas with historically cooler climates such as central and northern Alberta may still be particularly vulnerable to heat waves due to lower heat tolerances (Davidson, 2010).

To prepare for potential impacts of climate change on the health of Canadians, Health Canada (2011) has prepared a document, *Human Health in a Changing Climate*. Various areas of life and health of Canadians across the country could be impacted are discussed, both direct and indirect concerns. Though no specific plans or policies are set in place, adaptation for provinces and certain types of hazards have been examined.

The responsibility for ensuring the delivery of public health, health care and emergency social services will have to be shared between federal, provincial, and municipal governing bodies. Municipal governments will need to play a central role the

reduction of climate-related health risks, primarily because of their roles in providing emergency services, as well as their role in public health, social services, and community emergency preparedness planning. To do this, funding, and information and technical support, must be provided by provincial and federal governments (Health Canada, 2011).

Despite the concern surrounding how climate-induced drought will affect physical and mental health, no federal, provincial, or municipal policies were identified through this study.

5.3 Social Support

Rural communities are more vulnerable to economic and environmental stress and are more sensitive to these stressors than larger urban centers (Wittrock, Kulshreshtha, & Wheaton, 2010). The effects of drought on rural community life can be far-reaching and long-lasting. Though rural communities have been noted for their resiliency in times of such challenges (Alberta Mental Health Board, 2002; Alson & Kent, 2004), this resiliency will be tested by increasing frequency and duration of droughts. The negative impact of drought on social capital can be significant, and reduces a community's resiliency.

5.4 Economics

Drought disasters in the prairies have been some of the most costly to the economy in the last century (Sauchyn, 2012). There are many financial assistance programs for producers available through the federal and provincial governments, and are discussed later in this report. However, impact to local business can be severe.

Drought-related water scarcity that causes an unexpected and prolonged decline in water supply can significantly jeopardize business operations, or raise the cost of operations (United Nations Environment Programme Finance Initiative (UNEP FI) & Stockholm International Water Institute (SIWI), 2005). Concerns of drought in areas that rely on industries dependant on water, like agriculture, reinforces the need for drought cycle planning and preventive measures (UNEP FI & SIWI, 2005). Rural tourism, especially near recreational lakes and rivers, is subject to drought as well. Water is

essential to long-term business success. Equally important for businesses is the role that water plays in economic development, health, employment and markets in the communities and regions where they operate (World Business Council for Sustainable Development (WBCSD), 2004).

The Battle River Alliance for Economic Development (BRAED) and JEDI (Joint Economic Development Initiative) acknowledge that water resources are important marketing components, and will become a significant economic issue in the near future (Alberta Centre for Sustainable Rural Communities, 2011). However, they have no strategic plans in the event of a severe or prolonged drought or water shortage (R. Horncastle, personal communication February 24, 2012, H.L. James, personal communication February 27, 2012).

6.0 Drought on the International Stage

Many African countries such as Kenya and Somalia, India and other parts of South and Southeast Asia, the Middle East, China, Australia, the United States, and much of Europe face challenges associated with drought. The United Nations (UN) through several of its many organizations addresses the impacts, preparation, and response to drought. Some of these initiatives are investigated. Also in this section, the regulations, policies, and support programs put in place by the European Union, Australia, and by the United States will be highlighted.

6.1 United Nations

The United Nations Convention to Combat Desertification, established in 1994, is the only potentially legally binding international agreement that links environment and development to sustainable land management (United Nations Convention to Combat Desertification (UNCCD), 2012). Specifically, it addresses the arid, semi-arid and dry sub-humid areas of the world, known as the drylands, where some of the most vulnerable ecosystems and peoples are found. In the ten-year Strategy of the UNCCD (2008-2018), adopted in 2007, Parties to the Convention further specified the aim for the future to be

"to forge a global partnership to reverse and prevent desertification/land degradation and to mitigate the effects of drought in affected areas in order to support poverty reduction and environmental sustainability" (UNCCD, 2012, para.1). The 10-year strategic plan of the UNCCD works to enhance community resilience to drought and other water scarcity risks through mitigation measures, early warning systems, and knowledge sharing. The UNCCD complements these actions by:

- Providing advice, information and capacity building to support co-ordination initiatives on water scarcity and drought and associated initiatives relating to the right to food, migration, drought and adaptation to climate change;
- Synthesizing a framework of policies and research, including indicators, management models, research models and participation models to facilitate interactions between governments with different legal frameworks on water use; and
- Drawing on access to multilateral resources to promote, support and monitor National Action Programs against increasing water scarcity (Jimenez, 2009, p.2).

The United Nations International Strategy for Disaster Reduction (UNISDR), formed in 1999, coordinates disaster reduction and ensures cohesiveness throughout the related activities (United Nations International Strategy for Disaster Reduction (UNISDR), 2011). As result, the ISDR works in close collaboration with other pertinent UN agencies, like the UNCCD and the UN Framework Convention on Climate Change (UNFCCC), as well as international, regional and national institutions, in efforts to reduce the impacts of climate related disasters, such as those associated with drought (UNISDR, 2003).

The ISDR outlines five essential elements of an effective drought policy:

1) Policy and governance based on local needs, community participation and political commitment;
2) Drought risk identification, risk monitoring and early warning to promote resilience combined with enhancing knowledge to understand specific trends, vulnerability and impacts of drought for specific drought prone areas;

3) Drought awareness, knowledge management and education is essential for developing useful messages and helping to ensure the use of the information;
4) Reducing underlying factors of drought risk by effective environmental and natural resource management, social and economic development practices, and land-use planning; and
5) Enhancing mitigation measures and preparedness for drought, as substantial reduction of drought impacts and losses can be achieved if authorities, individuals, and communities are well-prepared, ready to act, and equipped with the knowledge and capacities for effective drought management (UNISDR, 2009).

The UNISDR works with governments of countries to create drought policies that work with the climate and challenges of the individual areas. Some of the countries where the UNISDR have help to create drought policies include India (Ministry of Home Affairs, 2004), Kenya (UNISDR, 2009), and throughout the Arab region (UNISDR, 2011).

6.2 Europe

Water availability has reached critical levels over much or Europe. This has resulted from over-extraction as well as prolonged periods of low rainfall or drought. As a result, reduced river flows, low lake and groundwater levels, wetlands drying up, together with the detrimental impacts on freshwater ecosystems, including fish and bird life, have all been reported (EEA, 2009). Though there currently lacks a harmonized approach toward drought risk management at the European Union (EU) level, work is progressing on shifting the paradigm approach from one of crisis management to risk management (Kampragou, et al., 2011). Ideally, under the Water Framework Directive (WFD), development of Drought Management Plans (DMPs) at various levels of governance in all countries is crucial to avoid crisis situations and to identify measures and actions that can be taken at specified triggering levels for the waterbody (Kampragou, et al., 2011). It has been suggested that stringent water constraints, as in some of the recent DMPs, will not effectively reduce drought risk. As this potential is attributed to illegal water withdrawals, DMPs must address how water property rights are

designed and enforced. DMPs must be properly designed and ought to consider all possible water sources to ensure that a comprehensive social–ecological water conservation framework is put into place, and remains robust and resilient (Gómez Gómez & Pérez Blanco, 2012).

The recently established joint reporting initiative of the European Environment Agency (EEA), Eurostat and the European Commission aims to address these shortcomings, improving water information Europe-wide, and therefore supporting the follow-up process of the European Commission's 2007 communication on water scarcity and drought. Member States will voluntarily submit regular data on both water availability and multi-sectoral water use. This information will be generated at a river watershed scale and on a seasonal basis. While potentially presenting a challenge for Member States' environmental and statistical reporting bodies and their interaction with the relevant sectoral authorities, the initiative is crucial to achieve pan-European assessment of water resources (EEA, 2009). To achieve sustainable water resource management will require the implementation of policies and practices by the EU and member states, including those pertaining to water pricing, efficient use of water, awareness raising and tackling illegal water abstraction (EEA, 2009).

Out of the European Commission's 2007 communication on water scarcity and drought came several potential policy directions needed for tackling water scarcity and drought issues (European Commission (EC), 2012):

- Putting the right price tag on water
- Allocating water and water-related funding more efficiently
- Improving drought risk management
- Considering additional water supply infrastructures
- Fostering water efficient technologies and practices
- Fostering the emergence of a water-saving culture in Europe
- Improve knowledge and data collection

Plans developed so far have included, for example, the mapping of water stress, the identification of warning or alert systems and sector-specific measures, such as temporary restrictions on irrigating water-intensive crops (EEA, 2009). As well,

alternative supplies should be considered, such as utilizing treated urban wastewater which provides a dependable water supply relatively unaffected by periods of drought or low rainfall. Collecting water from roofs and impervious surfaces, and using greywater from baths, showers, washbasins and the kitchen, can be sources for non-potable purposes such as the watering of gardens (EEA, 2009).

6.3 Australia

Australia has suffered under a long multi-year drought. Out of the situation, a plethora of policies and programs have emerged at national, state, and local level. Much of the documentation has focused on the social and health aspects of drought.

6.3.1 Health

The frequency and severity of drought events that have hit Australia pushed federal and state governments to create mental health support programs. Australian General Practice Network put together the Mental Health Support for Drought Affected Communities Initiative to provide community outreach and crisis counselling for distressed individuals and communities in drought-affected rural and remote areas, to raise community awareness, and to provide education and training to health workers and community leaders to enable them to recognize and respond to the early warnings of emotional stress.

The Drought Mental Health Assistance Package (DMHAP) was created in 2006 through the Centre for Rural & Remote Mental Health in New South Wales (NSW). Its purpose was to build and increase capacity to deal with the prolonged stress in rural communities affected by drought. One of the primary objectives was to provide Farmers Mental Health forums in rural communities, which were designed to promote mental health literacy, reduce stigma of mental health problems, and to enable people to access help locally (Centre for Rural & Remote Mental Health in New South Wales, 2008). The Commonwealth government (Australian national government) also provides personal counselling for people in drought affected areas through Centrelink 'Just Ask' National Mental Health hotline (Alson & Kent, 2004). The Victorian state also created a

'Tackling Mental Health' Drought Initiatives program (Department of Human Services, 2006).

6.3.2 Socio-economic

In Australia, ongoing and frequent droughts have had some significant effects on farmers, their families, and their communities. Rural communities have experienced accelerated loss of population during the drought. This has become evident in dropping numbers of children attending schools and the outmigration of workers who have lost their jobs. Rural Australian communities have also experienced a reduction in community participation and voluntary activities due to lack of time and resources and elevated levels of stress and overwork, resulting in isolation of farming families (Alson & Kent, 2004).

Despite the common occurrence of drought, the social security system in Australia has not addressed the issue of the self-employed or the issues surround asset rich/income poor farming families. As a result, these people have slipped through the safety net (Botterill as cited in Alson & Kent, 2004).

The Commonwealth (Australian) drought policy is based on criteria describing Exceptional Circumstances (EC). For farmers or small business owners to receive any type of financial relief, they must be in areas experiencing exceptional circumstances. Eligible farmers can receive the Exceptional Circumstances Relief Payment (ECRP), with assistance available for a total period of 24 months. Farmers can also receive an interest rate subsidy of 50% for two years (Alson & Kent, 2004).

Through the Commonwealth Drought Assistance Relief Package, eligible small businesses in EC declared areas can apply for interest rate relief on borrowings of up to $100,000 for a maximum of two years. The program provides financial assistance to small businesses significantly affected by the current drought. The interest rate relief is at a rate of 5% on commercial loans or 50% of the prevailing interest rate, whichever is lower (Alson & Kent, 2004).

A number of assistance measures and services are provided by the Commonwealth of Australia for drought affected farm families and rural businesses, such

as interest rate relief, a drought subsidy, Exceptional Circumstances assistance and relief payments, rural financial counsellors, emergency drought aid, drought recovery fund (Alson & Kent, 2004). Another important government program is Drought Force, which helps farmers and rural communities retain and build the skills of their local workforce during drought by involving volunteers and people from the local community who have lost their job due to drought work together on private farms or public land. Taking part in Drought Force does not affect those who are on income support, and producers can sponsor a Drought Force activity on their land (Department of Agriculture, Fisheries and Forestry, 2010).

In addition, the state government of New South Wales (NSW) provides a number of additional services. Rural financial counselling services through local committees, Livestock Management Subsidies, Drought hotline, Drought support workers, Drought transport subsidies, Farm Business Cost reduction, Drought Proofing funding, training for drought affected farm employees (TAFE), and Payroll Tax exemption (Alson & Kent, 2004).

6.4 United States

Federal and state policies pertaining to drought were not developed until the last couple decades. Before 1988, there were many drought plans in place prepared by different levels of government, some private utilities, and by watershed and subwatershed authorities (Wilhite et al., 2005). In 1989, the Great Lakes Commission formed a Task Force on Drought Management and Great Lakes Water Levels to develop a regional policy statement with research and recommendations on drought planning and management. The St. Lawrence River Basin Sustainable Water Resources Agreement outlines how the Great Lakes States, Ontario and Québec will work together to manage and protect the Basin and provide a framework for each State and Province to enact laws for its protection (Great Lakes Commision (GLC), 2009). Water rights and water laws in the Great Lakes area are also reviewed within the 1989 policy statement (GLC, 1989). The policy statement indicates that the water rights system in the Great Lakes states and provinces follow the riparian doctrine, so land owners have a right to reasonable

beneficial use of the water, although what is accepted as reasonable during normal conditions may differ from what is accepted as reasonable during droughts (GLC, 1989). They also published a reference guide on drought and its impacts answers questions about water level changes and lists federal, state, and provincial contacts for drought assistance, water levels, and emergency response programs (GLC, 1990).

United States Army Corps of Engineers (USACE) submitted a report to Congress outlining the problems related to past drought 'plans', as well as currant emerging issues in water management during drought (United States Army Corps of Engineers (USACE), 1995).

When the National Drought Policy Act passed in 1998, National Drought Policy Commission (NDPC) was established to ensure collaboration between different government agencies on drought-related issues. The Commission issued a report with recommendations, *Preparing for Drought in the 21st Century*, in 2000. Following the report, the National Integrated Drought Information System (NIDIS) was envisioned in a Western Governors' Association Report in 2004. The NIDIS Act was introduced in the U.S. Congress and signed by the President in 2006 (National Integrated Drought Information System (NIDIS), n.d.b). The Act highlights the need for an interagency, multi-partner approach to drought monitoring, forecasting, and early warning, led by the National Oceanic and Atmospheric Administration (NOAA) (Motha, 2011). The NIDIS Implementation Plan was created to:

- Develop the leadership and networks to implement an integrated drought monitoring and forecasting system at federal, state, and local levels;
- Foster and support a research environment focusing on risk assessment, forecasting, and management;
- Create an "early warning system" for drought to provide accurate, timely, and integrated information;
- Develop interactive systems, such as the Web Portal, as part of the early warning system; and
- Provide a framework for public awareness and education about droughts (NIDIS, n.d.b)

The NDPC was designed to provide advice and recommendations on the creation of an integrated and coordinated Federal policy that is designed to prepare for and respond to serious drought emergencies (Kerby, 1999; Wilhite et al., 2005). Before Congress passed the National Drought Policy Act, several of the recommendations focusing on preparedness produced by the NDPC had been implemented (Motha, 2011; Wilhite et al., 2005). The goals of the policy (National Drought Policy Commission (NDPC), 2000) were:

1. Incorporate planning, implementation of plans and proactive mitigation measures, risk management, resource stewardship, environmental considerations, and public education as key elements of an effective national drought policy
2. Improve collaboration among scientists and managers to enhance observation networks, monitoring, prediction, information delivery, and applied research and to foster public understanding of and preparedness for drought
3. Develop and incorporate comprehensive insurance and financial strategies into drought preparedness plans
4. Maintain a safety net of emergency relief that emphasizes sound stewardship of natural resources and self-help
5. Coordinate drought programs and resources effectively, efficiently, and in a customer-oriented manner

The National Drought Preparedness Act, passed in 2003, was created to "improve national drought preparedness, mitigation, and response efforts" (Wilhite et al., 2005, p. 165). Under this act, the National Drought Council was created. With the assistance of the USDA, the council developed a National Drought Policy Action Plan that (Wilhite et al., 2005, p. 165):

- "delineates and integrates responsibilities for activities relating to drought (including drought preparedness, mitigation, research, risk management, training, and emergency relief) among Federal agencies;
- ensures that those activities are coordinated with the activities of the States, local governments, Indian tribes, and neighboring countries;
- is integrated with drought management programs of the States, Indian tribes, local governments, watershed groups, and private entities; and
- avoids duplicating Federal, State, tribal, local, watershed, and private drought preparedness and monitoring programs in existence."

Thought the United States Department of Agriculture (USDA) was designated as the lead federal agency for drought in 1997(Wilhite et al., 2005), there is not one single U.S. federal agency that has responsibility for mitgating or responding to the effects of drought. The Federal Emergency Management Agency (FEMA) has, at different times, been involved with drought. However, it does sometimes exclude drought responsibility, tending to focus more on faster-moving disasters. The U.S. Department of Agriculture is highly involved in many aspects of preventing drought impacts and providing relief to affected agricultural producers. The National Oceanic and Atmospheric Administration (NOAA) is the lead federal agency in monitoring and attempting to predict drought. The U.S. Geological Survey plays a key role in monitoring the hydrological aspects of drought, including snowpack, streamflow, and groundwater. The U.S. Army Corps of Engineers and the Bureau of Reclamation manages river systems through such means as dams and levees, as well as reclamation primarily west of the Mississippi. The U.S. Environmental Protection Agency monitors water quality and the impacts of drought on water quality. The Center for Disease Control gets involved in drought as it often affects public health (National Drought Mitigation Center (NDMC), 2012).

State and regional policies regarding drought preparedness have been created throughout the United States. The Interstate Council on Water Policy (ICWP) is the national organization of state and regional water resource management agencies. ICWP was founded in 1959 to provide a voice for the states in national water policy. Primarily, it is a means for its members to exchange information, ideas, and experience, and to work with federal agencies in sharing water management responsibilities. The ICWP is particularly focused on water quality and water quantity issues, as well as on the dynamic interface between state and federal responsibilities and policies to establish more comprehensive and coordinated approaches to water management that integrate a variety of concerns (Interstate Council on Water Policy (ICWP), 2011).

During drought emergencies to avoid depleting water resources, the Susquehanna River Basin Commission (SRBC) has the authority to act, among other actions, to reduce

diversions and water allocations and coordinate reservoir operations within the watershed as needed to preserve public health and safety, support essential and high-priority water uses, and protect the environment (SRBC, 2007).

Federal programs exist to provide short term and long term drought relief and recovery, though most is associated with agriculture (NIDIS, n.d.a, United States Department of Agriculture (USDA), n.d.a). The Agricultural Assistance Act signed into law in February 2003 "provides assistance to producers who have suffered losses due to weather-related disasters or other emergency conditions" (USDA, 2003). Some of the available assistance programs are summarized below.

The Crop Disaster Program (CDP) provides payments to producers for qualifying losses to agricultural commodities (other than sugar or tobacco) due to damaging weather or related conditions (USDA, 2003). The Noninsured Crop Disaster Assistance Program (NAP) provides producers with financial assistance for non-insured crops for low crop yields, where natural disasters prevented planting, or loss of inventory. Supplemental Revenue Assistance Payments (SURE) Program provides assistance to producers who suffer crop losses due to natural disasters. Crop Insurance provides financial risk protection against low yields and/or lost revenue due to natural disasters including drought. Prevented planting, the failure to plant an insured crop with the proper equipment by the final planting date designated in the insurance policy, is a form of crop insurance that is valuable coverage for producers when drought prevents planting on non-irrigated acreage (Haugan, 2010; USDA, n.d.a).

To help livestock producers, the Livestock Forage Disaster Program provides assistance for grazing losses incurred by drought or fire (USDA, n.d.a). The Conservation Reserve Program (CRP) Emergency Haying and Grazing Emergency may authorize the haying and grazing of CRP land to provide relief to livestock producers in areas affected by a severe drought (USDA, 2012a). This is similar to the Livestock Assistance Program (LAP), which reimburses producers for grazing losses. The Livestock Compensation Program (LCP) provides payments for losses of livestock by a list of causes (USDA, 2003).

The Risk Management Agency (RMA) works to promote, support, and regulated appropriate risk management solutions to preserve and enhance agricultural economic stability through a variety of programs and policies (USDA, 2005).

Besides direct agricultural assistance, other financial assistance programs have been set up to assist landowners to maintain healthy land through landscape planning (USDA, 2012b). The Emergency Watershed Protection (Recovery) program carries out emergency measures to facilitate runoff retardation and soil erosion prevention to protect lives and property from floods, drought, as well as the products of erosion, in a watershed when fire, flood or any other natural occurrence causes a sudden impairment of the watershed (USDA, n.d.b). The Wetlands Reserve Program offers landowners the opportunity to protect, restore, and enhance wetlands on their land. Not only does the program offer financial assistance, but technical assistance as well (USDA, 2011, USDA, 2012c).

The USDA Rural Development division provides assistance to rural communities that have experienced a significant decline in quantity or quality of drinking water due to an emergency such as a drought, or where such decline is considered imminent, to obtain or maintain adequate quantities of water that meets the standards set by the Safe Drinking Water Act, through the Emergency Community Water Assistance Grant program (USDA, 2012d).

Economic Injury Disaster Loans are available to help small business or private, non-profit organization of any size who sustain economic injury after a disaster. If a business is located within a declared disaster area, the owners can apply for financial assistance. The Economic Injury Disaster Loans are long-term, low-interest loans designed to help business or non-profit organizations repair or replace damaged property. Working capital loan are also available by application from the United States Small Business Administration (SBA) to relieve the economic injury caused by the disaster (United States Small Business Administration (SBA), n.d.).

7.0 Drought and Canada

While some municipalities have created local programs and water management plans, described previously in sections, much of the support received by the agricultural sectors and rural communities comes through federal and provincial funding programs for producers and businesses. Most of the programs offered through federal and provincial departments are described below.

7.1 Joint Federal and Provincial Policies and Programs

Growing Forward "is a commitment to Canada's agriculture sector that's focused on achieving results, reflects input from across the sector, and delivers programs that are simple, more effective and tailored to local needs" (AAFC, 2011d). Growing Forward replaces the former Agricultural Policy Framework. Within the Growing Forward program, many policies and programs at both the federal and provincial level are available to farmers, producers, academics for research, land managers, industry, co-operatives, not-for-profit agricultural corporations, and many others. Some of the federal programs include AgriInsurance, AgriStability, AgriInvest, and AgriRecovery.

Under the Growing Forward program, at the provincial level, there are approximately 20 programs available to producers, farmers, and others. The Stewardship Plan, under Alberta Agriculture and Rural Development, emphasizes that the purpose of the Growing Forward program is not strictly to provide disaster. The Stewardship Plan program aims to provide "programs and resources to protect Alberta's food chain and position Alberta agri-business as a world leader in environmental responsibility" (ARD, 2010c). These plans are intended to "help producers demonstrate their environmental practices and plan for operational improvements that will reduce their environmental impact" (ARD, 2010c). There are three Stewardship Plan programs, including 1) Grazing & Winter Feeding Management; 2) Integrated Crop Management, and; 3) Manure Management.

Canadian-Alberta Pasture Recovery Initiative (CAPRI) is a federal and provincial initiative under the AgriRecovery program. The purpose of the initiative is to reduce the

financial pressures for livestock producers within designated areas while they make alternative plans for constraints that emerge as a result of drought (ie. pasture access, feed). AgriRecovery is a framework to quickly assess the impact of extraordinary events that significantly impact a region or industry, and that are not cyclical in nature or the result of a long-term trend. It is not intended to replace existing programs or the need for multi-year strategies required to assist industries to adjust to the long-term realities of their industry. Any AgriRecovery initiative is cost-shared 60:40 by the federal and provincial governments, respectively (Agriculture Financial Services Corporation, 2011).

The Canada-Alberta Farm Stewardship Program (CAFSP), the Alberta component of the National Farm Stewardship Program, is funded under the Agricultural Policy Framework (replaced by Growing Forward). The objective of the CAFSP is to accelerate adoption of ecologically-based beneficial management practices (BMPs) on farms and agricultural landscapes through the provision of cost shared incentives and technical assistance to producers for implementation of BMPs that address on-farm environmental hazards (ie. erosion, manure treatment and application, pest management, species at risk, etc.) (AAFC, 2004).

The Canada-Alberta Water Supply Expansion Program (CAWSEP), the Alberta branch of the National Water Supply Expansion Program, aims to address water supply concerns by providing support– both technical and financial – to Alberta agricultural groups and communities for planning and developing projects that will improve their ability to develop and enhance long-term, sustainable agricultural water supplies (AAFC, 2005).

7.2 Federal policies and programs

Most federal programs surrounding drought relief and aid from the Canadian federal government is though Agriculture and Agri-Food Canada (AAFC) and its partners. These include the: Advance Payments Program, Tax Deferral Program for Prescribed Drought Region, Farm Debt Mediation Service, Canadian Agricultural Income Stabilization, and the National Environmental Farm Planning Initiative.

The Advance Payments Program (APP) is a financial loan guarantee program that provides producers easier access to credit through cash advances, and at lower rates. Emergency cash advances are available thought the APP that provide producers a portion of a cash advance that can be issued as an emergency advance when the agricultural sector is facing severe economic hardship or reduced production due to unusual circumstances such as severe and damaging weather conditions or a natural disaster. The maximum emergency advance available is $400,000 (Agriculture and Agri-Food Canada (AAFC), 2011a).

Tax Deferral Program for Prescribed Drought Region (AAFC, 2011f) allows farmers who sell part of their breeding herd due to drought or excess moisture and flood conditions in designated regions to defer a portion of sale proceeds to the following year. Eligibility for a tax deferral includes a 50 percent reduction in hay and pasture yields (I. Simons-Everett, personal communication, February 21, 2012).

The Canadian Agricultural Income Stabilization (CAIS) program was created as a margin-based program with government payments matched according to a schedule of farmer deposits. The program was built on the philosophy that governments and farmers should share in the cost of replacing lost income. Farmers share the cost by paying an annual participation fee and by absorbing a portion of their lost income. For smaller losses, governments and farmers share the cost equally. As losses deepen, the percentage of the government's share would increase up to four times the farmer's share. In Alberta, the program is administered by the Agriculture Financial Services Corporation (AFSC) (Swanson et al., 2009).

The Prairie Shelterbelt Program (PSP) by Agri-Environment Services Branch (AESB) of Agriculture and Agri-Food Canada, provides aid to farmers to minimize the effects of dust storms and drying winds that occur in times of drought and extreme heat. This program provides technical services as well as tree and shrub seedlings to establish shelterbelts and other agroforestry, conservation and reclamation projects on agricultural and eligible lands across the Prairies and into the Peace River region of British Columbia (AAFC, 2010). Though the trees are provided free of cost (except for shipping), this

program has only limited participation in recent extreme weather events in southern Alberta (Swanson et al., 2009). The final delivery of trees in spring of 2013 as this program is due to be cut after 110 years of operation.

Greencover Canada, though no longer in operation, was part of Growing Forward. It aided producers in improving grassland-management practices, protecting water quality, reducing greenhouse-gas emissions, and enhancing biodiversity and wildlife habitat (AAFC, 2007). The major components of Greencover Canada were: land conservation, critical areas, technical assistance, watershed evaluation of BMPs, and shelterbelts (AAFC, 2007). Many of the services provided by the Greencover Canada Program are available under Growing Forward in new programs.

7.3 Provincial policies and programs

Under the provincial Agricultural Drought Risk Management Plan, ARD and AAFC monitor hay and pasture yields, and soil moisture and precipitation in drought-affected areas. The Drought Action Group of the ADRMP will recommend that areas be designated for tax deferral to Agriculture and Agri-Food Canada, which would loan money to eligible farmers at a reduced interest rate to help them recover after a drought (ARD, 2010b).

Hay, straw, and pasture listings available on the ARD site, and the water pumping program through ARD are important services and programs offered and facilitated by the provincial government. These programs demonstrate the group approach to drought adaptation, and have been used both many years. Elements of these programs have been used in orchestrating drought relief efforts also on municipal and local scales which were picked up in the media scan. As discussed in section 10.0, Ducks Unlimited Canada are involved in pasture leasing as well.

Some of the financial programs offered in the past through the provincial government for drought affected areas include (ARD, 2010b): initial assessment for tax deferral on breeding stock, drought disaster loans, grazing on unallocated public land, feed/livestock freight assistance, emergency water hauling, reduced rates for dugout water pumping, grasshopper control options, and direct acreage payments. Many of these

programs are still available, but often in an alternate form, requiring the farmer to track where various services are offered.

The Alberta Farm Recovery Program (AFRP) provides transitional funding which "targets" payments to farmers that demonstrate need. This method eliminates the risk of compensating farmers for their loss more than once through different programming (Swanson et al., 2009).

7.4 Municipal

Alberta's Rural Community Adaptation Grant Program is a $15 million initiative aimed at support projects that increase the capacity of rural communities and regions to transition and adapt to drought and climate change. The program funds up to 90 per cent of eligible non-capital projects costs and up to 50 per cent of eligible capital costs to a maximum grant of $500,000 (Municipal Affairs, 2011). The criteria used to select funded projects can be entered under several categories: assessment and planning, capacity building, rural economic development, and unique community solutions (Municipal Affairs, 2011).

The Alberta Rural Development Network (ARDN) is a partnership of Alberta's 21 publicly-funded, publicly-governed colleges, universities, and technical institutes, working together to support and enhance rural development (Alberta Rural Development Network (ARDN), 2010). Through post-secondary institutions, Alberta Innovates, and local/regional economic groups, ARDN aims to support Alberta rural development and help rural communities grow through learning (ARDN, 2010).

The Okotoks municipal water management plan provides bursaries through their Outdoor Water Conservation Rebate Program in 2010 and 2011. Through this program, rebates were given for rain barrels, irrigation system audits and repairs, weather-based irrigation system and/or controller, organic and inorganic mulch and drought tolerant groundcover/turf. In partnership with Climate Change Central, the Okotoks Water and Energy Rebate Program through 2008/9 provided rebates for low-flush toilets, dishwashers, clothes washers and refrigerators (Town of Okotoks, 2011).

The water conservation and water use policy of the City of Camrose (2006) has four water conservation implementation stages if a state of water shortage is declared. The City Manager can declare a water shortage due to drought, and implement water restrictions outlined in the policy under drought conditions where the water supply is reduced.

The County of Camrose, as with all municipalities, have the authority to declare a disaster within their jurisdictions (I. Simons-Everett, personal communication, February 21, 2012). As a result of declaring a drought emergency, Camrose County implemented a roadside grazing program. The Drought Advisory Group, under the ADRMP, assesses and explores a variety of response options and recommends possible responses to drought, including municipal roadside grazing/haying (ARD, 2010b). The initiation of the roadside grazing program is through the office of the agricultural services manager, as a direct request to county council to create the temporary use of roadsides for grazing (P. King, personal communication, February 24, 2012).

8.0 Legislation and Policy

To support assistance programs within Canada, policy and legislations dealing with the use and management of natural resources, as well as with land use and agriculture have been passed into both the federal and provincial levels of government. Though there is no national policy directly pertaining to drought, much of the existing legislation and regulations, if fully enforced, would help address some of the indirect effects of drought such as reduced water quality, and encouraging the development of water management plans. Many of the agricultural finance programs offered through both the federal and provincial governments are based on legislation.

8.1 Federal Legislation and Policy

Federal legislation and policy that would pertain to effects of drought are primarily embedded in environmental and natural resource regulations and acts, though Agriculture and Agri-Food Canada also has extensive programming and supports.

The *Canada Water Act* is divided into four parts. Part I, Comprehensive Water Resource Management, authorizes the federal Minister of Environment with the establishment of consultative arrangements and to finalization of agreements with the provinces respecting waters that are of significant national interest. Part II, Water Quality Management, allows the Minister to conclude agreements with provincial jurisdictions in designating certain areas as "water quality management areas" when the water quality therein has become a matter of urgent national concern. Part III, nutrients, contains provisions concerning allowable concentrations of nutrients in water treatment processes. This part of the act was incorporated into *Canadian Environmental Protection Act* (CEPA) by proclamation in 1988. Guidelines originally issued under this part of the Act are now listed under CEPA, including the Canadian Drinking Water Quality Guidelines and the Guidelines for Effluent and Waste Water Treatment at Federal Establishments. Part IV deals with administration and enforcement of the Act. Part III, Section 9, covers the unlicensed dumping of wastes into the water of a water quality management area. It further forbids dumping wastes in any place, or under any conditions, such that the waste or the derivatives of that waste might flow into the waters of the protected area (Natural Resources Canada, 2011).

The Federal Water Policy is a statement of the federal government's philosophy and goals for the nation's freshwater resources and the proposed ways of achieving them. The purpose of the Federal Water Policy is to identify the goals and actions the federal government intends to contribute to the management of information and expertise, technological development and transfer, and promotion of public awareness. In time of drought, the Federal Water Policy guides the federal government to support provincial initiatives directed at managing water supplies to realize their full value, and to resolving real and potential problems associated with droughts. Thus, the federal government encourages water conservation approaches and technologies to expand the use of limited water supplies. Federal support and research also support improved knowledge and understanding of drought and support integrated planning approach to managing the water supply (Environment Canada, 1987).

The *Canada Fisheries Act* is designed to protect fish, shellfish, crustaceans and marine animals in fishing zones in all Canadian waters. The Fisheries Act contains more stringent regulations against pollution of Canadian waters than the Canada Water Act. For example, under the Fisheries Act it is unlawful to harmfully alter, disrupt, or destroy fish habitat, or to deposit, cause or allow the deposit of material or substances that are harmful to fish in fish-bearing waters (Natural Resources Canada, 2011).

Farm Income Protection Act (FIPA) provided the framework for the integration of safety net programs for virtually all commodities – the whole farm approach. Five safety net programs were developed under this legislation to cover the direct needs of different products. Net Income Stabilization Account; crop insurance; provincial companion programs; cash advance programs; and Agriculture Income Disaster Assistance /Canadian Farm Income Program. The intent was "to encourage a more 'market-oriented' and 'self-reliant' philosophy that was at the same time intended to be trade- and production- neutral, equitable across provinces and environmentally sustainable with minimum overlap or duplication of purpose" (Swanson et al., 2009, p.33).

The Advance Payment Program is based both on *the Prairie Grain Advance Payments Act* which covered wheat and barley in the designated areas of the Canadian Wheat Board (CWB), as well as on the *Advance Payments for Crops Act* which covered all other crops produced across the country (Swanson et al, 2009).

The Community Pasture Program under the Prairie Farm Rehabilitation Administration (PFRA) aims to conserve the land resource, protect it from future deterioration due to drought while utilizing the land primarily for the grazing and breeding of livestock. The objectives of the program are to "manage a productive, bio-diverse rangeland and promote environmentally responsible land use practice", and "to utilize the resource to complement livestock production" (AAFC, 2011b).

8.2 Provincial Legislation and Policies

Several provinces and provincial agencies have set up legislation and policies regarding water quality and quantity issues as they pertain to drought response and situations of low water quantity.

8.2.1 Alberta

Alberta Environment and Sustainable Resource Development is responsible for water legislation and policy that will ensure the quality and quantity of Alberta's water resources, as well as to ensure thriving ecosystems. The current Alberta water management legislation, the Water Act, came into force on January 1, 1999. Its primary focus is on management planning, use and enforcement needed to protect Alberta's water resource. The Water Act emphasizes wise use and allocation of our water as it pertains to the protection of rivers, streams, lakes and wetlands (Alberta Environment, 2010). The Water Act also encourages the development of water management plans in accordance with the Framework for Water Management Planning. Public consultation is a key component of the development of these plans, providing opportunities for local and regional involvement (Alberta Environment, 2010). Water for Life – Alberta's Strategy for Sustainability described the Government of Alberta's approach to water management, outlinging specific strategies and action to address issues pertaining to the management of the water resource. The Act highlights the shared responsibility of all Alberta citizens for water conservation and wise use, and everyone's role in providing advice regarding water management planning and decision-making and work co-operatively with the four levels of government to meet our water management goals (Alberta WaterPortal, 2011).

The *Alberta Environmental Protection and Enhancement Act* (EPEA) passed in 1993 was created to provide guidelines and background environmental quality objectives for development in the province of Alberta. In accordance, Alberta Environment and Sustainable Resource Development established a protocol for water quality guideline development for the protection of freshwater aquatic life, which was used to create guidelines for selected substances that impact water quality (Alberta Environment, 1999).

Alberta's 2010 Agriculture Drought Risk Management Plan (ADRMP) developed by Alberta Agriculture and Rural Development (ARD) focuses on planning and preparedness measures through a risk management approach. Risk management not only reduces the impact of drought on producers in the short and long term, it is also more fiscally responsible and works better under global trade rules that can penalize agriculture programs. The ADRMP provides a framework for a coordinated, pro-active approach to reduce the short- and long-term effects of drought and of climate change on Alberta farmers and ranchers. It will also guide government agencies and non-governmental organizations in assisting producers to more effectively reduce the impacts of drought before, during, and after a drought event. As well, it will help agricultural producers to be more prepared and less vulnerable to drought (Alberta Agriculture and Rural Development, 2010b). The ADRMP is supported by the three main approaches to management action: 1) drought preparedness, 2) drought monitoring and reporting; and 3) drought response (ARD, 2010b).

8.2.2 Ontario

Ontario Low Water Response is intended to mitigate the effects of drought through the implementation of both short-term and long-term water management strategies (Ministry of Natural Resources et al., 2003). The plan sets out three levels of response to low water situations. Level 1 identifies conditions that potentially could develop into a water supply problem, and concentrates on conservation. Level 2 indicates a potentially serious water supply problem, and implements restrictions. Level III indicates the failure of the water supply to meet the demand, which result in progressively more severe and widespread socioeconomic effects, needing regulation to manage the issues. Precipitation data is the primary indicator used, as it is the most important and the most convenient. By reviewing precipitation data and comparing it to trends, warning signs of an impending water shortage can be identified. The Ministry of Natural Resources (MNR) will compare monthly data from each precipitation monitoring station with the average monthly precipitation for the station. Calculations are made for the previous 18 months (long-term), for the previous 3 months (seasonal) and, under

Level I condition or higher, the previous month (short-term), with weekly updates. If a watershed is under a Level I or Level II condition, MNR will add up the number of consecutive weeks that register no rain (less than 7.6mm). Streamflow is also used as an indicator. Gauges in streams measure water levels and provide indicators to demonstrate there is enough streamflow in the river to meet the basic needs of the ecosystem and to demonstrate water is available for other uses such as recreation, hydropower generation or irrigation. MNR will compare the monthly flow for each stream gauge station with the lowest average summer month flow for that station (Ministry of Natural Resources et al., 2003).

Low water threshold levels of precipitation and stremflow for each condition level is determined both for spring flow and other times of the year. If the indicator for precipitation or streamflow crosses a threshold, then a watershed, or a portion of it, may change to a Level I, Level II, or Level III condition. Level III designation requires documentation of ongoing and significant social, environmental and economic impacts. A water response is undertaken when a watershed condition changes. When a threshold is crossed, usually the Province alerts the Conservation Authority to the change. The values of thresholds have been set for precipitation and streamflow at selected stations. Indicators will be monitored and reviewed periodically to determine if the thresholds are set at the correct levels. A summary of the thresholds for each condition level for precipitation and streamflow can be found in Table 4.

Adherence to water conservation is voluntary up to and including a level I condition. Level II and III involve restrictions and regulations, respectively (Ministry of Natural Resources et al., 2003). Through the use of various levels of action, the plan recognizes the partnership between provincial and local authorities and that natural resource and environmental management must be approached at both the provincial and local levels. The Ontario provincial government provides overall direction and coordinates policies, science, and information systems. In extreme circumstances support is also provided where local declarations of an emergency have been made. At

Table 4
Summary of condition level thresholds (adapted from Ministry of Natural Resources et al., 2003)

Condition	Indicator	
	Precipitation	Streamflow
Level I	<80% of average	**Spring:** – monthly flow < 100% lowest average summer month flow **Other times:** – monthly flow < 70% of lowest average summer month flow
Level II	<60% of average weeks with < 7.6mm	**Spring:** – monthly flow < 70% of lowest average summer month flow **Other times:** – monthly flow < 50% of lowest average summer month flow
Level III	<40% of average	**Spring:** – monthly flow < 50% of lowest average summer month flow **Other times:** – monthly flow < 30% of lowest average summer month flow

the local level, the emphasis of the response plan is directed to collecting information, interpreting policy and delivering programs to minimize the effects of low water conditions. The response plan deals with the low water end of the spectrum of water management issues, which involves dealing with highly variable conditions. This document was not designed to be a disaster relief or emergency response plan (Ministry of Natural Resources et al., 2003).

8.2.3 British Columbia

The British Columbia Drought Response Plan is focused primarily on actions preceding, during, and immediately following a drought that requires the participation of all four levels of government to reduce its impacts (ecconics, 2010). It will work towards ensuring water needs for people and ecosystems are both met in times of water scarcity. The plan outlines the responsibilities of both provincial and local level agencies, as well as recommendations regarding federal involvement and First Nations. It also recommends actions that should be taken prior to the onset of drought, as well as those for after drought action subside. Though the plan does include some discussion on *drought preparedness*, steps taken before a drought to increase the level of readiness and resiliency of all stakeholders, this was not the primary focus. Though there is some

discussion on preparedness under normal conditions in the plan, drought preparedness and water conservation are addressed in other provincial government policies and guidelines (ecconics, 2010).

The Ministry of Agriculture in British Columbia has a number of drought-related programs, information, and strategies to deal with agricultural drought issues (Ministry of Agriculture, 2011). Information about drought, the British Columbia Drought Response Plan, and current drought levels can been found through the *Living Water Smart* program (Government of British Columbia, 2011).

8.2.4 Saskatchewan

Though no provincial drought plan was found in the course of this report, the Assiniboine Watershed Stewardship Association (AWSA), through the support of the Saskatchewan Watershed Authority and Natural Resources Canada, developed a *Drought and Excessive Moisture Preparedness Plan* (Rowan et al., 2011). AWSA hosted two workshops facilitated by the Saskatchewan Watershed Authority. The goal was to identify vulnerability and resilience of various watershed stakeholders through a series of activities, including mapping areas of highest concern, construction of timelines showing drought events and adaptations, scenario-based discussion, as well as adaptation planning (Rowan et al., 2011). By identifying issues and action items and prioritizing each issue, the preparedness plan provides a strategic plan in dealing with drought, and offers a starting point for engagement throughout other provincial and federal agencies (Rowan et al., 2011).

8.3 Municipal

The Water Conservation / Water Use Policy of the City of Camrose (2006) is supported by the Water Conservation / Water Use Bylaw, enforcing water restriction measures by means of financial penalties for breaching of restrictions. Under the bylaw, the city must help the residents of Camrose by providing information on how to conserve water.

9.0 Drought and Municipal Water Supply

As with agriculture, the ability of communities and cities to adapt to extreme climate conditions will determine how well they survive. Much of this depends on what mitigation and adaptation measures are implemented by municipalities and communities, and the effectiveness of those strategies. What measures should be implemented would be determined by the vulnerability of the community.

Larger urban centres themselves are generally more insulated from the effects of drought than smaller rural communities, having more sophisticated water acquisition and storage infrastructure. Major urban centers also generally have greater levels of adaptive capacity than smaller communities because cities have well-developed communication and transportation infrastructure; in most cases, they have economic reserves and well-developed emergency response capacities (Sauchyn & Kulshreshtha, 2008). However, there is a lack of knowledge and awareness among municipal decision-makers about the potential impacts of climate change and of the need for adaptation (Wittrock et al., 2001). As well, with the increasing magnitude and frequency of drought, impacts will be evident on the water supply and use in cities on the Canadian Prairies, highlighting the need for water efficiency initiatives (Sauchyn & Kulshreshtha, 2008).

Within the context of a changing climate and a high probability of longer and more frequent droughts, municipalities will be faced with making critical decisions surrounding water conservation during extreme weather events. Cities provide an important supporting role in the distribution of health services, communications, and goods. These roles would likely become increasingly important during drought events, but the roles of these services may also be disrupted by climate impacts (Wittrock et al., 2001). Municipalities will also have important roles and responsibilities to implement and enforce actions surrounding water use and security. It is critical that municipal governments improve their understanding surrounding the significant threats associated with extreme weather events (physical, social, environmental, and economic), and respond appropriately and effectively to both current and future risks (AADMC & AENV, 2009).

Incorporating climate change information in city and municipal decision-making is important for a variety of reasons, ranging from safety to cost-saving implications (Wittrock et al., 2001). Climate effects, especially severe and frequent droughts, will impact many sectors and activities, including property, construction, infrastructure, recreation and tourism, water and waste-water management, pests, diseases and human health, and safety, and may magnify some of the stresses commonly found in urban centers, such as transportation difficulties, decreased air quality, crime, and infrastructure problems. As many cities also depend on their surrounding regions for such things as water, food, goods and services, they need to know major stresses and opportunities facing their region (Wittrock et al., 2001).

Though some communities already have some drought adaptation strategies, these strategies were pushed to their limits with a multi-year drought (2001-2002). If droughts become more frequent, severe and extended as expected, current adaptation strategies may not be adequate (Wittrock et al., 2007).

Under the Alberta's 2010 Agriculture Drought Risk Management Plan (ADRMP) (ARD, 2010b), it is recommended that municipalities be responsible for developing secure water supplies, storage, and distribution facilities to improve water security, as well as being responsible for improving water conveyance efficiencies for agricultural, municipal, and industrial water. Along with this, the goal is to have municipalities in charge of increasing access to available water supplies, upgrade pumping facilities and increase storage capacity. Municipalities may also have the responsibility to manage community water supplies and are responsible for implementing water rationing and other adaptation and conservation strategies to extend the duration of available supply (ARD, 2010b).

Though there is no legislation in Alberta mandating municipal drought management, some municipalities and townships have chosen to implement their own. The Town of Okotoks, Alberta has been locally, regionally and nationally recognized as a municipal leader in wise and responsible water management. The community has developed their own water management plan, incorporating education, alternate water

source exploration, upgrading existing water infrastructure, restructuring of utility rates to primarily consumption-based rates for both potable water use and sanitary sewer collection, incorporation of a regulatory water conservation framework into municipal bylaws, compliance under the Alberta Water Act, and implementation of the Outdoor Water Conservation Rebate Program in 2010 and 2011(Town of Okotoks, 2011). Though the plan does not directly address drought management, it does outline measures for water conservation and steps that can be taken to reduce water demand beyond what is currently in place.

The City of Camrose Water Conservation/Water Use Policy established a four-stage water shortage policy designed to manage the use of water in the City of Camrose. The policy outlines measures to reduce the amount of water used by up to 50% (stage 4) (City of Camrose, 2006). There is potential provision to review the measures for businesses that depend on water, such as car washes, golf courses, and greenhouses (City of Camrose, 2006).

The Town of Lacombe's *Procedures for Providing Safe Water* policy (Town of Lacombe, 2003) permanently restricts outdoor watering to alternating days. This means that odd numbered houses can water outdoors on odd numbered calendar days, and even numbered homes can water on even numbered calendar days. Increased restrictions are also available for implementation should the need arise. The permanent restrictions may be adjusted by the CAO should conditions permit (Town of Lacombe, 2003).

10.0 Drought and environmental stewardship

Drought has direct and indirect impacts on freshwater systems. Direct ecological impacts are those that are caused by reduced water and flow, and habitat reduction and reconfiguration or fragmentation. Indirect impacts are those associated with changes in phenomena such as interactions between different species, especially predation and competition, and the nature of food resources. This would also include impacts to water quality (Lake 2003). As well, higher stream temperatures negatively affect fish access, survival and spawning (Morrison et al., as cited in Field et al., 2007).

Productivity in a stream decreases during a drought (Lake, 2003). This is due to a reduced ability for vegetative debris to decompose. As well, with drying and low flows, patches of blue-green algae may increase. Biochemical processes can also be changed (Lake, 2003).

Lake (2003) explains how impacts to rivers in normal flow may further degrade the habitat under a drought scenario to a point where the system cannot fully recover from the drought event:

> "Many streams and rivers have been degraded by loss of habitat, loss of flow and changes in flow regime. In streams subjected to habitat simplification, the loss of habitat may not only reduce diversity under normal circumstances but may greatly reduce the availability of refugia. Thus, the resilience of the stream's biota to drought may be greatly diminished" (p.1168).

One of the biggest challenges facing lentic ecosystems affected by drought is the maintenance of wetlands and riparian areas (the lush habitats surrounding wetlands and lakes). In the Prairie Pothole Region, an area historically rich with wetlands, increasing temperature trends, several ecological changes are expected, including fewer wetlands on average, shorter duration of flooding in wetlands, and greater annual variability in surface water (Anderson, 2009). These areas are further at risk because they provide forage and water for cattle, but are also drained to increase crop land. Wetlands help to recharge the aquifers and groundwater sources which are used by municipalities and rural Albertans in the Battle River watershed (Skinner, 2011). As well, the effects of drought may be moderated in a prairie ecosystem by wetlands. Without healthy riparian areas, pastures can become extremely vulnerable to drought conditions through a combination of shallow roots and no litter to conserve available moisture (Fitch et al., 2003). However, sometimes the maintenance of wetlands is viewed as an expense to the farming operation. As such, some incentive programs are available through government and non-government initiatives.

Land use initiatives that help landholders implement sustainable land management techniques and best management practices to create and maintain wildlife habitats on

their land and to protect water resources are also common throughout Alberta. Projects vary from addressing grazing practices, stocking rates, as well as alternative crop planting, such as winter wheat. Organizations, including Alberta Fish & Game Association, Alberta Conservation Association, Ducks Unlimited Canada, Delta Waterfowl Alternative Land Use Services, Alberta Land Trust Alliance, Wildlife Habitat Canada, Canadian Wildlife Federation, Alberta Stewardship Network, and Alberta EcoTrust, along with others, promote and support various land use initiatives.

In Alberta, there are several initiatives to encourage and support the care of wetland and riparian areas to help mitigate drought by organizations such as Ducks Unlimited Canada (2008), the Alberta Riparian Habitat Management Society (known more commonly as Cows and Fish) (Fitch et al., 2003), North American Waterfowl Management Plan (NAWMP) (Kwasniak, 2001), as well as through the federal and provincial governments (ie, Alberta Water Resources Commission, 1993).

Alberta Riparian Habitat Management Society, also known as Cows and Fish, is a non-profit society that works with of landowners, agricultural producers, communities, and others who value the use of Alberta's riparian areas, to foster a better understanding of how to improve grazing and other management of riparian areas to enhance landscape health and productivity for their benefit (Fitch et al., 2003).

Ducks Unlimited Canada (DUC) has worked with producers to establish forage and grazing systems and alternative cattle watering systems that increase land use sustainability. During the recent drought of 2001-2003, DUC instigated a drought response plan for affected areas in Alberta, Saskatchewan, and Manitoba. The DUC's Drought Response Program provided cattle producers with additional forage to get through the feeding season by tendering DUC uplands that contain native grasses that are normally hayed once the nesting season has ended. As well, producers may also be able to use DUC wetland projects for stock watering. The Prairie-wide initiative was established to respond to emergency drought situations faced by agricultural producers. All revenues generated from the tendering of the lands were reinvested into DUC conservation programs in the province where the funds originate. These programs

include grazing management, forage establishment and winter wheat, and others. (Morrison, 2002).

The Millennium Ecosystem Assessment (2005) stresses that changes in hydrology and in water body temperature will reduce the ability of wetlands to provide ecological services. Removing the existing pressures on wetlands and improving their resiliency one method of coping with the adverse effects of climate change. Conserving, maintaining, and rehabilitating wetland ecosystems are potentially viable tools for a drought mitigation strategy.

The Agri-Environment Services Branch (AESB) of Agriculture and Agri-Food Canada is an integration of three existing components: Prairie Farm Rehabilitation Administration (PFRA), National Land and Water Information Service (NLWIS), and Agri-Environmental Policy Bureau (AEPB) to address AAFC's agri-environmental issues. The mission of the AESB is to bring integrated expertise and innovative environmental solutions to the agriculture and agri-food sector (AAFC, 2011e). The AESB brings forward ideas and solutions to help producers and other in the field make the best decisions for the environment. This includes finding new opportunities and enabling innovation, supporting the voluntary stewardship approach, and improving the public image of the sector (AAFC, 2011e).

11.0 Drought and Water Quality

Many of the indirect effects of drought on freshwater rivers impact water quality. The reduction in river flow and volume can have many detrimental effects. With low volume and flow, water temperature increases, contributing to direct mortality of the fish and other aquatic organisms as well as anoxic water, also lethal to aquatic biota. Low flows can also contribute to accumulation of dissolved and particulate organic matter, sediments, and nutrients. The accrual of nutrients, especially phosphorus and nitrogen, can contribute to large algal blooms, exacerbating already anoxic conditions (Lake, 2003). Warming will likely extend and intensify summer thermal stratification, also contributing to oxygen depletion, though shorter ice-cover periods of shallow lakes in the

north could reduce the number and severity of winter fish kills caused by low oxygen conditions (Field et al., 2007).

Drought will likely make water quality standards harder to meet as confounding factors will increase as water quantity decreases beyond the range the standards were set at (Field et al., 2007). In the Prairie region of Canada, drought may compromise water quality through increased toxin and pathogen concentrations in water (Smoyer-Tomic et al., 2004). Flash flooding, which can occur at the end of a drought period, can lead to water-borne diseases (e.g. *E. coli*, *Cryptosporidium*, and *Giardia*) associated with the large number of intensive livestock operations in the Prairie Provinces (Klaver, 2002; Statistics Canada, 2004b), contributing to health concerns.

12.0 Drought and Industry

Many concerns exist regarding the use of water by industry. Industrial use of water, can potentially exacerbate surface and groundwater depletion from drought events (Griffiths & Woynillowicz, 2003). Though some policy exists pertaining to water use and industry, several options for improving policy surrounding water by industry have been suggested by the Pembina Institute (Griffiths & Woynillowicz, 2003), as well as .by the Canadian Association of Petroleum Producers (CAPP) (Golder Associates Ltd., 2010).

The *Water Conservation and Allocation Policy for Oilfield Injection* is a policy for the use of non-saline water for use in conventional oil and gas operations. The policy requires all applicants to assess alternative water supplies before requesting a license for fresh water resources. The goal of this policy is to reduce the injection of fresh water in oilfields, especially in areas where there is the potential for water shortage or anticipated increasing demand (Government of Alberta (GoA), 2006). This policy is currently being reviewed to better incorporate non-conventional oil and gas operations such as hydraulic fracturing.

Decreased river flow and dropped water reservoir levels are problems faced by electricity plants during drought as they require water for cooling. Low water issues for

thermoelectric power generating stations become critical when water levels fall near or below the level of the water intakes used for drawing water for cooling (National Energy Technology Laboratory (NETL), 2009). As well, the related problem of elevated water temperatures that often occurs during a drought means they must employ secondary, but less efficient cooling methods (B. Bosh, personal communication March 9, 2012; NETL, 2009). In extreme drought or water shortage periods, plants may be forced to shut down some reactors (NETL, 2009).

The Susquehanna River Basin Commission (SRBC) in the United States is one of the few watershed commissions that "has direct authority to require drought restrictions among all the member states and is specifically authorized to review and approve water diversions and regulate consumptive use" (NETL, 2009, p. 29). Consumptive users, including power plants, are required to compensate the SRBC for releases from lakes and reservoirs needed to replenish flows to maintain the river system (NETL, 2009). In the event of drought or other water shortage, the SRBC can declare a state of water emergency, and impose control on all allocation, diversions (including those of electric power-generating stations), and uses of water to meet the emergency condition (Susquehanna River Basin Commission (SRBC), 2006).

13.0 Drought and Special Areas

In Alberta, the Special Areas constantly struggle with drought. The original mandate for the Special Areas Board of 1938 (and previous individual boards) was created to secure control of as much land as possible. It rehabilitated abandoned land by planting crested wheat grass to stop soil drifting (Marchildon, 2007), and promoted the transfer of land use from grain farming to livestock operations (Marchildon et al., 2008). Land was also accumulated so the Board could manage land resources in the most economic manner possible, ensuring that farmer-ranchers could access additional grazing land inexpensively and as low-risk a manner as possible by renting out Crown land at low rates and through extensive community pastures (Marchildon, 2007, Marchildon et al.,

2008). In addition, the Board was responsible for providing and maintaining basic road, school and hospital services for residents in the context of continuing depopulation. Although farming was not prohibited, everything possible was done to help develop self-sufficient livestock operations that would replace large-scale grain production in the region (Marchildon et al., 2008).

Beyond adaptation, the Special Areas Board also able to reduce the physical exposure to drought. To convert land tenure from small wheat farms to large ranch-farm operations of cattle and sheep required an active policy of herd reduction, which was initiated by the provincial government but later taken over by administrative boards in the Special Areas (Marchildon, 2007).

In the 2001-2002 drought, the impact of the drought was mitigated for urban users by a secure water supply, while the agricultural community was severely impacted and required adaptation. However, farmers were relatively far less vulnerable during the 2001-2002 drought than in the 1920s and 1930s. This was likely due to several factors. Firstly, farming practices have undergone significant changes since the 20s, such as zero tillage and increasing parcel size. Secondly, farmers have a much higher adaptive capacity, as they come from a history of drought management, and have had a couple generations to become highly developed drought managers. Thirdly, adaptive capacity includes access to resources and capital, such as water. However, additional income needed to absorb income loss or using capital to meet feed needs highlights the importance of non- agricultural income sources, such as off- farm work and oil and gas leases (Wandel et al., 2009).

Locally- based institutions in the Special Areas also play a significant role in drought management and facilitate some drought management strategies. The ATCO pipelines and Henry Kroeger Regional Water Services Commission supply water for municipalities and those who have access from the pipelines. Agriculture and Agri- Food Canada Prairie Farm Rehabilitation Administration (AAFC-PFRA) field office was instrumental in dugout design and improvements. As well, the Special Areas Board maintains community pastures to lessen the stress on owned and leased parcels and

manages the Carolside- Deadfish irrigation project. The Board also maintains rental equipment for minimum tillage and constructing shallow water pipelines. The overall governance structure of the Special Areas facilitates long- term planning for increased adaptive capacity (Wandel et al., 2009).

14.0 Drought Adaptation

During the 1930s and the subsequent decades, as well as following the drought in the early 2000s, numerous adaptations have been implemented in the Canadian Prairies to foster more sustainable agriculture. Bryant et al. (2000), Wall & Smit (2005), Wittrock & Wheaton (2007), as well as Marchildon et al. (2008) describe the chronology and nature of these adaptations fully. Thought they have for the most part worked successfully, challenges associated with changing climate and water supply and demand will require more sustainable adaptations. In the Canadian Prairies, most adaptations undertaken pertain to agricultural technological developments, government agricultural programs and insurance, farm production practices, and farm financial management (Smit & Skinner, 2002; Wittrock & Wheaton, 2007).

The challenges faced by a changing climate and water management issues do not only affect agricultural production. There are other economic, environmental, health, and social impacts in both the rural and urban centres that require adaptation measures to be initiated to ensure sustainable communities and watersheds (Thompson, 2011).

Regardless of the type of adaptations that are put into place, in order for successful and legitimate adaptation is dependent upon what is perceived to be of worth in preserving and achieving. To create adaptation plans that reflect the diverse values in communities, adaptations require increased community involvement to identify what matters to local groups and organizations (O'Brien & Wolf, 2010). In turn, implementation of adaptation strategies may have more success.

15.0 Monitoring Programs

15.1 International

Drought is a universal risk that is monitored and managed in accordance with the needs of the people. The purpose behind creating a drought early warning system is to identify climate and water supply trends, thereby detecting the emergence and probability of drought occurrence, as well as the possible severity of the drought. Having this information can reduce impacts if delivered to decision makers in a timely and appropriate format and if mitigation measures and preparedness plans are in place. Understanding the underlying causes of vulnerability is also an essential component of drought management. The ultimate goal is to reduce risk for a particular location and for a specific group of people or economic sector (World Meteorological Organization (WMO), 2006).

The World Meteorological Organization (WMO) encourages the development of effective monitoring, and early warning and delivery systems that will continuously track indicators relating to water supply and drought, as well as indices of climate-based variables. An essential part of these systems is to deliver this information to decision makers, facilitating the early detection of drought conditions and triggering of mitigation and emergency response measures, the main ingredients of a drought preparedness plan (WMO, 2006).

The main objective of World AgroMeteorological Information Service (WAMIS) is to provide a dedicated webserver for disseminating agrometeorological products and information issued by WMO Members (World AgroMeteorological Information Service, 2011).

The North American Drought Monitor (NADM) was established as a cooperative effort among drought experts in Canada, Mexico and the United States to monitor drought across the continent on an ongoing basis (National Oceanic and Atmospheric Administration (NOAA), 2010).

15.2 Canadian

The Canadian Drought Alert and Monitoring Program (CDAMP) was developed by the Adaptation and Impacts Research Division of Environment Canada in response to the increasing importance of drought to Canadians. Extreme drought conditions in the recent past have led to major economic losses in several parts of Canada, and have made Canadians cautious of the potential of droughts associated with climate change to increase in frequency and in severity. CDAMP was a web-based self-analysis tool that can be used for drought evaluation through the use of simple precipitation measurement and tracking to help individuals, farms, and potentially communities and municipalities, analyze the level of their current rainfall deficiencies and adapt accordingly (Environment Canada, 2010). As of fall 2011, this program has been removed.

The National Agroclimate Information Service (NAIS) brings together expertise and resources from operational, research and policy units. The aim is to provide information to manage risk and increase adaptability under climate variability now and in the future (Hawden, 2011) with an emphasis on drought early warning and support to disaster relief through associated agencies (Howard, 2010.).

Agriculture and Agri-Food Canada's Drought Watch provides timely information of the impacts of climatic variability on water supply and agriculture, and promotes practices that reduce drought vulnerability (ie. fallow and crop management, securing livestock water, pest control, etc.) and improve management during a drought (AAFC, 2009).

On-Farm Surface Water Supply and Forage Conditions Monitoring Program provides assessments of on-farm water supplies, potential forage production, and forage supplies on a monthly basis from May to November throughout the Prairie region. Data collected by a voluntary network of producers and agricultural industry representatives, and accumulated by AAFC–Agri–Environmental Services Branch (AESB) district staff (AAFC, 2011e).

15.3 Alberta

Several monitoring programs have been set up in Alberta through the provincial government. All are accessible online, and more provide year-round precipitation information.

AgroClimatic Information Service (ACIS) is an "interactive tool that helps producers, farm consultants and researchers view weather forecasts, current and historic maps, and access weather data received from more than 270 weather stations in and around Alberta. This service was developed to describe Alberta's weather, climate and related agriculture features to help with your long-term planning and decision-making throughout the year" (ARD, 2010a)

The Agricultural Moisture Situation Update, also through Albert Agriculture and Rural Development was developed to provide weekly updates of soil moisture and precipitation conditions during the growing season and monthly during winter months by the drought modelling team (ARD, 2005).

16.0 Conclusion

16.1 Recommendations

16.1.1 Adaptation Recommendations

In many areas, policy frameworks exist to facilitate an institutional adaptive response for climate-induced drought. However, these policies and management practices need to be evaluated in terms of address all pertinent sectors and supporting sustainable adaptation (Sauchyn et al., 2010). Many recommendations have been brought forward regarding a potential course of action for drought management and policy. Many areas of the social, environmental, and economic sectors that impact those in the Battle River watershed have no policies or plans in place in the event of a severe, multi-year drought.

Drought management policies should be implemented on a local, regional, provincial and federal scale. Local and regional stakeholders ought to work together to develop policies and guidelines for local and regional implementation. These policies

should be created through collaboration, and foster coordination and cooperation to through all levels of government. Harmonization of these policies in terms of roles and responsibilities with other institutions and organizations will optimize effectiveness (Wilhite et al., 2007).

In their report pertaining to understanding drought adaptation processes in the Canada prairies, Wittrock & Wheaton (2007) suggested several recommendations on the drought adaptation process (p. 53):

• Improved methods to assess adaptation.

• Further research into the understanding and modeling of drought adaptation processes and measures, including their uptake, effectiveness, time lags, geographical patterns, practicality, costs, and benefits.

• Enhanced linkages of science and decision making using various methods, including interactive models, workshops, and implementation and management of adaptation.

• Improved knowledge regarding adaptation to prolonged and more severe droughts (and other extremes) including those that may be related to climate change.

• Determine changes in adaptation and thus vulnerability over time and space.

• Better ability to assess the consequences of alternative drought adaptation strategies.

The Saskatchewan Watershed Authority has recommended the development and creation of an Interprovincial Drought Communication Collaborative (Rescan, 2011). The framework for this collaborative would be to address some gaps and needs. These include (p.5-4):

- Develop a Prairie Drought Community of Practice,
- Coordinate Interprovincial drought communication through an existing interprovincial group, such as the Water Stewardship Council, and ensure representation from key federal departments,
- Organize annual or biannual interprovincial forums for learning,

- Utilize Agriculture and Agri-Food Canada decision-making tools, such as the Drought Preparedness Partnership Table-top Exercise, or Invitational Drought Tournament Simulation exercise to facilitate learning,
- Develop a website and portal as a 'one-stop shop' for Prairie drought,
- Share Technical tools utilized by practitioners in Prairie jurisdictions for drought characterization and preparedness, and
- Develop an easily searchable directory and database of individuals working on drought in the Prairies.

Climate variability is an important factor in the management of water in the Battle River watershed. With increasingly uncertain water supplies, major innovations in planning and management of water allocation, storage, use, and distribution are needed (Sauchyn et al., 2010). To better understand climate variability in the Battle River watershed for the purpose of managing risk, additional analysis is recommended to complete trends in wind, temperature and precipitation leading up to and during short-term drought periods observed in the watershed over the past century. This data will enable the development of a framework and guidelines that result in the creation of specific tools or methods to anticipate and manage water during deficit periods.

16.1.2 Policy Development Recommendations

Drought planning should be developed for different governance levels. At the national level focus should be put in policy, legal and institutional aspects, and funding aspects to mitigate extreme drought effects. At the river watershed level, plans should be mainly aimed at identifying and scheduling tactical measures to delay and mitigate the impacts of drought. As a result, measures involved are primarily focused on water demand and water conservation measures and environmental objectives. At the local level, the main issues would pertain to tactical and response measures to secure essential public water supply and to create and orchestrate awareness measures (EC, 2008).

In the development of federal, provincial, and local strategies for reducing drought risk as well as the implementation of these strategies, the UNISDR recommends that the process be guided by these principles:

1. Political commitment, high-level engagement, strong institutional setting, clear responsibilities both at central and local levels and appropriate governance are essential for integrating drought risk issues into a sustainable development and disaster risk reduction process;
2. A bottom-up approach with effective decentralization and active community participation for drought risk management in planning, decision making and implementation, is essential to move from policy to practice;
3. Capacity building and knowledge development are usually required to help build political commitment, competent institutions and an informed constituency;
4. Drought risk reduction policies should establish a clear set of principles or operating guidelines to govern the management of drought and its impacts, including the development of a preparedness plan that lays out a strategy to achieve these objectives;
5. Drought-related policies and plans should emphasize risk reduction (prevention, mitigation and preparedness) rather than relying solely on drought (often turned into famine) relief;
6. Drought monitoring, risk assessment and other appropriate risk reduction measures are principal components of drought policies and plans;
7. Institutional mechanisms (policy, legislative and organizational) should be developed and enforced to ensure that drought risk reduction strategies are carried out; and
8. Sound development of long-term investment in risk reduction measures (prevention, mitigation and preparedness) is essential to reduce the effects of drought (UNISDR, 2009, p.ix).

The UNISDR (2009) maintains that a drought policy should establish a clear set of principles or operating guidelines to govern the mitigation and management of drought and its impacts as well as the development of a preparedness plan that lays out a strategy to achieve these objectives. Any policy and plan should specify respective roles of government, local communities, land users, industry, and any other stakeholders, as well as the resources available and required to implement appropriate drought risk reduction activities. As drought policies may vary to reflect local needs, drought related polices should address the following concepts (UNISDR, 2009, p.27):

1. Provide for effective participation at the local, national, and regional levels of non-governmental organizations and populations (both women and men) in policy

planning, decision making, and implementation and review of national action programmes;

2. Be rooted in thorough vulnerability, risk, capacity, and needs assessments, highlighting the root causes of the issues related to drought at national, sub-national, local, and transboundary scales;
3. Focus on strengthening the capacities of governments and communities to identify, assess, and monitor drought risks at national and sub-national levels for effective development planning, including strengthening of people-centred early warning systems and preparedness;
4. Incorporate both short and long-term strategies to build the resilience of governments and communities to reduce the risks associated with drought, emphasize implementation of these strategies, and ensure they are integrated with national policies for sustainable development;
5. Link drought early warning indicators with appropriate drought mitigation and response actions to ensure effective drought management;
6. Allow for modifications to be made in response to changing circumstances and be sufficiently flexible at the local level to cope with different socio-economic, biological and geo-physical conditions;
7. Promote policies and strengthen institutional frameworks which develop cooperation and coordination, in a spirit of partnership, between the donor community, governments at all levels, local populations, and community groups, and facilitate access by local populations to appropriate information and technology;
8. Designate agencies and stakeholders responsible for carrying out drought mitigation and response actions, and require regular review of, and progress reports on, their implementation; and
9. Strengthen drought preparedness and management, including drought contingency plans at the local, national, sub-regional and regional levels that take into consideration seasonal to inter-annual climate predictions.

Out of the European Commission's 2007 communication on water scarcity and drought, several potential policy directions were suggested for tackling water scarcity and drought issues (European Commission (EC), 2012):

- Putting the right price tag on water
- Allocating water and water-related funding more efficiently
- Improving drought risk management
- Considering additional water supply infrastructures

- Fostering water efficient technologies and practices
- Fostering the emergence of a water-saving culture in Europe
- Improve knowledge and data collection

16.2 Summary

In the Battle River Basin, many programs are in place to assist the agriculture sector in the event of a drought. However, few other sectors have established extensive programs and policies to provide aid and support in the event of a drought. Many factors are involved in fostering watershed sustainability, but most have not accounted for the social, economic, and environmental impacts created by a severe drought or water scarcity event. Though many of the recommended adaptations appear to rely on government coordination, sustainable adaptation to multi-year drought event depends on individuals, communities, and other organizations working at different scales to implement appropriate water management measures and using monitoring tools that are available.

Information gathered in this report will assist the Battle River Watershed Alliance Policy Committee in collaborating and cooperation with residents, municipalities, industry, private businesses, and other stakeholders in the watershed to develop drought policy recommendations and potential implementation guidelines. Open dialogue will help to meet the needs of the residents, and address the economic, social, and environmental components in to help enable the sustainable use of our land and water resources.

17.0 References

Aboriginal Affairs and Northern Development Canada (AANDC). (2010). Measuring well-being: The Community Well-Being (CWB) Index. Retrieved from http://www.aadnc-aandc.gc.ca/eng/1100100016579/1100100016580

Adger, W.N., & Kelly, P.M. (1999). Social vulnerability to climate change and the architecture of entitlements. *Mitigation and Adaptation Strategies for Global Change* 4, 253–266.

Agriculture and Agri-Food Canada (AAFC). (2004). Canada-Alberta Farm Stewardship Program (CAFSP) Q&A's. Retrieved from http://www4.agr.gc.ca/resources/prod/doc/env/efp-pfa/pdf/ab/ab_CAFSP_qa_e.pdf

Agriculture and Agri-Food Canada (AAFC). (2005). The Canada-Alberta Water Supply Expansion Program. Retrieved from http://www4.agr.gc.ca/resources/prod/doc/env/h2o/pdf/CAWSEP_factsheet_e.pdf

Agriculture and Agri-Food Canada (AAFC). (2007). Greencover Canada. Retrieved from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1181580137261&lang=eng

Agriculture and Agri-Food Canada (AAFC). (2009). Drought Watch. Retrieved from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1261500976421&lang=eng

Agriculture and Agri-Food Canada (AAFC). (2010). Prairie Shelterbelt Program. Retrieved from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1286907236630&lang=eng#l1

Agriculture and Agri-Food Canada (AAFC). (2011)a. Advance Payments Program (APP). Retrieved from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1290176119212&lang=eng

Agriculture and Agri-Food Canada (AAFC). (2011)b. Community Pasture Program. Retrieved from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1298388156452&lang=eng

Agriculture and Agri-Food Canada (AAFC). (2011)c. Farm Stress Information. Retrieved from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1256682425701&lang=eng

Agriculture and Agri-Food Canada (AAFC). (2011)d. Growing Forward Agricultural Policy Framework. Retrieved from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1200339470715&lang=eng

Agriculture and Agri-Food Canada (AAFC). (2011)e. On-farm surface water supply and forage conditions monitoring: 2010 seasonal review. Department Agriculture and Agri-Food Canada, Branch Agri-Environment Services Branch, National Agroclimate Information Service (NAIS) (Publication No. AAFC No. 11414E) Retrieved from http://publications.gc.ca/collections/collection_2011/agr/A124-2-2010-eng.pdf

Agriculture and Agri-Food Canada (AAFC). (2011)f. Tax Deferral Designation. Retrieved from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1256659484318&lang=eng

Agriculture and Agri-Food Canada (AAFC). (2011)g. Watershed Evaluation of Beneficial Management Practices. Retrieved from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1285354752471&lang=eng

Agriculture and Agri-Food Canada (AAFC). (2011)h. Watershed Evaluation of Beneficial Management Practices – About Us. Retrieved from http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1296246973332&lang=eng

Agriculture Financial Services Corporation (AFSC). (2011). 2010 Canada - Alberta Pasture Recovery Initiative (CAPRI). Retrieved from http://www.afsc.ca/doc.aspx?id=3786

Alberta Agriculture and Rural Development (ARD). (2004). Drought Response Actions. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/ppe9025#response

Alberta Agriculture and Rural Development (ARD). (2004). Recognizing and handling stress in rural Alberta - Frequently asked questions. Retrieved from http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/faq8848

Alberta Agriculture and Rural Development (ARD). (2005). Agricultural Moisture Situation Updates. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/ppe9917

Alberta Agriculture and Rural Development (ARD). (2008). Drought proofing farm water supplies. Retrieved from

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/ppe1111?opendocument#on-farm

Alberta Agriculture and Rural Development (ARD). (2010)a. AgroClimate Information Service (ACIS). Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/cl12944

Alberta Agriculture and Rural Development (ARD). (2010)b. Alberta's Agriculture Drought Risk Management Plan May 2010. Retrieved from http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/ppe3883/$FILE/2010_ADRMP_Final.pdf

Alberta Agriculture and Rural Development (ARD). (2010)c. Stewardship Plans. Retrieved from http://www1.agric.gov.ab.ca/general/progserv.nsf/all/pgmsrv417

Alberta Association of Municipal Districts & Counties, & Alberta Environment. (2009). Rural municipal action on climate change – environmental scan. Retrieved from http://www.aamdc.com/docman/cat_view/111-reports?orderby=dmdate_published&ascdesc=DESC

Alberta Centre for Sustainable Rural Communities. (2011, March). BRAED "Voices of Prosperity". Symposium Report and evaluation results *from BRAED "Voices of Prosperity" Symposium*. Killam, Alberta: BRAED. Retrieved from http://www.braedalberta.ca/userfiles/file/2011/BRAED-VOPSymposiumReport.pdf

Alberta Environment (1999). Surface water quality guidelines for use in Alberta. (Publication No. T/483). Alberta Environment: Edmonton, Alberta.

Alberta Environment. (2010). Alberta Water Act (factsheet). Retrieved from http://environment.alberta.ca/documents/Alberta_Water_Act_August_2010.pdf

Alberta Mental Health Board. (2002)a. Managing stress. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/ppe9025 Accessed mar.6

Alberta Mental Health Board. (2002)b. Preventing suicide. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/ppe9025 Accessed Mar. 6

Alberta Mental Health Board. (2002)c. Resiliency in rural people. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/ppe9025

Alberta Riparian Habitat Management Society (Cows and Fish). (2011). What is Cows and Fish? Retrieved from http://www.cowsandfish.org/about/about.html

Alberta Rural Development Network. (2010). What is ARDN? Retrieved from http://ardn.ca/about-us/

Alberta Water Resources Commission. (1993). Wetland management on the settled area of Alberta: An interim policy. Retrieved from http://www3.gov.ab.ca/env/water/reports/1wmsa.pdf

Alberta WaterPortal. (2011). Alberta water legislation, regulations & guidelines. Retrieved from http://www.albertawater.com/index.php?option=com_content&view=article&id=54&Itemid=60

Alson, M. & Kent, J. (2004). Social impacts of drought: a report to NSW Agriculture. Charles Stuart University Centre for Rural Social Research, Wagga Wagga, N.S.W.

Anderson, M. (2009). Between the ducks and a hard place. *Conservator* 30(1), 16-22. Retrieved from http://www.ducks.ca/aboutduc/news/conservator/301/301.pdf

Antón, J., S. Kimura and R. Martini (2011), "Risk Management in Agriculture in Canada", *OECD Food, Agriculture and Fisheries Working Papers*, No. 40, OECD Publishing. Retrieved from http://dx.doi.org/10.1787/5kgj0d6189wg-en

Arnell, N., C. Liu, R. Compagnucci, L. da Cunha, K. Hanaki, C. Howe, G. Mailu, I. Shiklomanov, and E. Stakhiv. 2001: Hydrology and water resources. *Climate Change 2001: Impacts, Adaptation and Vulnerability. Contributions on Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, J. J. McCarthy, O. F. Canziani, N. A. Leary, D. J. Dokken, and K. S. White, Eds. Cambridge University Press, Cambridge, UK, 191-234.

Atkinson, M. M. & Coleman, W.D. (1992). Policy networks, policy communities and the problems of governance. *Governance* 5(2), 154-180. doi: 10.1111/j.1468-0491.1992.tb00034.x

Australian Institute of Family Studies. (2008). *Social and economic impacts of drought on farm families and rural communities*. Submission to the Productivity Commission's Inquiry into Government Drought Support. Retrieved from http://www.pc.gov.au/__data/assets/pdf_file/0006/83058/sub092.pdf

Barrow E., B. Maxwell and P. Gachon (Eds), 2004. Climate Variability and Change in Canada: Past, Present and Future (ACSD Science Assessment Series No. 2). Toronto, Ontario: Meteorological Service of Canada, Environment Canada. Retrieved from http://cccsn.ca/documents/Climate_Variability_and_Change_en.pdf

Barrow, E., & Yu, G. (2005). Climate scenarios for Alberta. Regina, Saskatchewan. Report for the Prairie Adaptation Research Collaborative (PARC) in co-operation with Alberta Environment.

Battle River Watershed Alliance (BRWA). (2012)a. Battle River watershed management planning process: Phase two terms of reference February 2012. Camrose Alberta: Battle River Watershed Alliance.

Battle River Watershed Alliance (BRWA). (2012)b. Battle River policy committee terms of reference February 2012. Camrose Alberta: Battle River Watershed Alliance.

Bélanger, D., Berry, P., Bouchet, V., Charron, D., Clarke, K., Doyon, B., Fleury, M., Furgal, C. , Gosselin, P., Lamy, S., Lindsay, L. R., McBean, G., Ogden, N. H., Séguin, J., Shuster, C. J., & Soskolne, C. L. (2011). Human Health in a changing climate: A Canadian assessment of vulnerabilities and adaptive capacity. (Catalogue No.: H128-1/08-528E). Ottawa, Canada: Health Canada. Retrieved from http://www.hc-sc.gc.ca/ewh-semt/climat/eval/index-eng.php

Bryant, C.R., Smt, B., Brklacich, M., Johnston, T.R., Smithers, J., Chiotti, Q., & Singh, B. (2000). Adaptation in Canadian agriculture to climate variability and change. *Climate Change 45*, 181-201.

Centre for Rural & Remote Mental Health in New South Wales. (2008). NSW Drought Mental Health Assistance Package. Final report of the NSW Drought Mental Health Assistance Package. Retrieved from http://www.health.nsw.gov.au/pubs/2008/pdf/drought_package.pdf

City of Camrose. (2006). Water conservation / water use policy. Retrieved from http://www.camrose.com/DocumentView.aspx?DID=214

Cohen, S., K. Miller, K. Duncan, E. Gregorich, P. Groffman, P. Kovacs, V. Magaña, D. McKnight, E. Mills, and D. Schimel, 2001: North America. *Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, J. J. McCarthy, O. F. Canziani, N. A. Leary, D. J. Dokken, and K. S. White, Eds. Cambridge University Press, Cambridge, UK, 735-800. Retrieved from http://www.grida.no/climate/ipcc_tar/wg2/pdf/wg2TARchap15.pdf

Coleman, W. D. & Skogstad, G. (Eds.). (1990). Policy communities and public policy in Canada. Toronto: Copp Clark Pitman.

Confalonieri, U., B. Menne, R. Akhtar, K.L. Ebi, M. Hauengue, R.S. Kovats, B. Revich and A. Woodward, 2007: Human health. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 391-431. Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter8.pdf

Davidson, D.J. (2010). Climate Change: Projections and Implications for Edmonton. The Edmonton Sustainability Papers – May 2010. (Discussion Paper 6). Retrieved from http://www.edmonton.ca/city_government/documents/Discussion_Paper_6_Climate_Change_Projections_and_Implications_for_Edmonton.pdf#xml=http://search1.edmonton.ca/texis/ThunderstoneSearchService/pdfhi.txt?query=drought+measures&pr=www.edmonton.ca&prox=page&rorder=750&rprox=250&rdfreq=0&rwfreq=0&rlead=750&rdepth=0&sufs=1&order=r&cq=&id=4e94355c51

Department of Agriculture, Fisheries and Forestry. (2010). Drought Force. Retrieved from http://www.daff.gov.au/agriculture-food/drought/assistance/drought_force

Department of Human Services. (2006). 'Tackling Mental Health' Drought Initiatives. Retrieved from http://www.deakin.edu.au/hmnbs/hsd/news/drought-genera-report-06-07.pdf

Ducks Unlimited Canada (DUC). (2008). Conservation easements. Retrieved from http://www.ducks.ca/province/ab/how/ground/protect/pdf/easement.pdf

econnics. (2010). British Columbia Drought Response Plan. Victoria, British Columbia: econnics. Retrieved from http://www.env.gov.bc.ca/wsd/public_safety/drought_info/cabinet/bc_drought_response_plan_june-2010.pdf

Environment Canada. (1987). Federal Water Policy. Retrieved from http://ec.gc.ca/eau-water/D11549FA-9FA9-443D-80A8-5ADCE35A3EFF/e_fedpol.pdf

Environment Canada. (2010). Canadian Drought Alert and Monitoring Program **(**CDAMP). Retrieved from http://www.cdamp.ca/intro-e.html

European Commission (EC). (2008). Drought Management Plan Report. (Technical Report No. 2008-023). Luxembourg: Office for Official Publications of the

European Communities. Retrieved from http://ec.europa.eu/environment/water/quantity/pdf/dmp_report.pdf

EC. (2012). Water scarcity & droughts in the European Union. Retrieved from http://ec.europa.eu/environment/water/quantity/eu_action.htm#2007_com

European Environment Agency (EEA). (2009). Water resources across Europe — confronting water scarcity and drought. (EEA Report No. 2/2009). Luxembourg: Office for Official Publications of the European Communities. doi: 10.2800/16803. Retrieved from http://www.eea.europa.eu/publications/water-resources-across-europe

Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652. Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter14.pdf

Fitch, L., B. Adams and K. O'Shaughnessy. (2003). Caring for the green zone: Riparian areas and grazing management - Third Edition. Lethbridge, Alberta: Cows and Fish Program.

Füssel, H., & Klein. R.J.T. (2006). Climate change vulnerability assessments: An evolution of conceptual thinking. *Climate Change* 75(3), 301-329.

Golder Associates Ltd. (2010). Water conservation, efficiency and productivity plan for the upstream oil and gas sector. Prepared for the Oil Sands Developers Group (OSDG) and the Canadian Association of Petroleum Producers (CAPP). (Publication No. 2010-0026). Calgary, Alberta: Canadian Association of Petroleum Producers (CAPP). Retrieved from http://www.albertawater.com/reports/CAPP_EDMSDraftPlan.pdf

Gómez Gómez, C.M., & Pérez Blanco, C.D. (2012). Do drought management plans reduce drought risk? A risk assessment model for a Mediterranean river basin, *Ecological Economics* 76, 42-48. doi:10.1016/j.ecolecon.2012.01.008

Government of Alberta. (2003). *Water for Life: Alberta's Strategy for Sustainability*. Government of Alberta. (Publication No. 1/955). Edmonton, Alberta: Alberta Environment. Retrieved from http://www.waterforlife.alberta.ca/01548.html

Government of Alberta. (2006). Water conservation and allocation policy. Government of Alberta. (Publication No. 1/969). Edmonton, Alberta: Government of Alberta. Retrieved from http://www.waterforlife.gov.ab.ca/docs/Oilfield_Injection_Policy.pdf

Government of British Columbia. (2011). Living water Smart - Drought. Retrieved from http://www.livingwatersmart.ca/drought/

Great Lakes Commission (GLC). (1989). Draft guide to drought planning, management and water level changes in the Great Lakes, second draft. Great Lakes Commission Task Force on Drought Management and Great Lakes Water Levels, Ann Arbor, MI. Retrieved from http://www.glc.org/policy/documents/DroughtManagement-Nov1989.pdf

GLC. (1990). A guidebook to drought planning, management and water level changes in the Great Lakes. Ann Arbor, Michigan: Great Lakes Commission.

GLC. (2009). Great Lakes Commission Policy Positions. Retrieved from http://glc.org/policy/documents/GLCPolicyPositions.pdf

Griffiths, M., & Woynillowicz. (2003). Oil and troubled waters: Reducing the impact of the oil and gas industry on Alberta's water resources. Drayton Valley, Alberta: Pembina Institute. Retrieved from http://www.pembina.org/pub/154

Haugan, D. (2010). Prevented planting insurance provisions: Drought. United States Department of Agriculture (USDA) – Risk Management Agency. Retrieved from http://www.usda.gov/wps/portal/usda/usdahome?navid=DISASTER_ASSISTANCE&navtype=RT&parentnav=RURAL_DEVELOPMENT

Hawden, T. (2011, April). Drought Monitoring in Canada - The Canadian Drought Monitor. *US Drought Monitor Forum*. Symposium conducted at the meeting of the US Drought Monitor, Fairfax, Virginia. Retrieved from http://eastfire.gmu.edu/DMF2011/Home/doc/Hadwen_DroughtMonitoring_in_Canada.pdf

Henry, C. (2002). Impacts of climate change on human health. (Climate Change Central Discussion Paper C3-08). Edmonton, Alberta: C3. Retrieved from http://www.bvsde.paho.org/bvsacd/cd68/impactscc.pdf

Howard, A. (2010, July). Agroclimate service in Canada. *XV Session of the Commission for Agricultural Meteorology (CAgM)*. Session conducted at the meeting of the World Meteorological Organization, Belo Horizonte, Brazil. Retrieved from http://www.wamis.org/agm/meetings/cagm15/OF_Howard_Canada.pdf

Intergovernmental Panel on Climate Change (IPCC). (2001). Annex B: Glossary of terms. In: *Climate Change 2001: Synthesis Report. A Contribution of Working Groups I, II, and III to the Third Assessment Report of the Intergovernmental Panel on Climate Change* [Watson, R.T. and the Core Writing Team (eds.)]. Cambridge University Press, Cambridge, United Kingdom, and New York, NY, USA, 365-389. Retrieved from http://www.grida.no/publications/other/ipcc_tar/

IPCC. (2007)a. Summary for Policymakers. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 7-22. Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf

IPCC. (2007)b. Summary for Policymakers. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf

International Scientific Steering Committee. (2005). Avoiding dangerous climate change. *International symposium on the stabilization of greenhouse gas concentrations*. Symposium conducted at the meeting of the International Scientific Steering Committee, Exeter, U.K. Retrieved from http://stabilisation.metoffice.com/Steering_Commitee_Report.pdf

Interstate Council on Water Policy (ICWP). (2011). About ICWP. Retrieved from http://www.icwp.org/cms/index.php?option=com_content&view=article&id=48&Itemid=28

Jimenez, K.J. (2009). Water scarcity and desertification. (UNCCD Thematic Factsheet Series No. 2). Bonn, Germany: United Nations Convention to Combat Desertification. Retrieved from http://www.unccd.int/Lists/SiteDocumentLibrary/Publications/Desertificationandwater.pdf

Kalkstein L., & Smoyer, K. (1993). The impact of climate change on human health: Some international implications. *Experientia*, 49(11), 969-79. doi: 10.1007/BF02125644

Kampragou, E., Apostolaki, S., Manoli, E., Froebrich, J., & Assimacopoulos, D. (2011). Towards the harmonization of water-related policies for managing drought risks across the EU. *Environmental Science & Policy* 14, 815-824. doi:10.1016/j.envsci.2011.04.001

Kerby, J. (1999). National Drought Policy Commission (NDPC) factsheet. Washington, DC United States Department of Agriculture (USDA). Retrieved from http://govinfo.library.unt.edu/drought/reference/reference.htm

Kharin, V.V., and F.W. Zwiers, 2005: Estimating extremes in transient climate change simulations. *Journal of Climate* 18, 1156-1173.

Klein, R.J.T., S. Huq, F. Denton, T.E. Downing, R.G. Richels, J.B. Robinson, F.L. Toth, 2007: Inter-relationships between adaptation and mitigation. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 745-777. Retrieved from http://www.ipcc.ch/publications_and_data/ar4/wg2/en/contents.html

Kulshreshtha, S.N. (2011). Climate change, prairie agriculture, and prairie economy: the new normal. *Canadian Journal of Agricultural Economics* 59(1), 19–44. doi: 10.1111/j.1744-7976.2010.01211.x

Kundzewicz, Z.W., L.J. Mata, N.W. Arnell, P. Döll, P. Kabat, B. Jiménez, K.A. Miller, T. Oki, Z. Sen and I.A. Shiklomanov, 2007: Freshwater resources and their management. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 173-210. Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter3.pdf

Kwasniak, A. (2001). Alberta's wetlands: A law and policy guide. Edmonton Alberta: North American Waterfowl Management Plan (NAWMP). Retrieved from http://www.edmonton.ca/environmental/documents/Alberta_Wetlands_Guide.pdf

Lake, P.S. (2003). Ecological effects of perturbation by drought in flowing waters. *Freshwater Biology*, 48(7), 1161-1172. doi:10.1046/j.1365-2427.2003.01086.x

Lee, K.N. (1993). *Compass and Gyroscope: Integrating science and politics for the environment*. Washington, DC: Island Press.

Lemmen, D.S., & Warren, F.J.(Eds.). 2004. Climate change impacts and adaptation: A Canadian perspective. Ottawa, Ontario: Natural Resources Canada. Retrieved from http://www.nrcan.gc.ca/sites/www.nrcan.gc.ca.earth-sciences/files/pdf/perspective/pdf/report_e.pdf

Lemmen, D.S., Warren, F.J., Lacroix, J., & Bush, E.(Eds). (2008). From impacts to adaptation: Canada in a changing climate 2007. Ottawa, ON: Government of Canada. Retrieved from http://www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/assessments/132

Maathuis, H., & Thorleifson, L.H. (2000). Potential impact of climate change on prairie groundwater supplies: Review of current knowledge. (SRC Publication No. 11304-2E00). Saskatoon, Saskatchewan: Saskatchewan Research Council. Retrieved from http://www.parc.ca/pdf/research_publications/renamed/QS-6.pdf

Marchildon, G.P. (2007). Institutional adaptation to drought and the special areas of Alberta, 1909-1939. *Prairie Forum* 32(2), 251-272.

Marchildon, G.P., S. Kulshreshtha, E. Wheaton, and D. Sauchyn. 2008. Drought and institutional adaptation in the Great Plains of Alberta and Saskatchewan, 1914-1939. *Natural Hazards* 45(3), 391-411.

Millennium Ecosystem Assessment. (2005). Ecosystems and human well-being: Wetlands and water synthesis. Washington, D.C.: World Resources Institute. Retrieved from http://www.maweb.org/documents/document.358.aspx.pdf

Ministry of Agriculture. (2011). Drought. Retrieved from http://www.agf.gov.bc.ca/emergency/Drought/Drought.htm

Ministry of Natural Resources, Ministry of Environment, Ministry AFRA, Ministry of Municipal Affairs and Housing, Ministry of Enterprise, Opportunity, and Innovation, Association of Municipalities of Ontario, Conservation Ontario. (2003). Ontario low water response. Available at http://www.mnr.gov.on.ca/MNR/water2000/OLWR_opt.pdf

Mitchell, B. (1997). *Resource and Environmental Management.* Waterloo, ON.: Longman Press.

Morrison, D. (2002). On dry land. *Conservator* 23(2), 30-35. Retrieved from http://www.ducks.ca/aboutduc/news/conservator/232/232.pdf

Motha, R. (2011). Elements of national drought policy in USA. In M.V.K Sivakumar, R.P. Motha, D.A. Wilhite, & J.J. Qu (Eds.), *Towards a Compendium on National*

Drought Policy (pp.46-55). Proceedings of an Expert Meeting on the Preparation of a Compendium on National Drought Policy. Washington DC: World Meteorological Organization. AGM-12; WAOB-2011. Retrieved from http://www.wmo.int/pages/prog/wcp/agm/meetings/hmndp13/hioc_1/documents/Doc_2.3_Proceedings_Compendium_NDP.pdf

Municipal Affairs. (2011). Community development trust fund. Retrieved from http://www.municipalaffairs.alberta.ca/municipalgrants-description.cfm?program_id=31

National Drought Mitigation Center (NDMC). (2012). U.S. drought policy. Retrieved from http://drought.unl.edu/Planning/USPolicy.aspx

National Drought Policy Commission (NDPC). (2000). Preparing for drought in the 21st century. Report of the National Drought Policy Commission. Washington, DC: U.S. Department of Agriculture (USDA). Retrieved from http://govinfo.library.unt.edu/drought/finalreport/accesstoreports.htm

National Energy Technology Laboratory (NETL). (2009). Impact of drought on U.S. steam electric power plant cooling water intakes and related water resource management issues. (Report No. DOE/NETL-2009/1364). Washington, DC: U.S. Department of Energy. Retrieved from http://www.netl.doe.gov/technologies/coalpower/ewr/water/pdfs/final-drought%20impacts.pdf

National Integrated Drought Information System (NIDIS). (n.d.)a. Long-term drought relief and recovery. Retrieved from http://www.drought.gov/portal/server.pt/community/recovery/275/long-term/538

NIDIS. (n.d.)b. U.S. drought portal: What is NIDIS? Retrieved from http://www.drought.gov/portal/server.pt/community/what_is_nidis/207

National Oceanic and Atmospheric Administration (NOAA). (2010). North American drought monitor. National Climatic Data Center. Retrieved from http://www.ncdc.noaa.gov/temp-and-precip/drought/nadm/index.html

Natural Resources Canada. (2011). Canadian environmental acts, regulations and guidelines. Retrieved from http://www.nrcan.gc.ca/minerals-metals/business-market/recycling/3313

O'Brien, K.L, & Wolf, J. (2010). A values-based approach to vulnerability and adaptation to climate change. *Wiley Interdisciplinary Reviews Climate Change* 1(2), 232-242.

Rescan. 2011. *Prairie Regional Adaptation Collaborative: Development of an interprovincial drought communication framework*. Prepared for Saskatchewan Watershed Authority. Saskatoon, Saskatchewan: Rescan Environmental Services Ltd. Retrieved from http://www.parc.ca/rac/index.php?page=droughtButton

Rowan, K., Pittman, J., Wittrock, V., Hershmiller, A., & Nielsen, J. (2011). Assiniboine Watershed Stewardship Association drought and excessive moisture preparedness plan. Yorkton, Saskatchewan: Saskatchewan Watershed Authority and Natural Resources Canada. Retrieved from http://www.parc.ca/rac/fileManagement/upload/AWSA_D_%20E_%20Plan_Final_May_19.pdf

Sauchyn, D. (2007). Climate change impacts on agriculture in the Prairie Region. In E. Wall, B. Smit, & J. Wandel (Eds.), *Farming in a changing cliamte: Agricultural adaptation in Canada* (pp. 80-93). Vancouver, British Columbia: UBC Press.

Sauchyn, D. (2012). Water, drought and climate change. Keynote Address, Battle River Watershed Alliance, Drought and Watershed Management Workshop February 29, 2012, Forestburg, AB.

Sauchyn, D., Diaz, H., & Kulshreshtha, S. (2010). Conclusion. In D. Sauchyn, H. Diaz, & S. Kulshreshtha (Eds.), *The new normal: The Canadian Prairies in a changing climate* (pp. 353-361). Regina, Saskatchewan: Canadian Plains Research Center.

Sauchyn, D. and Kulshreshtha, S. (2008): Prairies; *in* From impacts to adaptation: Canada in a changing climate 2007, *edited by* D.S. Lemmen, F.J.Warren, J. Lacroix and E. Bush; Government of Canada, Ottawa, ON, p. 275-328. Retrieved from http://www.parc.ca/pdf/misc/nacc_prairies_ch7_e.pdf

Sauchyn, D., Pietroniro, A., & Demuth, M. (2008). Upland Watershed Management and Global Change – Canada's Rocky Mountains and Western Plains. In A. Garrido & A. Dinar (Eds.), *Mountains, valleys and flood plains: managing water resources in a time of global change* (pp. 32- 49). New York: Routledge.

Skinner, S. (2011). State of the Battle River and Sounding Creek watersheds report 2011. State of the Watershed Steering Committee. Camrose Alberta: Battle River Watershed Alliance. Retrieved from http://www.battleriverwatershed.ca/publications/111/view

Skogstad, G. (2005). Policy networks and policy communities: Conceptual evolution and governing realities. University of Toronto, Toronto, Ontario. Prepared for the Workshop on "Canada's Contribution to Comparative Theorizing" Annual

Meeting of the Canadian Political Science Association University of Western Ontario, London, Ontario. Retrieved from http://www.cpsa-acsp.ca/papers-2005/Skogstad.pdf

Smit, B., Pilifosova, O., Burton, I., Challenger, B., Huq, S., Klein, R.J.T., & Yohe, G., 2001: Adaptation to climate change in the context of sustainable development and equity. *Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change,* J. J. McCarthy, O. F. Canziani, N. A. Leary, D. J. Dokken, and K. S. White, Eds. Cambridge University Press, Cambridge, UK, 877-912. Retrieved from http://www.grida.no/climate/ipcc_tar/wg2/pdf/wg2TARchap18.pdf

Smit, B., Klein, R.J.T, & Street, R. (1999). The science of adaptation: a framework for assessment. *Mitigation and Adaptation Strategies for Global* Change 4, 199–213.

Smit, B., & Pilifosva, O. (2003). From adaptation to adaptive capacity and vulnerability reduction. In J.B. Smith, R.J.T. Klein, & S. Huq (Eds.), *Climate change, adaptive capacity and development* (pp. 9-28). London, UK: Imperial College Press.

Smit, B., and Skinner, M.W. (2002). Adaptation options in agriculture to climate change: A typology. *Mitigation and Adaptation Strategies for Global Change* 7, 85–114.

Smoyer-Tomic, K., Klaver, J.D.A., Soskolne, C.L., & Spady , D.W. (2004). Health consequences of drought on the Canadian Prairies. *EcoHealth*, 1(Supplement 2), 144 – 154. doi: 10.1007/s10393-004-0055-0

Statistics Canada. (2004). Census of agriculture. Farm operators by type: Provinces. Retrieved from http://www.statcan.ca/english/Pgdb/econ121a.htm. [accessed November 30, 2011]

Stewart, J. (2009). Interim background report for riparian land conservation and management policy. Prepared by Westhoff Engineering Resources, Inc. for Rocky View County.(Publication No. WER 108-23). Calgary, Alberta: Westhoff Engineering Resources, Inc. Retrieved from http://www.aref.ab.ca/resourcelibrary/documents/Riparian%20Interim%20Background%20Report.pdf

Stranberg, R. (2005). Technical Report: Print media survey of the eastern Canadian droughts of2001 and 2002. Ottawa, Ontario: Adaptation and Impacts Research Division (AIRD) Environment Canada. Retrieved from http://www.src.sk.ca/images/Technical%20Report%20-%20Print%20Media%20Survey%20Eastern%20Canada.pdf

Strong, W., & Leggat, K.R. (1992). Ecoregions of Alberta. Resource Information Branch (Publication Number T:245). Edmonton, Alberta: Land Information Services Division, Alberta Forestry, Lands and Wildlife.

Susquehanna River Basin Commission (SRBC). (2006). Susquehanna Basin information sheet. Harrisburg, PA: Susquehanna River Basin Commission. Retrieved from http://www.srbc.net/pubinfo/docs/Susq%20River%20Basin%20General%20(11_06).PDF

SRBC. (2007). Susquehanna River Basin Commission regulation of Projects: 18 CFR Part 801.3. Harrisburg, PA: Susquehanna River Basin Commission. Retrieved from http://www.srbc.net/programs/docs/FinalRulemakingwCoverthru91009.pdf

Swanson, D, Venema, H.D., Rust, C., & Medlock, J. (2009). Understanding adaptive policy mechanisms through farm-level studies of adaptation to weather events in Alberta, Canada. Retrieved from International Institute for Sustainable Development website: http://www.iisd.org/pdf/2009/understanding_adaptive_policy_alberta.pdf

Tebaldi, C., Hayhoe, K., Arblaster J.M., and Meehl, G.A. (2006). Going to the extremes: An intercomparison of model-simulated historical and future changes in extreme events. *Climatic Change* 79, 185–211. doi: 10.1007/s10584-006-9051-4

Thompson, L. (2011). Vulnerabilities & adaptations to extreme climatic variability: North Saskatchewan River Watershed. Saskatchewan: Thomson Agri-Environmental. Retrieved from http://www.parc.ca/rac/fileManagement/upload/SWA_Vulner_%20AdaptationsExtreme%20Climatic%20Variability_%20North%20Saskatchewan%20River%20Watershed%20Final.pdf.pdf

Town of Lacombe. (2003). Procedures for providing safe water. (Policy No. 41/711 (03). Retrieved from http://www.lacombe.ca/index.php?option=com_content&task=view&id=879&Itemid=32

Town of Okotoks. (2011). Water Management Plan. Retrieved from http://www.okotoks.ca/data/1/rec_docs/1676_2011_Water_Management_Plan.pdf

United Nations Convention to Combat Desertification (UNCCD). (2012) About the convention. Retrieved from http://www.unccd.int/en/about-the-convention/Pages/About-the-Convention.aspx

United Nations Environment Programme Finance Initiative (UNEP FI) & Stockholm International Water Institute (SIWI). (2005). Challenges of water scarcity: A business case for financial institutions. Swedish International Development Cooperation Agency (Sida), Swedish Water House, and the United Nations Environment Programme Finance Initiative (UNEP FI). 36 p. Retrieved from http://www.unepfi.org/publications/water/index.html

United Nations International Strategy for Disaster Reduction (UNISDR). (2003). Drought - living with risk. Retrieved from http://www.unisdr.org/2005/task-force/tf-adhoc/droughts/WGD-doc1.pdf

UNISDR. (2009). Drought risk reduction framework and practices. Retrieved from http://www.unisdr.org/files/11541_DroughtRiskReduction2009library.pdf

UNISDR. (2011). Who we are. Retrieved from http://www.unisdr.org/who-we-are

United States Army Corps of Engineers (USACE). (1995). National study of water management during drought. (IWR Report No. 94-NDS-12). Retrieved from http://www.iwr.usace.army.mil/docs/iwrreports/94-NDS-12.pdf

United States Department of Agriculture (USDA). (n.d.)a. Disaster and drought assistance. Retrieved from http://www.usda.gov/wps/portal/usda/usdahome?navid=DISASTER_ASSISTANCE&navtype=RT&parentnav=RURAL_DEVELOPMENT

USDA. (n.d.)b. Emergency Watershed Protection. Retrieved from http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/landscape/ewpp/?&cid=nrcs143_008263

USDA. (2003). Agricultural Assistance Act of 2003. Retrieved from http://www.fsa.usda.gov/Internet/FSA_File/disasact03.pdf

USDA. (2005). Risk management agency (RMA). Retrieved from http://www.usda.gov/wps/portal/usda/usdahome?contentidonly=true&contentid=RMA_Agency_Splash.xml&x=14&y=6

USDA. (2011). Technical assistance. Retrieved from http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/technical

USDA. (2012)a. Conservation Programs – Farm Service Agency (FSA). Retrieved from http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp-eg

USDA. (2012)b. Landscaping. Retrieved from http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape

USDA. (2012)c. Wetlands reserve program. Retrieved from http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/wetlands

USDA. (2012)d. Utilities - Water and environmental programs. Retrieved from http://www.rurdev.usda.gov/UWEP_HomePage.html

United States Small Business Administration (SBA). (n.d.). Fact sheet for businesses of all sizes. Retrieved from http://www.sba.gov/content/fact-sheet-businesses-all-sizes

Walker, B., Holling, C.S., Carpenter, S.R., & Kinzig, A. (2004). Resilience, adaptability and transformability in social-ecological systems. *Ecology and Society* 9(2), 5. Retrieved from http://www.ecologyandsociety.org/vol9/iss2/art5/print.pdf

Wall, E, & Smit, B. (2005). Climate change adaptation in light of sustainable agriculture. *Journal of Sustainable Agriculture* 27(1), 113-123. doi: 10.1300/J064v27n01_07

Wandel, J., Young, G., & Smit, B. (2009). The 2001-2002 drought: Vulnerability and adaptation in Alberta's Special Areas. In G.P. Marchildon (Ed.), *A dry oasis: Institutional adaptation to climate on the Canadian Plains* (pp. 211-234). Regina, Saskatchewan: Canadian Plains Research Center.

Warren, F.J. and Egginton, P.A. (2008). Background Information; *in* From impacts to adaptation: Canada in a changing climate 2007, *edited by* D.S. Lemmen, F.J. Warren, J. Lacroix, and E. Bush; Government of Canada, Ottawa, ON, p. 27-56. Retrieved from http://www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/assessments/132

Wetherald, R.T., and S. Manabe, 1995: The mechanisms of summer dryness induced by greenhouse warming. *Journal of Climate* 8, 3096-3108.

Wheaton, E., Kulshreshtha, S.N., Wittrock, V., and Koshida, G. (2008). Dry times: hard lessons from the Canadian drought of 2001 and 2002. *Canadian Geographer* 52(2), 241–262. doi: 10.1111/j.1541-0064.2008.00211.x

Wilhite, D.A., Botterill, L., & Monnik, K. (2005). National drought policy: Lessons learned from Australia, South Africa, and the United States. In D.A. Wilhite (Ed.), *Drought and water crises: Science, technology, and management issues* (pp. 137-172). New York: CRC Press.

Wilhite. D.A., Diodato, D.M., Jacobs, K., Palmer, R., Raucher, B. Redmond, K., Sada, D., Smith, K.H., Warwick, J., & Wilhelmi, O. (2007). Managing drought: A roadmap for change in the United States. A Conference Report from *Managing Drought and Water Scarcity in Vulnerable Environments — Creating a Roadmap for Change in the United States, September 18-20, 2006*. Longmont, CO: Geological Society of America. Retrieved from http://www.geosociety.org/meetings/06drought/roadmap.pdf

Wilhite, D.A., Glantz , M.H.. (1985). Understanding the drought phenomenon: The role of definitions. *Water International* 10(3), 111–120. doi: 10.1080/02508068508686328

Wittrock, V., C. Beaulieu, and E. Wheaton. 2001. *Adaptability of Prairie Cities: The Role of Climate - A Proposal*. Saskatchewan Research Council [SRC] Publication No. 11296-1E01. Saskatoon, SK: SRC. Retrieved from http://www.parc.ca/pdf/research_publications/communities6.pdf

Wittrock, V., Kulshreshtha, S.N., & Wheaton, E. (2010). Canadian prairie rural communities: Their vulnerabilities and adaptive capacities to drought. *Mitigation and Adaptation Strategies for Global Change* 16(3), 267-290. doi: 10.1007/s11027-010-9262-x

Wittrock, V., Kulshreshtha, S.N., Wheaton, E., & Khakapour, M. (2007). Vulnerability of prairie communities during the 2001 and 2002 droughts: Case studies of Taber and Hanna, Alberta and Outlook, Saskatchewan. (SRC Publication No. 11899-8E07). Saskatoon, Saskatchewan: Saskatchewan Research Council. Retrieved from: http://www.parc.ca/mcri/pdfs/comm_vul/can1.pdf

Wittrock, V., & Wheaton, E. (2007). Towards understanding the adaptation process for drought in the Canadian Prairie Provinces: The case of the 2001 to 2002 drought and agriculture. (SRC Publication No.11927-2E07). Saskatoon, Saskatchewan: Saskatchewan Research Council. Retrieved from http://www.nrcan.gc.ca/earth-sciences/projdb/pdf/146b_e.pdf

World AgroMeteorological Information Service (WAMIS). (2011). Objectives. Retrieved from http://www.wamis.org/objectives.php

World Meteorological Organization (WMO). (2006). Drought monitoring and early warning: Concepts, progress and future challenges. Retrieved from http://www.wamis.org/agm/pubs/brochures/WMO1006e.pdf

World Business Council for Sustainable Development (WBCSD). (2004). Water and Sustainable Development: a business perspective. Retrieved from http://www.wbcsd.org/publications-and-tools.aspx

Yohe, G., & Tol, R.S.J. (2001). Indicators for social and economic coping capacity – moving toward a working definition of adaptive capacity. *Global Environmental Change* 12, 25–40. doi: 10.1016/S0959-3780(01)00026-7

Zhang, X., Vincent, L.A., Hogg, W.D., & Niitsoo, A. (2000). Temperature and precipitation trends in Canada during the 20th century. *Atmosphere-Ocean* 38(3), 395-429.

At Battle River Watershed Alliance we desire to live, work and play in a watershed that sustains all life by using sound knowledge, wisdom and wise actions to preserve our watershed for future generations.

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