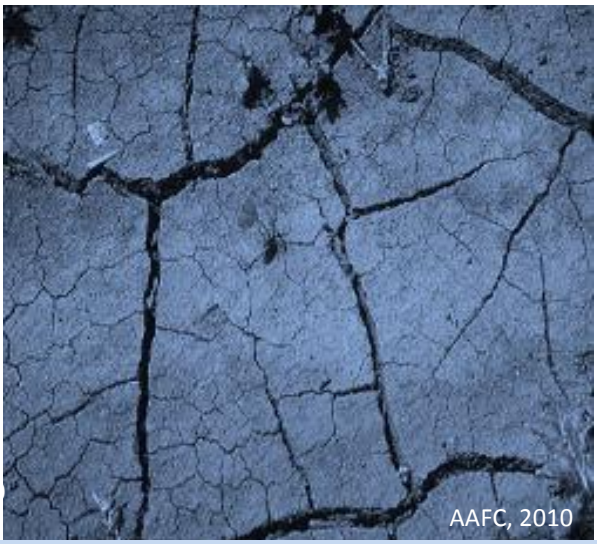
North Saskatchewan River Watershed


AAFC, 2010


Booth Leader Post, 2010

Drought and Excessive Moisture Preparedness Plan

Kara Rowan, Jeremy Pittman, Virginia Wittrock,
Katherine Finn and John Kindrachuk

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Report compiled by *Kara Rowan*

Preparedness planning approach developed by *Jeremy Pittman, Saskatchewan Watershed Authority*

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Table of Contents

List of Figures

List of Tables

List of Appendices

I

North Saskatchewan River Watershed Drought and Excessive Moisture Preparedness Plan

Drought and Excessive Moisture events across the Canadian prairies are becoming more common. In 2010, the Saskatchewan Watershed Authority (SWA) initiated drought and excessive moisture preparedness planning workshops to be delivered through four pilot workshops across the province. The North Saskatchewan River Watershed (NSRW) was chosen as one of the four Watersheds to develop a Drought and Excessive Moisture Preparedness Plan for the Watershed.

1.1 North Saskatchewan River Watershed Overview

The North Saskatchewan River Watershed is comprised of the North Saskatchewan River and multiple tributaries including Battle River, Eagle Creek and Goose Lake – an internal drainage basin located northeast of Rosetown (SWA, 2007; NSRBC, 2008). The Saskatchewan area of the North Saskatchewan River Watershed covers approximately 41,000 km^2 and is 1,367 km long (SWA, 2007; NSRBC, 2008). Headwater tributaries include the Cline, Brazeau, Ram and Clearwater Rivers (NSWA, 2005). The North Saskatchewan River flow is regulated by Bighorn Dam and Brazeau Dam (NSWA, 2005). Ninety percent of water that flows in the North Saskatchewan River are from mountain and foothill streams (NSWA, 2005). The North Saskatchewan River originates from the Saskatchewan Glacier found in the Columbia icefields in Alberta (NSWA, 2005). The North Saskatchewan River flows easterly through Alberta, then loops north through Edmonton, Alberta, then continues east flowing into Saskatchewan (NSWA, 2005). Once entering Saskatchewan, the River travels southeast then shifts northeast near Langham, SK (NSWA, 2005; SWA, 2007). The North Saskatchewan and South Saskatchewan rivers join at "The Forks" east of Prince Albert. The Saskatchewan River flows into the Nelson River System in Manitoba where it empties into Hudson Bay (NSWA, 2005; SWA, 2007).

The North Saskatchewan River Watershed is divided into Four Watershed Planning Units – Battle River, West, Central and East (Figure 1). The NSRW includes (SWA, 2007):

- 51 Rural Municipalities
- 29 First Nations
- 100 Towns and Villages
- Cities of Lloydminster, North Battleford and Prince Albert
- A portion of Prince Albert National Park

Approximately 116,500 people occupy the NSRW and fifty percent of those depend on surface drinking water (SWA, 2007; NSRBC, 2008). Generally, groundwater supply is more stable than surface water; however, defining available groundwater supply is difficult and costly (ARWAC and SWA, 2006). For a detailed background analysis on the North Saskatchewan River Watershed see the Preliminary Background Report: North Saskatchewan River Watershed at http://www.swa.ca/Publications/Documents/N%20Sask%20River%20Watershed%20April%2020-07.pdf.

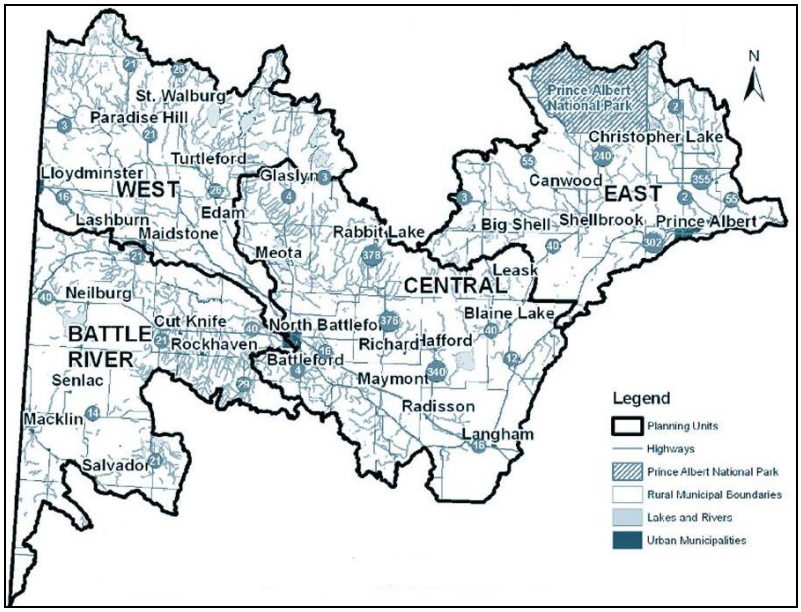


Figure 1. North Saskatchewan River Watershed Planning Units
(Source: Saskatchewan Watershed Authority, 2008)

Source water protection planning, and aquifer protection from extreme drought or excessive moisture events, is crucial in this area in order to manage and prepare for potential threats to the quantity and quality of groundwater and surface water. The area's water quality and supply is threatened by external factors including climate change, water-demand growth, extended hydrological droughts, and excessive moisture events.

1.2 What is Drought?

Drought is considered to be one of the most complex, and subsequently, least understood of all natural hazards, affecting more people than any other hazard (Sivakumar and Wilhite n.d., as cited in Hagman, 1984). Drought originates from a reduction in the amount of precipitation over an extended period of time, resulting in a water shortage, usually a season or more in length (Sivakumar and Wilhite, n.d.). Droughts are unique in their intensity, duration and spatial extent (Wilhite and Knutson, n.d.; Maybank et al. 1995). Drought is a slow-onset, creeping natural hazard that is a normal part of climate; it results in economic, social and environmental impacts (Sivakumar and Wilhite, n.d., as cited in Wilhite, 2000; Maybank et al. 1995).

There is a broad consensus that global temperatures are rising (IPCC 2007, SWA, 2005). The implications for Saskatchewan are not yet well understood – however, warmer winters, increased drought risk, and more extreme precipitation and temperature events are expected (Sauchyn and Kulshreshtha, 2008). Water supplies may be affected resulting in reduced summer flow, increase in

frequency and magnitude of flooding and drought, and changes to groundwater recharge and discharge (SWA, 2005).

The onset and cessation of drought is difficult to predict, as is the severity of a drought. Human activities and a specific areas water supply characteristics influence sensitivities to drought in a given watershed. Droughts can be categorized as meteorological, hydrological, agricultural or socioeconomic, each of which results in different impacts (Wilhite, 1996; Maybank et al. 1995; V. Wittrock, personal communication, January 12, 2011). Appendix I. describes each type of drought in detail.

The greatest natural disasters in Canada (in terms of economic costs) have been attributed to drought, specifically the 1930s drought and 1999-2004 drought. The 2001-2002 drought, which largely occurred in Saskatchewan and Alberta, resulted in a national loss of $6 billion in GDP and the loss of 41,000 jobs (Wheaton *et al.,* 2008).

Drought conditions can impact communities and individuals in a variety of ways. In the North Saskatchewan River Watershed drought-related impacts include land degradation, water shortages and feed shortages, unstable economics (lower crop yields, crop damage/failure), soil moisture shortages and increased stress.

Effective drought management has three major components (Sivakumar and Wilhite, n.d.):

- Monitoring and early warning,
- Risk and vulnerability assessment, and;
- Preparedness, response, and recovery

Previous attempts to manage drought have been borne from a reactive, crisis-management approach which inherently results in costly remedies (Wilhite and Knutson, n.d.). The goal is to reduce drought vulnerability by identifying relevant impacts and assess their underlying causes.

1.3 What is Excessive Moisture?

Too much water is just as damaging as too little water, and may also negatively impact water supplies, agriculture and ecosystems (SWA, 2010). Increased variability and changes in the frequency and severity of extreme events such as floods is also occurring. A broad suite of management practices is required in preparing for such extreme events (Pittman, 2010a).

Heavy precipitation events result in crop damage, soil erosion, and the inability to cultivate land. Excessive moisture can adversely affect the quality of surface and groundwater as well as contaminate water supplies.

1.4 About This Plan

The North Saskatchewan River Watershed held workshops throughout the watershed during the month of March. The goal was to identify the vulnerability and resilience of various watershed

stakeholders through numerous workshop activities, including mapping areas within the watershed of highest concern, scenario-based discussion, and adaptation planning. The workshops are an important element in preparedness, response, and recovery planning which will help to increase the North Saskatchewan River Watershed's capacity to deal with drought and excessive moisture events, and lead to more resilient urban and rural communities.

This plan involves identifying issues and action items within the Watershed, then prioritizing each issue. The purpose of the plan is to provide a strategic plan in dealing with Drought and Excessive Moisture for the North Battleford area, and offer a starting point for engagement throughout federal and provincial agencies.

1.5 Planning Approach

Representatives from local governments, individual licensees and users, agricultural producers, and urban and rural municipalities participated in the NSRW workshops. The goal of the workshops was to share ideas, information and knowledge across multiple stakeholder groups to develop a preparedness plan for the watershed. Various workshop activities were undertaken to facilitate vulnerability assessment and adaptation planning (Figure 2). Ideas and knowledge obtained from the workshops were ultimately incorporated into the plan.

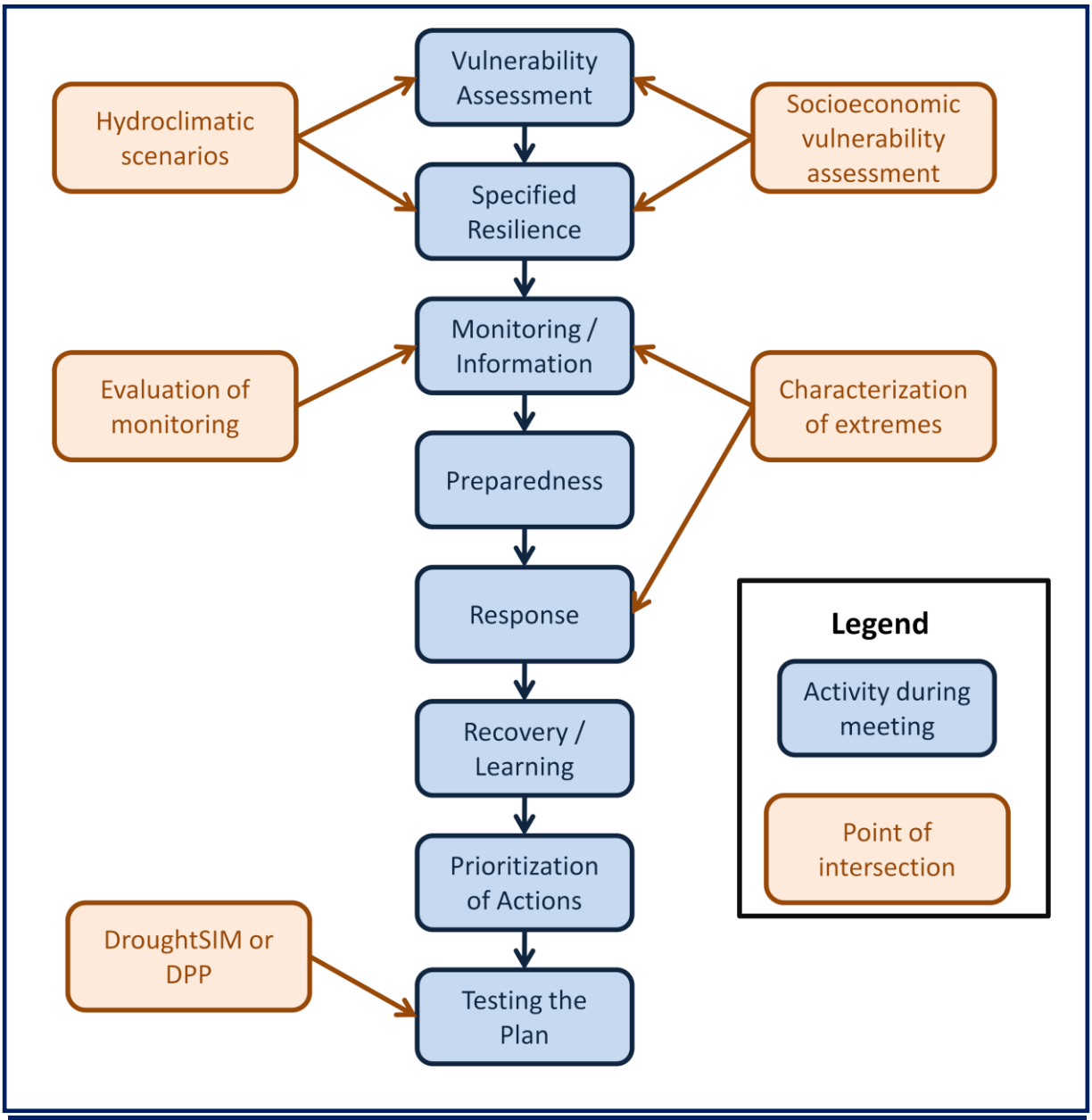


Figure 2. Preparedness Planning Approach

II

Vulnerability Assessment

Preparing for drought and excessive moisture events involves looking at the past and understanding where vulnerabilities lie. Preparing for such events involves discussion during normal conditions, rather than at the onset of drought and excessive moisture events.

The vulnerability of any system is a function of an area's exposure, sensitivity and adaptive capacity to an event, such as drought and excessive moisture, and its' capacity to cope, adapt, or recover from the impacts (Pittman *et al.*, 2010; ICLEI 2010; Ford and Smit, 2004; Smit and Wandel, 2006). Understanding the North Saskatchewan River's vulnerabilities will help decision makers in developing suitable adaptation actions (ICLEI, 2010).

Exposure and sensitivity of a system are virtually inseparable and are one component in assessing vulnerability (ICLEI, 2010; Smit and Wandel, 2006). Determining the North Saskatchewan River's exposure-sensitivity involves asking questions to understand whether the area is subject to any existing stress and whether a drought or excessive moisture event will exacerbate that stress (ICLEI, 2010).

Adaptive capacity refers to a system or community's potential or ability to plan for, cope, and adjust to changes and stresses with minimal disruption or additional cost (ICLEI, 2010; Ford and Smit, 2004; Smit and Wandel, 2006). The ability to undertake adaptations is influenced by economic wealth, technology, equity of access to resources, knowledge and skills, and social capital and institutions (Pittman *et al.,* 2010; ICLEI, 2010; Smit and Wandel, 2006; Ford and Smit, 2004). Adaptive capacity varies from country to country and community to community (Smit and Wandel, 2006).

The North Saskatchewan River's capacity to cope with drought and excessive moisture events, varies over time in response to social, economic, political and future environmental changes (Ford and Smit, 2004). An increase in the frequency of events, near the upper limit of the coping range, may decrease a system's adaptive capacity and inhibit coping ability, adaptation or recovery of that system (Smit and Wandel, 2006).

By increasing the North Saskatchewan River's adaptive capacity, it's vulnerability to current and future drought and excessive moisture events will be reduced (ICLEI, 2010). The goal of this analysis is to identify current and past exposures and sensitivities that the North Saskatchewan

River has experienced. Once these conditions have been identified, analyst's and decision-makers can identify potential future exposures and sensitivities, and plan for, or respond to these conditions (Smit and Wandel, 2006).

The following section features current vulnerabilities experienced within the North Saskatchewan River, and are separated into four subsections: (1) participatory mapping; (2) drought and excessive moisture characterization; (3) scenario planning; and (4) information requirements of stakeholders.

2.1 Participatory Mapping

Maps and diagrams are an important part of any planning activity (IIED, 1991). Participatory mapping is the creation of maps by local communities and stakeholders, with the involvement of organizations such as government, universities, and non-government organizations (IFAD, 2009). Generally, mapping and timeline initiatives are conducted by outsider groups and the maps created contribute to an outsider's perspective (IFAD, 2009).

Participatory mapping provides valuable visual representation of what stakeholders perceive as its place, and features they feel are significant (i.e. beaver dams, culverts, flooding activities, washouts etc.) (IFAD, 2009; IIED, 1991). The process of participatory mapping contributes to community cohesion, and may stimulate stakeholders to engage in land and resource-related decision-making. This process raises awareness of land-related issues and ultimately empowers local communities and stakeholders (IFAD, 2009).

Participatory mapping has proved to be an effective way for communities to demonstrate to external agencies what the community values, and the communities' relationship and interactions with the landscape (IFAD, 2009).

During the mapping exercise with the North Saskatchewan River, participants were grouped and asked to identify areas and infrastructure previously affected by flooding and drought, and delegate areas of highest concern for future events. Figures 3, 4 and 5 identify areas throughout the watershed that stakeholders have identified are of concern, or particular importance.

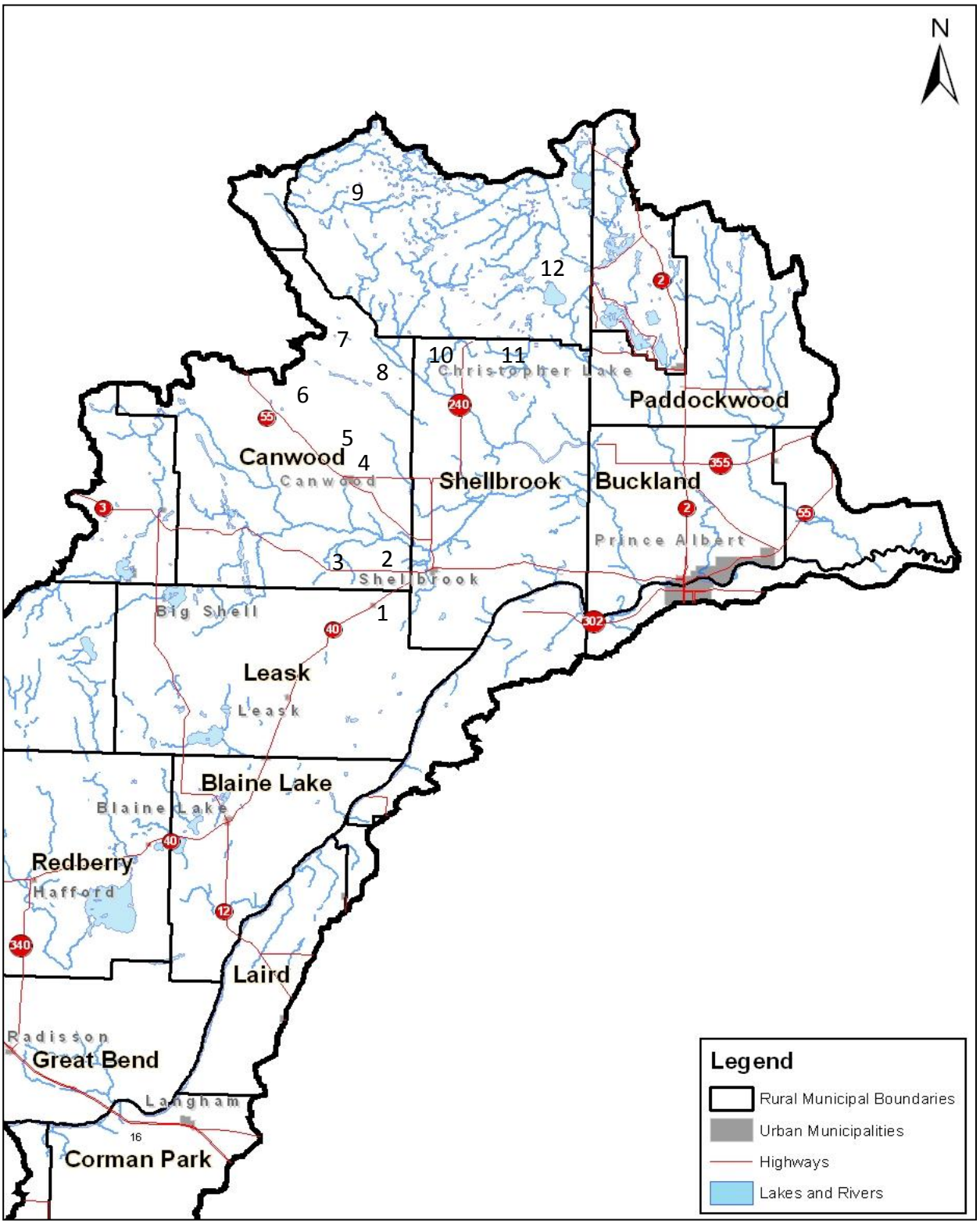


Figure 3. East Planning Unit within the North Saskatchewan River Watershed, Participatory Mapping Exercise, March 2011

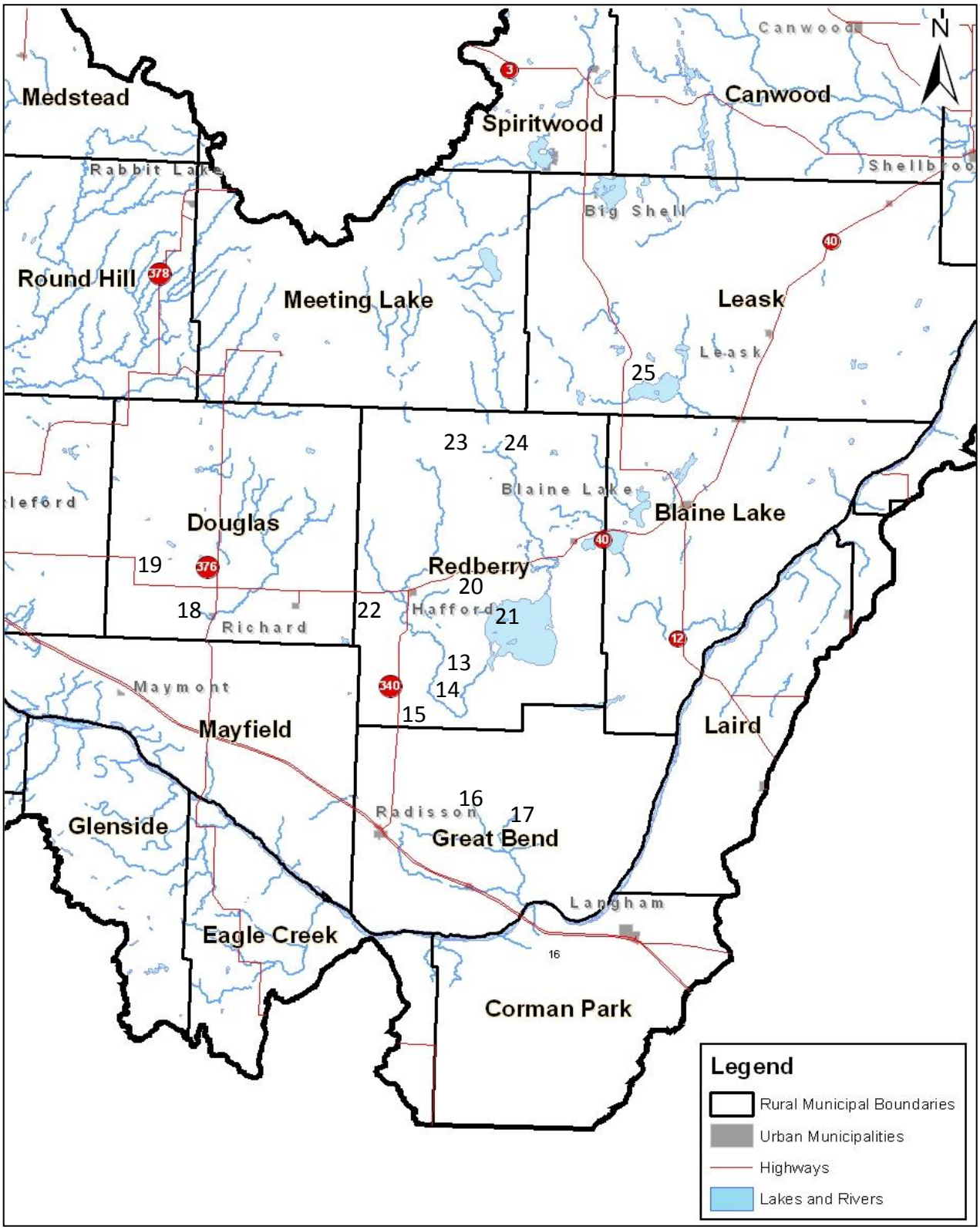


Figure 4. Central Planning Unit within the North Saskatchewan River Watershed, Participatory Mapping Exercise, March 2011

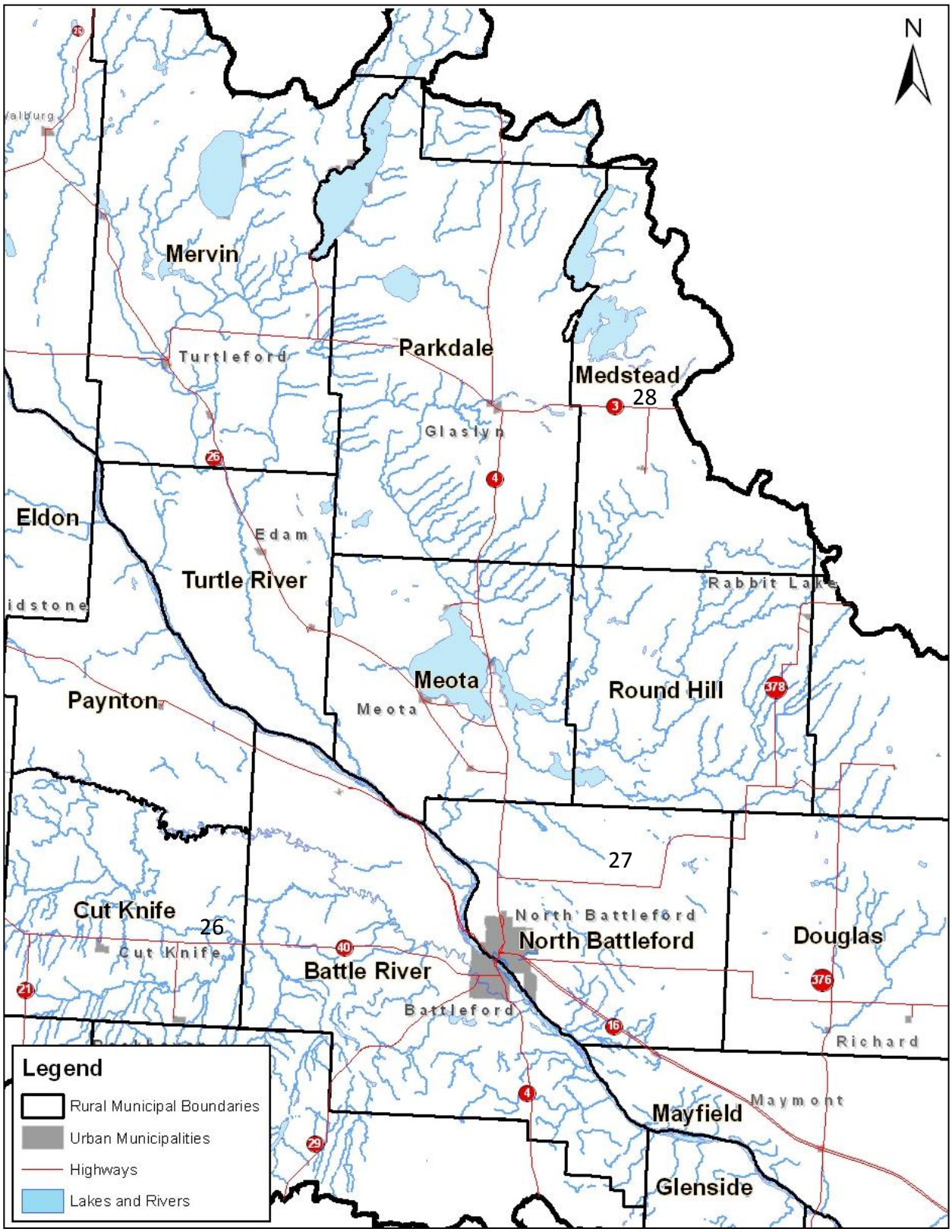


Figure 5. Battle River and West Planning Unit within the North Saskatchewan River Watershed, Participatory Mapping Exercise, March 2011

Table 1. Participatory Mapping Exercise for East, Central, Battle River and West Planning Units within the North Saskatchewan River Watershed, March 2011			
1	Beavers causing flooding in the area (spring fed)	**23**	Well flooded
2	Too much water, wet areas impact haying	**24**	Oscar Lake – if levels increase it may pose a problem
3	Forty acres inaccessible due to high water levels	**25**	Road flooded in 2011
4	Drought in 2002, large impact	**26**	Creek flooded Highway 40
5	Dugout	**27**	Potholes cause access issues
6	Lake system that is pastured	**28**	Converted hay into native prairie
7	Lake dry since 2003		
8	Area received 9 inches of rain in 1996		
9	Precipitation divide		
10	Seeded to hay		
11	Lack of moisture is main issue, had to feed cattle all summer		
12	Lake overflows – impacts to local infrastructure (roads, culverts)		
13	Good drainage, - in 2001 new dugout had to be dug		
14	Good drainage, not much lost to flooding		
15	Bushy, sandy area		
16	Poor access. Back roads flooded in 2010, no access to quarter.		
17	Well		
18	Marsh hay, poor feed.		
19	Goose Lake		
20	High water levels 2010. Sandy loam soils very dry during drought.		
21	Lake levels dropped since the 1920s		
22	Highway flooded in 2007		

Areas identified on the North Saskatchewan River Watershed map include frequently flooded areas such as roads, pastures, and low-lying areas (Table 1). Many areas within the watershed are inaccessible due to high water levels (Table 1).

2.2 Drought and Excessive Moisture Characterization for the North Saskatchewan River Watershed

Wittrock et al. 2011 provided information to help characterize drought and excessive moisture events within the North Saskatchewan River Watershed. This work compares and contrasts dry and wet patterns within the North Saskatchewan River Watershed, to aid in risk management and planning strategies for future extreme events. Table 2. compares the top ten extreme drought and excessive moisture events within the North Saskatchewan River Watershed between 1901 to 2005 using both the Palmer Drought Severity Index (PDSI) and the Standard Precipitation Index (SPI).

The Palmer Drought Severity Index (PDSI) is primarily a hydrological drought index which is used to quantify excessive moisture and drought. Values are calculated based on soil water content, temperature data and daily/monthly precipitation information. PDSI values are beneficial as the values have a "long-term memory" built into the model and are helpful when looking at long-term trends (Wittrock *et al.*, 2011).

The Standard Precipitation Index (SPI) quantifies meteorological drought and is valuable in identifying emerging droughts earlier than the PDSI index, as previous moisture conditions are not taken into account. SPI is generally used in short-term, month-to-month analysis. SPI does not incorporate temperature, which is critical when monitoring agricultural drought (Wittrock et. al., 2011). PDSI values range from ≤ -5 (Exceptionally Dry) to ≥5 (Exceptionally Wet). SPI values range from ≤-2.5 (Exceptionally Dry) to ≥ 2.5 (Exceptionally Wet).

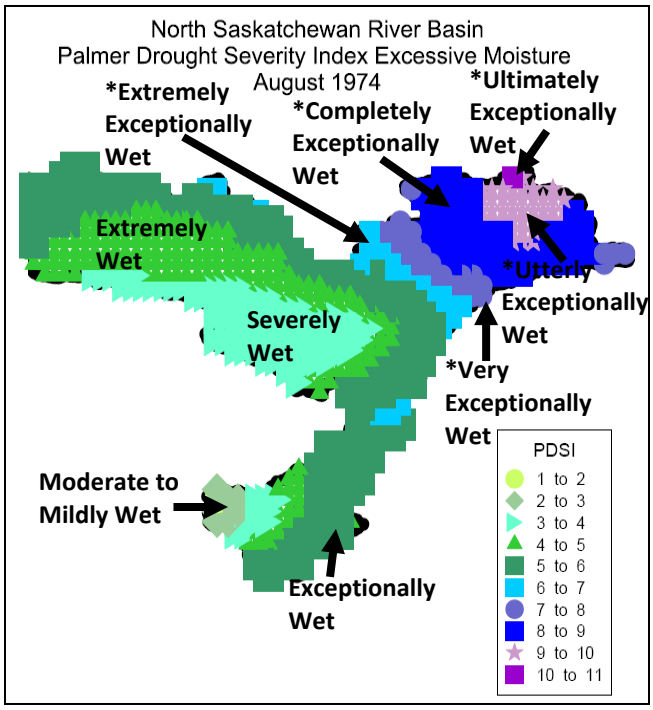
Table 2. Top 10 Extreme Years. Palmer Drought Severity Index (PDSI) and Standardized Precipitation Index (SPI) for the North Saskatchewan River Watershed (1901-2005 Agriculture Year)

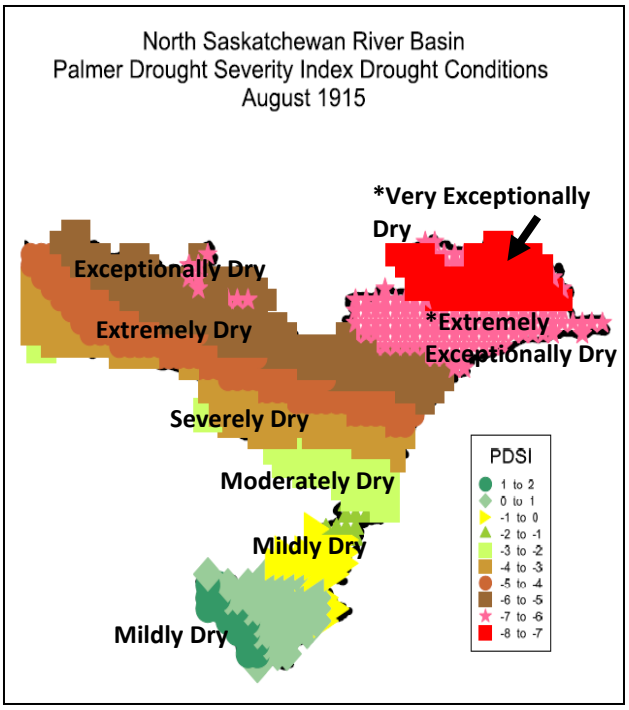
Palmer Drought Severity Index (PDSI)				Standardized Precipitation Index (One Month Extremes)					
Drought		Excessive Moisture		Drought			Excessive Moisture		
Year	Value	Year	Value	Year	Month	Value	Year	Month	Value
1915	-7.5	1974	10.1	1961	August	-3.7	1977	May	3.4
1919	-7.3	1916	7.3	1967	May	-3.7	1965	Feb	3.2
1929	-6.8	1973	7.3	1952	Dec	-3.7	1942	Jan	3.1
2002	-6.3	1954	7.1	1995	Sept	-3.4	1955	April	3.1
1972	-6.0	1975	7.0	1964	June	-3.3	2000	July	3.1
2003	-5.7	1965	6.5	1974	Nov	-3.2	1991	April	3.1
1973	-5.6	1907	6.4	1980	April	-3.2	1986	July	3.1
1937	-5.5	1927	6.3	2002	May	-3.2	1985	April	3.0
1988	-5.5	1960	6.2	1988	April	-3.2	1954	August	3.0
2001	-5.5	2005	5.9	1928	January	-3.2	1916	July	3.0

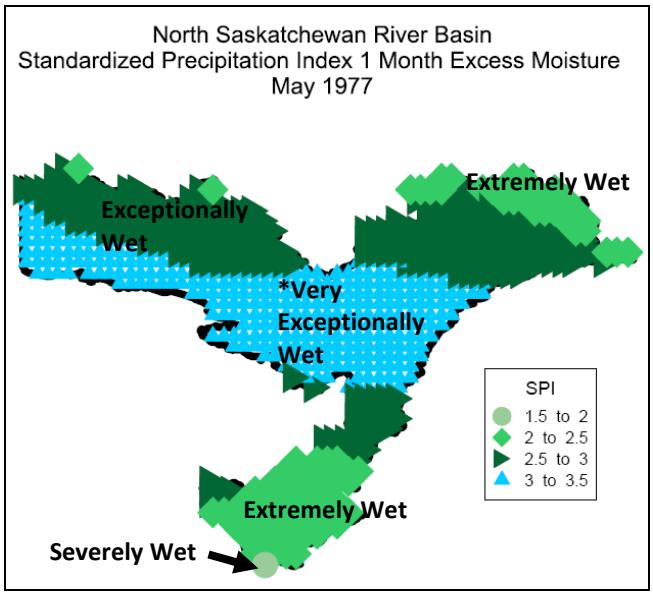
Wittrock *et al.* (2011) incorporated new categories, (categories and values beyond the current PDSI and SPI scale) for extreme events within the North Saskatchewan River Watershed, as such extreme values were not represented in the current model. Additional categories included were (see Figure 6):

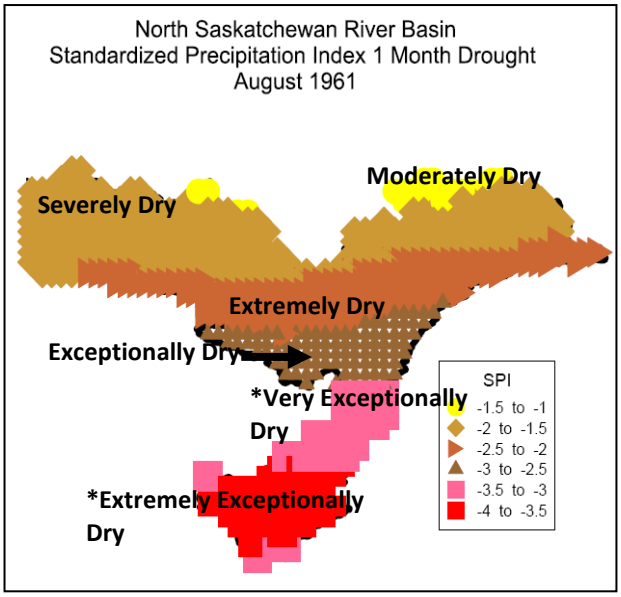
- PDSI 6.0 to 7.0 (Extremely Exceptionally Wet)
- PDSI 7.0 to 8.0 (Very Exceptionally Wet)
- PDSI 8.0 to 9.0 (Completely Exceptionally Wet)
- PDSI 9.0 to 10.0 (Utterly Exceptionally Wet)
- PDSI 10.0 to 11.0 (Ultimately Exceptionally Wet)
- PDSI -6.0 to -7.0 (Very Exceptionally Dry)
- PDSI -7.0 to -8.0 (Extremely Exceptionally Dry)
- SPI 3.0 to 3.5 (Very Exceptionally Wet)
- SPI -3.0 to -3.5 (Very Exceptionally Dry)
- SPI -3.5 to -4.0 (Extremely Exceptionally Dry)

Figure 6 compares the wettest year (1974) and driest year (1915) within the North Saskatchewan River Watershed using the PDSI method for the agricultural year (September to August). The wettest month (May 1977) was compared to the driest month (August 1961) using the SPI index. Wittrock *et al.'s* (2011) additional PDSI and SPI categories were overlaid on the North Saskatchewan River Watershed map (Figure 6).









Note: Areas marked with an asterisk "*" are categories arbitrarily created by the author.

Figure 6. Comparison of North Saskatchewan River Watershed PDSI Wettest Year (1974) and Driest Year (1915) and SPI Wettest Month (May 1977) and Driest Month (August 1961)

These maps (Figure 6) indicate the spatial variability within the watershed. The PDSI excessive moisture map shows that the northeast portion of the watershed was experiencing extreme moisture conditions - "ultimately exceptionally wet" and "utterly exceptionally wet" – categories not recognized on the standard PDSI scale. The southern portion of the watershed varied in moisture from "mildly wet" to "exceptionally wet". The PDSI drought conditions map illustrate that the northeast and northwest portion of the watershed was under "extreme" to "extremely exceptional" drought conditions while the southern portion of the watershed was experiencing "mild to severe" drought conditions.

The one month SPI excessive moisture month (May 1977) illustrates the northeast, northwest and central portions of the watershed were dealing with "extreme" to "very exceptional" conditions. The one month SPI drought of 1961 illustrates the variability that can occur during a drought event. The central and southern portion of the watershed was under "extreme" to "extremely exceptional" drought conditions while the northern portion of the watershed varied from "moderate" to "severe" drought conditions. This illustrates the potential impacts of the drought may have been greater in the southern portion, than the northern region of the watershed. A more comprehensive analysis of the watershed can be found in Wittrock *et al.,* 2011.

2.3 Scenario Planning

Scenario planning is a method used for imagining possible futures by considering various uncertainties (Peterson *et al.,* 2003; Schoemaker, 1995). The purpose of scenario planning is to improve a community's ability to quickly respond to a variety of futures and avoid potential traps and benefit from potential opportunities (Peterson *et al.*, 2003). Generally, there are two common errors in decision making – underprediction and overprediction of change – scenario planning attempts to compensate for this, and allows us to chart a middle ground (Shoemaker, 1995).

Building scenarios involves anchoring each scenario in the past, and determining what issues may significantly affect the area - including economic, political, technological and industry factors (Schoemaker, 1995). Scenario planning provides a forum for policy creation and evaluation, when stakeholders are involved in the process (Peterson *et al.*, 2003). Scenario planning is an effective coping method when control is difficult and uncertainty is high, factors which are evident in managing drought and excessive moisture events within the watershed.

During the workshops in March 2011, various issues affecting the North Saskatchewan River Watershed were identified through mapping exercises. Following the mapping exercises, stakeholders were separated into two breakout groups to discuss three scenarios which could potentially affect the Watershed (Figure 7).

- **Scenario 1 – What would happen if a wet year like 2010 happened twice in 5 years?**
  - What would the impacts be?
  - Who would be most vulnerable? And why?
  - What could be done to prepare for this scenario?
- **Scenario 2 – What would happen if a long-term drought (lasting longer than previously experienced) occurred?**
  - What would the impacts be?
  - Who would be most vulnerable? And why?
  - What could be done to prepare for this scenario?
- **Scenario 3 – What would happen if it switched back and forth from wet to dry years very quickly?**
  - What would the impacts be?
  - Who would be most vulnerable? And why?
  - What could be done to prepare for this scenario?

Figure 7. Scenario Assessment Discussion Questions

Table 3. Scenario One	Vulnerability	Adaptation
What would happen if a wet year like 2010 happened twice in 5 years?	• Increased flooding • Increased disease (livestock) • Increased land loss • Decreased accessibility to land • Increase in invasive species on land that cannot be accessed for several years and subsequently are not seeded • Increased rate of decomposition and decrease in organic matter • Increased degradation of soil structure (alkali issues) • Increased runoff and chemical leeching • Potential impact on abandoned wells and water quality • Longer road bans • Increased damage to roads and fields (rutting etc.) • Increased taxes • Increased loss of trees and shelterbelt establishments • Negative financial impact on producers • Haying issues • Decreased accessibility to corrals, particularly low-lying corral systems • Increased expense to gain access to corrals (cleaning), particularly low-lying corral systems • Grain producers and livestock producers vulnerable due to loss of grazing areas and loss of accessibility to cropland • Decrease in feed quality	• Change land management strategies • Lengthen crop rotations and increase rotation diversity • Shorten time on pastures • Monitor beaver dams and other pest control • Clean, maintain, replace culverts • Wetlands can reduce impacts downstream • Crop farms seed to grass or alfalfa • Municipalities should not allow zoning in flood areas • Change crop types

Table 3 cont'd. Scenario Two	Vulnerability	Adaptation
What would happen if a long-term drought (lasting longer than previously experienced) occurred?	• Lost revenue • Forced to reduce herd size • Increased expenses (buying feed) • Decrease in household and shallow wells • Increase in hauling water and well exploration and drilling (shallower wells would need to tap into deeper wells increasing the stress on deeper wells) • Dugouts, sloughs and creeks dry up – decrease in waterfowl and other wildlife – impact to ecosystems • Increased stress on crop insurance • Increased insurance premiums • Increased erosion • Increased farm failure • Hauling water	• Building organic matter in good years • Proper grazing management (rotational grazing) • Effective use of rain (modeling after places like the South Dakota Research Farm in terms of crop rotation and rain management) • Storage facilities for water • Maintaining wetlands • Maintaining well reservoirs • Fencing of dugouts (off-site watering systems) • Zero-till, less moisture loss • Crop insurance policies need to be re-evaluated • Leave beaver dams intact • Stockpile feed, water, enhance dugouts • Investigate potential snow fencing areas
Scenario Three	**Vulnerability**	**Adaptation**
What would happen if drought and excessive moisture events switched back and forth from wet to dry years very quickly?	• Increased drainage in wet years, then in dry years there is a deficit • Crop producers may be more vulnerable	• Responding in moderation – not reactive • Would a "No-Trenching" by-law in RMs be beneficial? • Change philosophies on drought management. Approach land management with thinking of each day after a rain as the start of a drought, rather than after so many days without rain. • Leaving the land the way – and better – than when you found it • Raising awareness • Considering organic matter as an asset to the land • Diversify

The scenario planning exercise identified vulnerabilities associated with each potential scenario and possible adaptations stakeholders could foresee to mitigate impacts of such events (Table 3).

2.4 Information Requirements

During the workshops, participants were asked to complete a questionnaire to help decision makers understand the diversity of groups and what information may be valuable to them (Appendix III).

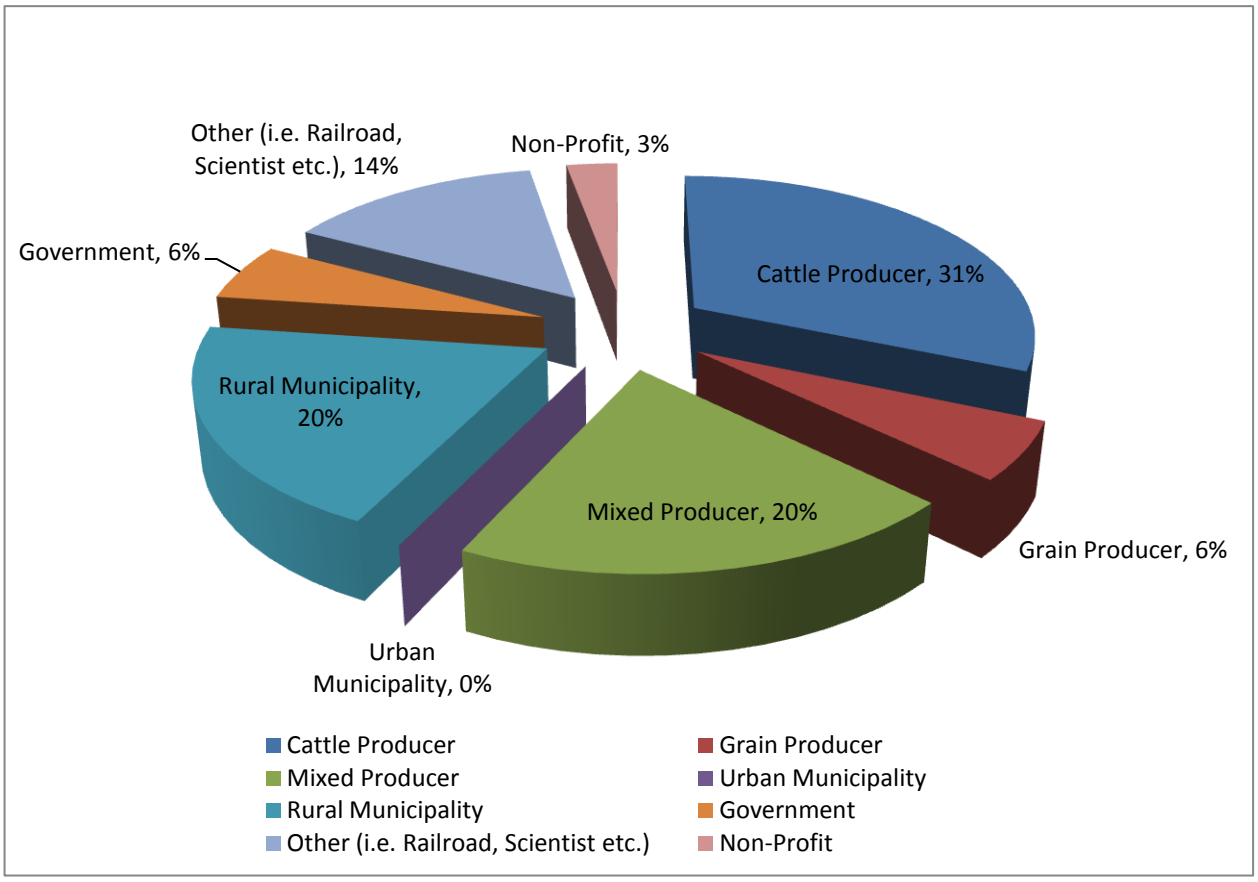


Figure 8. Representative User Groups Present within the North Saskatchewan River Watershed, March 2011

The majority of the representative user groups present within the North Saskatchewan River Watershed were Cattle Producers (31%), and Rural Municipalities and Mixed Producers (each 20% respectively).

The North Saskatchewan River Watershed workshop attendees were asked to identify what information may be beneficial to them. Figure 9. compares preferred information requirements among all user groups within the North Saskatchewan River Watershed.

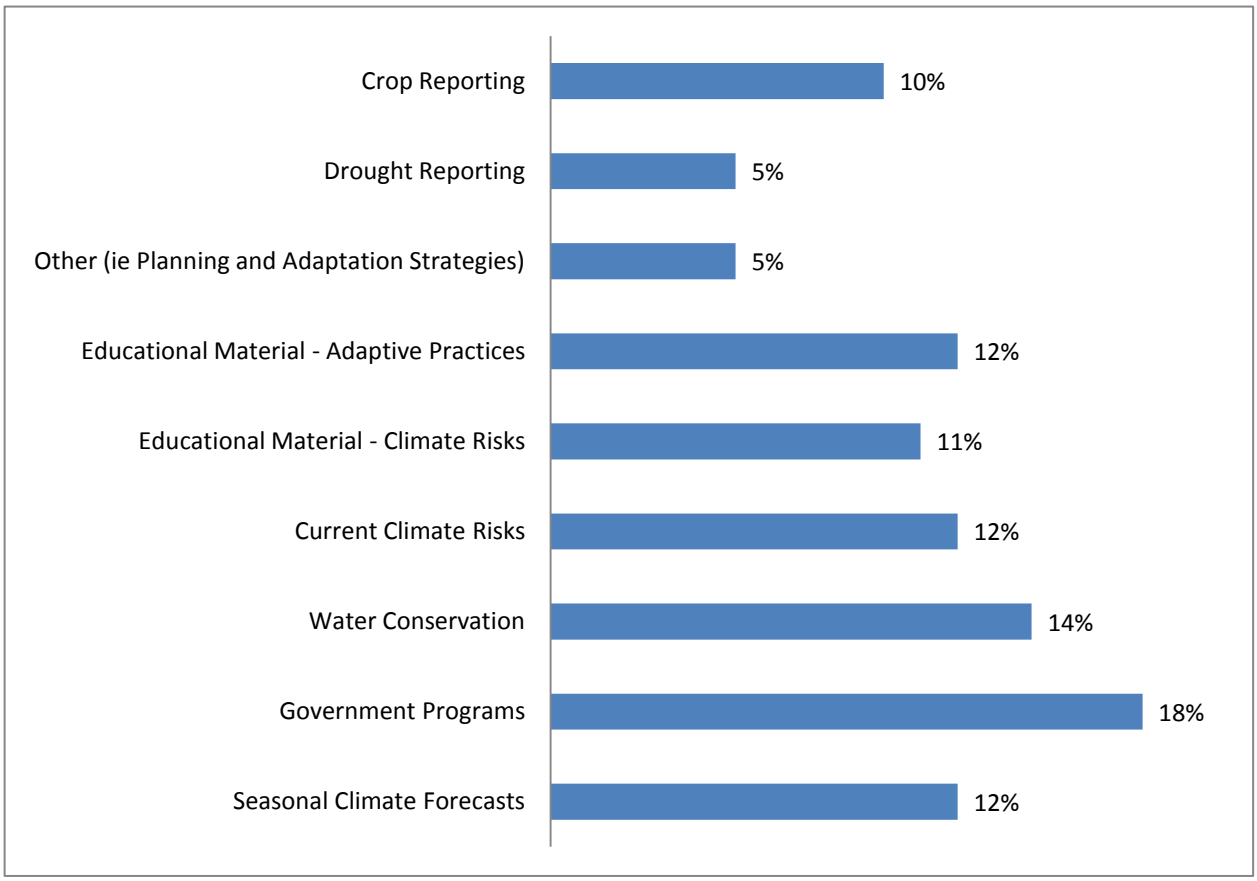


Figure 9. Comparison of Preferred Information Requirements among User Groups within the North Saskatchewan River Watershed, March 2011

User groups identified Government Programs (18%) as the most important information requirement followed by Water Conservation (14%) and Information Concerning Current Climate Risks, Educational Material on Adaptive practices, and Seasonal Climate Forecasts (each 12% respectively) (Figure 9).

Table 4. compares preferred information requirements from each user group within the North Saskatchewan River Watershed.

Table 4. Comparison of Preferred Information Requirements of Each User Group within the North Saskatchewan River Watershed, March 2011

	USER GROUP							
INFORMATION REQUIREMENTS	Cattle Producer	Grain Producer	Mixed Producer	Urban Municipality	Rural Municipality	Government	Non-Profit	Other
Information on Government Programs	16%	14%	24%	0%	18%	14%	0%	18%
Information on Water Conservation	16%	14%	12%	0%	18%	14%	25%	18%
Seasonal Climate Forecasts	14%	14%	16%	0%	18%	14%	25%	14%
Information on Current Climate Risks	16%	14%	16%	0%	15%	14%	0%	14%
Educational Materials (EM) on Climate Risks	14%	14%	12%	0%	12%	14%	25%	18%
Educational Materials (EM) on Adaptive Practices	14%	14%	16%	0%	12%	14%	25%	14%
Other (ie. Flood/Drought Forecasting, Holistic Management, Weather changes and patterns, Animal movements)	9%	14%	4%	0%	6%	14%	0%	5%
Total	100%	100%	100%	0%	100%	100%	100%	100%

Grain Producers and Government expressed equal interest in all information requirements (14% each respectively); Mixed Producers expressed a high interest in information on government programs (24%); Cattle Producers, Rural Municipalities, Non-Profit and Other groups had a broader interest in all information requirements (Table 4).

III

Adaptation Planning and Actions

Adaptation is defined by the Intergovernmental Panel on Climate Change (IPCC) as "an adjustment in natural or human systems in response to actual or expected climatic stimuli (variability, extremes, and changes) or their effects, which moderates harm or exploits beneficial opportunities" (UKCIP, n.d., as cited in IPCC TAR, 2001).

Good adaptation practices are founded on the engagement of informed stakeholders and community, with the willingness and ability to adapt (UKCIP, n.d.).

Within the North Saskatchewan River Watershed the process of building adaptive capacity involves understanding the nature of issues and risks within the Watershed, (which were identified by the community and stakeholders during the vulnerability exercises), then assessing the situation (coping capacities and thresholds), and finally identifying potential adaptive responses (UKCIP, n.d.).

The recommendations and adaptation actions were compiled by the workshop facilitator. The discussions from each workshop were then grouped into three vulnerability themes within the North Saskatchewan River Watershed (Table 5):

- Agri-Environmental Group Plan (AEGP)/Producers
- Municipal Preparedness
- Government Policy and Programming

Table 5. Agri-Environmental Group Plan (AEGP) and Individual Producers, Municipal, and Government Policy and Programming Issues within the North Saskatchewan River Watershed								
	Issue	**Priority**						
Action Item #	**AEGP/Producers**	**Low**	**Medium**	**High**	**Preparedness**	**Response**	**Recovery**
1	Increase funding for AEGP awareness initiatives (i.e. workshops, outreach, tours, etc) to gain more local support				X	X	X
2	Engage local media in order to promote good land management and its benefits during climate variability				X	X	X
3	Enhance awareness and provide more demonstrations on the cumulative, negative impacts of drainage				X	X	
4	Increase outreach and education on enhancing building organic matter on land to safeguard against drought				X	X	
5	Promote education on efficient use of rainfall in the agricultural landscape. Promote information from the South Dakota Research Farm.				X	X	X
6	Promote funding support for water supply expansion				X	X	
7	Establish communication networks in order to share resources during extreme climate events				X	X	X
8	Promote best management agricultural operations during extreme climate events				X	X	X
9	Promote the value of local water storage such as wetlands				X	X	X
	Issue **Municipal**						
10	Promote enhanced land management practices through mailouts and other opportunities to enhance local resiliency				X	X	
11	Encourage local water storage				X	X	X
12	Invest in improving or preparing infrastructure for more extreme flood events				X	X	X
13	Promote negative impacts of trenching, work with provincial government to enforce trenching practices or provide incentives for water storage				X	X	X
14	Promote/disseminate information on drought resistant land practices				X	X	
15	Provide financial incentives to those who make investments which improve the quality and resiliency of their land				X	X	
16	Enhance communication efforts and provide more information on beneficial land management				X	X	
17	Promote producers expanding their watering systems				X	X	
18	Provide and support networks for sharing resources during extreme climate events				X	X	X

Action Item #	Issue Government Policy and Programming	Priority Low	Medium	High	Preparedness	Response	Recovery
19	Provide funding for the Farm Stewardship Program and expand AEGP capacity as this program enhances local resiliency and safeguards against drought and excessive moisture events				X	X	X
20	Develop guidelines or best practices to manage water issues locally (i.e. if your yard is flooded and you need to drain the area, what is the best approach?)				X	X	X
21	Invest in LIRA research to assess means to prepare for excessive moisture				X	X	
22	Provide financial compensation to individuals who are willing to store water during excessive moisture events				X	X	
23	Collaboration with SARM and the watershed RMs to promote negative impacts of trenching				X	X	
24	Enhance the amount of information available on the efficient use of rain in both rural/agricultural and urban environments				X	X	
25	Provide compensation funding to producers impacted by climate events, based on their best management practices				X	X	
26	Compensate producers for loss of insurance if they choose to use lost crops to support themselves or other producers in the network				X	X	
27	Provide funding for long-term proactive flood preparedness investments made by individuals and municipal governments				X	X	X
28	Watershed RMs and SARM should work with government to adjust crop insurance regulations during extreme climate events				X	X	X

This portion of the plan attempts to rate potential adaptations (action items) identified by stakeholders during the discussion sessions, as low (green), medium (yellow), or high (red) priority. The adaptations outlined in Table 5 were then recognized as part of a preparedness, response or recovery item in the occurrence of a potential drought or excessive moisture event.

IV

Future Refinements

Adaptation will involve a mixture of response strategies which may require a 'sequential approach': building climatic resilience; increased preparedness and planning (living with the potential risks); and to a certain extent - some acceptance of loss (UKCIP, n.d.).

The goal of this plan was to identify current and past exposures and sensitivities that people within the North Saskatchewan River Watershed encounter, examine how the community deals with these conditions or risks, and identify processes and factors which may constrain their choices (Smit and Wandel, 2006). Once these conditions are identified, analysts and policy makers can help the Watershed plan-for (preparedness), and respond-to (response), these conditions and potentially determine future vulnerability (Smit and Wandel, 2006).

Adaptation must evolve with internal and external circumstances in order for adaptation to be continually effective. The viability of the Watershed's adaptive responses will be challenged - as climate, technological innovations, increased scientific understanding, and socio-economic's are constantly changing. As such, adaptive planning and responses will need to be reassessed periodically within the Watershed.

By adopting a continuous improvement approach and incorporating lessons-learned from previous adaptation efforts - the North Saskatchewan River Watershed will be better prepared in the event of future drought or excessive moisture events.

V

Land and Infrastructure Resiliency Assessment Project

Adaptation to extreme climate events is a subject of ever-increasing importance, and in addition to the development of this plan, the North Saskatchewan River Watershed has also been engaged in an Agriculture and Agri-Food Canada project, known as the Land and Infrastructure Resiliency Assessment (LIRA) project. The focus of the LIRA project is to provide decision makers with a methodology that will help address proactive adaptation to extreme climate events on a local landscape, improve regional economic development opportunities, and analyze the costs and benefits of implementing adaptation and mitigation measures.

The LIRA project is a five phase process that is now being used to transition the methodology from research to operational status. One site, in which this methodology is currently being applied, is the Redberry Lake Biosphere Reserve; which is located in the central portion of the North Saskatchewan River Watershed. The two year pilot study is the phase four component of the project in which the methodology is being tested in a rural setting.

The Redberry Lake Biosphere Reserve pilot project is now in the process of identifying the adaptation and mitigation measures that may be utilized to minimize the social, economic and environmental damage of extreme precipitation events. It is anticipated that the specific adaptation and mitigation measures may also serve to minimize drought related impacts. The content developed in the North Saskatchewan River Watershed Drought and Excessive Moisture Preparedness Plan is also anticipated to assist the development of the Redberry Lake Biosphere Reserve LIRA pilot project.

Appendix I
Glossary of Terms

Definitions for terms used in this plan are included below. Many of the terms used in the plan have a variety of definitions, depending on the discipline used; however, for the purpose of this plan, the definitions have been adapted to the natural hazard of drought and excessive moisture.

Adaptation: "an adjustment in natural or human systems in response to actual or expected climatic stimuli (variability, extremes, and changes) or their effects, which moderates harm or exploits beneficial opportunities" (UKCIP, n.d., as cited in IPCC TAR, 2001).

Adaptive Capacity: refers to a system or community's potential or ability to plan for, cope, and adjust to changes and stresses with minimal disruption or additional cost (ICLEI, 2010; Ford and Smit, 2004; Smit and Wandel, 2006).

Agricultural Drought: characterized by a lack of water to grow a particular type of crop or support livestock. Defining factors include not only the amount of precipitation received, but the correct use of available water. Agricultural drought generally occurs after a meteorological drought and before a hydrological drought (Econnics, 2010).

Drought: drought originates from a reduction in the amount of precipitation over an extended period of time, resulting in a water shortage, usually a season or more in length. Droughts differ in intensity, duration and spatial extent (Knutson *et al.*, 1998).

Excessive Moisture: periods of flooding due to heavy precipitation events or spring runoff which may disrupt social and environmental systems (Pittman, 2010b).

Hydrological Drought: occurs when low precipitation results in low water levels in lakes, rivers, reservoirs and aquifers. Generally, a hydrological drought follows a meteorological drought. Water uses that depend on ground and surface water levels such as urban water use, recreational and industrial water use, and ecosystems are affected by hydrological droughts (Econnics, 2010).

Meteorological Drought: occurs when precipitation in a certain area, within a particular time period, is compared to the average rainfall for that same area. Soil moisture is depleted during a meteorological drought and impacts crop production (Econnics, 2010).

Preparedness: process of performing pre-disaster activities to ensure a level of readiness to respond in the event of a drought or excessive moisture emergency (Knutson *et al.*, 1998).

Recovery: activities undertaken to promote the rebound of social and environmental systems following an extreme event (Pittman, 2010b).

Response: activities undertaken to reduce the negative consequence of the impacts from drought and excessive moisture events (Pittman, 2010b).

Risk: the possibility of adverse effects as a result of drought or excessive moisture events based on the temporal and spatial severity of the event and one's corresponding vulnerability (Knutson *et al.*, 1998).

Socio-economic Drought: occurs when a weather-related shortfall in water supply results in the inability to meet the demand for economic goods. The severity and impact of Socio Economic Drought is affected by water demand (Econnics, 2010).

Vulnerability: the susceptibility of a population or the environment in the event of drought or excessive moisture (Knutson *et al.*, 1998).

Vulnerability Assessment: framework for identifying a population or environments' susceptibility and the underlying causes of drought-related impacts (Knutson *et al.*, 1998).

Appendix II
Resources

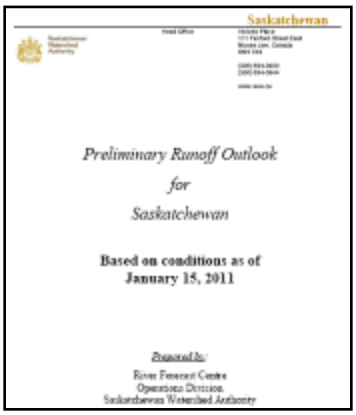
Provincial Government Resource Websites

Farm and Ranch Water Infrastructure (Government of Saskatchewan)
A province-wide Farm and Ranch Water Infrastructure Program will support the development of secure water sources in Saskatchewan to expand the livestock industry, encourage rural economic activity and mitigate the effects of future drought. http://www.agriculture.gov.sk.ca/FRWIP_2009

Provincial Disaster Assistance Program (PDAP) (Government of Saskatchewan)
Provides financial assistance in certain circumstances where there has been a natural disaster, such as flooding, tornadoes, plow winds and severe weather.
http://www.cpsp.gov.sk.ca/Default.aspx?DN=4c191c20-5666-48fd-b412-979717005ef2

Free testing of flood-impacted drinking water wells (Saskatchewan Watershed Authority)

Offers free testing of drinking water wells affected by flooding. http://www.gov.sk.ca/news?newsId=503d61fe-9281-4b4b-b582-a6fcdb23c452



2011 Preliminary Spring Runoff Outlook (Saskatchewan Watershed Authority)

SWA has compiled detailed information on potential spring runoff conditions for the province. http://www.swa.ca/WaterManagement/Documents/ProvincialForecast2011Jan15th.pdf

Stream Flows and Lake Levels (Saskatchewan Watershed Authority)

Real-time information on stream flow and water level data is collected at hydrometric stations throughout the province of Saskatchewan to monitor water conditions in Saskatchewan. http://www.swa.ca/WaterManagement/StreamFlowsAndLakeLevels.asp

Flooding Preparedness (Government of Saskatchewan)

Documents and related links to assist homeowners in flood preparation, disaster cleanup, emergency measures and disaster assistance. http://www.health.gov.sk.ca/flooding-preparedness

Crop Reporter (Government of Saskatchewan)

Volunteer Crop Reporters fill out a weekly online summary and report crop conditions and precipitation for their areas. Reporting begins April 1st and runs for approximately 27 weeks. A regional crop report is released weekly.
http://www.agriculture.gov.sk.ca/Crop-Report

Current News/Information (Government of Saskatchewan)

- Strong Uptake for Emergency Flood Damage Reduction Program http://www.gov.sk.ca/news?newsId=efd27cc6-9f3f-4228-9d91-0e223e8e7ea7

- Province Releases Details of $22 Million Emergency Flood Damage Reduction Program http://www.gov.sk.ca/news?newsId=a21f4d25-0afc-4561-9e1c-e02c2156d7c1

Federal Government Resource Websites

Real-time Hydrometric Data (Environment Canada)
This site provides public access to real-time hydrometric (water level and streamflow) data collected at over 1700 locations in Canada.
http://www.wateroffice.ec.gc.ca/text_search/search_e.html?search_by=p&region=SK

The Weather Office (Environment Canada)
Provides historical, current conditions and forecasts.
http://www.weatheroffice.gc.ca/canada_e.html

AESB Water Supply and Drought Monitoring – Drought Watch (Agriculture and Agri-Food Canada)
http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1256658312655&lang=eng
Information and maps which provide users with an overview of the risk of drought in Canada.

Drought Management Information (Agriculture and Agri-Food Canada)
Extensive information on managing drought in regards to crops, livestock, pests, pasture management and water.
http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1256665877504&lang=eng

Managing Wet Soils (Agriculture and Agri-Food Canada)
This webpage, located on Agriculture and Agri-Food Canada's Internet site provides information on Impacts of Excess Soil Moisture and Cover Crops.
http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1195497988026&lang=eng

Environment Canada Seasonal Forecast (Environment Canada)
Provides monthly and seasonal forecasts, information on El Nino and La Nina, climatology of temperature and precipitation.
http://www.weatheroffice.gc.ca/saisons/index_e.html

Snow Water Equivalent Mapping (Natural Resources Canada)
Displays recent information of snow cover across Canada and North America.
http://atlas.nrcan.gc.ca/auth/english/maps/environment/climate/snowcover/snowdepth

Additional Resources

Irrigation Saskatchewan
Provides links to three websites - Irrigation Crop Diversification Corporation, Saskatchewan Ministry of Agriculture and Saskatchewan Irrigation Projects Association – which provide information on irrigation systems, scheduling, crop varieties and news and events.
http://www.irrigationsaskatchewan.com/ICDC/icdc_index..htm

Drought Research Initiative (DRI)
The Drought Research Initiative was a five year program (2005-2010) to coordinate and integrate drought research in Canada through combining university and provincial/federal government researchers with expertise in various aspects of droughts including atmospheric, hydrologic, land surface and predictive aspects. http://www.drinetwork.ca/

National Drought Mitigation Center (NDMC) University of Nebraska – Lincoln
The NDMC employs preparation and risk management rather than crisis management in helping people and institutions deal with drought. The NDMC site provides information on monitoring, drought planning, and impacts and mitigation.
http://www.drought.unl.edu/

National Integrated Drought Information System (NIDIS) U.S. Drought Portal
The U.S. Drought Portal is a system used to provide early warning data on drought and help individuals and organizations to plan and manage for the impacts of drought. The system also provides agencies and stakeholders with information on potential risks, impacts and comparison models for previous and potential droughts.
http://www.drought.gov/portal/server.pt/community/drought_gov/202;jsessionid=0559F10E8EC21CA540B604A9F2BEF6E1

Weatherfarm

Provides online information for Western Canadian producers providing real-time weather and farm-management information.
http://www.cwb.ca/public/en/farmers/weather/stations/

Weatherbug

Provides online information for current weather and local forecast.
http://weather.ca.weatherbug.com/SK/Regina-weather.html?zcode=z6286&lang_id=en-ca

ICLEI Adaptation Handbook – Changing Climate, Changing Communities: Guide and Workbook for Municipal Climate Adaptation

ICLEI is an international association of local governments that provide technical consulting, training and information which work towards sustainable development at the local level.
http://www.iclei.org/index.php?id=10832

SaskAdapt – Saskatchewan's Climate Change Impacts and Adaptation Information Center (Prairie Adaptation Research Collaborative)

Provides the latest Saskatchewan and Prairie-specific science and information to help residents, government and business organizations make decisions on adapting to climate change.
http://www.parc.ca/saskadapt/introduction

Drought Preparedness Planning: The Ten Step Process (2007 National Drought Mitigation Center)

A ten step process which provides a checklist of key elements of a drought plan. http://www.p2pays.org/ref/50/49988.pdf

University of Nebraska-Lincoln - Drought Monitor

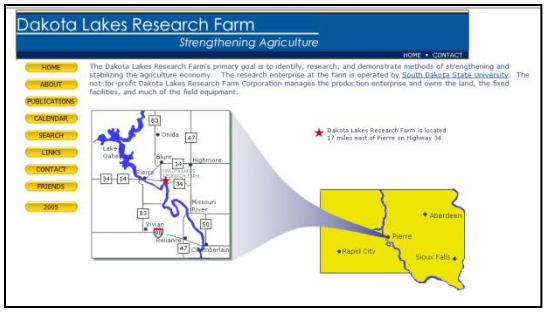
Provides forecasts, current conditions and drought monitoring within the United States.
http://www.drought.unl.edu/dm/index.html

British Columbia Drought Response Plan

Drought response plan which addresses preparedness, response and recovery for the province of British Columbia.
http://www.env.gov.bc.ca/wsd/public_safety/drought_info/cabinet/bc_drought_response_plan_june-2010.pdf

Living with Drought (Australian Government)

Australian weather, seasonal climate information, climate data, information on living with drought.
http://www.bom.gov.au/climate/drought/livedrought.shtml



Dakota Lakes Research Farm (South Dakota State University)

Not-for-profit research farm operated by South Dakota State University whose main goal is to research and provide methods for strengthening and stabilizing the agriculture economy.

http://www.dakotalakes.com/

Appendix III
Information Requirements Questionnaire

INFORMATION REQUIREMENTS QUESTIONNAIRE

1. Which group(s) do you represent? (Please choose all that apply)
    a. Cattle producer ___
    b. Grain producer ___
    c. Mixed producer ___
    d. Urban municipality ___
    e. Rural municipality ___
    f. Government ___
    g. Other:_____ ___

2. What information would be valuable to you? (Please choose all that apply)
    a. Information on government programs ___
    b. Information on water conservation ___
    c. Seasonal climate forecasts ___
    d. Information on current climate risks ___
    e. Educational materials on climate risks ___
    f. Educational materials on agronomic practices ___
    g. Other: _____ ___
    h. Other: _____ ___
    i. Other: _____ ___
    j. Other: _____ ___
    k. Other: _____ ___

3. Are you interested in the following: (Please choose all that apply)
    a. Volunteer crop/climate reporting ___
    b. Volunteer drought and other climate impact reporting ___

Appendix IV
North Saskatchewan River Watershed Adaptation Planning (Issues) Template

How can we address the issues?

	Issue:		
	Action items	**Priority (high, medium, low)**	**Who should work on this?**
1			
2			
3			
4			
5			
6			
7			

Appendix V
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