CITY OF SPRUCE GROVE

CLIMATE RESILIENCE EXPRESS ACTION PLAN

MARCH 2018

All One Sky Foundation
MCCAC Municipal Climate Change Action Centre

"*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 Municipal Climate Change Action Centre, the Calgary Foundation, Natural Resources Canada, All One Sky Foundation, and Alberta Ecotrust.

A key objective of the Climate Resilience Express project is to partner with communities across Alberta to complete a streamlined ("express") process aimed at developing a community-specific climate resilience action plan through a one-day workshop, and to develop and maintain an 'Action Kit' to support other communities in working through the process.

In 2016, six communities from across Alberta were selected to pilot the workshop process and aspects of the toolkit. In 2017, an additional seven communities participated in the project, including the City of Spruce Grove[i].

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

Summary

The effects of climate change are already apparent in Spruce Grove, with observable changes in temperature, precipitation, and extreme weather events over the last century. The impacts of climate change on the City 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, Spruce Grove has prepared this Action Plan, which identifies some initial actions to help manage potentially significant risks and opportunities anticipated to result from climate change over the next several decades.

In total, thirteen climate-related risks and six climate-related opportunities were identified by participants at a workshop in Spruce Grove on December 5th, 2017. Four risks were judged to be priorities requiring immediate action:

- Water supply shortage;
- Urban flooding;
- Freezing rain; and
- Thunderstorms.

Starter action plans were developed at the workshop for these priority risks.

Spruce Grove is already committed to numerous actions that help manage the above priority risks, including: management and maintenance of the stormwater infrastructure system including control gates, catch basins, dry ponds and wet ponds; ongoing maintenance and operations to support management of freezing rain and freeze-thaw cycles, including placement of sand and calcium chloride with sanders, plows and spreaders; back-up power generators at some critical facilities; universal water metering and pricing, and a rain barrel rebate program to support water conservation; and education programs and ongoing communications with residents.

In addition to existing actions that help mitigate the consequences of the priority risks, eighteen further actions were identified for consideration to help the City better prepare for climate change. Several of these actions could 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 Spruce Grove 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 Spruce Grove, with observable changes in temperature, precipitation, and extreme weather events over the last century. The average annual temperature in the Spruce Grove area has increased by about +1.5°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.

The impacts of climate change on communities can 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—be it through 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.

Municipalities are at the forefront of these impacts—both because extreme weather events can be especially disruptive to interconnected urban systems and because they are where much of our population live, work and raise their 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.

Spruce Grove, through the preparation of this Action Plan, is taking steps towards a safe, prosperous and resilient future. The Action Plan identifies several 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

Climate Resilience Express is a high-level ("express") screening process designed to support communities in beginning to identify and prioritize climate change risks and opportunities and develop a starter 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;

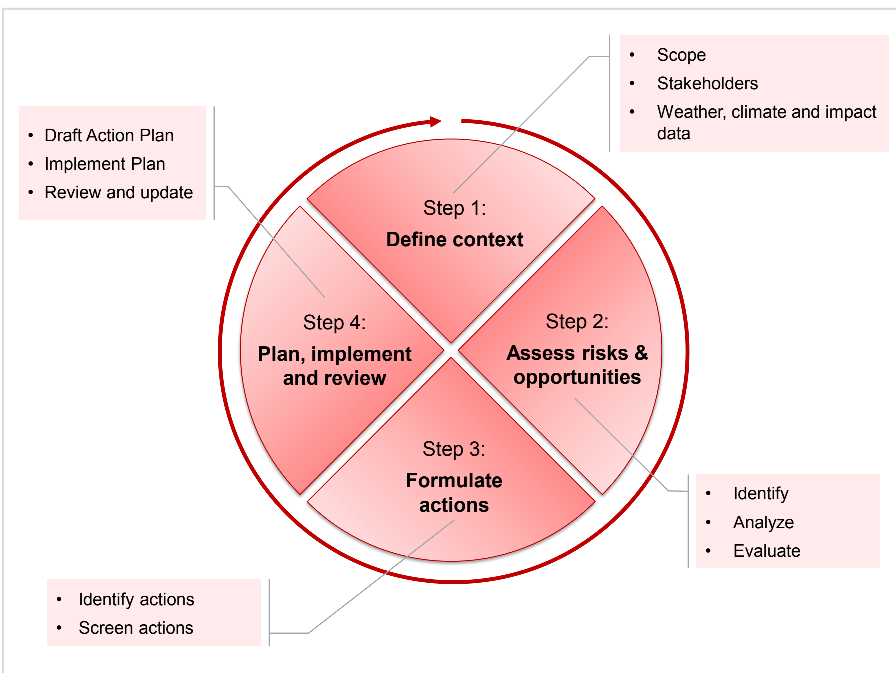
Step 2: Assess potential climate-related risks and opportunities to establish priorities for action;

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 takes place after the workshop.

Figure 1: Climate Resilience Express—action planning process



Tiered Approach to the Assessment

The Climate Resilience Express adopts a tiered approach to climate risk management, in which communities move from the broad to the more focused, in terms of both assessing risks and opportunities (at Step 2) and assessing viable adaptation actions (at Step 3). Rather than jumping straight into a data-driven, quantitative assessment of every climate impact and management option, Climate Resilience Express starts with a high-level qualitative screening of risks and opportunities, and corresponding actions. Communities can subsequently use this information to justify more detailed quantitative assessments of significant risks and opportunities, and to generate full business cases for priority actions if necessary.

Before the Workshop: Step 1

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

- **Defining the spatial scope**

  The spatial scope is limited to direct impacts within the geographic boundaries of the City of Spruce Grove.

- **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 Spruce Grove 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 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 Spruce Grove 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, corresponding 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 changes could impact Spruce Grove, 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 4.

- **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 Spruce Grove has been affected by weather-related events in the recent past, considering impacts on the local economy, property and infrastructure, the natural environment, and resident's 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

- ✓ Freeze-thaw cycles and cold cause infrastructure damage – heaving and broken pipes
- ✓ Heavy rainfall causes overland flooding, washouts, and drainage problems
- ✓ Wind storms damage buildings, infrastructure
- ✓ Winter recreation season is shifting
- ✓ Intense rainfall events and increased temperatures affect water quality in the river
- ✓ Drought conditions for the last 10 years
- ✓ Pests (pine beetle) affect local trees
- ✓ Tree pollen blocks air filters
- ✓ Heavy rain events occurring in off-seasons
- ✓ Freezing rain and snow cause hazardous road and sidewalk conditions

Local Climate Trends

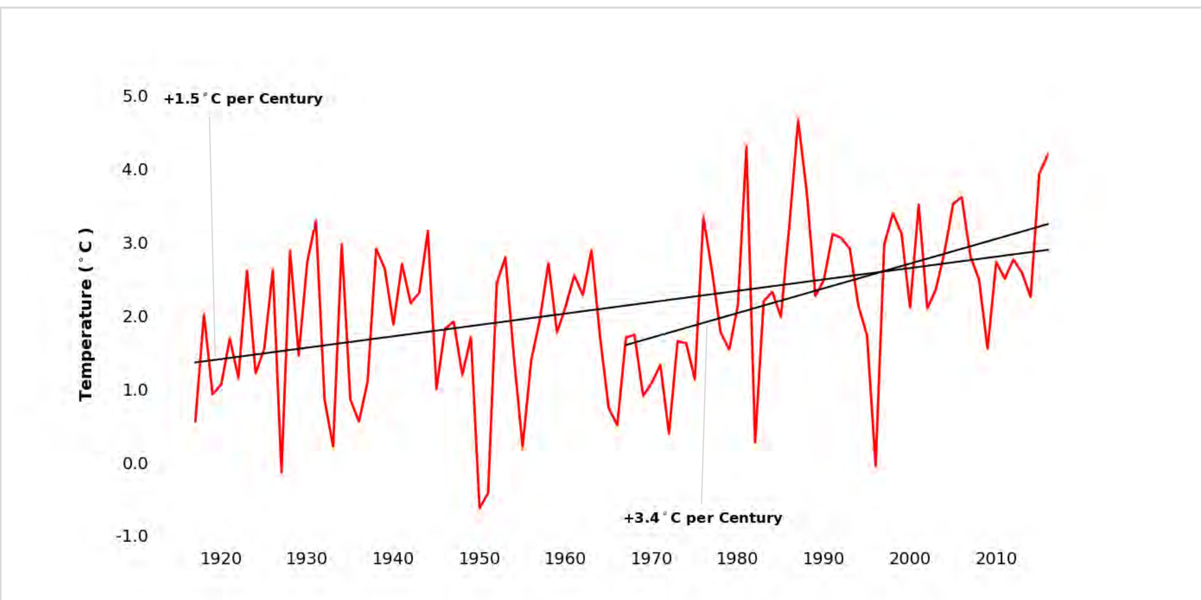
To provide a perspective of historic climate trends in Spruce Grove, data was collected and analyzed from ten Adjusted and Homogenized Canadian Climate Data (AHCCD) stations in the region (Athabasca, Cold Lake, Campsie, Edmonton, Calmar, Camrose, Lacombe, Rocky Mountain House, Edson, and Whitecourt)[ii]. These stations were selected because the available data cover multiple decades, are high quality, and the stations span an area that is comparable to the same area for which future climate projections are available.

Climate records of temperature and precipitation for Spruce Grove are assembled by averaging the individual records from these ten climate stations and applying appropriate statistical techniques to assess the robustness of estimated trends[iii].

➡ Temperature records

Temperature records for the area over the period 1917-2016 show that mean annual temperature has increased at a rate of +1.5°C per century (Figure 2), which is approximately 60% faster than the observed global rate of surface warming over the same period. The rate of warming observed over the last 50 years is higher still at +3.4°C per century.

Figure 2: Mean annual temperature in Spruce Grove area (1917-2016)



The largest seasonal increase in temperature in Spruce Grove occurred during the winter (December-February). The observed rate of warming in winter over the last 100 years is +3.0°C per century (Figure 3). Over the last 50 years mean winter temperature increased at a rate of +7.0°C per century, which is substantially greater than the mean annual rate of warming. In contrast, warming during the summer (June-August) over the last 100 years occurred at a slower rate of +1.2°C per century, and +1.9°C per century over the last 50 years (Figure 4).

Similar warming trends are also observed for mean spring and fall temperatures over the last 50 and 100 years.

Figure 3: Mean winter temperature in Spruce Grove area (1917-2016)

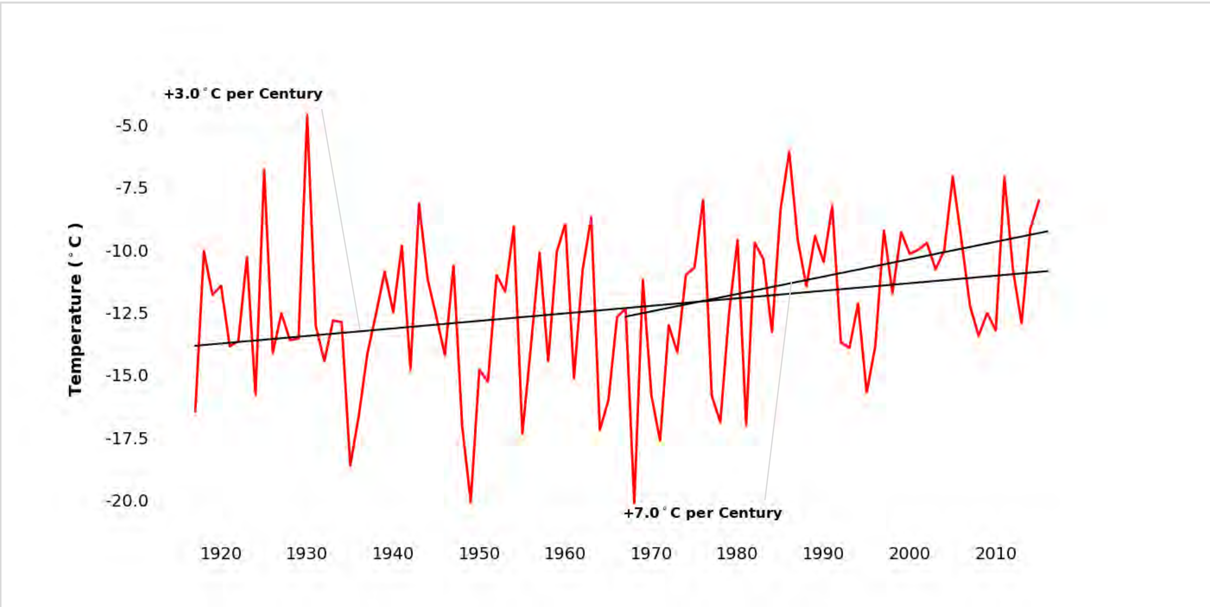
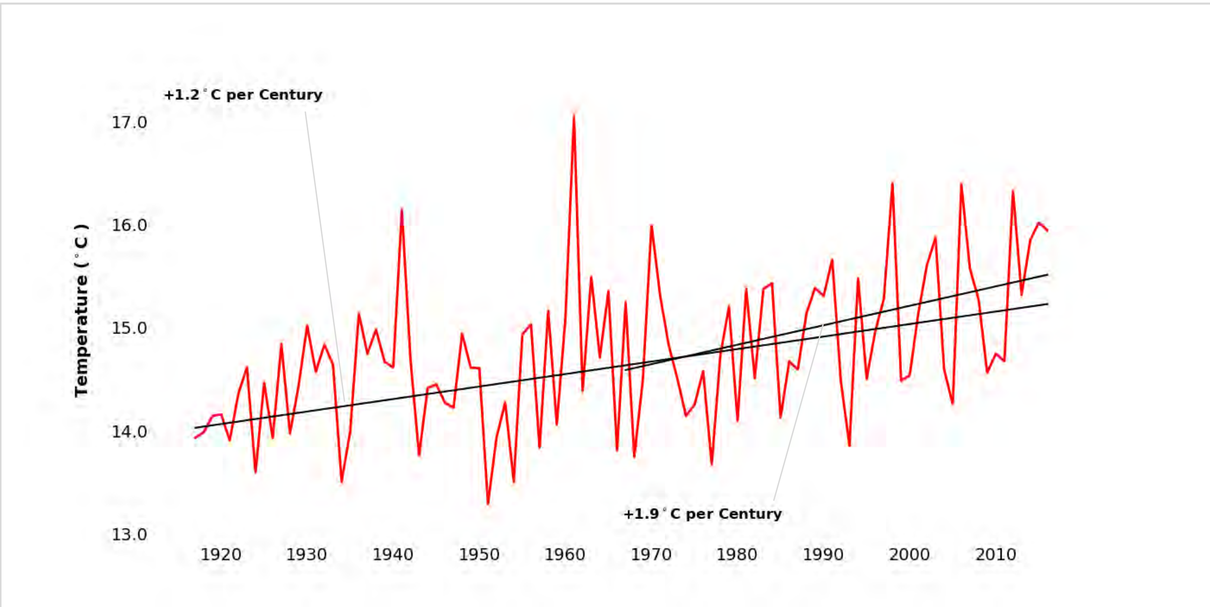


Figure 4: Mean summer temperature in Spruce Grove area (1917-2016)



➡ Precipitation records

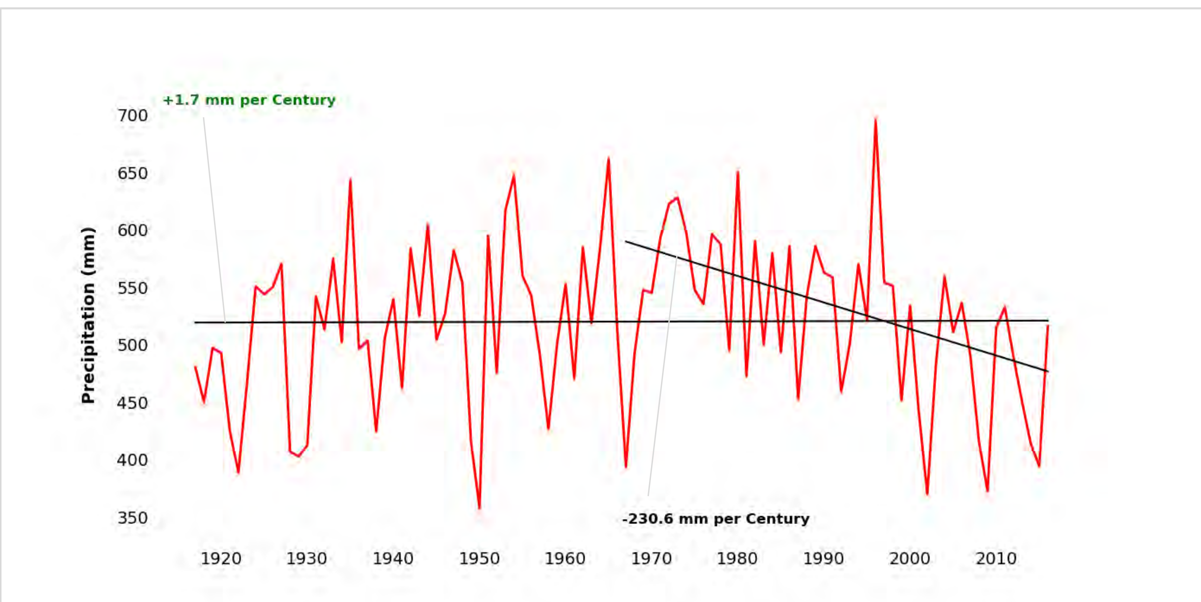
Over the last 100 years, mean annual precipitation in Spruce Grove increased at a rate of less than 2 mm per century; this trend is not statistically significant. However, over the last 50 years, mean annual precipitation has declined at a statistically significant rate of 231 mm per century (Figure 5).

Changes in seasonal precipitation over the last 50 years show the following trends:

- +38 mm per century in spring;
- -29 mm per century in fall;
- -131 mm per century in summer; and
- -67 mm per century in winter.

Trends in summer and winter precipitation over the last 50 years are statistically significant at the 95% confidence level; trends in spring and fall precipitation are not statistically significant.

Figure 5: Mean annual precipitation in Spruce Grove area (1917-2016)



Note: trends depicted in green font are not significant at the 95% confidence level

Climate Projections for the Spruce Grove Area

The outputs from global climate models provide us with projections of how the Earth's climate may change in the future. Global climate models are a mathematical representation of the climate that divide the earth, ocean and atmosphere into millions of grid boxes. The future values of climate variables predicted by these models, such as temperature and precipitation, are calculated for each grid box over time. The results presented below represent the averaged results from 10 km by 10 km grid boxes encompassing the City of Spruce Grove.

Predicting the future is inherently uncertain. To accommodate this uncertainty, projections of future climate change consider a range of plausible scenarios known as RCPs (Representative Concentration Pathways). Scenarios have long been used by planners and decision-makers to analyse futures in which outcomes are uncertain.

For this assessment, we have considered climate model projections for the Spruce Grove area under two RCPs: a ‘business as usual’ scenario (which is formally denoted RCP 8.5) where little additional effort is made to curtail factors contributing to climate change; and a ‘strong mitigation’ scenario (formally denoted RCP 4.5) where considerable additional effort is made to mitigate factors contributing to climate change. The numbers 8.5 and 4.5 refer to the additional warming (in Watts per square metre) anticipated under each scenario by 2100.

Both scenarios will result in significant changes to the local climate by mid-century, necessitating the development of robust adaptation strategies. However, changes projected under RCP 8.5 (business-as-usual) represent a worst-case scenario for adaptation planning.

➡ Temperature projections

Mean annual temperature in Spruce Grove is anticipated to increase by between +3.0°C (yellow line, ‘strong mitigation’ or RCP 4.5 scenario) and +3.6°C (red line, ‘business-as-usual’ or RCP 8.5 scenario) above the 1961-1990 baseline, which will increase the absolute mean annual temperature in the 2050s to between +5.2°C and +5.8°C, respectively (Figure 6)[iv]. These projected increases in temperature are consistent with the rate of change in mean annual temperature that has been observed in Spruce Grove over the last 50 years.

Projected increases in mean winter temperature are +3.7°C and +4.3°C for the ‘strong mitigation’ (RCP 4.5) and ‘business-as-usual’ (RCP 8.5) scenarios, respectively (Figure 7). In summer, mean temperatures are projected to increase by +2.6°C and +3.7° for the ‘strong mitigation’ and ‘business-as-usual’ scenarios, respectively (Figure 8).

➡ Precipitation projections

While annual and winter precipitation declined over the last 50 years, both variables are projected to increase by the 2050s. This may be explained by the higher uncertainty associated with projections of future precipitation compared with those for temperature. Mean annual precipitation is projected to increase by 5% to 10% for the ‘strong mitigation’ (RCP 4.5) and ‘business-as-usual’ (RCP 8.5) scenarios, respectively (Figure 9). Larger increases in precipitation are projected for the winter (Figure 10), while summer precipitation is projected to decrease slightly (Figure 11). All changes are expressed relative to the average value over the baseline period 1961-1990.

Figure 6: Projected mean annual temperature in Spruce Grove

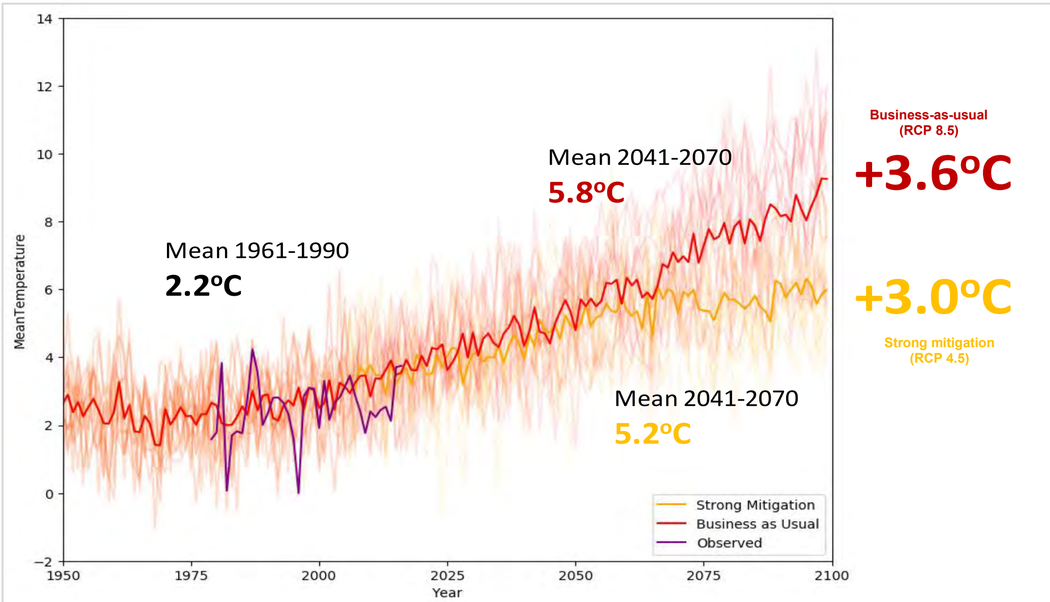


Figure 7: Projected mean winter temperature in Spruce Grove

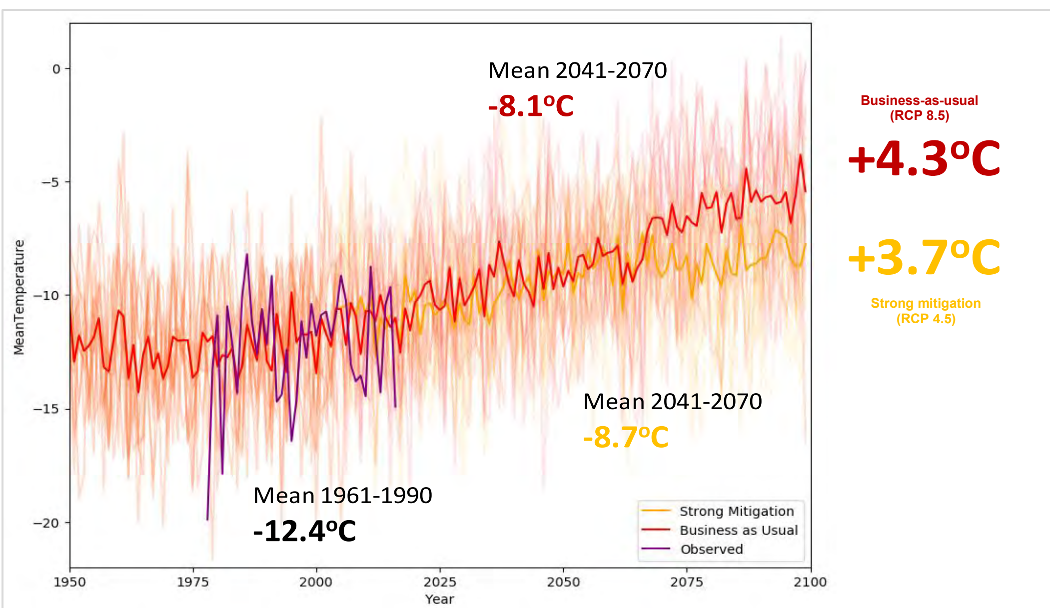


Figure 8: Projected mean summer temperature in Spruce Grove

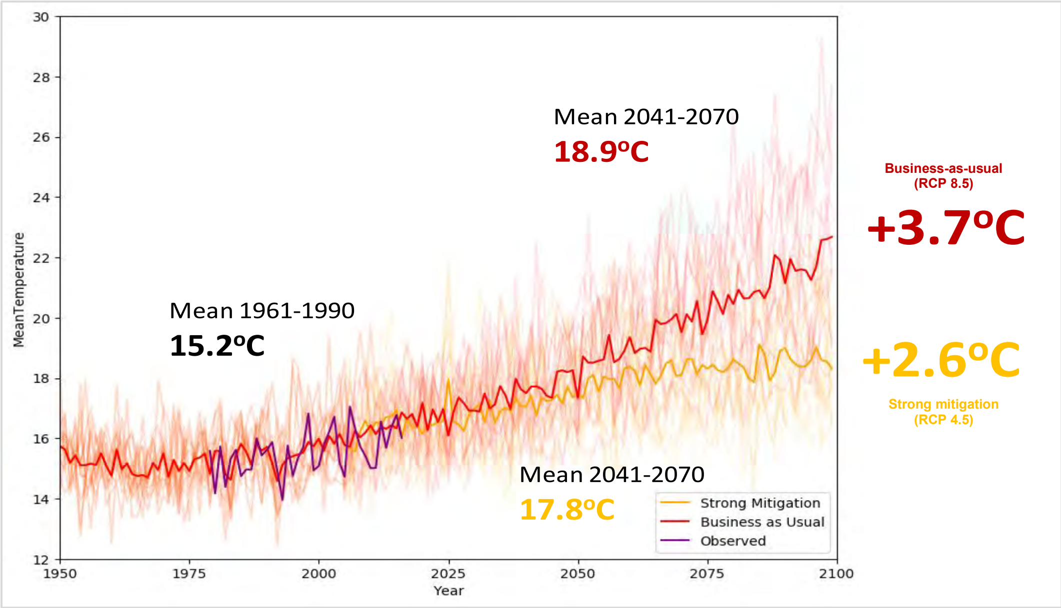


Figure 9: Projected mean annual precipitation in Spruce Grove

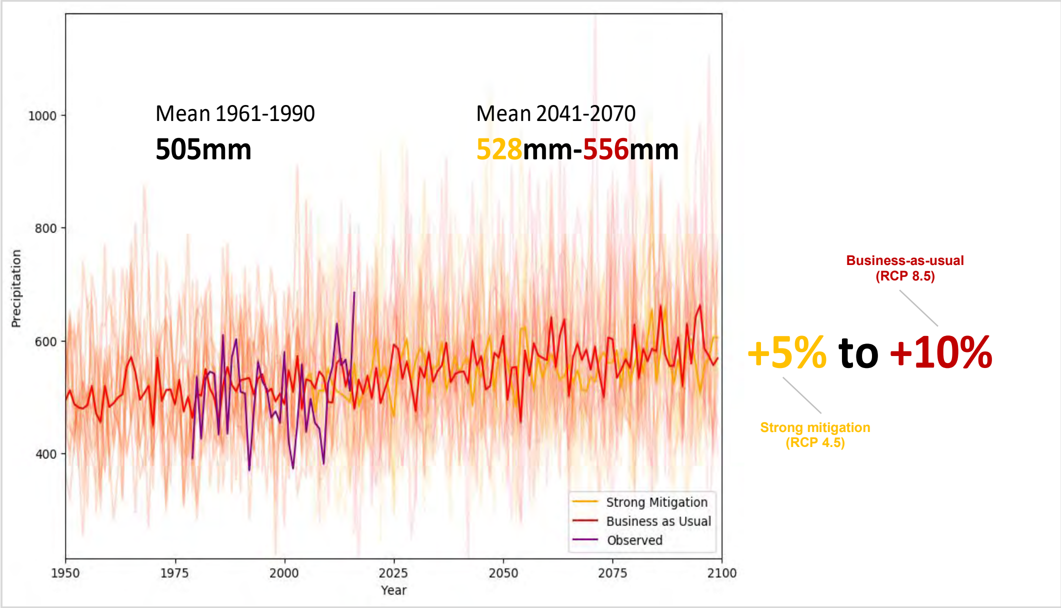


Figure 10: Projected mean winter precipitation in Spruce Grove

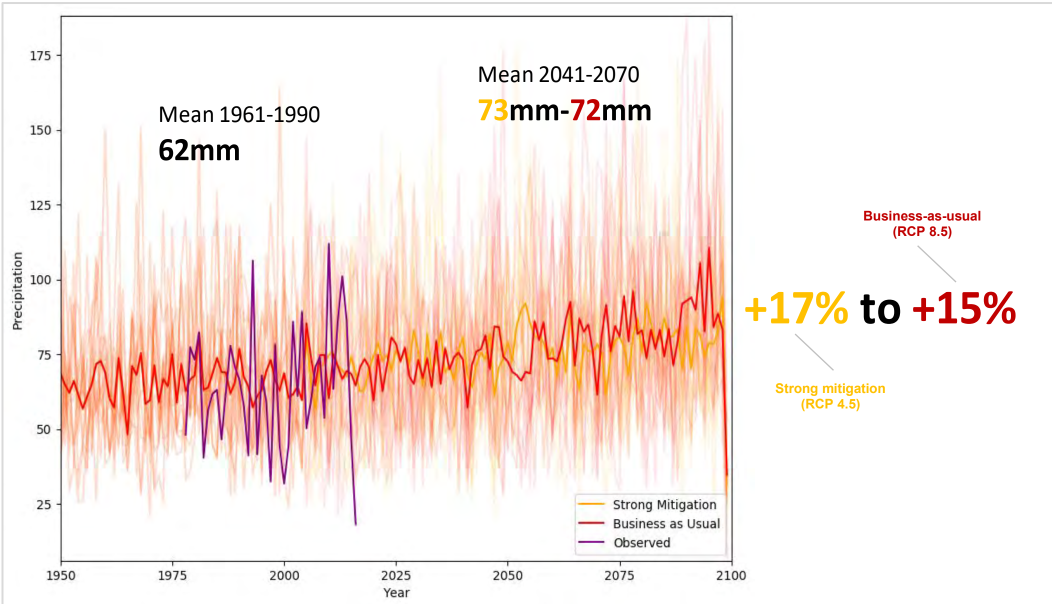
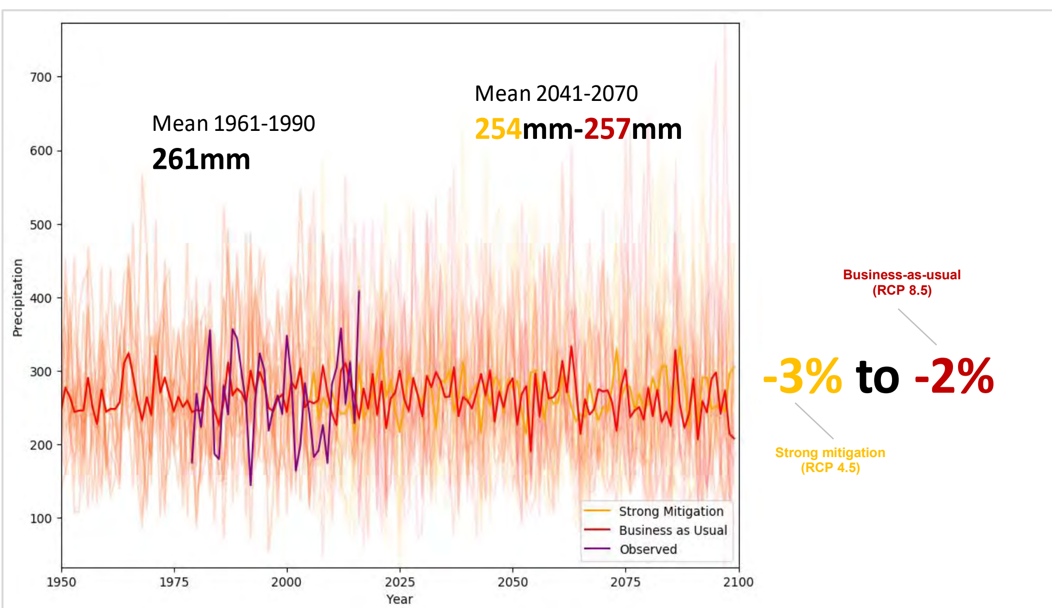


Figure 11: Projected mean summer precipitation in Spruce Grove



➡ Precipitation extremes

In recent years, numerous extreme precipitation events have occurred at various locations globally; several have occurred in western Canada with serious consequences, notably the 2013 flood that affected southern Alberta. Recent studies have demonstrated that extreme rainfall intensity increases by about 7% for every degree increase in global atmospheric temperature[v]. Model projections of short-duration, high intensity 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[vi]. Consequently, it is very likely that Spruce Grove will see more extreme precipitation events as the climate continues to warm in the coming decades.

Table 1 presents a summary of projected climate changes for Spruce Grove by the 2050s.

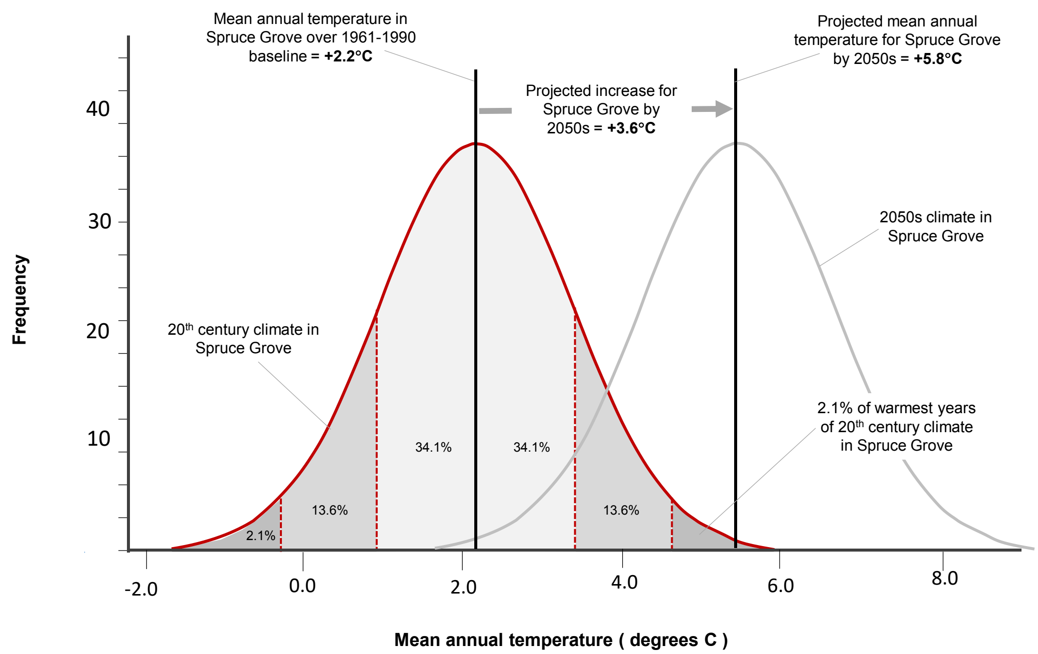
Table 1: Summary of projected cliamte changes for Spruce Grove

Climate variable	Season[vii]	Baseline value (1961-1990)	Strong mitigation scenario (RCP4.5)		Business-as-usual scenario (RCP8.5)	
			Change (+/-)	Absolute value	Change (+/-)	Absolute value
Temperature (°C)	Annual	+2.2	+3.0	+5.2	+3.6	+5.8
	Winter	-12.4	+3.7	-8.7	+4.3	-8.1
	Spring	+3.2	+2.7	+6.0	+3.1	+6.4
	Summer	+15.2	+2.6	+17.8	+3.7	+18.9
	Fall	+3.1	+2.3	+5.4	+3.5	+6.6
Precipitation (mm)	Annual	505	+5%	528	+10%	556
	Winter	62	+17%	73	+15%	72
	Spring	87	+21%	106	+36%	118
	Summer	261	-3%	254	-2%	257
	Fall	82	+15%	94	+15%	95

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

To place the magnitude of the projected temperature changes by the 2050s into context, the 20th century climate of Spruce Grove (1917-2016) was fitted to a normal distribution (bell curve). The mean of the probability distribution is then shifted by the projected temperature increase under the *business-as-usual scenario* of +3.6°C above the 1961-1990 baseline. This increase in mean annual temperature represents a shift of more than 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 Spruce Grove will be like the warmest 1-2% of 20th century climate.

Although a change in mean annual temperature of +3.6°C may not appear to be a large absolute shift in climate, when compared with the probability distribution of 20th century climate in Spruce Grove, a shift of this magnitude is substantial. By analogy, the projected shift in mean annual temperature will replace the climate of Spruce Grove with the historical climate (1961-1990) of Lethbridge, Alberta.



Projected Environmental Changes

Projected changes in average temperature and precipitation in Spruce Grove will have broad consequences across the natural environment, including for soil moisture, growing season, regional ecosystems, wetlands, river flows and wildfires.

➡ Available moisture and growing season

Although mean annual precipitation is projected to increase in Spruce Grove by the middle of the century, 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 Spruce Grove. By the 2050s, the area surrounding Spruce Grove is projected to experience an increase of approximately 306 (growing) degree days (from 1,327 to 1,633), on average (see Figure 12); growing degree days are a measure of the length and warmth of the growing season[x]. Put another way, the average growing season in Spruce Grove by the middle of the century will be more like the growing season experienced around Lethbridge, Alberta in today's climate.

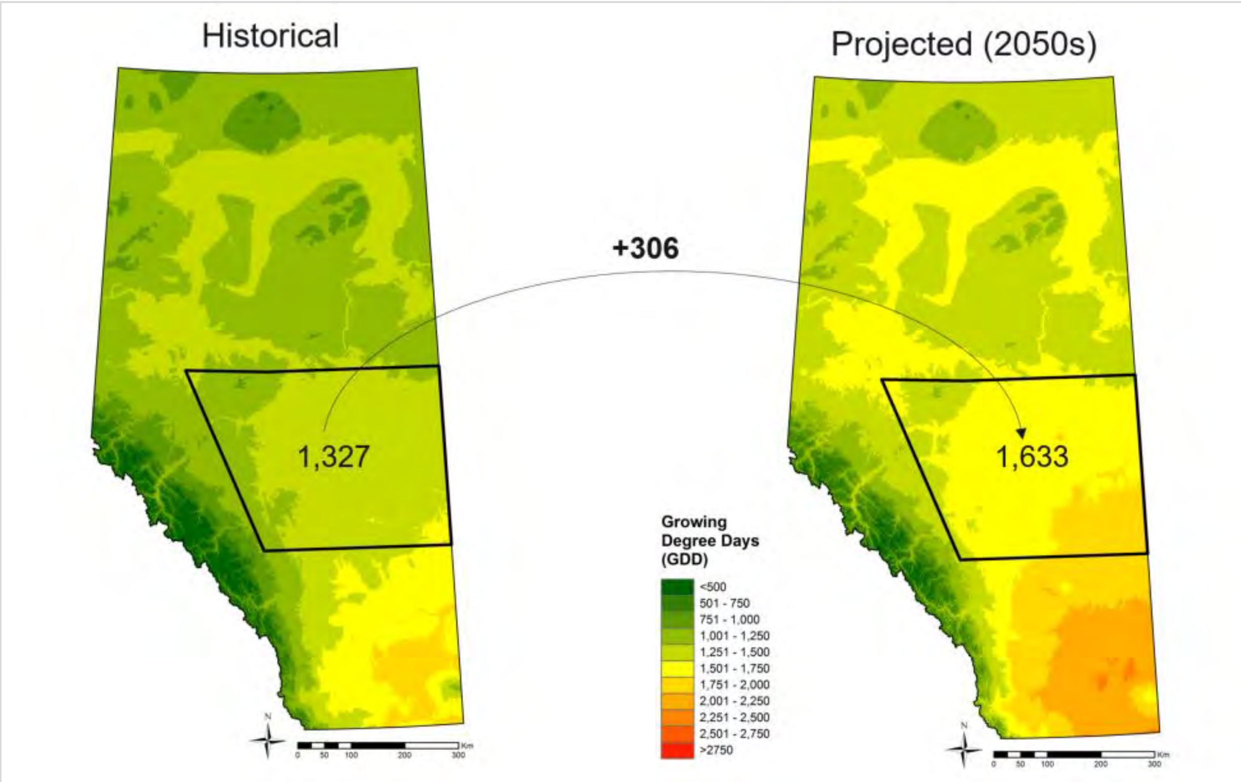
A reduction in available moisture and an extended growing season are projected consequences of climate change common to most of the Alberta boreal and prairie regions[xi]. Because of its more northern location relative to much of the rest of the prairie region, the benefit for agriculture of the projected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

➡ 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. Spruce Grove is currently located at the interface between the Central Parkland and the Dry Mixedwood Forest regions (see Figure 13). The Central Parkland ecosystem is a mosaic of grasslands and deciduous (aspen) forests, which, at higher elevations and further north, transition to a more continuous aspen forest with spruce stands—the Dry Mixedwood Forest ecosystem[xiii].

The warmer and drier conditions projected for the Spruce Grove area will have consequences for these regional ecosystems. The projected climate for the 2050s will be more favourable for Central Parkland ecosystems; Dry Mixedwood forests move north and Mixed Grassland ecosystems move north towards Spruce Grove (as shown in Figure 13) [xiv]. As a result, natural spruce and aspen forests in the area 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[xv,xvi]. The changes in regional ecosystems will also have consequences for the diversity of species that reside in the natural areas in and around Spruce Grove.

Figure 12: (A) Historic (1961-1990) and (B) projected distribution of Growing Degree Days in Spruce Grove Region by the 2050s (2041-2070)[xvii]



➡ **Wildfire**

The warmer and drier climate projected for Spruce Grove 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[xviii, xix].

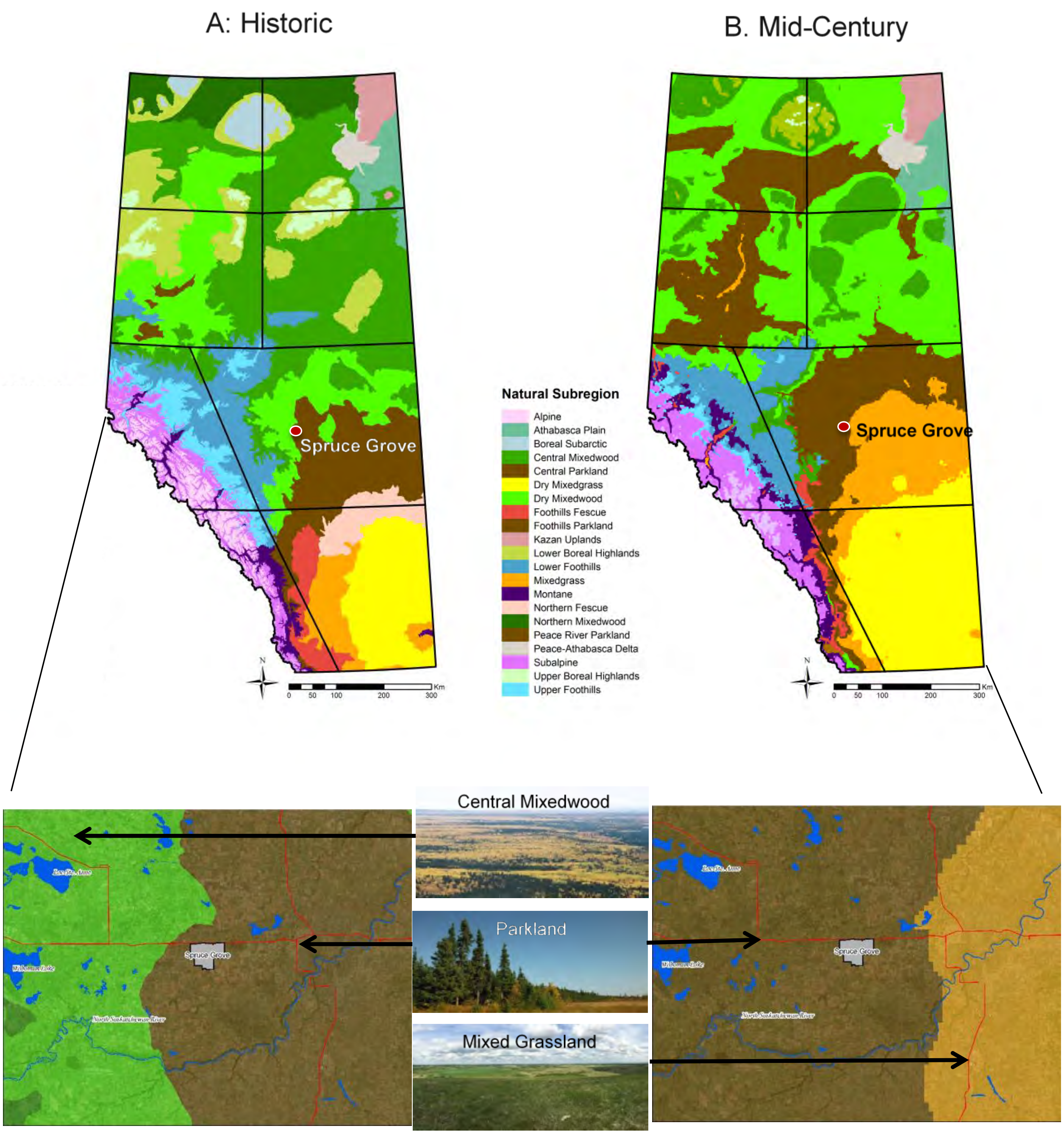
➡ Streamflow

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.

➡ Lakes and Wetlands

Lakes and wetlands in the Spruce Grove region and in the prairie region more broadly are highly sensitive to climate change and variability[xxiii]. 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[xxiv,xxv].

Figure 13: (A) Historic (1961-1990) and (B) projected (2050s) distribution of natural sub-regions in Alberta and in Spruce Grove[xxvi]



4. Climate Risks and Opportunities for Spruce Grove

Session 3 at the workshop invited participants to:

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

2. Translate the identified impacts into risks and opportunities 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 mainly positive (+) consequences for Spruce Grove

• Freezing rain (-)	• Decline in winter recreation (-)
• Increased water demand (-)	• Drought (-)
• Water shortage (-)	• Decline in outdoor summer recreation (-)
• Increased summer power demand (-)	• Improved recreation in spring (+)
• Stress on parks and urban forest (-)	• Increased winter recreation opportunities (+)
• Heat stress on people (-)	• Reduced heating costs (+)
• Freeze-thaw cycles (-)	• Increased construction season (+)
• Urban flooding (-)	• Reduced winter road maintenance (+)
• Thunderstorm (-)	• Longer growing season (+)
• Urban forest fire (-)	

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 Spruce Grove or had positive and negative consequences that were judged to cancel out; these are not considered further. This produced a smaller list of the most important potential impacts for Spruce Grove.

Workshop participants were invited to translate these impacts into risks (impacts with mainly negative consequences) and opportunities (impacts with mainly positive consequences), and to prioritize the risks and opportunities. Priorities are assigned to impacts by scoring, first, the severity of potential consequences, and second, the likelihood of consequences at that level of severity 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 Spruce Grove. The description includes a selection of key consequences, along with the label used to identify the impact in the "risk map" shown in Figure 14.

The risk map is a two-dimensional representation of the average level of adverse consequence assigned each impact by workshop participants, plotted against the average level of likelihood assigned each impact.

Impacts in the upper right corner of the map have relatively larger adverse consequences combined with a relatively higher likelihood of occurrence. These impacts represent priorities for action.

Table 3: Climate change risks facing Spruce Grove by the 2050s

Potential local risks		Key consequences for Spruce Grove
Label for risk map	**Description**	
"Freezing rain"	Freezing rain event due to potential increase in ice and snow in fall, spring and winter	• Power outage – disruption to city operations and services • Increased road and sidewalk maintenance – sand, gravel, labour, fuel, etc. • Damage to trees
"Water demand"	Increased demand for water in summer from reduced summer precipitation, and drier conditions overall	• Reduced water supply, potential inability to meet water demands • Increased cost for water
"Water shortage"	Potential water shortages related to reduced precipitation in summer and drier conditions overall	• Inability to meet water demands • Reduced groundwater recharge
"Power demand"	Increased summer power demand (air conditioning) due to hotter conditions and extreme heat	• Increased costs for residents, businesses and City • Increased likelihood of power outages (brownout)
"Parks and forests"	Increased stress on urban parks and forests related in increased extreme heat	• Negative impacts on local wildlife • Increased operational costs for the City
"Heat stress"	Heat stress on people due to extreme heat events	• Increased injuries and fatalities related to heat exposure • Increased cancer rates • Increased emergency response costs
"Freeze-thaw"	Increased freeze-thaw and icy conditions due to warmer temperatures in spring, winter and fall	• Increased infrastructure damage and associated maintenance costs • Increased lawsuits • Hazardous walking and driving conditions – safety concern
"Urban flooding"	Increased accumulation of water in the storm system and widespread flooding caused by increased precipitation and intense rainfall	• Damage to property and infrastructure, including basement flooding and road damage • Increased capital costs for flood mitigation • Transportation disruption • Increased insurance costs • Increased runoff and erosion • Potential impacts to water quality (turbidity) – increased water treatment costs

Potential local risks		Key consequences for Spruce Grove
Label for risk map	Description	
"Thunderstorm"	Damaging thunderstorm, including lightning, hail and high winds, caused by increased intensity of summer storms,	• Power outage – disruption to city operations and services • Damage to property and infrastructure, including trees, signs, roofs, siding, automobiles, etc. • Costs for repair and replacement of damaged property • Cancellation of important local events
"Forest fire"	Urban forest fire	• Power outage – disruption to city operations and services • Damage to property and infrastructure • Costs for repair and replacement of damaged property • Cancellation of important local events • Loss of recreation assets and opportunities – social impact • Increased costs and municipal resources required • Increased turbidity and water treatment costs
"Forest pests"	Increased prevalence of forest pests related to fewer periods of extreme cold	• Increased operational pest management costs • Impacts to buildings (wood structures) – increased maintenance and replacement costs
"Winter recreation"	Decline in winter recreation (e.g. Nordic skiing) due to less precipitation as snow	• Negative impacts on quality of life of residents • Increased demand for indoor recreation services
"Summer recreation"	Decline in outdoor summer recreation due to increased precipitation in spring and fall, and flooded sports fields	• Negative impacts on quality of life of residents • Increased demand for outdoor recreation services

Figure 14: Risk map for climate change impacts with mainly negative consequences for Spruce Grove

CONSEQUENCES						
	(5) Major					Higher priorities for action
	(4)		Forest fire	Urban flooding	Water shortage	
	(3) Moderate			Parks and forests Heat stress	Freezing rain Water demand Thunderstorm Freeze-thaw	
	(2)			Forest pests	Power demand	
	(1) Negligible	Lower priorities for action		Winter recreation Summer recreation		
		(1) Low	(2)	(3) Moderate	(4)	(5) High
		LIKELIHOOD				

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 at this time; 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 Spruce Grove. The description includes a selection of potential benefits, along with the label used to identify the impact in the opportunity matrix shown in Figure 15. Impacts in the upper right corner of the map offer greater potential benefits combined with a relatively high likelihood of being realized.

Table 4: Cliamte change opportunities for Spruce Grove by the 2050s

Potential local opportunities		Key benefits for Spruce Grove
Label for opportunity map	**Description**	
"Spring recreation"	Improved spring recreation opportunities due to warmer temperatures	• Improved health, and quality of life for residents • Increased use of outdoor recreation facilities
"Winter recreation"	Improved winter recreation opportunities due to warmer winter temperatures, and less extreme cold	• Improved health, quality of life and happiness • Increased use of outdoor recreation facilities
"Heating cost"	Reduced space heating cost because of warmer winter temperatures, and less extreme cold	• Costs savings for residents, businesses and the City • Reduced greenhouse gas emissions
"Construction season"	Extended construction season length due to warmer temperatures in spring and fall, and reduced summer precipitation	• Increased efficiency of summer construction projects (more projects complete, more opportunities) • Economic benefits for local businesses
"Road maintenance"	Reduced winter road maintenance issues and associated costs, due to less precipitation as snow	• Costs savings for municipal operations
"Growing season"	A longer growing season for local farmers and home gardeners related to increased temperatures across the growing season	• Longer farmers market season • Reduced cost of local food • Fresher local produce

Figure 15: Opportunity map for climate change impacts with mainly positive consequences for Spruce Grove

CONSEQUENCES						
	(5) Major					Higher priorities for action
	(4)				Construction season	
	(3) Moderate			Growing season Spring recreation Winter recreation		
	(2)		Road maintenance	Heating cost		
	(1) Negligible	Lower priorities for action				
		(1) Low	(2)	(3) Moderate	(4)	(5) High
		LIKELIHOOD				

5. CLIMATE RESILIENCE ACTIONS

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

For the priority risks and opportunities, Session 5 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 subset of priority risks and opportunities, chosen by workshop participants. The four priorities selected for action planning are:

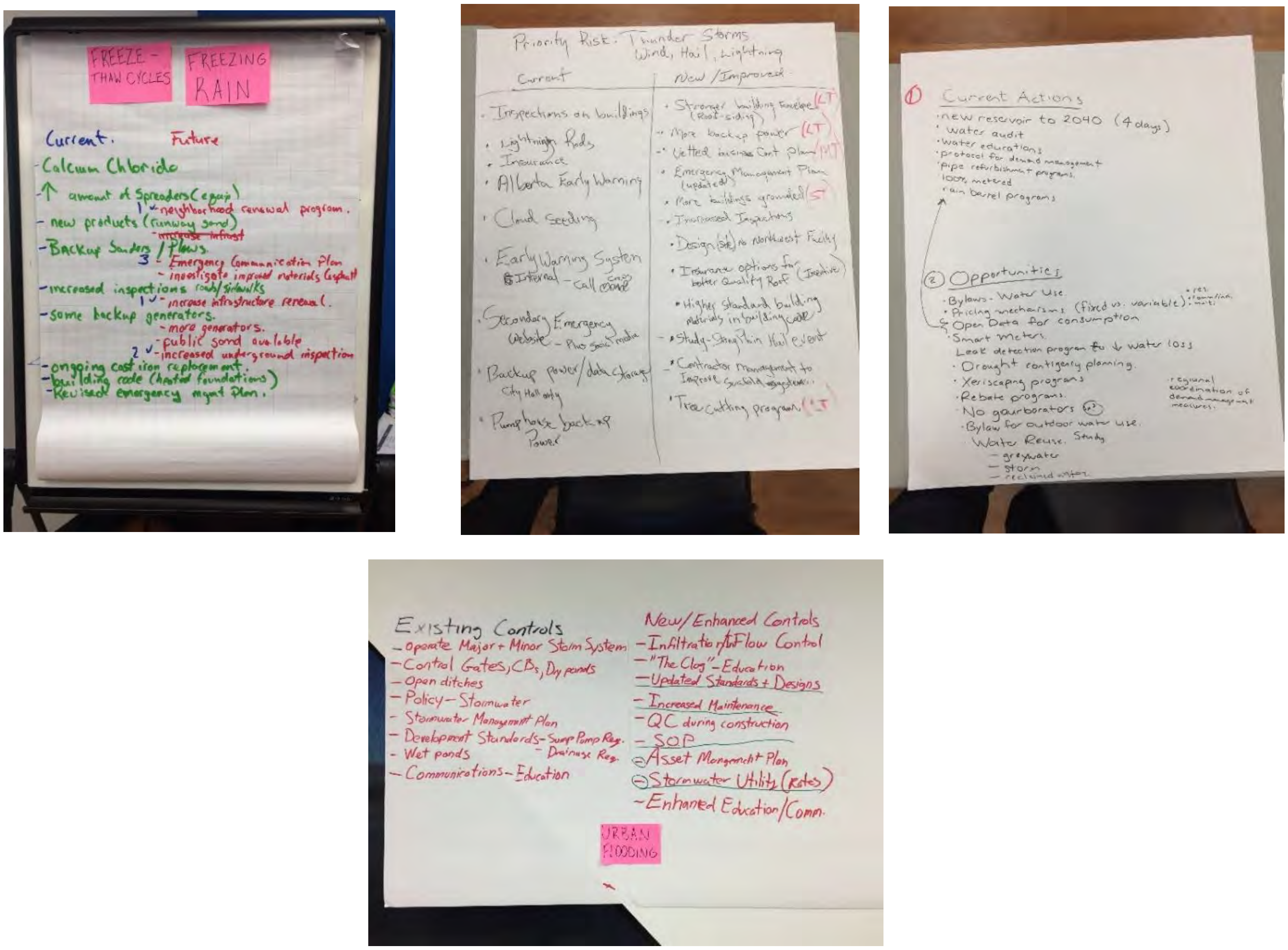
- Water supply shortage;
- Urban flooding;
- Freezing rain; and
- Thunderstorms.

For each of these four priorities, a starter action plan is 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 (shown in Figure 16) is screened to identify three to five of the most promising actions for inclusion in the starter action plan for each priority risk or opportunity. When screening actions, participants considered: the effectiveness of the action in mitigating the risk; how feasible it would be to implement (in terms of available funding and human resources); and how generally acceptable it would be to stakeholders, including elected officials.

Figure 16: Brainstorming actions to mitigate priority risks in Spruce Grove



To inform decision-making and support implementation of the recommended actions, workshop participants also provided information on:

1. Total implementation costs;
2. The timeframe for implementation (i.e., how long before the action is operational); and
3. The lead department or organization.

These three factors are key inputs to the development of an implementation strategy. important initiatives that will also serve to enhance the City's climate resilience.
 was used to help participants provide approximations for (1) and (2).

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, Spruce Grove is already committed to numerous actions that will help manage the risks and opportunities of climate change identified in Section 4. Some of these actions were identified during Session 5 of the workshop and include:

- A Stormwater Management Plan and Policy;
- A robust stormwater infrastructure system which is operated to mitigate urban flooding, including control gates, catch basins, dry ponds and wet ponds;
- Development standards for urban flooding including sump pump regulations and drainage regulations;
- Ongoing maintenance and operations to support management of freezing rain and freeze-thaw cycles, including placement of sand and calcium chloride;
- Back-up power generators at some critical facilities (City Hall and pump stations);
- Ongoing replacement of cast-iron water supply pipes, with more resilient piping;
- A revised emergency management plan;
- Plans for a new water supply reservoir (2040);
- Water demand management policies, including universal water metering and pricing, and a rain barrel program to support water conservation;
- An internal early warning system for imminent storms and potential emergencies;
- Ongoing inspections and maintenance of buildings and facilities; and
- Ongoing education and communications with residents, including through social media.

It is important that the City continue to support the implementation of these important initiatives that will also serve to enhance the City's climate resilience.

Table 5: Climate resilience actions — definitions

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	More than 10 years

Due to time constraints at the workshop, climate resilience actions are necessarily defined at a coarse level. As consideration is given to initiating any of the identified actions (listed in the tables below), it is expected that they will be further developed to support decision-making and enable implementation (see Section 6).

Water Supply Shortage

Action	Cost	Timeframe	Lead
Modify water pricing mechanisms so high consumptive water users pay an increased rate	Moderate	Near-term	Finance
Develop a water supply leak detection program	High	Long-term	Utilities
Develop an outdoor water use bylaw to allow for water restrictions during times of reduced water supply	Low	Near-term	Utilities / Finance / Engineering / Planning

URBAN FLOODING

Action	Cost	Timeframe	Lead
Enhance internal and external stormwater management education programs (e.g. "the Clog")	Moderate	Near-term	Public Works / Engineering
Increase frequency of maintenance and monitoring of the stormwater systems	Very high	Short-term	Public Works
Updated design standards for installation of stormwater infrastructure in residential and commercial developments	Moderate	Short-term	Engineering
Develop an infiltration / in-flow control strategy to reduce stormwater infiltration into the sanitary system	Very high	Long-term	Engineering
Develop a model for a Spruce Grove stormwater utility, paid for local fees, to ensure sustainability of the stormwater management system	High	Near-term	Finance

FREEZING RAIN

Action	Cost	Timeframe	Lead
Improve neighbourhood infrastructure renewal, replace roads and sidewalks simultaneously	Very high	Medium-term	Engineering
Enhance underground utility inspections (water, sewer, etc.) and keep records up to date	Very high	Medium-term	Engineering
Develop an Emergency Communications Plan	Moderate	Short-term	Communications
Investigate options for improved materials and technologies to manage ice, including asphalt and sanding/salting strategies	Low	Short-term	Engineering / Public Works

THUNDERSTORMS

Action	Cost	Timeframe	Lead
Install back-up power at critical facilities in the city	Very high	Long-term	Facilities
Complete the Business Continuity Plan to ensure continuous operation of municipal services during an emergency	Very high	Medium-term	Risk
Increase inspections of buildings and facilities (e.g. roofs and siding) for leaks and vulnerability to high wind	Moderate	Short-term	Facilities
Conduct a review of the 2010 Stony Plain hail event to assess impacts, lessons learned and local vulnerability	Moderate	Medium-term	Facilities
Enhance contractor management to improve the resilience of scaffold systems	Moderate	Short-term	Risk
Install lightning rods and/or grounding on buildings and facilities	Low	Medium-term	Facilities

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'. City 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. Several 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 City website 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 City's efforts to make the community more resilient.

Mainstreaming

This Action Plan is developed as a 'stand-alone' document. However, it is important that climate resilience is integrated (i.e., 'mainstreamed')—as a matter of routine—into the City'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 (e.g., the Municipal Development Plan) and neighborhood scale plans should consider potential future climate change impacts; and

- o Decisions related to the design, maintenance, and upgrading of long-life infrastructural 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 Spruce Grove'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:

- o Lessons learned from the implementation of actions;
- o New scientific information about climate projections and corresponding impacts; and
- o Changes to the City'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
Caitlin Van Gaal	Environmental Advisor - City of Spruce Grove
Patrick Inglis	Manager of Environment and Transit - City of Spruce Grove
Corey Levasseur	General Manager of Planning and Infrastructure - City of Spruce Grove
Kevin Stener	Director of Public Works - City of Spruce Grove
Darcy Bryant	Supervisor of Utilities - City of Spruce Grove
Bill Ruether	Supervisor of Roads and Drainage - City of Spruce Grove
Keith Frank	Supervisor of Parks - City of Spruce Grove
Paul Simons	Director of Facilities and Fleet - City of Spruce Grove
Mark Hussey	Director of Engineering - City of Spruce Grove
Debra Irving	Director of Planning and Development - City of Spruce Grove
Robert Hayder	Asset Management Specialist - City of Spruce Grove
Dan Howarth	Insurance and Risk Advisor - City of Spruce Grove
Robert Smith	Operations Manager - Cargill
Heather Zarski	Specialist, Planning- EPCOR
Filip Dundur	Manager Hydraulic Modeling - EPCOR
Jerry Yang	Engineering Planning Manager – Alberta Capital Region Wastewater Commission
Paul Delano	ATCO Gas
Sandra McIntosh	Economic Development Coordinator - City of Spruce Grove
Stuart Houston	Mayor - City of Spruce Grove
Chantal McKenzie	Councillor - City of Spruce Grove

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

Score	Description
(1) **Negligible**	• 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) **Major**	• 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 the scoring the likelihood of consequences

Score	Descriptor	Interpretation
(1)	**Low**	*Very unlikely* - to see that level of consequences
(2)	↕	*Unlikely* – to see that level of consequences
(3)	**Moderate**	*Possible* – to see that level of consequences
(4)	↕	*Likely* – to see that level of consequences
(5)	**High**	*Almost certain* – to see that level of consequences

8. ENDNOTES

[i] Participating communities include: Banff, Beaver County, Big Lakes County, Black Diamond, Brazeau County, Bruderheim, Canmore, Lacombe County, Mackenzie County, Okotoks, Spruce Grove, Sylvan Lake and Turner Valley.

[ii] 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.

[iii] 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).

[iv] In figures 6 through 11, light red lines show individual 'Business as Usual' scenario model runs for the Pacific Climate Impacts Consortium (PCIC) downscaled ensemble. Heavy red lines show the ensemble mean for 'Business as Usual' scenario model runs. Light yellow lines show individual 'Strong Mitigation' scenario model runs for the PCIC downscaled ensemble. Heavy yellow lines show the ensemble mean for 'Strong Mitigation' scenario model runs. Purple lines show the observed record based on data from the Climate Data Guide: ERA-Interim (Dee, Dick & National Center for Atmospheric Research Staff (Eds). 2017) available at: https://climatedataguide.ucar.edu/climate-data/era-interim

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

[vi] Trenberth, K.E., 2011. Changes in precipitation with climate change. Clim Res., 47, 123-138.

[vii] Seasons are defined by the standard meteorological definitions of Winter (Dec-Jan-Feb), Spring (Mar-Apr-May), Summer (Jun-Jul-Aug), and Fall (Sep-Oct-Nov).

[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://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] Nyirfa, W.N. and B. Harron. 2004. Assessment of Climate Change on the Agricultural Resources of the Canadian Prairies. Prepared for the Prairies Adaptation Regional Collaborative, Regina, SK. 27p. Available at http://www.parc.ca/

[xiii] 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.

[xiv] 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

[xv] Ibid.

[xvi] 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/

[xvii] Maps created with climate data available at http://ualberta.ca/~ahamann/data/climatewna.html (Hamann et al. 2013). The mid-century growing degree days projection based on the German ECHAM5 global climate model and the A2 emissions scenario (IPCC 2000).

- Hamann, A.T., Wang, D.L. Spittlehouse and T.Q. Murdock. 2013. A comprehensive, high-resolution database of historical and projected climate surfaces for western North America. *Bulletin of the American Meteorological Society* 94:1307–1309
- IPCC. 2000. Special Report on Emissions Scenarios - Summary for Policy Makers. Intergovernmental Panel on Climate Change Working Group III.

[xviii] De Groot, W.J., M.D. Flannigan and A.S. Cantin. 2013. Climate change impacts on future boreal fire regimes. *Forest Ecology and Management* 294:35-44.

[xix] Flannigan, M.D., M.A. Krawchuk, W.J. de Groot, B.M. Wotton, and L.M. Gowman. 2009. Implications of changing climate for global wildland fire. *International Journal of Wildland Fire* 18:483-507.

[xx] Sauchyn, D. J. St. Jacques, E. Barrow, S. Lapp, C.P. Valdivia, and J. Vanstone. 2012. Variability and trend in Alberta climate and streamflow with a focus on the North Saskatchewan River Basin. Final Report for the Prairies Regional Adaptation Collaborative. Regina, SK. Available at http://www.parc.ca/

[xxi] Ibid.

[xxii] Ibid.

[xxiii] Liu, G. and F.W. Schwartz. 2012. Climate-driven variability in lake and wetland distribution across the Prairie Pothole Region: from modern observations to long-term reconstructions with space-for-time substitution. *Water Resources Research* 48: W08526

[xxiv] Ouyang, Z., R. Becker, W. Shaver, and J. Chen. 2014. Evaluating the sensitivity of wetlands to climate change using remote sensing techniques. *Hydrological Processes* 28:1703-1712

[xxv] Johnson, W.C., B. Werner, G.R. Guntenspergen, R.A. Voldseth, B. Millett, D.E. Naugle, M. Tulbure, R.W.H. Carroll, J. Tracy, and C. Olawsky. 2010. Prairie wetland complexes as landscape functional units in a changing climate. *BioScience* 60:128-140.

[xxvi] Maps created with data available at http://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://biodiversityandclimate.abmi.ca/
- IPCC. 2000. Special Report on Emissions Scenarios - Summary for Policy Makers. Intergovernmental Panel on Climate Change Working Group III.

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