



TOWN OF SYLVAN LAKE

CLIMATE RESILIENCE EXPRESS ACTION PLAN

MARCH 2018



“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 Town of Sylvan Lake¹.

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 the Sylvan Lake region, with observable changes in temperature, precipitation, and extreme weather events over the last century. The impacts of climate change on the Town of Sylvan Lake 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 Sylvan Lake 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, 15 climate-related risks and three climate-related opportunities were identified by participants at a workshop in the Town of Sylvan Lake on November 15th, 2017. Four risks were judged to be priorities requiring immediate action:

- Wind storms;
- Shoreline erosion and wildlife habitat stress;
- Increased water temperatures and reduced water availability; and
- Overland flooding.

Starter action plans were developed for these priority risks.

The Town is already committed to numerous actions that help manage the above priority risks, including: land use management, planning, bylaws and development approvals designed to reduce overland flooding and impacts; emergency response planning which includes inter-municipal agreements, communications protocols, and staff training; an Environmental Master Plan containing an inventory of environmentally significant areas; rain barrel and toilet rebate programs to support water conservation; education and lake stewardship; water monitoring on Sylvan Lake; and back-up power at critical facilities around the Town.

In addition to existing actions that help mitigate the consequences of the priority risks, 14 further actions were identified for consideration to help the Town 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 the Town of Sylvan Lake 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 the Sylvan Lake region, with observable changes in temperature, precipitation, and extreme weather events over the last century. The average annual temperature in the region 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. At the same time however, 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.

The Town of Sylvan Lake, 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.

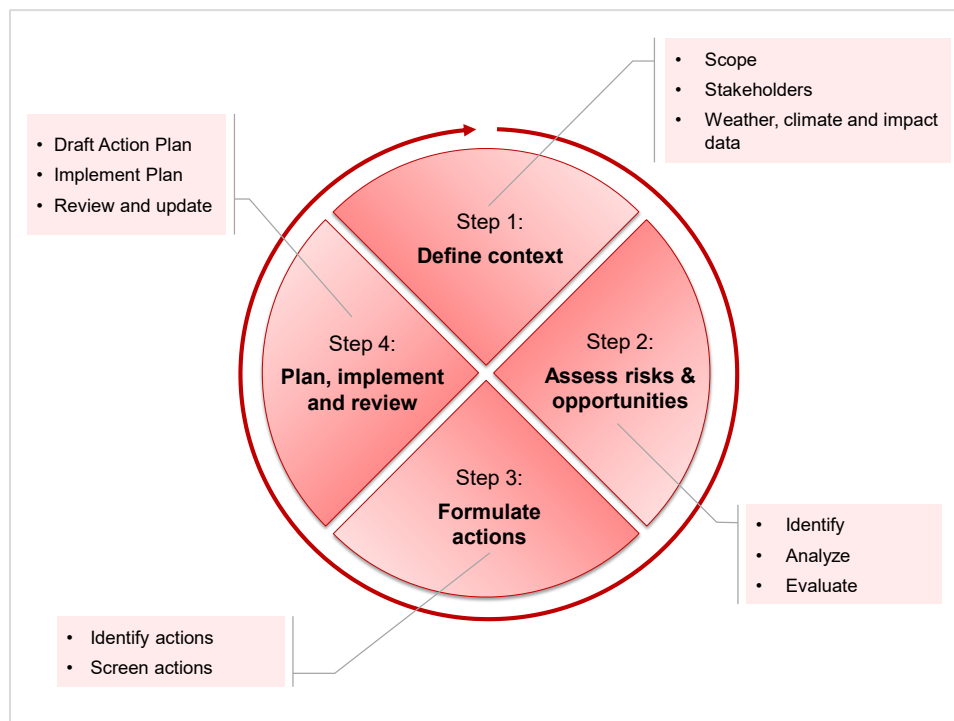
2. DEVELOPING THE ACTION PLAN

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 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 the Town Sylvan Lake was established. This involved:

➔ Defining the spatial scope

The spatial scope is limited to direct impacts within the geographic boundaries of the Town of Sylvan Lake. However, it is recognized that impacts could occur outside the municipal boundaries which could affect the Town. It is also important to recognize that Sylvan Lake is a shared resource and impacts to the Lake will also affect surrounding communities.

➔ 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 Sylvan Lake 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 was to explore the relationship between weather, climate and key aspects of the Sylvan Lake region 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 was 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 was twofold; first, to determine how projected climate changes could impact the Town, 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, 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 has been affected by weather-related events in the past, considering impacts on the local economy, property and infrastructure, the natural environment, and local 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

- ✓ Extreme rainfall events, overland flooding
- ✓ Tornado (Pine Lake)
- ✓ Drainage issues into Sylvan Lake / Creek
- ✓ Displacement of wildlife and ecosystems (trees) due to changing environmental conditions
- ✓ Hot, dry summers, increase water usage
- ✓ Grass fires and smoke from nearby fires
- ✓ Shoreline erosion and reduced recreation access
- ✓ Blue-green algae in Sylvan Lake
- ✓ Change in nutrient content of Sylvan Lake
- ✓ Decrease in Sylvan Lake fish populations
- ✓ Severe wind storms (e.g. 2017)
- ✓ Warmer winters reduce ice cover on lake and affect winter recreation

LOCAL CLIMATE TRENDS

To provide a perspective of historic climate trends in the Sylvan Lake region, data was collected and analyzed from ten climate stations in the region (Athabasca, Cold Lake, Campsie, Edmonton, Calmar, Camrose, Lacombe, Rocky Mountain House, Edson, and Whitecourt)ⁱⁱ. These climate stations were selected because the data cover multiple decades, are high quality,

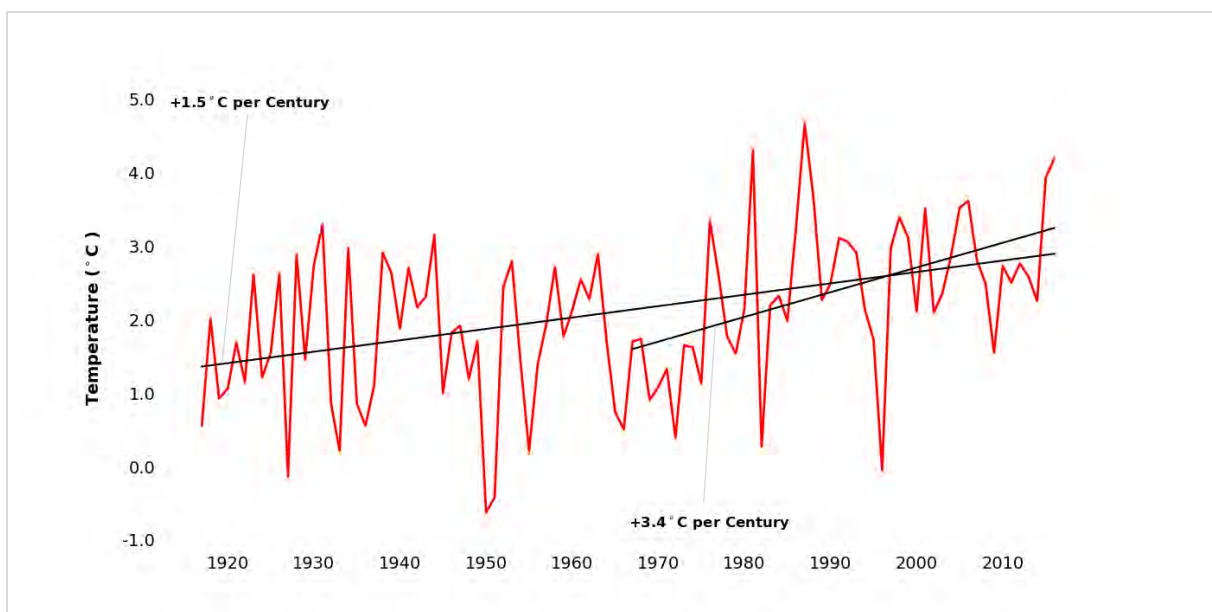
and the stations span an area that is comparable to the same area for which climate projections are available.

Climate records of temperature and precipitation for the Sylvan Lake region were assembled by averaging the individual records from these ten climate stations and applying appropriate statistical techniques to assess the robustness of estimated trendsⁱⁱⁱ.

➔ Temperature records

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

Figure 2: Mean annual temperature in Sylvan Lake region (1917-2016)



The largest seasonal increase in temperature in the Sylvan Lake region occurred during the winter (December-February). The observed rate of warming in winter over the last 100 years is $+3.0^{\circ}\text{C}$ per century (Figure 3). Over the last 50 years mean winter temperature increased at a rate of $+7.0^{\circ}\text{C}$ 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 $+1.2^{\circ}\text{C}$ per century, and $+1.9^{\circ}\text{C}$ 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 Sylvan Lake region (1917-2016)

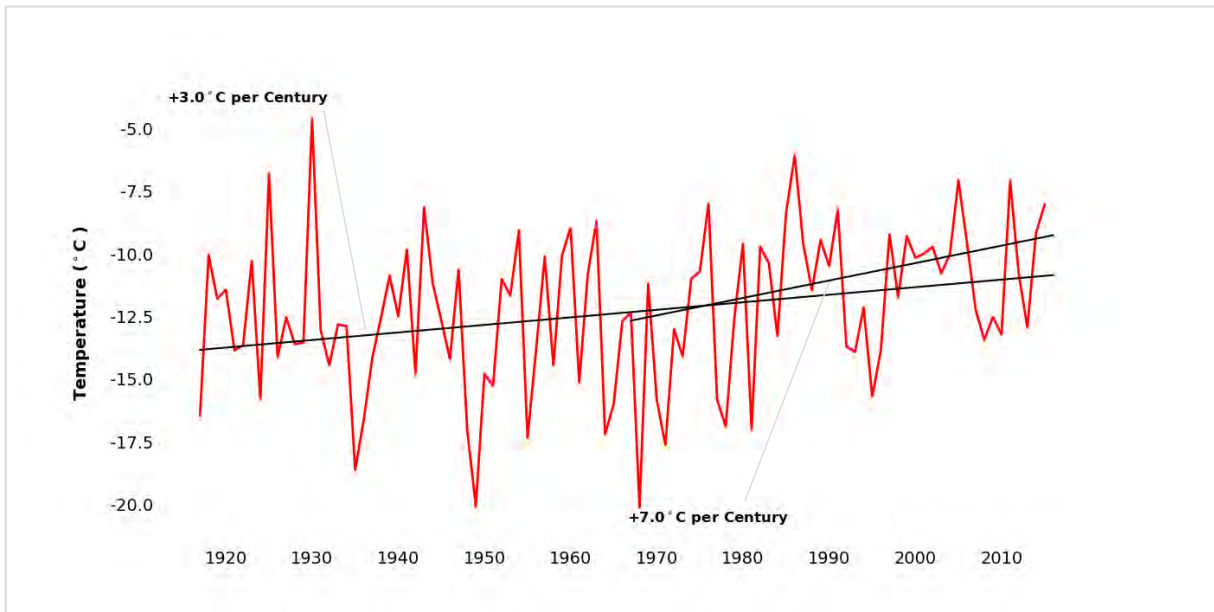
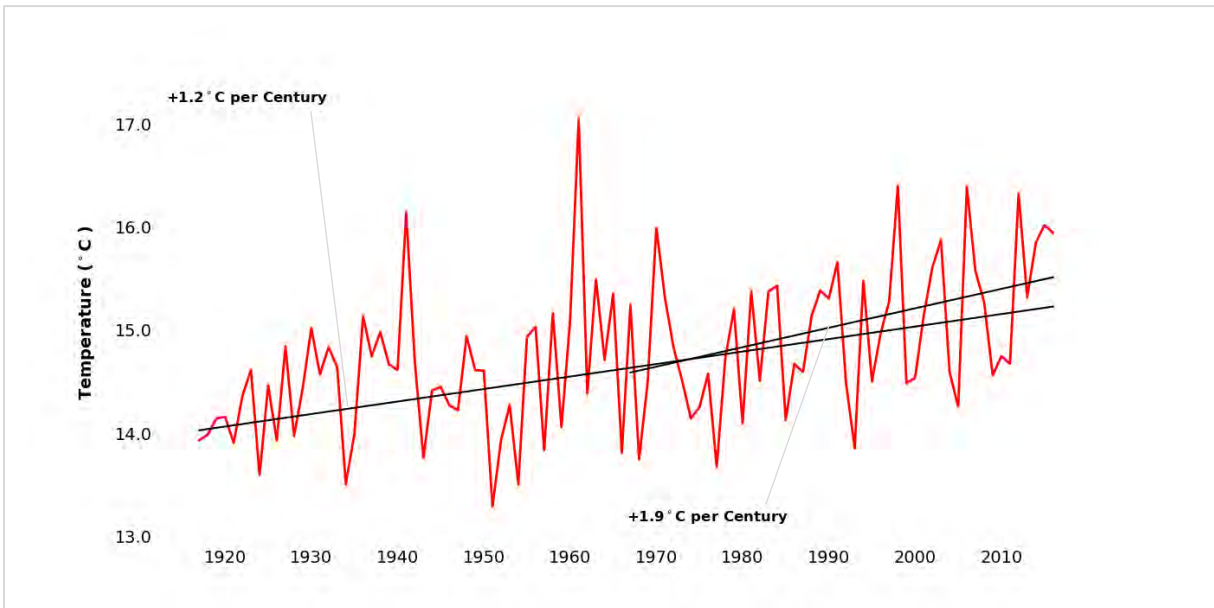


Figure 4: Mean summer temperature in Sylvan Lake region (1917-2016)



➔ **Precipitation records**

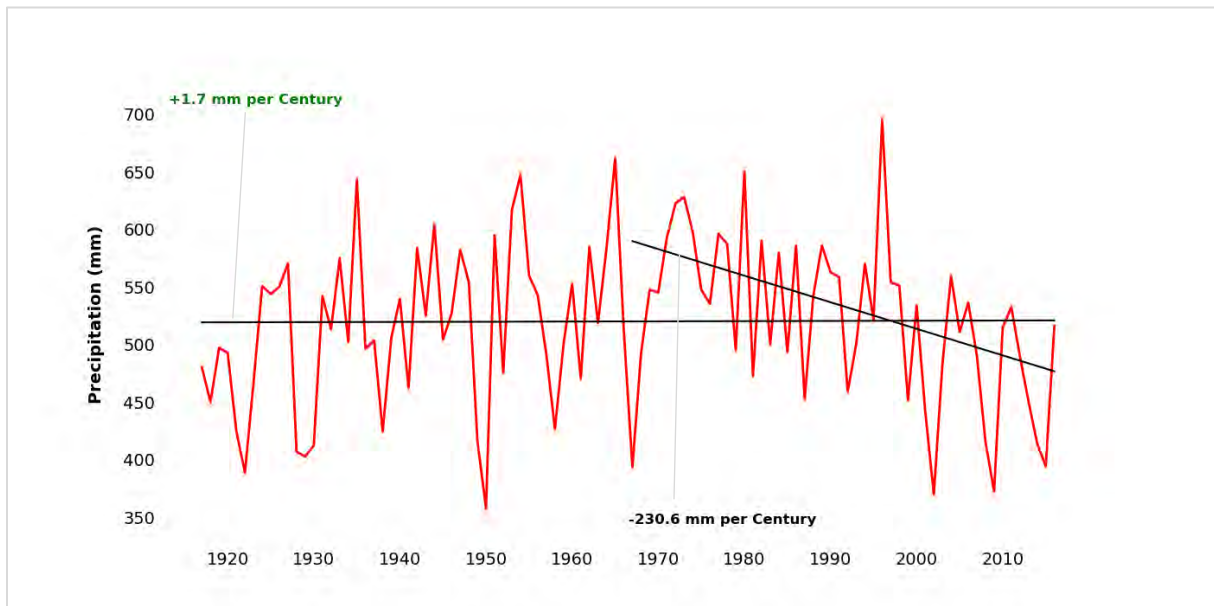
Over the last 100 years, mean annual precipitation in the Sylvan Lake region increased at a rate of less than 2 mm per century; this trend is not statistically significant. However, over the last 50 years, mean annual precipitation has declined at a rate of 231 mm per century (Figure 5).

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 Sylvan Lake region (1917-2016)



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

CLIMATE PROJECTIONS FOR THE TOWN OF SYLVAN LAKE

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 Town of Sylvan Lake.

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.

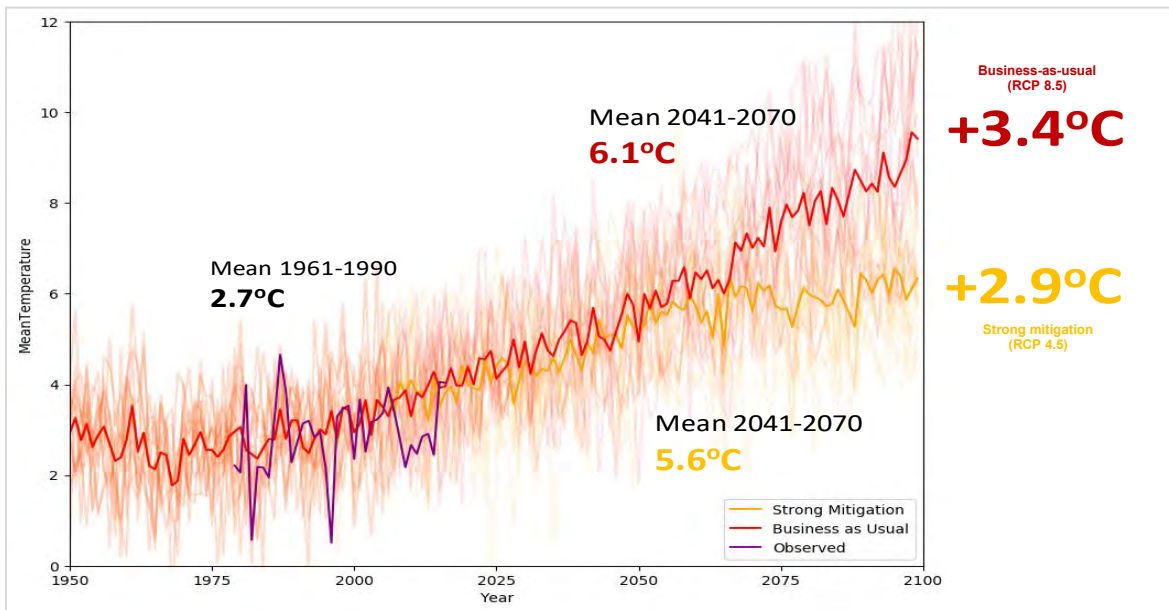
For this assessment, we have considered climate model projections for the Sylvan Lake area under two RCPs: a 'business as usual' scenario (which is formally denoted RCP 8.5) where little additional effort is made to curtail factors contributing to climate change; and a 'strong mitigation' scenario (formally 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 the Town of Sylvan Lake is anticipated to increase by between +2.9°C (yellow line, 'strong mitigation' or RCP 4.5 scenario) and +3.4°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 +5.6°C and +6.1°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 the Sylvan Lake region over the last 50 years.

Figure 6: Projected mean annual temperature for the Town of Sylvan Lake



Projected increases in mean winter temperature are +3.4°C and +3.6°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 +2.8°C and +3.9°C 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 6% to 9% 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 7: Projected mean winter temperature for the Town of Sylvan Lake

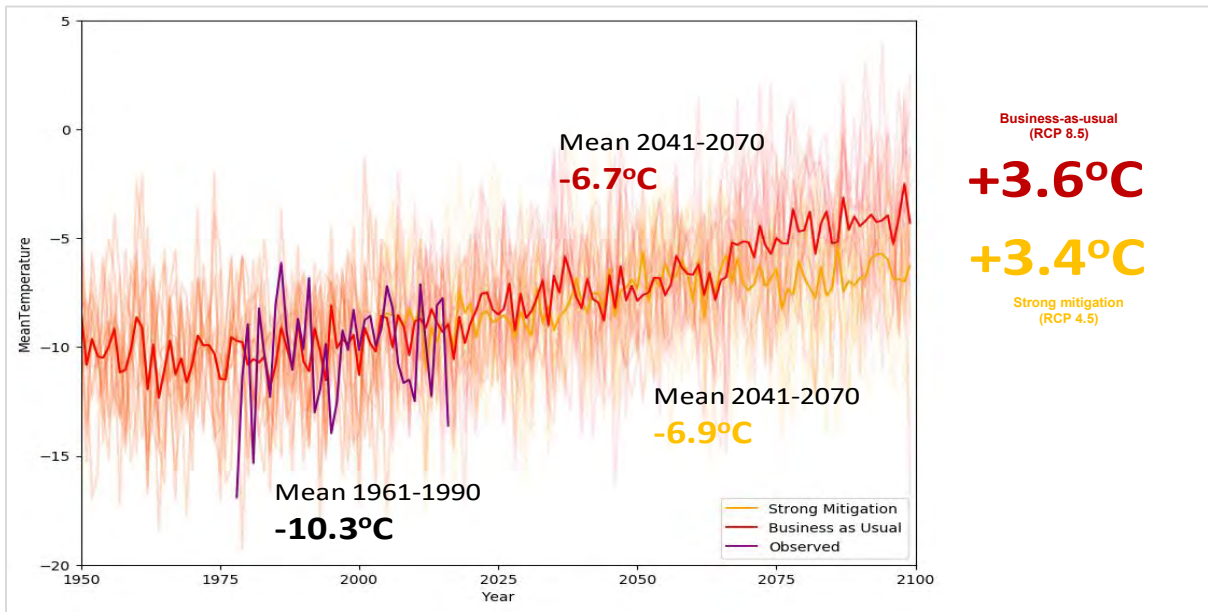


Figure 8: Projected mean summer temperature for the Town of Sylvan Lake

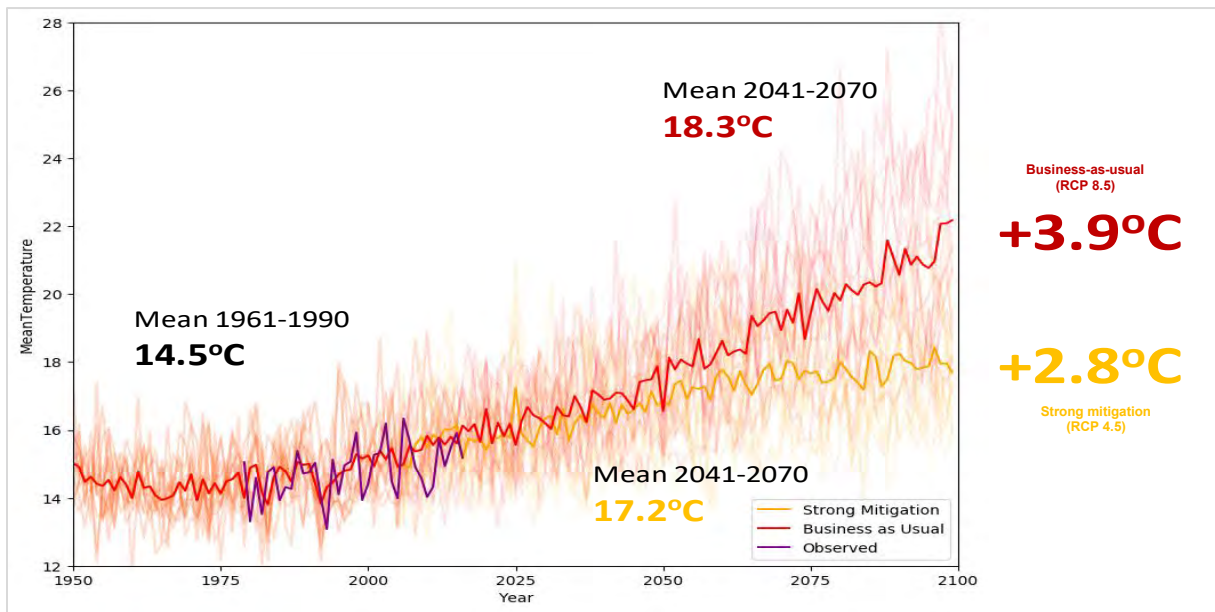


Figure 9: Projected mean annual precipitation for the Town of Sylvan Lake

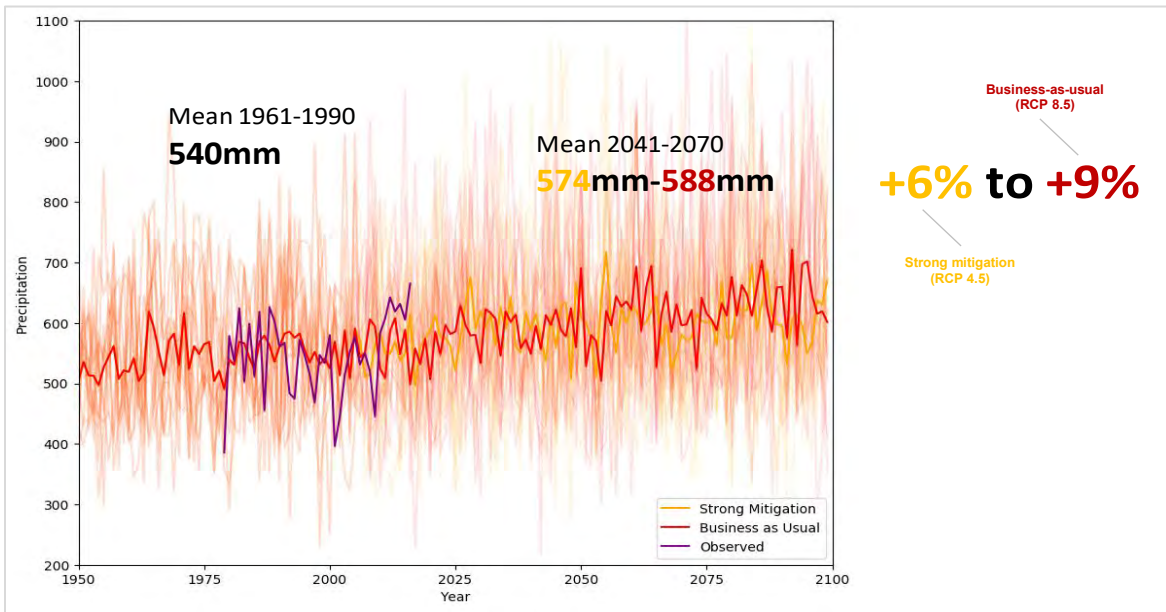


Figure 10: Projected mean winter precipitation for the Town of Sylvan Lake

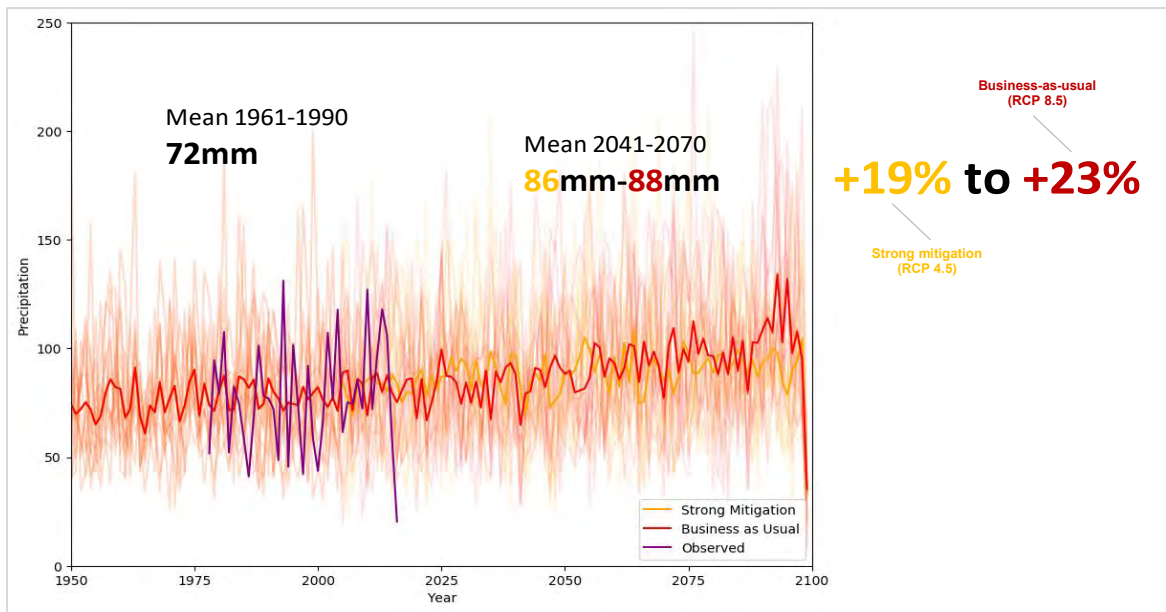


Figure 11: Projected mean summer precipitation for the Town of Sylvan Lake

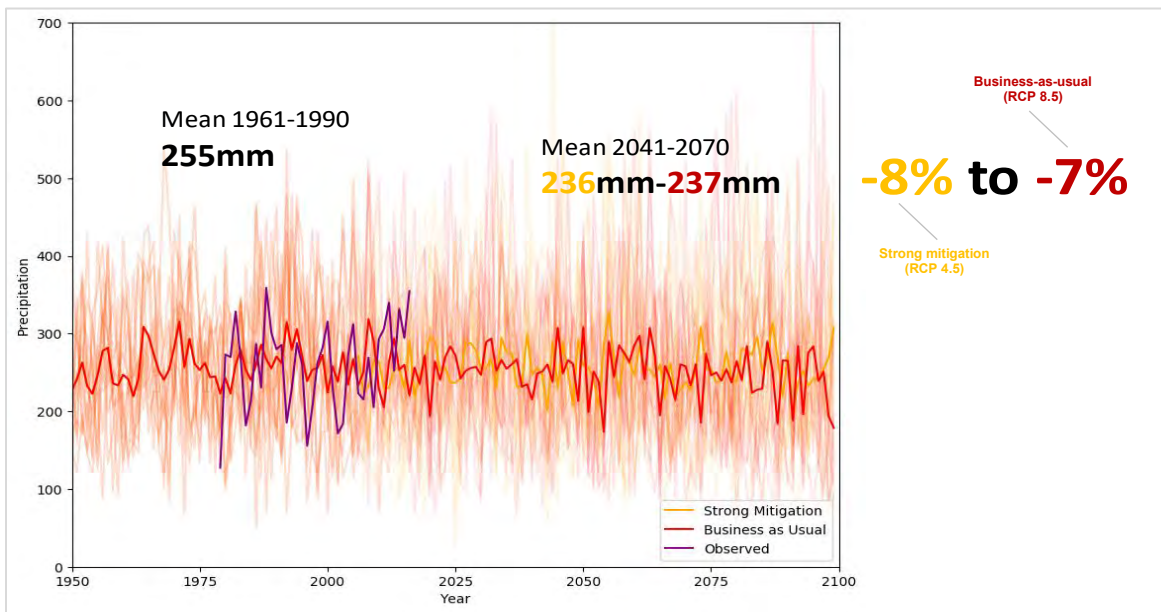


Table 1 presents a summary of projected climate changes for the Town of Sylvan Lake by the 2050s.

Table 1: Summary of projected climate changes for the Town of Sylvan Lake

Climate variable	Season ^v	Baseline value (1961-1990)	Strong mitigation scenario (RCP4.5)		Business-as-usual scenario (RCP8.5)	
			Change (+/-)	Absolute value	Change (+/-)	Absolute value
Temperature (°C)	Annual	+2.7	+2.9	+5.6	+3.4	+6.1
	Winter	-10.3	+3.4	-6.9	+3.6	-6.7
	Spring	+3.1	+3.0	+6.1	+3.1	+6.2
	Summer	+14.5	+2.8	+17.2	+3.9	+18.3
	Fall	+3.3	+2.3	+5.5	+3.6	+6.8
Precipitation (mm)	Annual	540	+6%	574	+9%	588
	Winter	72	+19%	86	+23%	88
	Spring	107	+26%	135	+38%	148
	Summer	255	-8%	236	-7%	237
	Fall	90	+11%	100	+10%	99

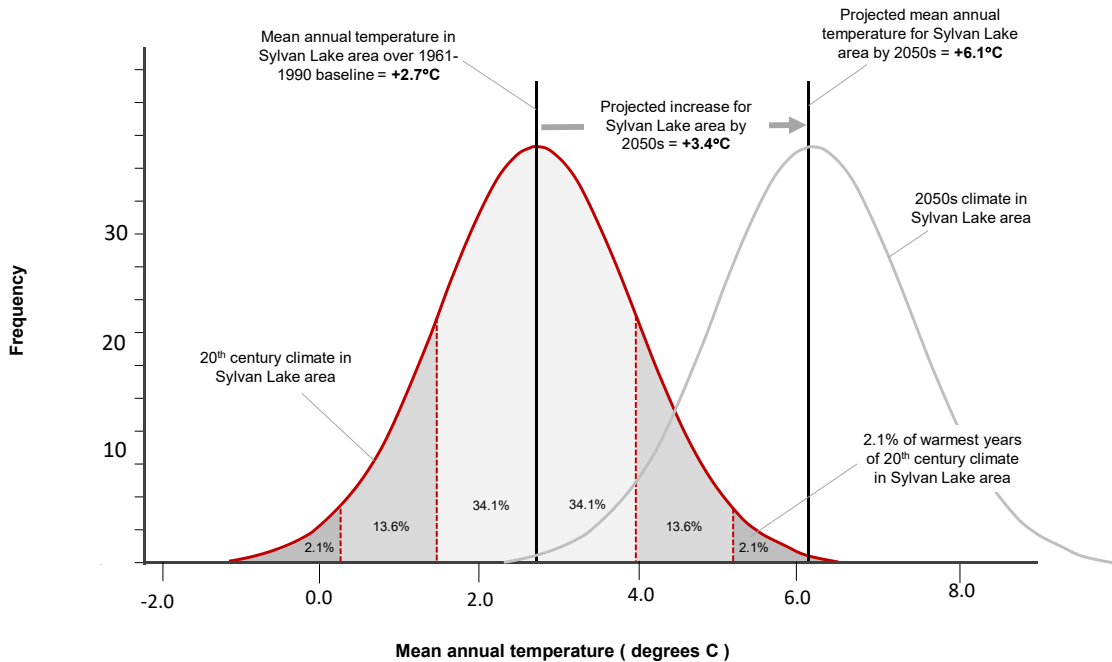
➔ Precipitation extremes

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^{vi}. 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^{vii}. Consequently, it is very likely that the Sylvan Lake region 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

To place the magnitude of the projected temperature changes by the 2050s into context, the 20th century climate in the Sylvan Lake region (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 +3.4°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 the Town of Sylvan Lake will be like the warmest 1-2% of 20th century climate.

Although a change in mean annual temperature of +3.4°C may not appear to be a large absolute shift in climate, when compared with the probability distribution of 20th century climate, a shift of this magnitude is substantial. By analogy, the projected change in mean annual temperature will replace the climate of the Sylvan Lake region with the historical climate (1961-1990) of Lethbridge, Alberta.



PROJECTED ENVIRONMENTAL CHANGES

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

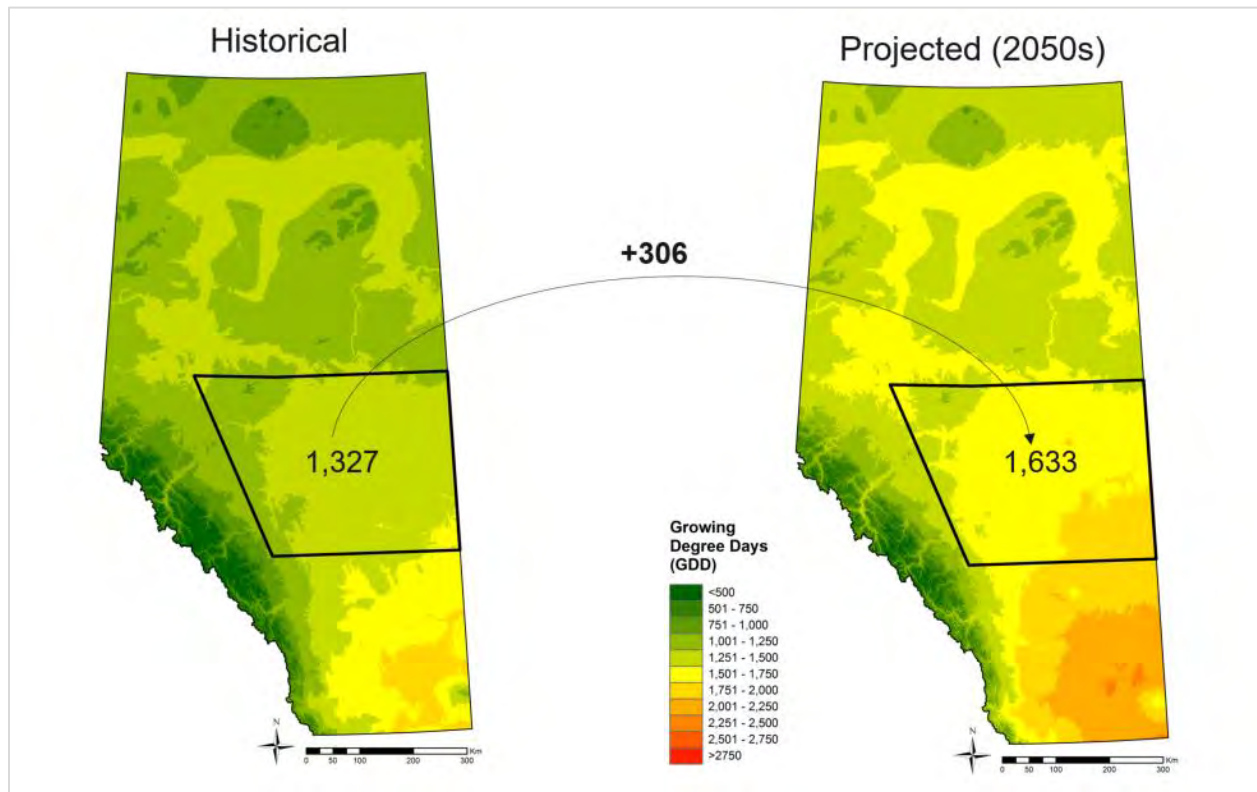
➔ Available moisture and growing season

Although mean annual precipitation is projected to increase in the Sylvan Lake region 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 the Sylvan Lake region. By the 2050s, the region 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 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 the Sylvan Lake region may be greater than the potential negative impacts of the projected reduction in available moisture^{xii}.

Figure 12: (A) Historic (1961-1990) and (B) projected distribution of Growing Degree Days in Sylvan Lake region 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 Sylvan Lake 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^{xiv}.

The warmer and drier conditions projected for the Sylvan Lake region will have consequences for these regional ecosystems. The projected climate for the 2050s will be more favourable for Mixed Grassland and Central Parkland ecosystems, and less favourable for Dry Mixedwood Forest ecosystems (as shown in Figure 13)^{xv}. 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^{xvi,xvii}. The changes in regional ecosystems will also have consequences for the diversity of species that reside in the natural areas in and around the Town of Sylvan Lake.

➔ **Wildfire**

The warmer and drier climate projected for the Sylvan Lake region 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}.

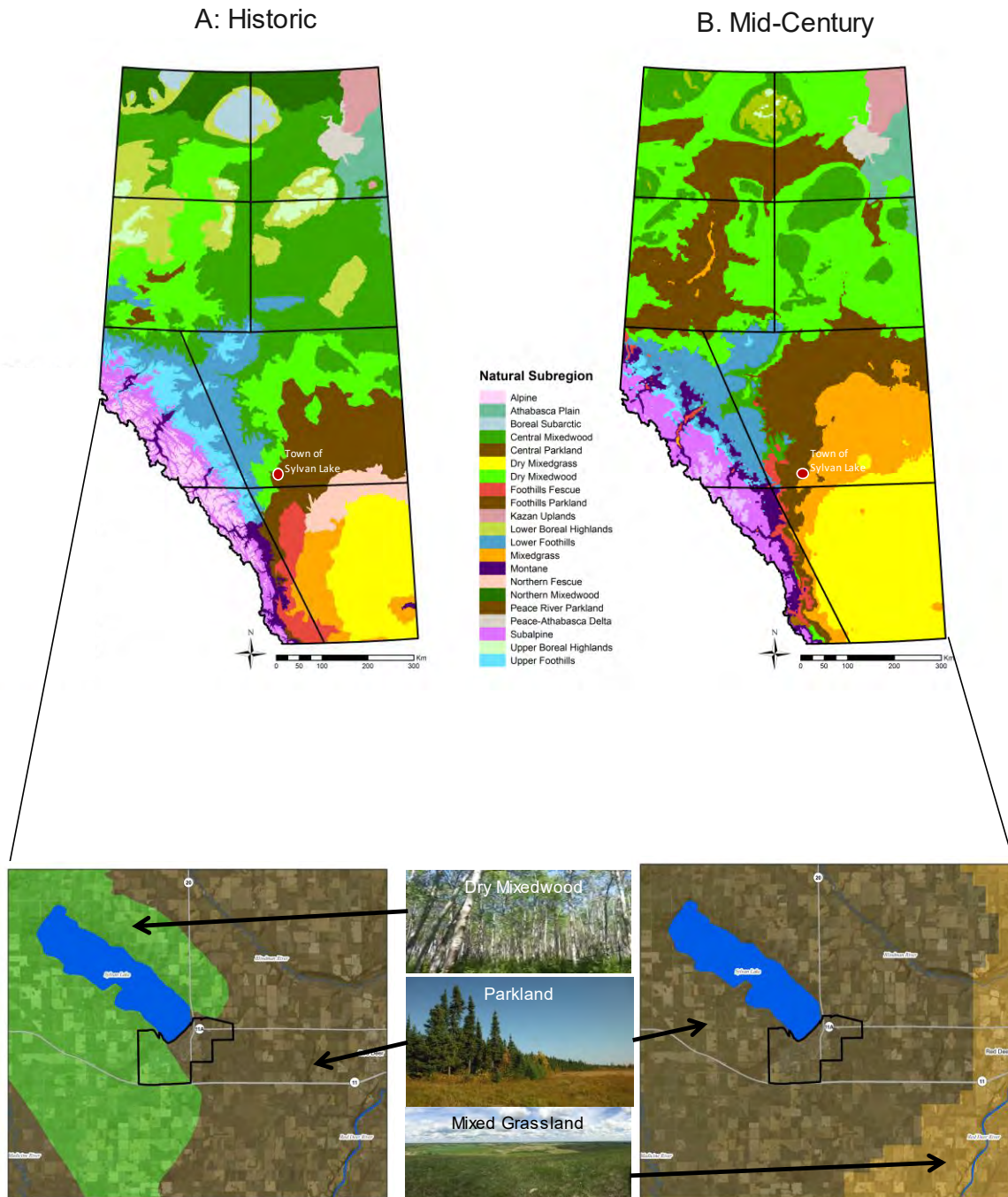
➔ **Streamflow**

Streamflow and rivers in Alberta depend 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 nearby rivers^{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 Sylvan Lake 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 the Sylvan Lake region^{xxvi}



4. CLIMATE RISKS AND OPPORTUNITIES FOR THE TOWN OF SYLVAN LAKE

Session 3 at the workshop invited participants to:

1. Identify how projected climate or environmental changes for the 2050s could impact the Town of Sylvan Lake; 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 the Town of Sylvan Lake

• Increased summer tourism (-)	• Wildfire (-)
• Increased water temperature (-)	• Heat stress on people (-)
• Increased space cooling (-)	• Heat-related illness and disease (-)
• Reduced water availability (-)	• Wind storm (-)
• Decreased winter tourism (-)	• Ice storm / freezing rain (-)
• Increased pests and diseases (-)	• Reduced air quality (-)
• Overland flooding (-)	• Increased summer tourism (+)
• Shoreline erosion (-)	• Increased winter tourism (+)
• Wildlife / habitat stress (-)	• Reduced snow maintenance costs (+)

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 of Sylvan Lake 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 the Town.

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 the Town of Sylvan Lake. 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 the Town of Sylvan Lake by the 2050s

Potential local risks		Key consequences for Town of Sylvan Lake
Label for risk map	Description	
“Heat stress”	Increased stress on vulnerable populations from extreme heat	<ul style="list-style-type: none"> • Potential impacts on human health – stress, fatalities • Increased demand on local health services • Increased costs for infrastructure (sun shelters, water fountains, etc.)
“Wind storm”	Damaging wind storms caused by an increase in the intensity of summer storms	<ul style="list-style-type: none"> • Damage to property and infrastructure, repair costs • Potential power outages – health and safety concerns
“Water availability”	Reduced water availability, and potential inability to meet demand, due to warmer temperatures and reduced summer precipitation	<ul style="list-style-type: none"> • Economic impacts from loss of tourism (if Lake levels reduced) • Increased water conservation practices • Reduced lake levels • Increased irrigation costs • Negative impacts to trees and vegetation
“Wildlife / habitat stress”	Increased stress on local wildlife and habitat from hotter drier climate	<ul style="list-style-type: none"> • Decrease in natural spaces (treed areas) • Loss of biodiversity and ecosystem services
“Flooding”	Increased overland flooding risk, and excessive moisture, caused by extreme precipitation events	<ul style="list-style-type: none"> • Potential liability issues and claims • Increased capital and operating costs for stormwater management • Increased insurance costs for home owners • Flooding of basements and damage to homes, property and buildings • Increased runoff and contamination into Sylvan Lake – higher nutrient content in water, increased plant algae, and reduced oxygen • Potential impacts on human health • Potential flooding of roads and highway, transportation disruption
“Fire”	Increased wildfire risk due caused by increased summer temperatures and extreme heat, and less precipitation in summer	<ul style="list-style-type: none"> • Increased fire mitigation costs for the Town and residents • Damage to property and infrastructure • Damage to crops and agricultural products
“Ice storm”	Damaging freeze rain / ice storm caused by an increase in winter, spring and fall temperatures and intensity of summer storms	<ul style="list-style-type: none"> • Damage to property and infrastructure, repair costs • Potential power outages – health and safety concerns

Potential local risks		
Label for risk map	Description	Key consequences for Town of Sylvan Lake
“Water temperature”	Increased water temperatures in Sylvan Lake from warmer summer temperatures and decreased precipitation (lower lake levels) in summer	<ul style="list-style-type: none"> • Water quality concerns for people, wildlife and fish • Increased potential for diseases and health risks • Reduced lake-based tourism in winter
“Winter tourism”	Increase in winter tourism from increased temperatures in winter and few cold extremes	<ul style="list-style-type: none"> • Increased crime • Increased noise and traffic • Parking issues • Reduced quality of life for residents • Increased costs for management
“Heat illness”	Increase in heat-related illness and disease caused by increased temperatures	<ul style="list-style-type: none"> • Increased potential for fatalities • Increased demand on local health services
“Space cooling”	Increased space cooling costs from increased summer temperatures and extreme heat	<ul style="list-style-type: none"> • Increased expenses for residents, businesses and the Town • Increased greenhouse gases
“Summer tourism”	Increase in summer tourism from increased summer and shoulder season temperatures	<ul style="list-style-type: none"> • Increased crime • Increased noise and traffic • Parking issues • Reduced quality of life for residents • Overcrowding on land and lake • Reduced water quality • Increased costs for management
“Air quality”	Increase in health impacts associated with poor air quality due to drier conditions, dust, and smoke from wildfires	<ul style="list-style-type: none"> • Increased potential for injuries, fatalities and illnesses • Increased demand on local health services
“Pests”	Increased prevalence of forest pests and diseases as a result of drier conditions, fewer cold extremes	<ul style="list-style-type: none"> • Decrease in natural spaces (treed areas) • Increase wildfire risk
“Shoreline erosion”	Increased shoreline erosion on Sylvan Lake from increased extreme precipitation events	<ul style="list-style-type: none"> • Damage to infrastructure • Damage to riparian areas • Reduction in available beaches, impact of quality of life and tourism • Increased runoff contamination

Figure 14: Risk map for climate change impacts with mainly negative consequences for the Town of Sylvan Lake

CONSEQUENCES	(5) Major				Wind storm	<i>Higher priorities for action</i>
	(4)		Ice storm	Heat stress Fire	Water availability Wildlife / habitat stress Flooding	
	(3) Moderate			Water temperature Space cooling Heat illness Pests Winter tourism Air quality Summer tourism	Shoreline erosion	
	(2)					
	(1) Negligible	<i>Lower priorities for action</i>				
		(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 the Town of Sylvan Lake. 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: Climate change opportunities for the Town of Sylvan Lake by the 2050s

Potential local opportunities		
Label for opportunity map	Description	Key opportunities for the Town of Sylvan Lake
“Winter tourism”	Increased tourism in the winter from milder winter temperatures, and fewer periods of extreme cold	<ul style="list-style-type: none"> Economic benefits for local tourism businesses Quality of life benefits – increased opportunities to be active outdoors
“Summer tourism”	Increase in summer tourism from increased summer and shoulder season temperatures	<ul style="list-style-type: none"> Increased tourism business / investment opportunities Increased parking revenue Increased local amenities (festivals, events, shops, etc.)
“Reduced road maintenance”	Reduction in road maintenance and snow removal costs due to less precipitation falling as snow	<ul style="list-style-type: none"> Costs saving for the Town and residents

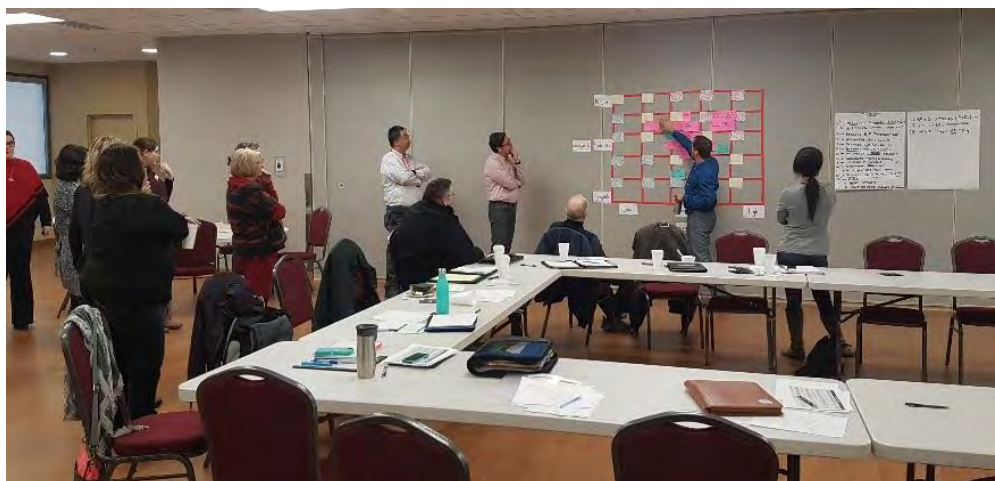


Figure 15: Opportunity map for climate change impacts with mainly positive consequences for the Town of Sylvan Lake

CONSEQUENCES	(5) Major					Higher priorities for action
	(4)					
	(3) Moderate			Increased winter tourism	Increased summer tourism	
	(2)					
	(1) Negligible	Lower priorities for action		Reduced road maintenance		
		(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:

1. Wind storms;
2. Shoreline erosion and wildlife habitat stress;
3. Increased water temperatures and reduced water availability; and
4. Overland flooding.

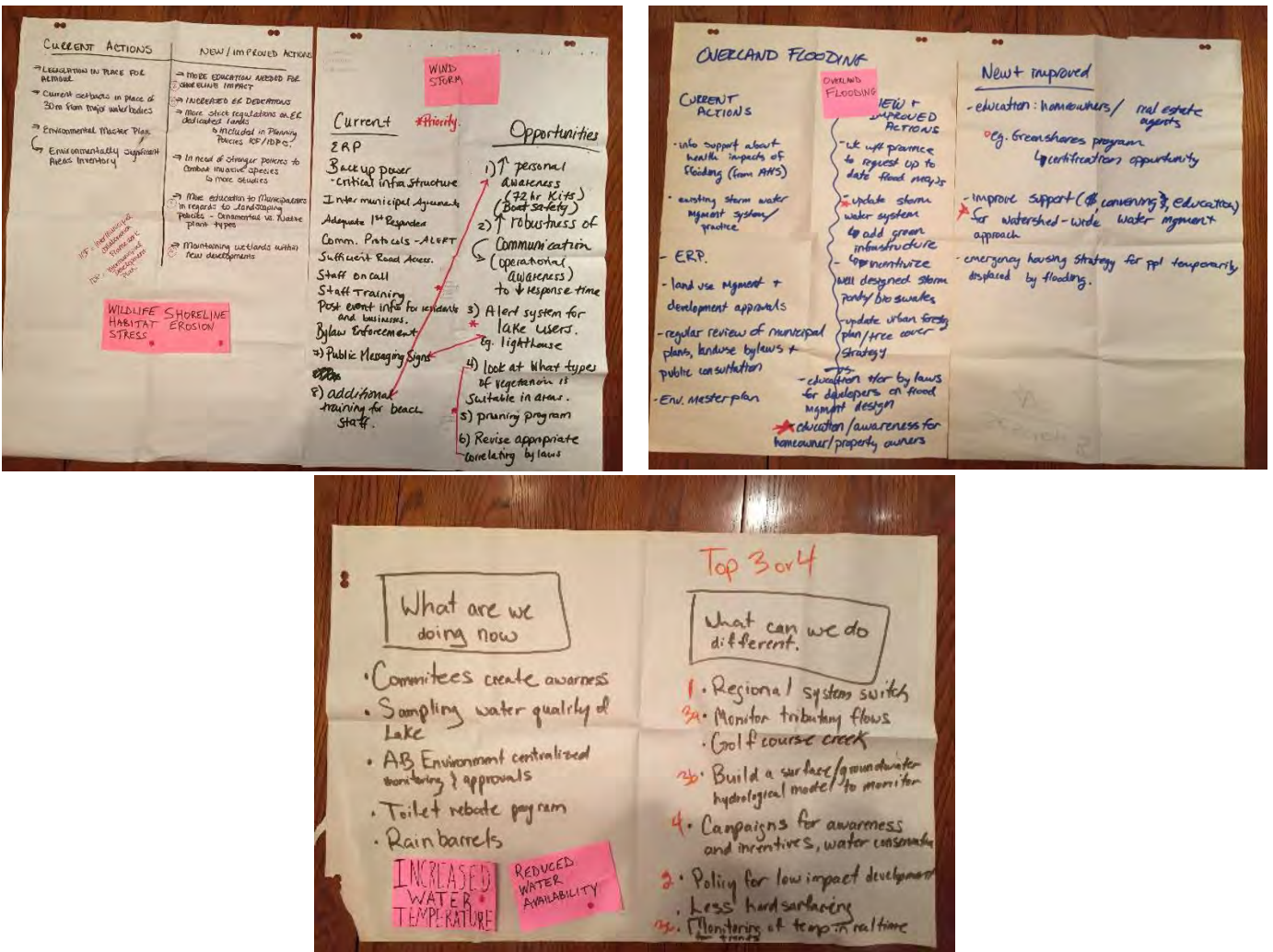
For each of these four priorities, a starter action plan is developed by, first, addressing the following two questions:

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 the Town of Sylvan Lake



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. Table 5 was used to help participants provide approximations for (1) and (2).

Starter action plans for each of the four selected priority risks 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 Sylvan Lake 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:

- Emergency response planning, including intermunicipal agreements, communications protocols, and staff training;
- Land use management, planning, bylaws and development approvals designed to reduce overland flooding and impacts;
- An Environmental Master Plan which includes an inventory of environmentally significant areas;
- Rain barrel and toilet rebate programs to support water conservation;
- Education and lake stewardship, supported by local non-profit groups and committees;
- Water monitoring on Sylvan Lake; and
- Back-up power at critical facilities.

It is important that the Town of Sylvan Lake continue to support the implementation of these important initiatives that will also serve to enhance the Town’s climate resilience.

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	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).

WIND STORM

Action	Cost	Timeframe	Lead
Develop a public alert system for lake users (e.g., the lighthouse)	High	Near-term	Emergency management
Develop a tree and vegetation management initiative, including identification of wind-tolerant trees and a pruning program. Update bylaws accordingly.	Moderate	Ongoing	Parks
Develop an emergency education program to improve awareness of boater safety on Sylvan Lake, and 72-hour emergency kits	Low	Ongoing	Administration

SHORELINE EROSION AND WILDLIFE HABITAT STRESS

Action	Cost	Timeframe	Lead
Improve education for municipalities and residents regarding landscaping policies (e.g. ornamental vs. native plants)	Moderate	Ongoing	Town, County, Summer Villages
Continue with an education program to improve awareness of lake shoreline impacts	Low	Short-term	Town, Province, County, Summer Villages
Dedicate new areas as Environmental Reserve lands, enhance regulations, and include in intermunicipal planning	Low	Medium-term	Town, County, Summer Villages
Develop a wetland management plan to ensure wetland protection and require naturalization of stormwater management ponds	Moderate	Near-term	Town

INCREASED WATER TEMPERATURES AND REDUCED WATER AVAILABILITY

Action	Cost	Timeframe	Lead
Switch to a regional water supply system	Very high	Short-term	Sylvan Lake Regional Water Commission
Develop and implement a policy for low impact development	Low	Ongoing	Planning and Development
Develop a watershed hydrologic model, and continue with a lake monitoring program to monitor tributary flows and temperatures in Sylvan Lake	High	Near-term	Public Works, AB ENV
Develop an education campaign and provide incentives to support water conservation (e.g. require rain barrels in new residential developments)	Moderate	Ongoing	Planning, Communications, Public Works

OVERLAND FLOODING

Action	Cost	Timeframe	Lead
Future upgrades to the stormwater management system should include green infrastructure components (e.g. storm ponds and bioswales)	Very high	Ongoing (short-term for initial planning and start-up)	Town (consultant)
Develop an education campaign / program for property owners to improve awareness of stormwater management issues and best practices for homeowners	Low	Ongoing (short-term for initial planning and start-up)	Town
Provide funding and convening support for watershed management planning	Very high	Ongoing (short-term for initial planning and start-up)	Province, Town, Counties, Summer Villages

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. 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 Town 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 Town’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 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 (e.g., the Municipal Development Plan) and neighborhood scale plans should consider potential future climate change impacts; and

- 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 the Town of Sylvan Lake’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
Steven Probert	Alberta Health Services, operations manager
David Yee	Town of Sylvan Lake Public Works, Project Manager
Rebecca Schapansky	Red Deer County, Planner
Kevin Gannon	Town of Sylvan Lake Environmental Services Manager
Jennifer Berry	County of Lacombe, Environmental Coordinator
Pamela Kutuadu	Alberta Health Services, Public Health Inspector
Koralyn Lemmon	Summer Villages, Development Officer
Chris Lust	Community Advocate/Former Town Councilor
Graeme Strathdee	Sylvan Lake Watershed Society, President
Sandra Babiuk	RC BioSolutions, Senior Terrestrial Ecologist
Kari Tyler	Alberta Transportation. Lead Adaptation Policy Implementation
Betty Osmond	Town of Sylvan Lake Chief Administrative Officer
Bob Shorten	Alberta Environment and Parks
Kim Devlin	Town of Sylvan Lake, Senior Planner
Trina Lamanes	Town of Sylvan Lake, Planner

Appendix B: Scale for scoring the consequences of risks

Score	Description
<p>(1) Negligible</p>	<ul style="list-style-type: none"> • 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
<p>(2)</p>	
<p>(3) Moderate</p>	<ul style="list-style-type: none"> • 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
<p>(4)</p>	
<p>(5) Major</p>	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Increase in income / jobs for a <i>few</i> businesses • Lifestyle improvement for <i>some</i> residents • Cost savings for municipality, businesses or residents
(2)	
(3) Moderate	<ul style="list-style-type: none"> • Increase in income / jobs for a <i>sector</i> • Lifestyle improvement for a <i>select group</i> of residents • Cost savings for municipality, businesses or residents • <i>Short-term</i> boost to reputation and image of municipality
(4)	
(5) Major	<ul style="list-style-type: none"> • Increase in income / jobs for <i>key sectors</i> of local economy • Lifestyle improvement for a <i>majority</i> of residents • Cost savings for municipality, businesses or residents • <i>Long-term</i> boost to reputation of municipality

Appendix D: Scale for the scoring the likelihood of consequences

Score	Descriptor	Interpretation
(1)	Low	<i>Very unlikely</i> - to see that level of consequences
(2)	↑ ↓	<i>Unlikely</i> – to see that level of consequences
(3)	Moderate	<i>Possible</i> – to see that level of consequences
(4)	↑ ↓	<i>Likely</i> – to see that level of consequences
(5)	High	<i>Almost certain</i> – 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 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).
- ^{vi} Westra, S., Alexander, L.V., Zwiers, F., 2013. Global increasing trends in annual maximum daily precipitation. *J Clim* 26(11) 3904–3918.
- ^{vii} Trenberth, K.E., 2011. Changes in precipitation with climate change. *Clim Res.*, 47, 123-138.
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- ^{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.
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- ^{xiii} 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).
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- ^{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/>
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- ^{xxi} Ibid.
- ^{xxii} Ibid.
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- ^{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).
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