   

TOWN OF BRUDERHEIM

CLIMATE RESILIENCE ACTION PLAN

- MARCH 2016 -

"A resilient [community] *is one that has developed capacities to help absorb future shocks and stresses to its social, economic, and technical systems and infrastructures so as to still be able to maintain essentially the same functions, structures, systems, and identity."*

[Working Definition, ResilientCity.org]

This Climate Resilience Action Plan (Action Plan) has been produced through the **Climate Resilience Express** project with financial support from The Calgary Foundation, Natural Resources Canada, All One Sky Foundation, the Municipal Climate Change Action Centre, and Alberta Ecotrust.

The goal of Climate Resilience Express is to produce a streamlined ("express") process for developing a climate resilience action plan for smaller communities through a one-day workshop process, and to subsequently prepare a 'self-help' toolkit to support these communities in working through the process. Four smaller communities from across Alberta were selected to pilot the workshop process and aspects of the toolkit. The Town of Bruderheim was one of the selected communities.

Climate Resilience Express is a collaboration between All One Sky Foundation, the Municipal Climate Change Action Centre, the Miistakis Institute and the Alberta Biodiversity Monitoring Institute.

For more information on the Climate Resilience Express visit: http://allonesky.ca/climate-resilience-express-project/ or mccac.ca/programs/climate-resilience-express.

March 2016

Summary

The effects of climate change are already apparent in the Bruderheim area, with observable changes in temperature, precipitation, and extreme weather events over the last century. The impacts of climate change could be numerous and diverse, giving rise to uncertain consequences, for infrastructure and services, property, the local economy and environment, and the health and lifestyles of citizens. To better prepare for these potential impacts, the Town of Bruderheim has prepared this Action Plan, which identifies a number of anticipatory measures to manage priority risks and opportunities expected to result from climate change over the next several decades.

In total, 12 climate-related risks, and four climate-related opportunities were identified, of which four risks were judged to be priorities requiring immediate action, and are the focus of this Action Plan:

1. Storm-water and creek flooding;
2. Freezing rain / ice storm;
3. Water supply shortage; and
4. Extreme wind storm.

Starter action plans are developed for each of these priority risks.

The Town of Bruderheim is already committed to numerous actions that help manage the above priority risks, including operational procedures to help manage storm-water flooding issues, automated alert systems for the sewage and water supply systems, a Disaster Services Plan, and a tree pruning program to protect against extreme wind events.

In addition to existing actions that help mitigate priority climate risks, 16 actions are identified for consideration to help Bruderheim better prepare for climate change. A number of actions can be implemented quickly with minimal investment, whereas other actions have longer-term timeframes and require a higher level of investment. Implementation of these actions will ensure that the Town of Bruderheim remains resilient under a wider range of potential future climate conditions.

This Action Plan is a living document and should be periodically reviewed and updated to ensure it remains relevant and effective.

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1. INTRODUCTION

The effects of climate change are already apparent in Bruderheim, with observable changes in temperature, precipitation, and extreme weather events over the last century. The average annual temperature in the Bruderheim area has increased by about +1.8°C since the early 1900s, with winter months seeing greater warming than summer months. Over the same period, the amount and timing of precipitation in the area have also changed.

We are sure to experience further changes to our climate in the decades ahead—the result of past greenhouse gas (GHG) emissions. There is a time lag between GHG emissions and when we see the impacts, as the planet takes a while to respond. How much the climate will change beyond the next few decades depends on how far and how fast global GHG emissions are reduced from current levels.

Mitigation will help avoid the unmanageable … **adaptation** is essential to manage the unavoidable.

The impacts of climate change on communities across Alberta will be numerous and diverse, giving rise to potentially significant, though uncertain consequences for municipal infrastructure and services, private property, the local economy and environment, and the health and lifestyles of citizens. Potential impacts may include changing patterns of precipitation with increased risk of flooding and drought, increased strain on water resources, rising average temperatures and more common heatwaves, more frequent wildfires, or more intense ice, snow, hail or wind storms. Climate change may also present opportunities for communities.

Alberta communities are at the forefront of these impacts—both because extreme weather events can be especially disruptive to urban systems and because they are where much of the population lives, works and raises families. Smaller communities with limited resources are particularly vulnerable and may lack the capacity to adequately respond to increasing impacts. It is therefore essential that communities take steps now to anticipate and better prepare for future climate conditions, to ensure they continue to prosper as a desirable place to live and work for generations to come.

The Town of Bruderheim, through the preparation of this Action Plan, is taking steps towards a safe, prosperous and resilient future. The Action Plan identifies a number of anticipatory measures to manage priority risks and opportunities anticipated to result from climate change in the area over the next several decades.

2. Developing the Action Plan

The overall approach to developing climate resilience action plans through Climate Resilience Express is grounded in existing standards for risk management based on the International Organization for Standardization's (ISO) 31000, Risk Management – Principles and Guidelines. It follows a four-step, iterative process (shown in Figure 1):

Step 1: Establish the local context for climate resilience action planning;

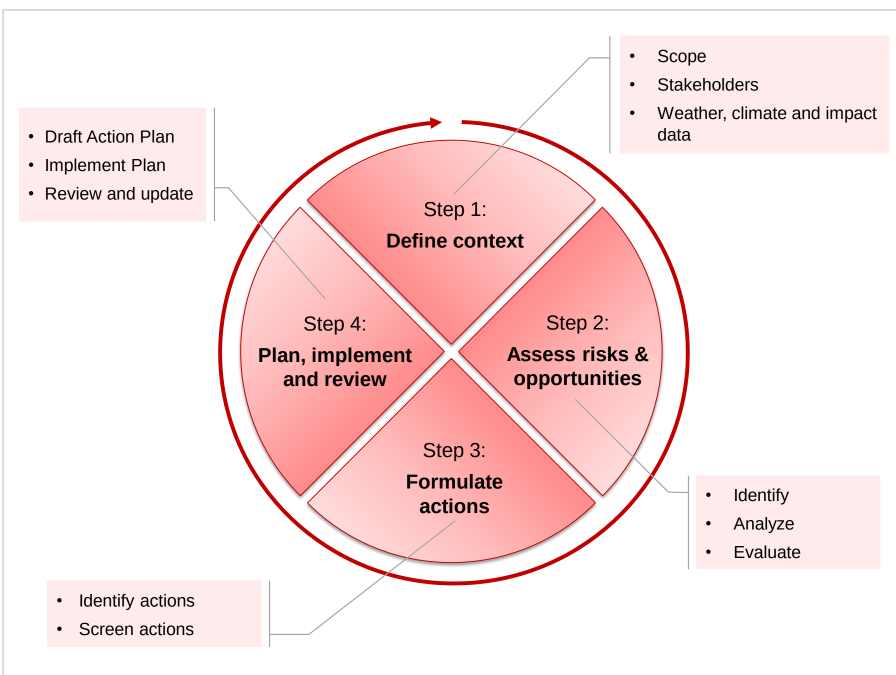
Step 2: Assess potential climate-related risks and opportunities to establish priorities for action;

Step 3: Formulate actions to manage priority risks and opportunities; and

Step 4: Prepare and implement an Action Plan, review progress, and update the Plan to account for new information and developments.

Step 2 and Step 3 of the process are the focus of the one-day workshop with local stakeholders, which is at the heart of Climate Resilience Express. Step 1 is undertaken in advance of the workshop; preparing the Action Plan and Step 4 take place after the workshop.

Figure 1: Climate Resilience Express — action planning process



Before the Workshop: Step 1

Prior to the workshop the context for climate resilience action planning in Bruderheim is established. This involves:

- **Defining the spatial scope**

  The spatial scope is limited to impacts within the geographic boundaries of the Town of Bruderheim. Consideration is also given to climate impacts to critical lifelines, which occur outside the municipal boundaries—e.g., the Town's water supply is sourced and piped from the North Saskatchewan River at Edmonton.

- **Defining the operational scope**

  The assessment of risks and opportunities considers potential community-wide impacts, which includes impacts to municipal infrastructure, property and services, as well as impacts to private property, the local economy, the health and lifestyle of residents and the natural environment.

- **Defining the temporal scope**

  The assessment considers impacts arising from projected climate and associated environmental changes out to the 2050s. This timeframe looks ahead to the types of changes and challenges which decision-makers and residents might face within their lifetimes. It also reflects a planning horizon that, although long in political terms, lies within the functional life of key public infrastructure investments and strategic land-use planning and development decisions.

- **Compiling climate and impact data**

  Climate projections for the 2050s are compiled for the Bruderheim area and historical weather data is analyzed to identify observed trends in key climate variables. Information is also compiled on the main projected environmental changes for the area by the 2050s. This activity is discussed further in Section 3.

- **Developing scales to score risks and opportunities**

  Scales are required to establish the relative severity of impacts in order to determine priorities for action. The scales used in the risk and opportunity assessment at the workshop are provided in Appendices.

AT THE WORKSHOP: STEP 2 AND STEP 3

The one-day workshop used to generate the information underpinning this Action Plan comprises four main sessions. Workshop participants are listed in Appendix A.

- **Session 1: Exploring local weather and impacts**

  The session objective is to explore the relationship between weather, climate and key aspects of Bruderheim in relation to past weather-related impacts. Outcomes from this session at the workshop are presented in Section 3.

- **Session 2: Introduction to climate science and impacts**

  The session objective is to present information about climate science, local climate trends and projections, projected environmental changes, and potential impacts for the area. This information is also presented in Section 3.

- **Session 3: Assess future risks and opportunities**

  The session objective is twofold; first, to determine how projected climate or environmental changes could impact the Town of Bruderheim, and second, to prioritize the identified impacts in order to establish priorities for action planning. Outcomes from this session at the workshop are presented in Section **Error! Reference source not found.**.

- **Session 4: Action planning**

  The session objective is to determine what actions are necessary to increase resilience to priority risks and to capitalize on priority opportunities. Outcomes from this session at the workshop are presented in Section 5.

AFTER THE WORKSHOP: STEP 4

Outcomes from the workshop are used as the basis for this Action Plan. Building resilience to climate change is not a static process, however, but rather needs to be monitored and reviewed to both check progress on implementation and to take account of changing scientific knowledge about the physical impacts of climate change. Implementing this Action Plan, reviewing progress, and updating the Plan to keep it relevant are discussed in Section 6.

3. Observed Impacts, Climate Trends and Projections

Observed Local Weather and Climate Impacts

Session 1 at the workshop invited participants to identify how the Town of Bruderheim has been affected by weather-related events in the recent past, considering impacts on the local economy, property and infrastructure, the natural environment, and residents' health and lifestyles. A selection of observed weather-related impacts on the community identified by participants is provided in Box 1.

Box 1: Summary of observed weather events and impacts

- ✓ Wildfires in 2007, 2009 and 2015 led to some health impacts from smoke, had significant clean-up costs, and placed high burdens on emergency services and the volunteer fire department.
- ✓ Fire bans were in place in May 2015, which is unusual at that time of year.
- ✓ A snow storm in 1970 cut power and communications to the Town for a three-day period.
- ✓ Torrential rain can overload the storm drainage and sewer systems.
- ✓ Extended dry periods (droughts) in 2001 and 2002, and the declaration of an agriculture disaster in Lamont County in 2015 due to heat and drought, had severe economic and social impacts on local residents and farmers.
- ✓ Water levels in nearby wetlands, and also at Elk Island National Park, have been reduced, affecting recreation opportunities and visitation rates by tourists.
- ✓ Wind storms have damaged property and infrastructure (e.g. grain bins).
- ✓ Insects and pests that damage crops are more common.
- ✓ The Town used to see very cold winter spells with one month of temperatures of minus 20°C or colder. Such cold spells are very uncommon in recent years.

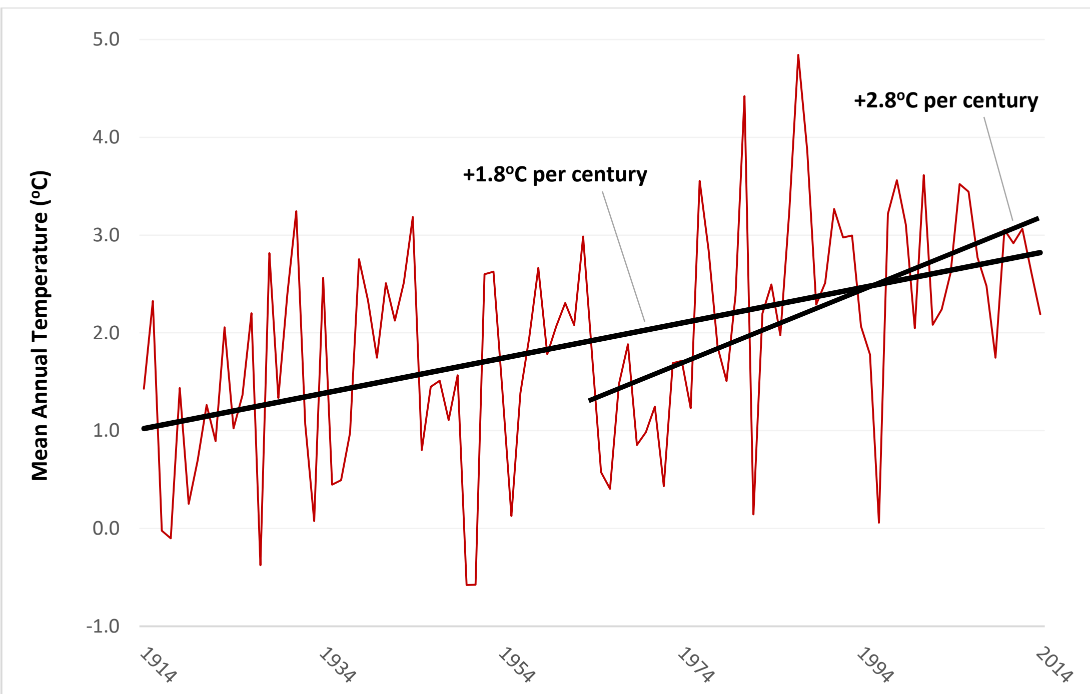
Local Climate Trends

To provide a perspective of historic climate trends in the Bruderheim area, data is collected and analyzed from five climate stations in the region (Calmar, Campsie, Cold Lake, Edmonton and Ranfurly) [i]. These climate stations were selected because the data cover multiple decades, are high quality, and the stations span an area that is comparable to the same area for which climate projections are available. Climate records of temperature and precipitation for the Bruderheim area are assembled by averaging the individual records from the five climate stations and applying appropriate statistical techniques[ii].

➡ Temperature records

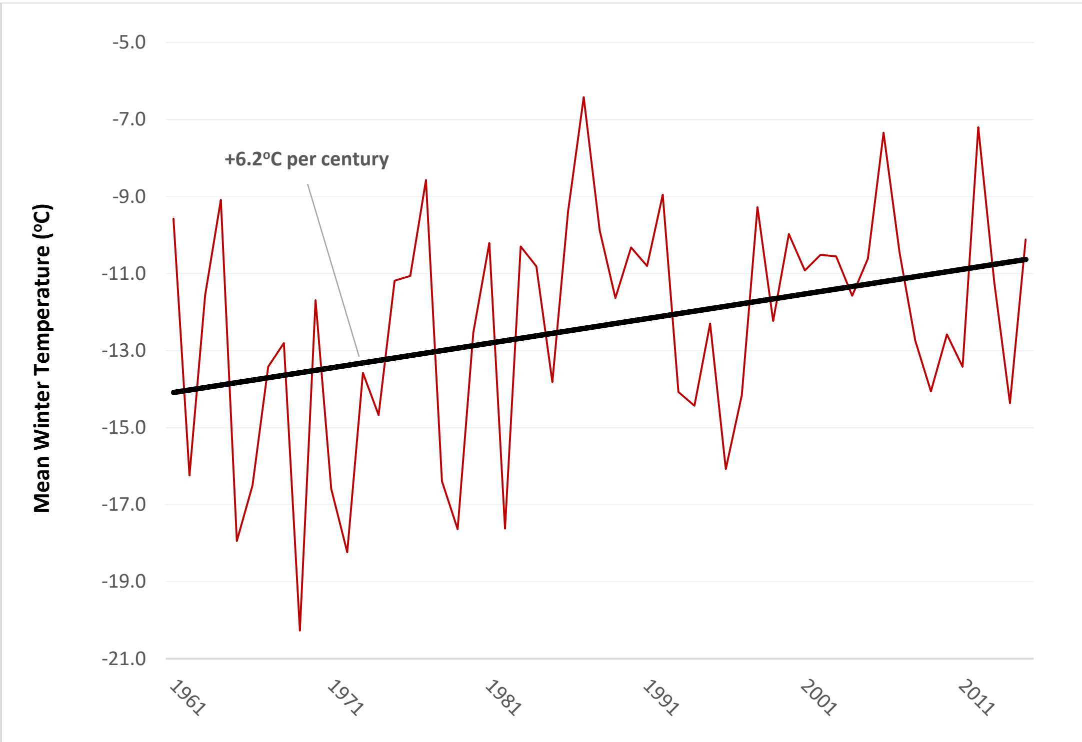
Temperature records for the area over the period 1914-2014 show that mean annual temperature has increased at a rate of +1.8°C per century (Figure 2), which is approximately double the observed global rate of warming over the same time period. The rate of warming observed over the last +50 years is higher still at 2.8°C per century.

Figure 2: Mean annual temperature in the Bruderheim area (1914-2014)



Over the last 50 years, the largest seasonal increase in temperature in the Bruderheim area occurred during the winter (December-February). The observed rate of warming in winter since 1961 is +6.2°C per century (Figure 3), which is substantially greater than the annual rate of +3.1°C per century. In contrast, warming during the summer (June-August) since 1961 increased at a slower rate of +1.9°C per century. Trends in mean spring and fall temperature are also positive over the last 50 years.

Figure 3: Mean winter temperature in the Bruderheim area (1961-2015)



Precipitation records

Mean annual precipitation in the Bruderheim area has not changed significantly over the last century. Further, changes in seasonal precipitation since 1914 and since 1961 show no significant trends with one exception; spring precipitation has increased at a rate of 55mm per century over the last 50 years (**Error! Reference source not found.**). Also, since 1961, the amount of precipitation falling as snow has been declining at a rate of 43 mm per century (**Error! Reference source not found.**), which is consistent with the observed warming in the region over this time frame.

Figure 4: Mean spring precipitation in the Bruderheim area (1961-2015)

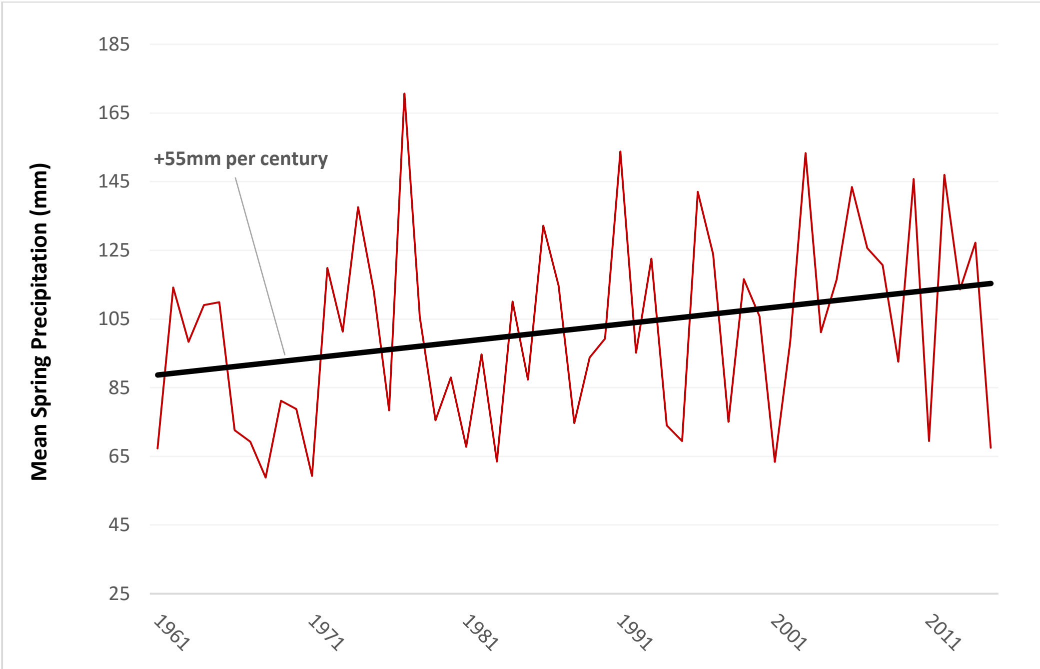
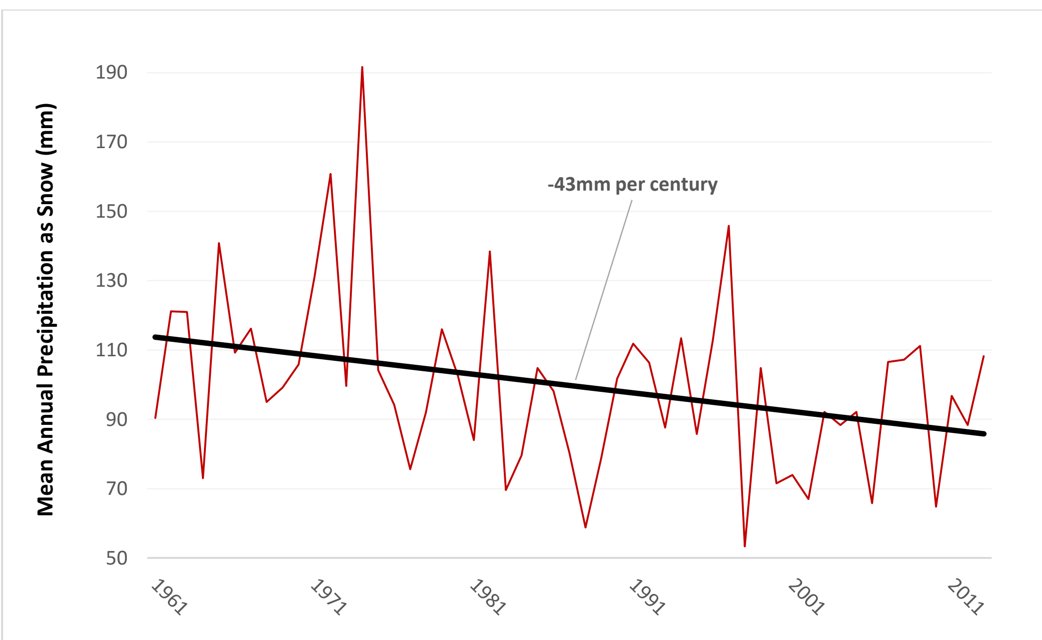


Figure 5: Precipitation falling as snow in the Bruderheim area (Sept-Jun) (1961-2013)



Source: CWNA[iii]

Climate Projections for Area

Climate projections for the Bruderheim area, for the 2050s, were derived using the Pacific Climate Impacts Consortium's (PCIC) Regional Analysis Tool[iv]. The projections are based on results from 15 different Global Climate Models (GCMs). Each model generates output for one high and one low GHG emission scenario. Projected climate change within the models is primarily driven by assumed increases in concentrations of GHGs in the atmosphere. The results from all 15 GCMs for both GHG emission scenarios are averaged.

"Since the mid-20th century human activities, including the burning of fossil fuels and changes in land use patterns have been the dominant cause of climate change… This trend is expected to continue through the present century and beyond, leading to rates of global warming that will exceed any experienced during the past several thousand years." [v]

Climate projections for the 2050s in the Bruderheim area are summarized in Table 1. The mean annual temperature is anticipated to increase by +2.0°C above the 1961-1990 baseline which will increase the absolute mean annual temperature in the 2050s to about +4.1ºC. This projected increase in temperature is consistent with the rate of change in mean annual temperature that has been observed in the Bruderheim area over the last 50 years. The projected increase in mean annual temperature is expected to be accompanied by an increase in mean annual precipitation of approximately 5%.

Table 1: Summary of climate projections for the Bruderheim area by the 2050s

Climate variable	Season	Baseline (1961-1990)	Projected change	
			Mean	Range
Average temperature	Annual	+2.1˚C	+2.0˚C	(+1.3 to +2.8)
Average precipitation	Annual	518 mm	+5%	(0% to +14%)
Average temperature	Summer	+15.4˚C	+2.0˚C	(+1.4 to +2.8)
Average precipitation	Summer	256 mm	-1%	(-8% to +14%)
Average temperature	Winter	-13.0˚C	+2.5˚C	(+0.9 to +3.4)
Average precipitation	Winter	76 mm	+13%	(-5% to +20%)
Average temperature	Spring	+2.9˚C	+1.7˚C	(+1.0 to +2.5)
Average precipitation	Spring	95 mm	+11%	(0% to +20%)
Average temperature	Fall	+3.0˚C	+1.8˚C	(+1.2 to +2.6)
Average precipitation	Fall	91 mm	+7%	(-4% to +15%)

Notes: The mean projected change is the average value over the 30-year period 2040-2069. The range is defined by the 10th and 90th percentile values. Summer includes Jun-Aug, fall includes Sep-Nov, winter includes Dec-Feb, and spring includes Mar-May.

The projected increases in mean summer temperatures (+2.5°C) and precipitation (+13%) both exceed the mean annual projections. Mean summer temperature is expected to increase by +2.0°C with little change in mean summer precipitation (-1%). Mean temperatures are expected to rise less dramatically in the spring and fall (+1.7°C and +1.8˚C, respectively); precipitation is projected to increase by 7% in the fall and by 11% in the spring.

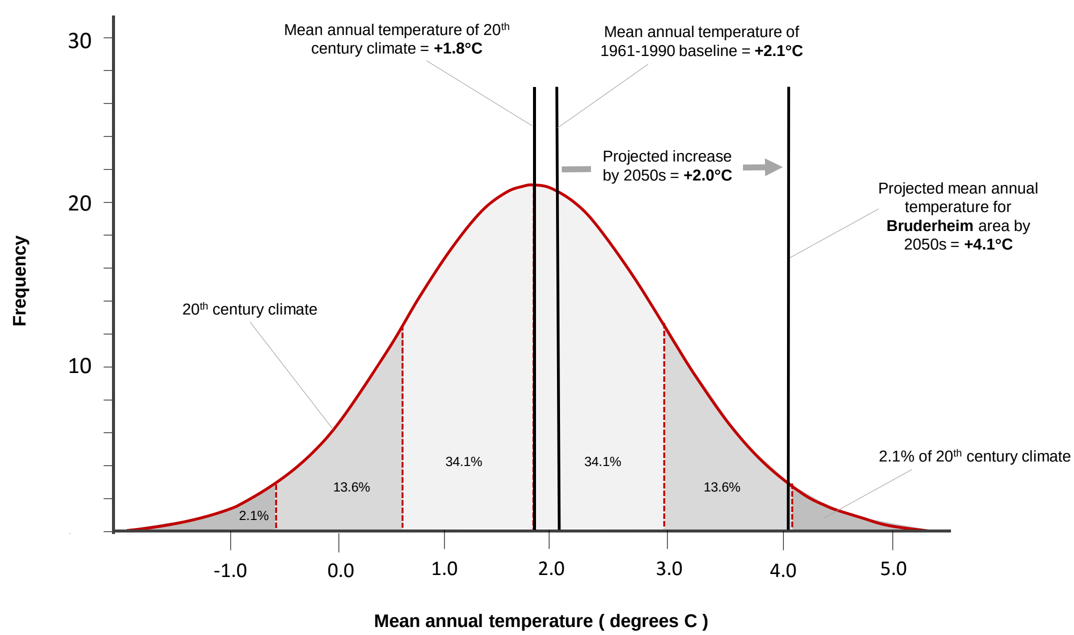
➨ Precipitation extremes

In recent years, numerous extreme precipitation events have occurred at various locations globally at monthly, daily and sub-daily timescales; several have occurred in western Canada with serious consequences. Recent studies have demonstrated that extreme rainfall intensity increases by about 7% for every degree increase in global atmospheric temperature[vi]. Model projections of short-duration precipitation is an emerging area of research and presents challenges due to—among other things—difficulties in modelling convective storms and the limited availability of hourly climate data for establishing long-term trends. However, as global temperatures increase, the capacity of the atmosphere to carry water vapor also increases. This will supply storms of all scales with increased moisture and produce more intense precipitation events[vii]. Consequently, it is very likely that Bruderheim will see more extreme precipitation events as the climate continues to warm in the coming decades.

Box 2: Putting projected changes in mean annual temperature in context

In order to place the magnitude of the projected temperature changes in the 2050s into context, a normal distribution (bell curve) was fitted to the 20th century climate of the Bruderheim area (1914-1999). The mean of the probability distribution is then shifted by the projected temperature increase of +2.0°C above the 1961-1990 baseline. This increase in mean annual temperature represents a shift of two standard deviations above the 20th century mean temperature. In other words, the climate projections indicate that the mean annual temperature of the 2050s in the Bruderheim area will be similar to the warmest 3% of 20th century climate.

Although a change in mean annual temperature of +2.0°C may not appear to be a large absolute shift in climate, when compared with the probability distribution of 20th century climate in the Bruderheim area, a shift of this magnitude is substantial. By analogy, the projected shift in mean annual temperature will be similar to replacing Bruderheim climate over the period 1961-1990 with that of Brooks, Alberta.



PROJECTED ENVIRONMENTAL CHANGES

Projected changes in average temperature and precipitation in the Bruderheim area will have broad consequences across the natural environment, including for moisture availability, growing season, regional ecosystems, invasive plants, streamflow, wetlands, and wildfires.

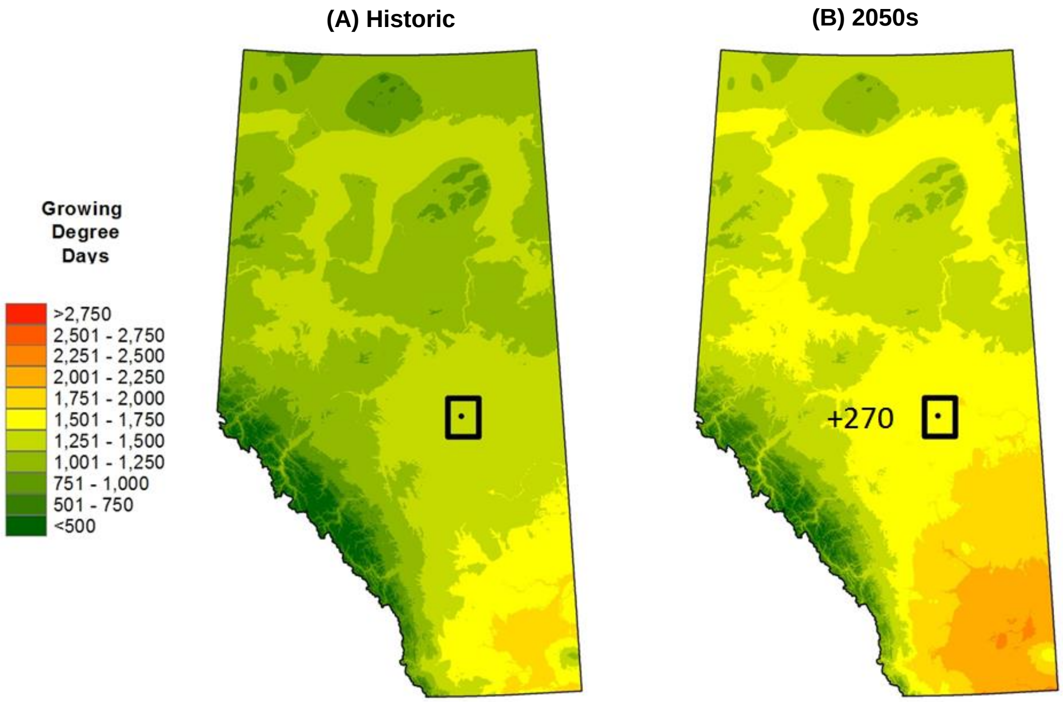
➨ Available moisture and growing season

Although mean annual precipitation is projected to increase in the Bruderheim area, the region is projected to become drier overall because warmer temperatures will increase the rate of evaporation from vegetation and soils, such that overall moisture loss will exceed the projected increase in mean annual precipitation[viii]. In addition, while mean annual precipitation is projected to increase, the slight projected decline in precipitation during the warm summer months will likely contribute to moisture stress[ix].

The projected increases in average temperatures in spring, summer and fall will result in increases in both the length and the warmth of the growing season in the Bruderheim area. By the 2050s, the Bruderheim area is projected to experience an increase of approximately 270 (growing) degree days, on average (see Figure 6); growing degree days are a measure of the length and warmth of the growing season[x]. Put another way, the average growing season in the Bruderheim area by the middle of the century will be more similar to the growing season experienced around Brooks, Alberta in today's climate.

A reduction in available moisture and an extended growing season are projected consequences of climate change common to most of the prairie region[xi]. Because of its more northern location relative to much of the rest of the prairie region, the benefit for agriculture of the longer growing season in the Bruderheim area is likely to be greater than the potential negative impacts of the projected reduction in available moisture[xii].

Figure 6: (A) Historic (1961-1990) and (B) projected distribution of growing degree days in Alberta by the 2050s (2041-2070)[xiii]

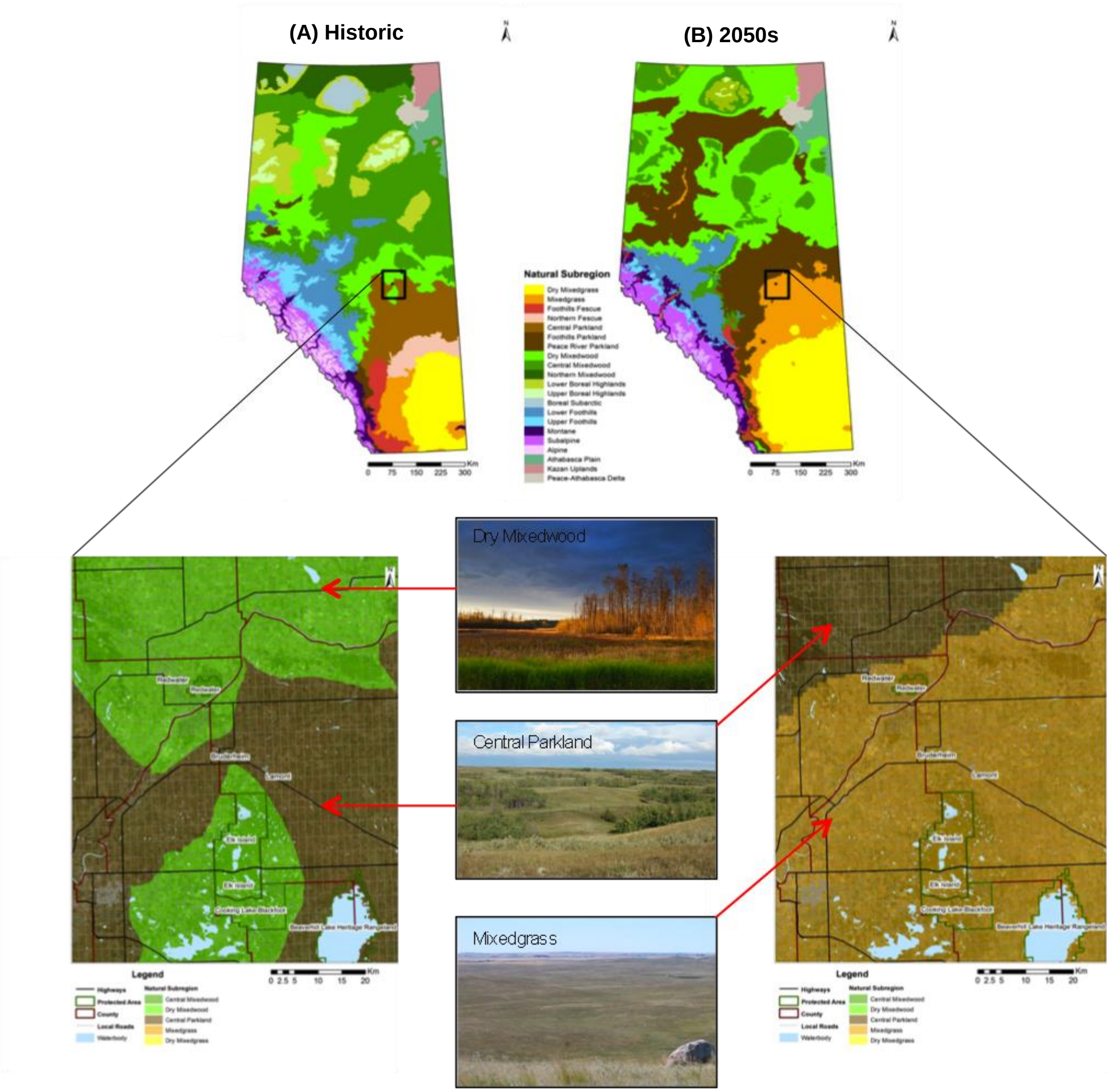


Regional ecosystems

Alberta's natural sub-regions, which are defined by unique combinations of vegetation, soil and landscape features, represent the diversity of ecosystems in the province. The Town of Bruderheim is currently located at the interface between the Central Parkland and the Dry Mixedwood Forest regions, at the southern margin of the Boreal Forest (see Figure 7). Natural landscapes in this region reflect the prairie-boreal forest boundary: the Central Parkland ecosystem is a mosaic of grasslands and deciduous (aspen) forests, which, at higher elevations (such as in Elk Island National Park and the Beaver Hills) and further north, transition to a more continuous aspen forest with spruce stands—the Dry Mixedwood Forest ecosystem[xiv].

The warmer and drier conditions projected for the Bruderheim area will have consequences for these regional ecosystems: the projected climate for the 2050s will be more favourable for Mixedgrass grassland ecosystems and less favourable for the Dry Mixedwood Forest ecosystem (as shown in Figure 7)[xv]. As a result, natural spruce and aspen forests in the Bruderheim area, including in Elk Island National Park, may be less likely to recover from disturbances like fire or insect outbreaks, leading to an expansion of grasslands at the expense of forests in natural areas[xvi,xvii]. The changes in regional ecosystems will also have consequences for the diversity of species that reside in the natural areas around Bruderheim.

Figure 7: (A) Historic (1961-1990) and (B) projected (2050s) distribution of natural sub-regions in Alberta and in the Bruderheim area[xviii,xix]



Streamflow

Streamflow in the North Saskatchewan River depends on both snowmelt runoff from the eastern Rocky Mountains and glacial meltwater[xx]. Warmer winter temperatures, an increased proportion of rain versus snow in winter months, and earlier snowmelt will all influence winter snow pack, and consequently streamflow in the river[xxi]. Streamflow in the North Saskatchewan River is projected to increase in winter, peak earlier in the spring, and decrease in the summer[xxii]. Meltwater from glacial sources will become increasingly less reliable in the future: as glaciers in the eastern Rockies continue to melt, the North Saskatchewan River will experience a decrease in glacier-derived streamflow[xxiii].

Wetlands

Wetlands in the Bruderheim area and in the prairie region more broadly, are highly sensitive to climate variability[xxiv]. Projected declines in summer precipitation and overall available moisture, and more frequent drought conditions in the future will lead to reductions in wetland area and depth, and will reduce wetland permanence[xxv,xxvi].

Wildfire

The warmer and drier climate projected for the Bruderheim area by the 2050s will create conditions more favourable for wildfires. In particular, a longer fire season with more severe fire weather conditions in the future is likely to result in fires that are more difficult to control and in an increase in the average area burned[xxvii,xxviii].

4. Climate Risks and Opportunities for Town of Bruderheim

Session 3 at the workshop invited participants to:

1. Identify how projected climate or environmental changes for the 2050s could impact Bruderheim; and

2. Translate the identified impacts into risks and opportunities in order to establish priorities for action planning.

Potential Climate Impacts

Workshop participants identified a range of climate-related impacts for the local economy, property and infrastructure, the natural environment, and residents' health and lifestyles. The list of identified impacts is provided in Table 2.

Table 2: Potential climate change impacts with mainly negative (-) or positive (+) consequences for the Town of Bruderheim

• Increase in non-native plants and pests (-)	• Increase in food-borne diseases (-)
• More freeze-thaw cycles (-)	• Water supply shortage and drought (-)
• Reduced crop yields (-)	• Loss of community gardens (-)
• Stress on livestock and pastures (-)	• Wildfire (-)
• Creek and river flooding (-)	• Flooding of storm-water systems (-)
• More intense snowstorms and blizzards (-)	• Structural collapse from snow load (-)
• Loss of local wildlife (-)	• Increased stress to local wildlife (-)
• Windstorms (-)	• Loss of wetlands (from drought) (-)
• Freezing rain (-)	• New crop growing opportunities (+)
• Increased frost penetration (-)	• Reduced energy use and heating costs (+)
• Loss of winter recreation (e.g., outdoor rink) (-)	• Reduced winter maintenance costs (+)
• Heat waves (-)	• Increase in construction season (+)
• Hail storms (-)	• Increase in winter recreation opportunities (+)
• Stress to buildings and foundation (dry soils and freeze-thaw cycles) (-)	• Increased migration to the area (as a result of less favourable climate elsewhere) (+)

PRIORITY CLIMATE RISK AND OPPORTUNITIES

The potential impacts listed in Table 2 served as a starting point for the risk and opportunity assessment. Following plenary discussion at the workshop, some impacts were merged and the descriptions modified. Other impacts were deemed not particularly relevant to the Town, or had positive and negative consequences that were judged to cancel each other out; these were not considered further. This produced a smaller list of the most important potential impacts for Bruderheim.

Workshop participants were invited to translate these impacts into risks (impacts with mainly negative consequences) and opportunities (impacts with mainly positive consequences), and to simultaneously prioritize the risks and opportunities. Priorities are assigned to impacts by scoring, first, the severity of potential consequences for the area, and second, the likelihood of those consequences being realized. Participants assigned scores to impacts using the consequence scales found at Appendix B (for risks) and Appendix C (for opportunities), and the likelihood scale found at Appendix D.

➡ Potential risks

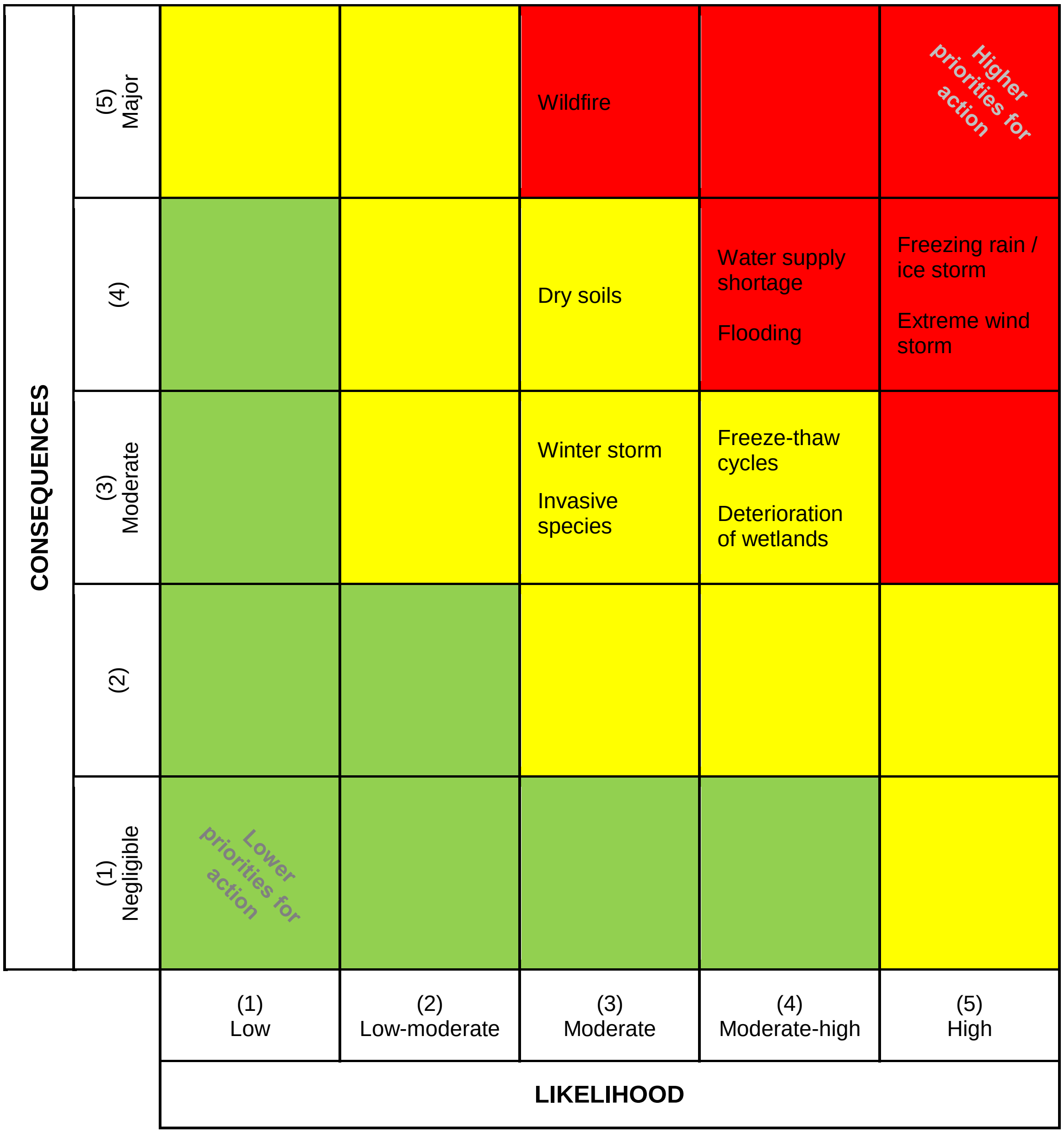
Table 3 provides a description of the potential climate change risks facing the Town of Bruderheim. The description includes a selection of key consequences, along with the label used to identify the impact in the "risk map" shown in Figure 8. The risk map is a two-dimensional representation of adverse consequences plotted against likelihood. Impacts in the upper right corner of the map have larger adverse consequences combined with a high likelihood of occurrence. These impacts are priorities for action.

Table 3: Climate change risks facing the Town of Bruderheim by the 2050s

Potential local risks		Key consequences for Bruderheim
Label for risk map	**Description**	
"Invasive species"	Outbreaks of invasive species due to a lack of cold winter temperatures and increased survival of pests and invasive species.	• New dangerous animals (killer bees) • Crop destruction (grasshoppers, etc.) • Negative impact on forests (visual / economic)
"Freeze-thaw cycles"	Increase in freeze-thaw cycles caused by warmer winter temperatures / increased variability of temperatures in winter.	• Injuries to humans and wildlife • Infrastructure impacts - upheaval of sidewalks and streets • Increased road maintenance cost (sanding)
"Water supply shortage"	Inability to meet water demand of town due to warmer summer temperatures, or long-term drought, and loss of natural water sources.	• Stress on municipal water supply infrastructure • Potential competing demands between residents, industry and other consumers • Loss of natural water sources and wetlands • Increase landscaping costs (more watering)
"Wildfire"	Increased interface wildfire risk caused by increased summer temperatures and heat waves, less precipitation in summer, less available moisture and a longer fire season.	• Visual impacts • Health impacts from smoke • Potential evacuations and displacement of residents • Stress on emergency service personnel • Increased costs for firefighting, public works and insurance • Damages to property • Disruption to economic activity
"Flooding"	Flooding of the storm-water system, and nearby creeks and rivers caused by an increase in the number of extreme precipitation events, and intensity of summer storms	• Road closures • Evacuation / displaced residents • Public health/injuries • Water contamination (public health concerns) • Infrastructure failure (costs for repair and renewal) • Disruption to water supply • Transportation disruption (bridges and roads washed out) • Stress on emergency service personnel • Increase in insurance premiums • Increased sediment in creeks and rivers (water quality concerns) • Power outage

Potential local risks		Key consequences for Bruderheim
Label for risk map	**Description**	
"Winter storm"	Major snowstorm / blizzard caused by an increase in winter precipitation and in the number of extreme precipitation events	• Service delivery disruption • Access disruption to town (entry and exit) • Stress on emergency service personnel • Potential injuries (snow loading and accidents) • Damage and repair costs (snow loading)
"Extreme wind storm"	Major windstorm event caused by an increase in the intensity of summer storms	• Property damage • Damage to gardens and crops • Increased insurance cost • Increased emergency service costs – mutual aid, transportation, communications • Soil erosion (e.g., at sewage lagoons)
"Freezing rain/ice storm"	Freezing rain event caused by warmer winter temperatures and increased proportion of winter precipitation falling as rain	• Injuries (slips and falls) • Higher insurance cost • Stress on emergency service personnel • Dangerous roads (injuries and access issues) • Increased road maintenance (salting and sanding) • Power outages • Vegetation impacted (trees)
"Dry soils"	Stress (and potential subsidence) on buildings and foundations, caused by warmer summer temperatures and reduced soil moisture.	• Building and infrastructure (including roads) failure / collapse • Damage / disruption to underground utilities
"Deterioration of wetlands"	Deterioration or loss of local wetlands caused by shifting ecosystems, warmer summer temperatures, or long-term drought.	• Increased water supply / infrastructure costs • Loss of natural water sources • Aesthetic / ecological impacts
"Heat wave"	Extreme heat event caused by warmer summer temperatures	• Public health impact, particularly for vulnerable populations (infants and elderly)
"Hail storm"	Hail storm event caused by an increase in the intensity of summer storms	• Damage to property (buildings and vehicles) • Damage to crops and gardens

Figure 8: Risk map for climate change impacts facing the Town of Bruderheim



Impacts in the red and yellow zones are priorities for further investigation or management. Impacts in the red zone are the highest priorities for action. Impacts in the green zone represent broadly acceptable risks; no action is required now for these impacts beyond monitoring of the risk level as part of periodic reviews (see Section 6).

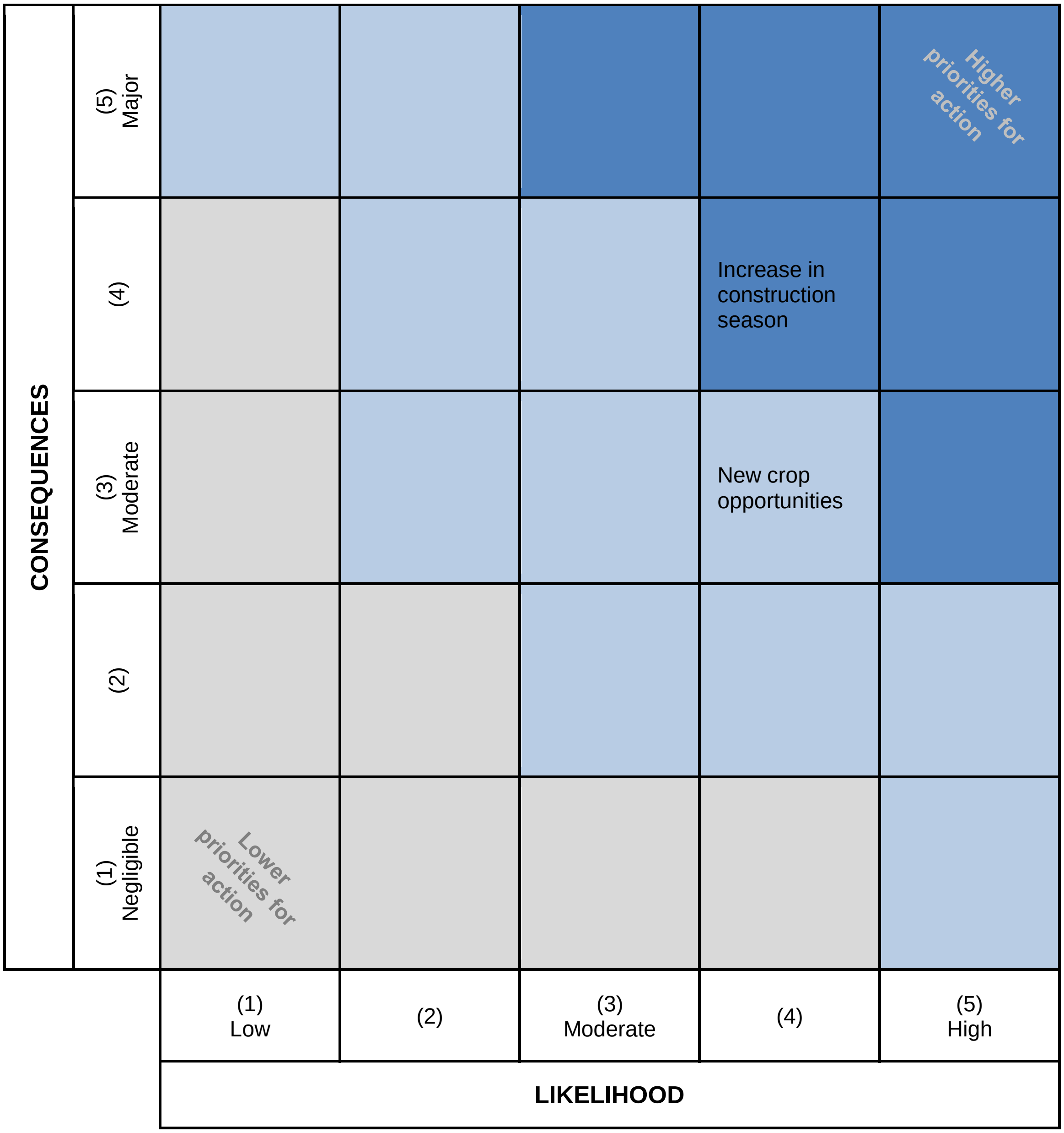
Potential Opportunities

Table 4 provides a description of the potential climate change opportunities for Bruderheim. The description includes a selection of potential benefits, along with the label used to identify the impact in the opportunity map shown in Figure 9. Impacts in the upper right corner of the map have greater potential benefits combined with a high likelihood of occurrence. These impacts are priorities for action.

Table 4: Climate change opportunities for the Town of Bruderheim by the 2050s

Potential local opportunities		Key consequences for Bruderheim
Label for opportunity map	**Description**	
"New crop opportunities"	Opportunities for new crop types / expansion of existing growing opportunities, resulting from potential ecosystem shifts and a longer growing season	• More jobs • Increased demand for relevant supplies from local businesses • Increased economic growth • New crops / income sources for local farmers (e.g., corn, sugar beets, peas)
"Increase in construction season"	Lengthening of the construction season in local and surrounding area (including industrial facilities) due to increased temperatures in spring, fall and winter	• Reduced construction costs • Quicker completion of construction / maintenance • Increased demand for relevant supplies from local businesses • Opportunities for new businesses
"Reduced energy costs"	Reduction in heating demand and energy use in winter due to increased temperatures	• Cost savings for residents, businesses and Town
"Reduced road and sidewalk maintenance"	Potential reduction in winter road and sidewalk maintenance costs as a result of less precipitation falling as snow.	• Cost savings for Town – less equipment, materials and staff time required

Figure 9: Opportunity map for climate change impacts facing the Town of Bruderheim



Impacts in the dark blue and light blue zones are priorities for further investigation or promotion. Impacts in the dark blue zone are the highest priorities for action. Impacts in the grey zone represent marginal opportunities; no action is required now for these impacts beyond monitoring of the level of opportunity as part of periodic reviews (see Section 6).

IMPACTS FOR FUTURE REVIEW

Some potentially important impacts have been inadvertently omitted from the risk and opportunity assessment—namely:

- Heatwaves and extreme temperature events (with mainly negative consequences for human health);
- Hail storms (with mainly negative consequences for property (buildings, vehicles), crops and gardens);
- Heating demand in winter (with mainly positive consequences for energy costs); and
- Less snow in winter (with mainly positive consequences for road and sidewalk maintenance costs).

These impacts should be assessed by Town of Bruderheim and incorporated into the risk and opportunity maps as soon as it is practical to do so.

5. Climate Resilience Actions

The next step is to formulate actions (a) to increase resilience to priority risks and (b) to increase capacity to capitalize on priority opportunities.

For the priority risks and opportunities plotted in Figure 8 and Figure 9 respectively, Session 4 at the workshop invited participants to devise a list of recommended adaptation actions. Ideally, actions should be devised for all priority risks and priority opportunities. However, within the time constraints of the one-day workshop used by Climate Resilience Express, action planning focuses on a subset of priority risks and opportunities, chosen by workshop participants. The four priorities selected for action planning are:

1. Storm-water and creek flooding;
2. Freezing rain / ice storm;
3. Water supply shortage; and
4. Extreme wind storm.

For each of these four priority risks, a starter action plan was developed by first addressing the following two questions:

1. What actions are currently being taken to manage the risk or opportunity?
2. What new actions, or improvements to existing actions, are needed to more effectively manage the risk or opportunity in the future?

Second, the resulting long-list of potential actions is screened to identify, for each priority risk or opportunity, three to five of the most promising actions for inclusion in the climate resilience plan. When screening actions, participants should consider • the likely effectiveness of the action in mitigating the risk, • how feasible it would be to implement, • how generally acceptable it would be to stakeholders, including elected officials, and • how equitably spread are the costs and benefits of the action across the community.

To support the successful implementation of recommended actions, workshop participants also provided information on:

1. Total implementation costs;
2. The timeframe for implementation; and
3. The lead department or organization.

These three factors are key inputs to the development of an implementation strategy. Table 5 was used to help participants provide approximations for (1) and (2).

Table 5: Climate resilience actions – definitions for total implementation costs and implementation timeframe

Information	Descriptor	Description
Total implementation costs	Low	Under $10,000
	Moderate	$10,000 to $49,999
	High	$50,000 - $99,999
	Very high	$100,000 or more
Timeframe to have action implemented (operational)	Ongoing	Continuous implementation
	Near-term	Under 2 years
	Short-term	2 to 5 years
	Medium-term	5 to 10 years
	Long-term	10 years or more

Starter action plans for each of the four selected priorities are provided below. It is important that the other priority risks and opportunities are put through a similar action planning exercise as soon as it is practical to do so.

Of note, the Town of Bruderheim is already committed to numerous actions that will help manage the risks and opportunities of climate change identified in Section **Error! Reference source not found.**. Some of these actions were identified during Session 4 of the workshop and include:

- Operational procedures to help manage storm-water flooding issues, including the cleaning and maintenance of floodways and ditches;
- Automated alert systems for the sewage and water supply systems;
- A Disaster Services Plan; and
- A tree pruning program to protect against extreme wind events.

It is important that the Town continue to support the implementation of these important climate resilience activities.

STORM-WATER AND CREEK FLOODING

Action	Implementation Cost	Implementation Timeframe	Implementation Lead
Educate residents about storm-water drainage	Low	Short-term	Public works, Administration, Communications
Develop bylaw to address residential discard (e.g. grass and yard clippings) onto streets and into catch basins	Low	Short-term	Public works, Administration
Slope and clean critical storm-water drainage areas	Moderate (equipment rental)	Short term	Public works
Upgrade (replace, resize or both) storm sewer lines based on updated and projected future rainfall intensity	Very high	Long-term	Administration, Council
Update storm-water engineering design standards to reflect current and projected future rainfall intensities	Very high	Medium-term	Town engineer and developers

Freezing Rain / Ice Storm

Action	Implementation Cost	Implementation Timeframe	Implementation Lead
Review and update the disaster services policy	Low	Short-term	CAO, Disaster Services
Review and update the snow and ice removal policy	Low	Short-term	CAO, Disaster Services
Educate residents about impacts and actions to reduce impacts of freezing rain and ice storms	Moderate	Medium-term	Communications
Improve walking trail safety with additional lighting and sandboxes	High	Medium-term	CAO, Public Works, Communities in Bloom

Extreme Wind Storm

Action	Implementation Cost	Implementation Timeframe	Implementation Lead
Increase budget and resources for more aggressive tree pruning	Moderate	Medium-term	Public works
Review current practices and develop a plan to reduce snow build-up and drifting on roads	Low	Medium-term	Public works
Purchase a satellite phone(s) for emergency response communication	Low	Medium-term	Emergency services

Water Supply Shortage

Action	Implementation Cost	Implementation Timeframe	Implementation Lead
Develop a comprehensive water plan for the Town, including an assessment of current water supply sources, public notification requirements, and potential partnerships with industry	Low	Medium-term	Public works
Target economic development towards low water use businesses	Low	Ongoing	CAO
Conduct a study of potential future water sources (wells) and water treatment plant opportunities	Very high	Short-term	Public works
Update bylaws to reflect water usage and appropriate pricing for water use	Low	High	Council

6. Implementation and Next Steps

> Writing a plan and leaving it on the shelf is as bad as not writing the plan at all. If this Action Plan is to be an effective tool, it must be implemented and reviewed periodically.

Acting

The recommended actions listed in Section 5 serve as a 'shopping-list'. Town staff should establish priorities from the listed actions, and begin implementation as soon as practical. Consideration should be given to forming a cross-departmental and cross-community implementation team from among workshop participants to oversee implementation of the Action Plan. A number of actions can be implemented quickly with minimal investment, whereas other actions have longer-term timeframes, require a higher level of investment, and may require a more detailed implementation strategy with specific budgets and funding sources, timelines and milestones for specific activities, and defined roles and responsibilities for specific stakeholders and groups.

Effective communication with the public and other community stakeholders about climate change impacts can be valuable in helping them understand why certain measures are needed. Community outreach, for example through the Town websites or at public events can be an effective way to both:

- Gather input from community members on the content of the Action Plan; and
- Promote the Towns' efforts to become more resilient.

Mainstreaming

This Action Plan is developed as a 'stand-alone' document. However, it is important that climate resilience generally is integrated (i.e., 'mainstreamed')—as a matter of routine—into the Town's strategies, plans, policies, programs, projects, and administrative processes. For example:

- Climate resilience should be considered in all future land use and development decisions, including administrative processes such as bids, tenders and contracts for planning and development work;
- Strategic plans and neighborhood scale plans should consider potential future climate change impacts; and

- Decisions related to the design, maintenance, and upgrading of long-life infrastructure assets and facilities should likewise consider future climate changes and impacts.

REVIEW AND UPDATE

Building resilience to climate change is not a static process. The priority risks and opportunities identified in this Action Plan, along with the recommended actions to address them, should be viewed as the first step in Bruderheim's journey towards a climate resilient future.

The climate resilience action planning process is dynamic. For a start, the rapidly changing scientific knowledge about the physical impacts of climate change means that climate change risk and opportunity assessments are not one-off activities, but rather need to be reviewed and updated regularly. This Action Plan should be reviewed and updated every 5 years to ensure it remains relevant and effective, taking account of:

- Lessons learned from the implementation of actions;
- New scientific information about climate projections and corresponding impacts; and
- Changes to the Town's goals and policies.

Keeping the Action Plan relevant may only involve a few minor adjustments, or it may require revisiting some of the steps in the climate resilience planning process and preparing a new Action Plan.

7. APPENDICES

Appendix A: Workshop participants

Name	Title
Karl Hauch	Mayor
George Campbell	Councillor
Virginia Differenz	Councillor
Patricia Lee	Councillor
Wayne Olechow	Councillor
Shelley Ross	Councillor
Judy Schueler	Councillor
Dave Rarog	Director of Public Works
Willard Marsh	Operator 2, Public Works
Judy Koschade	Director of Community Relations
Sharron Sinclair	Director of Finance
Sherry Cote	Acting Director of Legal and Legislative Services
Jill Yanch	Outreach & Communications Specialist
Bob Cote	Bruderheim Fire Chief
Jessica Littlewood	MLA Fort Saskatchewan - Vegreville
Jeremy Johnston	
Charles Iggulden	Infinity Energy
Randy Siemens	Lamont County Emergency Management
Doug Sullivan	Economic Development

Appendix B: Scale for scoring the consequences of risks

Score	Description
(1) **Negligible**	• Negligible impact on health & safety and quality of life for residents • Very minimal impact on local economy • Insignificant environmental disruption or damage • Slight damage to property and infrastructure, very short-term interruption of lifelines, or negligible cost to municipality
(2)	
(3) **Moderate**	• Some injuries, or modest temporary impact on quality of life for some residents • Temporary impact on income and employment for a few businesses, or modest costs and disruption to a few businesses • Isolated but reversible damage to wildlife, habitat or and ecosystems, or short-term disruption to environmental amenities • Damage to property and infrastructure (including critical facilities and lifelines), short-term interruption of lifelines to part of community, localized evacuations, or modest costs to municipality
(4)	
(5) **Major**	• Many serious injuries or illnesses, some fatalities, or long-term impact on quality of life for most residents • Long-term impact on businesses and economic sectors, major economic costs or disruption • Widespread and irreversible damage to wildlife, habitat and ecosystems, or long-term damage, disruption to environmental amenities • Widespread damage to property & infrastructure (including critical facilities and lifelines), extensive and long-term interruption of services, widespread evacuations, or major cost to municipality

Appendix C: Scale for scoring the consequences of opportunities

Rating	Description
(1) **Low**	• Increase in income / jobs for a *few* businesses • Lifestyle improvement for *some* residents • Cost savings for municipality, businesses or residents
(2)	
(3) **Moderate**	• Increase in income / jobs for a *sector* • Lifestyle improvement for a *select group* of residents • Cost savings for municipality, businesses or residents • *Short-term* boost to reputation and image of municipality
(4)	
(5) **High**	• Increase in income / jobs for *key sectors* of local economy • Lifestyle improvement for a *majority* of residents • Cost savings for municipality, businesses or residents • *Long-term* boost to reputation of municipality

Appendix D: Scale for scoring the likelihood of consequences

Rating	Recurring Impact	Trending Impact
(1) **Low**	Once in 50 years or more	*Very unlikely* – less than 5% chance of occurrence in next 50 years
(2)	Once in 10 to 50 years	*Unlikely* – 5% to 35% chance of occurrence in next 50 years
(3) **Moderate**	Once in 5 to 10 years	*Possible* – 35% to 65% chance of occurrence in next 50 years
(4)	Once in 1 to 5 years	*Likely* – 65% to 90% chance of occurrence in next 50 years
(5) **High**	Up to once per year	*Almost certain* – 95% or greater chance of occurrence in next 50 years

8. ENDNOTES

[i] Environment Canada's Adjusted and Homogenized Canadian Climate Data (AHCCD) are quality controlled climate data that incorporate a number of adjustments applied to the original meteorological station data to addresses any inaccuracies introduced by changes in instruments and observing procedures.

[ii] The significance of the trends was determined using the Mann-Kendall test after removing lag-1 autocorrelation with the Zhang (1999) method (described in Wang and Swail, 2001).

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[iv] The Pacific Climate Impacts Consortium (PCIC) is a regional climate service centre based at the University of Victoria. PCIC provides a number of tools that support long-term planning for climate change including the model projections derived from the Regional Analysis Tool.

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[vi] Westra, S., Alexander, L.V., Zwiers, F., 2013. Global increasing trends in annual maximum daily precipitation. J Clim 26(11) 3904–3918.

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[viii] Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Biodiversity Management and Climate Change Adaptation Project, Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available at: http://www.biodiversityandclimate.abmi.ca/

[ix] Ibid.(same as previous reference)

[x] Specifically, they are a measurement of heat accumulation, calculated by determining the total number of degrees by which average daily temperature exceeds a threshold temperature (in this case 5°C) over the course of a growing season.

[xi] Sauchyn, D. and S. Kulshreshtha. 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. pp. 275-328.

[xii] Ibid.

[xiii] Maps created with climate data available at http://ualberta.ca/~ahamann/data/climatewna.html (Hamann et al. 2013). The mid-century climate moisture index projection is based on the German ECHAM5 global climate model and the A2 emissions scenario (IPCC 2000). Climate moisture index represents the balance between annual precipitation and annual evapotranspiration; it is positive when precipitation exceeds evapotranspiration (Hogg 1997).

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- Hogg, E.H. 1997. Temporal scaling of moisture and the forest-grassland boundary in western Canada. Agricultural and Forest Meteorology 84:115-122.

[xiv] Natural Regions Committee. 2006. Natural Regions and Subregions of Alberta. Compiled by D.J. Downing and W.W. Pettapiece. Government of Alberta. Pub. No. T/852. Edmonton, AB.

[xv] Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Biodiversity Management and Climate Change Adaptation Project, Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available at: http://www.biodiversityandclimate.abmi.ca

[xvi] Ibid.

[xvii] Qualtiere, E. 2011. Impacts of climate change on the western Canadian southern boreal forest fringe. Saskatchewan Research Council Publication No. 12855-3E11. Saskatoon, SK. 129pp. Available at: http://www.parc.ca/

[xviii] Maps created with data available at http://www.biodiversityandclimate.abmi.ca. The mid-century Natural Subregion projection from Schneider (2013) is based on the German ECHAM 5 global climate model and the A2 emissions scenario (IPCC, 2000)

- Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Biodiversity Management and Climate Change Adaptation Project, Alberta Biodiversity Monitoring Institute, Edmonton, AB. Available at: http://www.biodiversityandclimate.abmi.ca/
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[xix] Photo credits (top to bottom): ABMI; Jonathan Bennett; and Monical Dahl.

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[xxi] Ibid.

[xxii] Ibid.

[xxiii] Demuth M.N. and A. Pietroniro. 2003. The impact of climate change on the glaciers of the Canadian Rocky Mountain astern slopes and implications for water resource-related adaptation in the Canadian prairies: headwaters of the North Saskatchewan River basin. Prairie Adaptation Research Collaborative, Regina SK, Project P55. Available at http://www.parc.ca/

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www.allonesky.ca

Email: helen@allonesky.ca
Phone: 403.471.6247

809 49th Ave SW, PO Box 19012, Calgary, AB T2S 1A0, Canada