City of Spruce Grove

Climate Change Action Plan

Climate Change Vulnerability and Risk Assessment

Technical Report #1

17 December 2021

Prepared for:

City of Spruce Grove

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Table of Contents

Tables:

Figures

1. INTRODUCTION

The City of Spruce Grove (the City) is taking steps to proactively address climate change by developing a comprehensive Climate Change Action Plan (CCAP). The CCAP is a 12-year guiding document that will outline feasible, effective and equitable actions to both reduce greenhouse gas (GHG) emissions and enhance community resilience. The long-term goal is to ensure Spruce Grove remains a resilient, safe and attractive City to live, work and play, and that the City does its part to address global climate change.

This report is one of three technical reports that will inform the design of the CCAP. This report presents the results of the climate change vulnerability and risk assessment (VRA) for the City of Spruce Grove. The goal of the VRA was to determine which climate change impacts pose the greatest risk and opportunity to the City. These risks and opportunities will be prioritized for action in the final design of the CCAP.

2. PREVIOUS CLIMATE CHANGE ACTION PLANNING

The City has a long history of being mindful of its overall sustainability. The 2011 Environmental Sustainability Action Plan, and the 2016 mid-process review report, describe an array of planned actions to improve the sustainability of the city's land use and natural areas, transportation, waste, water, and energy. However, the City has only recently begun to focus explicitly on climate change adaptation.

In 2018, the City participated in the Climate Resilience Express Action Planning process. In this one-day workshop, city staff and local stakeholders conducted an abbreviated climate risks assessment and action planning process. This resulted in the identification of a number of higher-priority risks and related actions that the city could take to reduce its exposure to climate change risks.

3. VULNERABILITY AND RISK ASSESSMENT APPROACH

The VRA process complied with recognized best practices, such as the ISO 14092 Technical Specification: Adaptation to climate change – Requirements and guidance on adaptation planning for local governments and communities. The VRA process included several steps which are summarized below.

3.1 Preparing for the assessment

To provide context, and prepare for the climate change VRA, the following tasks were completed:

3.1.1 Define the scope and assessment assumptions

Prior to completing the climate change VRA, the following scope and assessment assumptions were agreed to:

- **Spatial scope:** In general, the spatial scope was limited to climate-related impacts on assets, services, populations, sectors and activities within the municipal boundaries of the City of Spruce Grove. Based on feedback from city stakeholders, the following exception to the geographic was incorporated:

- Consideration of disruption to the City's drinking water supply as a result of flood damage to the water treatment plant in Edmonton.

- **Operational scope:** The VRA is a community-wide assessment considering impacts to municipal infrastructure, assets and services, as well as impacts to private properties, the local economy, the health and lifestyle of residents, social equity and the natural environment.

- **Climate impact scope**: The assessment identifies climate impacts, and the probability of impacts occurring in the future under a 'business as usual' (high emissions) scenario known as RCP 8.5 (see text box – RCP 8.5).

- **Temporal scope**: The assessment considers impacts arising from projected climate and associated environmental changes predicted during the 30-year time period of 2051-2080, the midpoint of which is the 2060s.

- **Impacts to important City objectives**: The assessment of potential consequences in the VRA focuses on impacts to important City of Spruce Grove objectives. These objectives are outlined in, for example, the Corporate Plan and Municipal Development Plan, and are reflected in the Scale for Rating the Consequences of Risks (Table 1) and Scale for Rating the Consequences of Opportunities (Table 2).

> *RCP 8.5*
>
> The magnitude and rate of change in the climate over the remainder of this century is uncertain and will largely depend on global efforts to reduce emissions of greenhouse gases and to protect and enhance carbon sinks. One way of capturing this uncertainty is through the use of different emission scenarios, known as Representative Concentration Pathways (or "RCPs"). Each RCP is based on different levels of "radiative forcing" by the end of the century. Radiative forcing is a measure of how much energy inflows from the sun and outflows back out into space are out of balance because of different factors, including concentrations of greenhouse gases in the atmosphere. RCP 8.5 (indicating an end-of-century increase in radiative forcing of 8.5 watts per metre squared relative to pre-industrial times) is associated with a future where greenhouse gas emissions continue to increase and is consistent with a predicted mean increase in global temperatures of approximately 3.7°C by 2100 .

- **Existing and planned mitigation measures:** When assessing the consequences of potential climate impact events, consideration was given to existing and planned risk management and mitigation measures. The goal was to identify the incremental impacts of climate change on the City, within the context of existing and planned mitigation measures. That is, we attempted to overlay the Spruce Grove of today with the climate of the 2060s in order to determine impact priorities.

3.1.2 Compile climate change projections

Future climate change projections for Spruce Grove were compiled by the Prairie Climate Centre using data from the Climate Atlas of Canada. In general, using the climate scenario described above, Spruce Grove could expect to see the following changes in climate in the coming decades:

- Average temperatures are projected to increase in all seasons, with mean annual temperature increasing from 3.1°C historically (1976-2005) to 7.3°C in the 2060s (2051-2080).

- The largest seasonal temperature increases are projected for the winter months (December to February), with mean winter temperatures projected to increase from -13.3°C historically to -8.2°C in the 2060s; an increase of 5.1°C.
- Spruce Grove can expect more extreme hot temperatures in the future. The annual number of days that are projected to reach 30°C in the future will become much more common, with an average of 24 days in the 2060s, compared to 3 days historically.
- Mean annual precipitation is projected to increase by 11% by the 2060s, from 465mm historically to 518mm. The largest increases in precipitation are projected for the spring (March, April, May) at 25%.
- An increase in extreme precipitation events and increase in summer storm intensity are also projected.

More detailed climate change projections are provided in Appendix B.

3.1.3 Develop assessment scales

Climate impact assessment scales were developed to guide the assessment of both the *likelihood* and *consequences* of climate impact events. Three assessment scales were developed. Where possible the scales align with the City's current processes, in order to develop an integrated risk management program. The three scales are:

- A scale for measuring *climate risk* impact consequences. This scale captures potential consequences for public health and safety, the economy, environment, infrastructure and service delivery, as well as cultural effects and issues of equity and social justice (Table 1).
- A related scale for measuring the magnitude of potential climate change *opportunities* (Table 2).
- A scale for measuring the *likelihood* of climate impacts, which captures both slow-onset climate changes, as well as acute climate events or hazards (Table 3).

Table 1: Scale for Rating the Consequences of *Risks*

Score	Descriptor	Description
(1)	Very low	• Negligible impact on health & safety and quality of life for residents • Very minimal impact on local economy • Financial loss equal to <1% tax impact ($400,000) • Negligible impact on vulnerable groups (low income, immigrants, older adults, children, vulnerable occupations, persons with disabilities and persons with pre-existing chronic medical conditions) and on existing disparities, inequalities and deprivation • Insignificant environmental disruption or damage • Slight damage to property and infrastructure, very short-term interruption of lifelines, or negligible cost to municipality
(2)	Low	
(3)	Medium	• 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 • Financial loss of between 3% and 5% tax impact ($1.2 - $2 million) • Some vulnerable groups are disproportionately affected, exacerbating existing disparities, inequalities and deprivation • 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
(4)	High	
(5)	Very high	• 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 • Financial loss equal to >7% tax impact ($2.8 million) • Many vulnerable groups are significantly affected resulting in long-term increases in existing disparities, inequalities and deprivation • 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

Table 2: Scale for Rating the Consequences of *Opportunities*

Score	Descriptor	Description
(1)	Very low	• Minimal increase in income / jobs for a few businesses • Minimal lifestyle improvement for some residents, including vulnerable groups • No savings to municipality, businesses or residents
(2)	Low	
(3)	Medium	• Increase in income / jobs for a sector • Lifestyle improvement for a select group of residents, including vulnerable groups • Cost savings to municipality, businesses or residents • Short-term boost to reputation and image of municipality
(4)	High	
(5)	Very high	• Increase in income / jobs for key sectors of local economy • Lifestyle improvement for a majority of residents, including vulnerable groups • Cost savings to municipality, businesses or residents • Long-term boost to reputation of municipality

Table 3: Likelihood Assessment Scale

Likelihood ranking	Description	Annual probability	Return period
Rare (1)	*Likely* to occur once every 50 years or less	≤ 2%	1:50 or less
Unlikely (2)	*Likely* to occur between once every 21 years and once every 50 years	2 to < 5%	1:21 to 1:50
Possible (3)	*Likely* to occur between once every 5 years and once every 20 years	5 to < 20%	1:5 to 1:20
Likely (4)	*Likely* to occur between once every 2 years, and once every 5 years	20 to < 50%	1:2 to 1:5
Almost certain (5)	*Likely* to occur annually or several times per year	≥ 50%	1:1 or more

3.1.4 Identify action planning decision thresholds

The goal of the VRA was to prioritize climate change risks and opportunities, with the understanding that the City has finite resources and capacity and will be unable to address all potential climate change risks and opportunities. Based on the assessment results from the VRA, the likelihood and consequence scores were multiplied together to determine an overall risk (and opportunity) score for each impact event. The decision thresholds in Table 4 were used to determine which risks and opportunities will be further considered in the climate action planning process.

Table 4: VRA risk and opportunity action planning decision thresholds

Label	Risk Score	Decision
High Priority	> 12	Adaptation actions must be developed as part of action planning.
Medium Priority	6 – 12	Adaptation actions should be developed, particularly where low-cost options are available that provide other social, economic or environmental benefits.
Low Priority	< 6	No additional action is required at this time beyond monitoring, and consideration as part of regular reviews.

3.1.5 Public input on climate change risks and vulnerabilities.

Public input on climate change risks and vulnerabilities was obtained through an online workshop on May 27, 2021, and a public survey that ran from May 18 to June 8, 2021. The survey received 86 responses.

A range of opinions were noted by workshop attendees. Most attendees wanted the city to take strong action relating to climate change, and to help residents take actions in their own lives. A few individuals expressed reservations about climate science, but still supported energy efficiency and protection of local agricultural land and natural areas.

Almost half of survey respondents think that climate change will affect them personally (45%) and other residents of spruce Grove (43%) either substantially or enormously. Twenty-one percent of respondents thought climate change would not affect them or residents of Spruce Grove at all. Slightly more than half (58%) of respondents were concerned or very concerned about anticipated climate changes in Spruce Grove, while 10% were unsure, and 32% were either unconcerned of very unconcerned.

Of the potential impacts of climate changes in Spruce Grove, survey respondents were the most concerned about water use and water supply as well as the impacts of more extreme weather events, such as hail and wind (for both, 69% concerned or very concerned). However, even the projected climate change with the lowest reported levels of concern, increased precipitation and flooding, was concerning or very concerning to 59% of respondents.

The top three services that residents predicted that climate change could locally affect (very or somewhat negatively affected) were agriculture and food security (68%), the natural environment (70%), and the local water supply (68%).

Most respondents (80%) were not aware of any existing climate change preparations currently being made within the city. For respondents who were concerned about climate change, suggested actions for the city to take included improving the water and sewer system, the promotion of electric vehicles, solar panels, green energy infrastructure, net zero buildings, resilient buildings and drought resistant landscaping, education and communication efforts by the city, and actions that made economic sense.

Most survey respondents (64%) were 25-44 years old, female (65%), and had an annual household income above $100,000. No statistically significant differences were observed in 'level of concern' regarding any of the predicted climate projections for Spruce Grove based on age or income. A statistically significant different was observed between men and women, with women reporting higher average levels of concern (2.4 on a scale where 1= very concerned and 5 = very unconcerned) than men (average value of 3.1) ($p=0.04$).

A detailed summary of public results is available in Appendix D.

3.2 Risk and opportunity assessment

3.2.1 Identify climate impact events

To complete the VRA, locally significant climate change impact events were identified which could result in impacts to City objectives, for example: injuries or loss of life, damage to homes and infrastructure, services disruption, economic impacts, and/or environmental damage. For each impact event, it was necessary to articulate a plausible scenario to consider in the risk assessment. The scenario defines one possible permutation of a climate change impact event and is defined by determining a threshold or proxy indicator which forms the basis of the likelihood and consequence scores in the risk and opportunity assessment. Detailed climate impact event descriptions are provided in Appendix A.

Impact events were identified initially based on a review the City of Spruce Grove's Climate Resilience Action Plan, climate adaptation strategies from other similar communities, local plans and policies, and regional climate change-related research. A preliminary list of impact events was reviewed with City Staff at a meeting on June 1, 2021. The list of events was updated based on staff feedback and provided to participants in advance of the risk and opportunity assessment workshop on June 21, 2021. Feedback at the workshop led to additional revisions to the list of impact events. In total, 20 climate change impact events with negative consequences, and four impacts with positive consequences were identified for the assessment.

3.2.2 Determine impact event likelihoods

The annual probability of each climate impact event was assessed in terms of its likelihood of occurring historically, where data was available, and in the future. Annual probability estimates were then translated onto the Likelihood Assessment Scale (Table 3) to determine the likelihood score. Three different methods were used to determine the likelihood of climate impact events occurring in Spruce Grove in the future:

1) **Analysis of frequency distribution**: Data on climate impact events was downloaded from the Climate Atlas of Canada, from which it was possible to approximate the likelihood by using the equation for the 'best fit' trend line of a graph of the cumulative probability of the likelihood of the defined threshold or intensity level happening for that time period.
2) **Research from other assessments or studies**: Existing assessments or research studies containing relevant likelihood estimates, or data from which estimates could be generated or extrapolated.
3) **Known return intervals**: Climate impact events which are associated with a known return interval, both historically and in the future, such as a 1-in-100 year 24-hour rainfall event.

Table 5 provides a summary of the method used to determine the likelihood score for each climate impact event, as well as a summary of the results of the likelihood assessment. Appendix A provides the full details of each climate impact event, including the calculations of annual probability.

Table 5: Likelihood assessment method for climate impact events in the VRA

Climate impact	Description	Likelihood Assessment Value
	Risks	
Drought	Palmer Drought Severity Index (PDSI) value of -2 or below	2
Freezing Rain	A freezing rain event	2
Heat wave	Three consecutive days of temperatures above +30°C	1
Hailstorm	A hailstorm with 45 mm diameter or greater hailstones	2
Water supply shortage	North Saskatchewan River flow rate of 25 m3 per second	2
High winds	A windstorm with gusts of greater than 110km per hour	2
Increased water demand	Mean maximum summer temperature of 26.2°C	1
Invasive tree species	The coldest minimum temperature in a year does not drop below -30°C	1
Reduced winter recreation	Less than or equal to 88 winter days in any given year	1
Lightning	One year with greater than 60 hours of lightning activity	2
Increased space cooling	Cooling Degree Days greater than or equal to 282 in a year	1
Wildfire smoke	One year with greater than 9 days (216 hours) of wildfire smoke	1
Freeze-thaw cycles	68 freeze-thaw cycles in any given year	1
Ground level ozone	Mean maximum summer temperature of 26.2°C or higher	1
Urban flooding	One day (24-hours) with 114mm of rainfall	3
Heavy snowfall	Snow accumulation of at least 50cm	2
Cold stress	One very cold day with temperatures -30°C or less	1
Tornado	An EF3+ tornado	2

Climate impact	Description	Likelihood Assessment Value
River flooding	North Saskatchewan River flow rate of 5,800 m3 per second	2
Wildland fire	Wildfire penetrates the municipal boundary causing damage	2
Opportunities		
Increased summer recreation season	Frost-Free Season equal to or greater than 168 days (5.5 months) in length	1
Reduced space heating demand	Heating Degree Days (HDDs) in any given year being less than or equal to 4171	1
Longer construction season	Frost-Free Season equal to or greater than 168 days (5.5 months) in length	1
Increased agricultural productivity	Annual Corn Heat Units (CHU) of greater than or equal to 2400	1

3.2.3 Consequence assessment

To complete the risk and opportunity assessment and determine the potential consequences of each climate impact event on Spruce Grove, a workshop was held virtually with City staff and stakeholders on June 21, 2021. A list of workshop attendees is provided in Appendix C. The workshop participants reviewed each climate impact event in turn and:

- Discussed and expanded on the list of potential consequences of the climate impact event on Spruce Grove, including impacts to public health and safety, the economy, environment, infrastructure, as well as cultural effects and issues of equity and social justice.
- Using the scale for measuring climate impacts with negative consequences (Table 1), assigned an initial consequence score to each climate impact event. Online voting software was used to capture consequences scores real-time. The software records the scores assigned to each impact and allows participants to view the collective results in real time. In cases where an initial vote produced a large variance in scores, participants engaged in a facilitated dialogue to share their expertise and perspectives, and to stimulate deeper analysis of climate change impacts, such as the frequency and severity of historic climate events and their consequences, and the vulnerability (sensitivity) of City activities, assets and services to projected climate stressors. Participants were then encouraged to re-vote in an attempt to reach consensus.

The assessment of climate impacts with positive consequences was completed through a post-workshop with City staff and stakeholders, using the scale in Table 2.

3.2.4 Risk and opportunity evaluation

Following completion of the risk and opportunity assessment, a risk evaluation and verification process was conducted to verify the results. The evaluation process allows stakeholders to review the relative risk/opportunity score of each impact event in relation to one another and make well-reasoned arguments to adjust their location if they are judged to have been either over or under-estimated in comparison to one another.

The risk evaluation was completed through an online survey with City staff and stakeholders. The following impact statements were modified through the evaluation process:

1. The consequences of **wildfire smoke** were under-estimated at the workshop. The consequence score was changed from 'Medium' (3) to 'High' (4)
2. The likelihood of **wildfire smoke** was under-estimated at the workshop. The likelihood score was changed from 'Rare' (1) to 'Unlikely' (2)
3. The consequences of **invasive species** were over-estimated at the workshop. The consequence score was changed from 'Medium' (3) to 'Low' (2)
4. The consequences of **reduced space heating demand** were over-estimated through the post-workshop survey. The consequence score was changed from 'Medium' (3) to 'Low' (2).
5. The consequences of **agricultural productivity** were over-estimated through the post-workshop survey. The consequence score was changed from 'Medium' (3) to 'Low' (2)

4. RISK AND OPPORTUNITY ASSESSMENT RESULTS

Table 6 and Table 7 summarize the results of the VRA for climate impacts with negative consequences (risks) and positive consequences (benefits) respectively. Items colored red were assessed to be high priority, yellow items moderate priority, and green items lower priority. The following information is provided in the summary tables:

- **Climate impact**: the short name for the climate impact event.
- **Description**: a description of the climate impact event definition or threshold, which defines the climate impact scenario used to calculate the likelihood and consequence scores.
- **Likelihood**: the likelihood score as determined using the scale in Table 3.
- **Consequence:** the consequence score as determined by City staff and stakeholders using the approach outlined in Section 2.2.3 and using the scales in Table 1 and Table 2[1].
- **Risk score:** the risk score which was determined by multiplying the likelihood score by the consequence score. Colours indicate the risk level according to the action planning thresholds outlined in Table 4.

Additional details about each climate impact event are provided in Appendix A, including a list of the consequences of climate impacts on Spruce Grove, which informed the assessment.

[1] **Note**: Consequence scores are rounded to the nearest decimal point

Table 6: Summary of scores for climate change impacts with negative consequences

Climate impact	Description	Likelihood	Consequence	Risk Score
Drought	Palmer Drought Severity Index (PDSI) value of -2 or below	5	3.3	16.7
Freezing Rain	A freezing rain event	5	2.8	14.0
Heat wave	Three consecutive days of temperatures above +30°C	5	2.7	13.5
Hailstorm	A hailstorm with 45 mm diameter or greater hailstones	4	3.2	12.8
Water supply shortage	North Saskatchewan River flow rate of 25 m3 per second	3	3.9	11.8
High winds	A windstorm with gusts of greater than 110km per hour	4	2.9	11.5
Increased water demand	Mean maximum summer temperature of 26.2°C	5	2.0	10.0
Invasive tree species	The coldest minimum temperature in a year does not drop below -30°C	5	2.0	10.0
Reduced winter recreation	Less than or equal to 88 winter days in any given year	5	1.8	9.2
Lightning	One year with greater than 60 hours of lightning activity	4	2.3	9.2
Increased space cooling	Cooling Degree Days greater than or equal to 282 in a year	4	2.3	9.1
Wildfire smoke	One year with greater than 9 days (216 hours) of wildfire smoke	2	4.0	8.0
Freeze-thaw cycles	68 freeze-thaw cycles in any given year	4	2.0	8.0
Ground level ozone	Mean maximum summer temperature of 26.2°C or higher	4	2.0	8.0
Urban flooding	One day (24-hours) with 114mm of rainfall	3	2.6	7.9
Heavy snowfall	Snow accumulation of at least 50cm	3	2.3	6.8
Cold stress	One very cold day with temperatures -30°C or less	3	1.7	5.0
Tornado	An EF3+ tornado	1	4.5	4.5
River flooding	North Saskatchewan River flow rate of 5,800 m3 per second	1	4.5	4.5
Wildland fire	Wildfire penetrates the municipal boundary causing damage	1	1.9	1.9

Table 7: Summary of scores for climate change impacts with positive consequences

Climate impact	Description	Likelihood	Consequence	Opportunity Score
Longer construction season	Free Season equal to or greater than 168 days (5.5 months) in length	4	3.8	15.3
Increased summer recreation season	Frost-Free Season equal to or greater than 168 days (5.5 months) in length	4	3.0	12.0
Increased agricultural productivity	Annual Corn Heat Units of greater than or equal to 2400	5	2.0	10.0
Reduced space heating demand	Heating Degree Days in any given year being less than or equal to 4171	4	2.0	8.0

4.1 Priority risks and opportunities for action planning

Table 8 provides a summary of the priority level of each climate impact event according to the action planning decision thresholds. Spruce Grove's Climate Change Action Plan will focus on enhancing resilience to the high and medium priority climate impact events identified in the VRA.

Table 8: Action planning decision thresholds applied to climate impact events

Label	Risk Score	Decision	Climate risks and opportunities
High Priority	> 12	Adaptation actions must be developed as part of action planning.	Drought Heat wave Longer construction season (Benefit) Freezing rain Hailstorm
Medium Priority	6 – 12	Adaptation actions should be developed, particularly where low-cost options are available that provide other social, economic or environmental benefits.	Water supply shortage High winds Increased water demand Invasive tree species Reduced winter recreation Lightning Increased space cooling Wildfire smoke Freeze-thaw cycles Ground level ozone Urban flooding Heavy snowfall Water supply shortage Invasive tree species Reduced winter recreation Increased summer recreation season (Benefit) Increased agricultural productivity (Benefit) Reduced space heating demand (Benefit)
Low Priority	< 6	No additional action is required at this time beyond monitoring, and consideration as part of regular reviews.	Cold stress Tornado River flooding Wildland fire

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APPENDIX A: CLIMATE IMPACT EVENT DESCRIPTIONS

This section provides detailed information about each climate impact event that was assessed in the VRA. In the pages below, for each climate impact event, following information is provided:

Climate driver	*[the projected change in climate that is leading to an impact on Spruce Grove]*
Impact event / scenario	*[a locally significant impact event or scenario, the result of the climate driver]*
Potential consequences	*[the potential consequences of the impact event or scenario for Spruce Grove on: health and safety; local economy; City finances; natural environment, property and infrastructure; and culture, equity and social justice]*
Proxy indicator / threshold	*[the proxy indicator or threshold used for the VRA, to both calculate the likelihood score and inform the assessment of potential consequences]*

Historic value	Near Future (2030s)	Distant future (2060s)
[the historic value, either actual or modelled, for the proxy indicator/ threshold. Or examples of occurrences of historic events in the region]	*[the projected value for the proxy indicator/ threshold to the 2021-2050 time period]*	*[the projected value for the proxy indicator/ threshold to the 2051-2080 time period]*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
[the annual probability of the proxy indicator/ threshold historically]	*[the annual probability of the proxy indicator/ threshold in the 2060s (2051-2080)]*	*[the historic likelihood score as per the Likelihood Scale,* Table 5*)]*	*[the future likelihood score as per the Likelihood Scale*
		Final Consequence Score	*[the final consequence score from the risk workshop]*
		Final Risk Score	*[the final risk score which is the final likelihood score multiplied by the final consequence score]*

Appendix A1. Climate impacts with negative consequences (*risks)*

Heat wave

Projected climate change	Hotter summer temperatures and more extreme heat
Impact event description	Heat wave
Potential consequences	• Injuries and fatalities related to heat exhaustion and heat stroke • Impacts exacerbated for vulnerable populations, including the young, elderly, disabled and long-term sick, as well people experiencing homelessness or living in poor-quality homes. • Increased water demand [see water demand] • Impacts to the power grid (outages)
Proxy indicator / threshold	Three consecutive days of temperatures above +30°C

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
0.4 heat waves per year	*1.3 heat waves per year*	*3.2 heat waves per year*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
8%	*82%*	*3*	*5*
		Final Consequence Score	*2.7*
		Final Risk Score	*13.5*

Data notes:

- Historic and future climate projections from PCC, 2021.

Urban flooding

Projected climate change	Increased extreme precipitation
Impact event description	114 millimetres (mm) of rain in a 24-hour period (1:100-year rainfall event)
Potential consequences	• Flooding 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 • Impacts to water quality (turbidity) – increased water treatment costs
Proxy indicator / threshold	One day (24-hours) with 114mm of rainfall

Historic value	Near Future (2030s)	Distant future (2060s)
32 mm [Maximum 1-day precipitation]	*34 mm [Maximum 1-day precipitation]*	*36 mm [Maximum 1-day precipitation]*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
1%	*5%*	*1*	*3*
		Final Consequence Score	*2.6*
		Final Risk Score	*7.9*

Data notes:

- Historic and future climate projections from PCC, 2021.
- Historic and future annual probability estimates from the Computerized Tool for the Development of Intensity-Duration-Frequency Curves under Climate Change – Version 4.5. Available at: https://www.idf-cc-uwo.ca/

Freezing rain

Projected climate change	Increased average temperatures and precipitation in fall, winter and spring
Impact event description	Precipitation event in which rain freezes on impact to form a coating of clear ice on the ground and on exposed objects
Potential consequences	• Public safety risk of injuries from slips, trips and falls • Road and sidewalk maintenance • Transportation disruption and mobility impacts, particularly for people with disabilities. Vulnerable groups disproportionately affected • Damage to trees • Power outage – disruption to city operations and services
Proxy indicator / threshold	A freezing rain event

Historic value	Near Future (2030s)	Distant future (2060s)
0.4 events per year	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic (Eng et al, 2017)	Future	Historic	Future
40%	*100%*	*4*	*5*
		Final Consequence Score	*2.8*
		Final Risk Score	*14.0*

Data notes:

- Historic annual probability estimate from Eng et al. (2017) with data from Environment and Climate Change Canada (ECCC) for issuance of freezing rain warnings for the City of Edmonton. The ECCC warning criteria is defined as "When freezing rain is expected to pose a hazard to transportation or property, or when freezing rain is expected for at least two hours." (ECCC, 2017).
- Future annual probability estimate from Boyd et al. 2018.
- Data on freezing rain events indicate an increasing trend for parts of Alberta (e.g., Cheng et al., 2011), but no specific estimates of future projections are available for the Spruce Grove area.

Heavy snowfall

Projected climate change	Increased precipitation in winter, and increased heavy rainfall
Impact event description	Snowfall accumulation of 50cm
Potential consequences	• Structural damage to buildings (roof collapse) • Public safety risk of injuries from slips, falls and heart attacks from shoveling • Road and sidewalk maintenance • Transportation disruption • Damage to trees • Damage to electrical or communications systems – disruption to city operations and services
Proxy indicator / threshold	Snow accumulation of at least 50cm

Historic value	Near Future (2030s)	Distant future (2060s)
Between 1960 and 2015, there were an estimated 7 years where snowfall accumulations exceeded 50cm (Eng et al., 2017)	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
13%	*5%*	*3*	*3*
		Final Consequence Score	*2.3*
		Final Risk Score	*6.8*

Data notes:

- Threshold value from Eng. Et al (2017) based on characteristics of snow accumulations which may lead to structural roof overloads and the potential for roof failures or collapses, based on building code snow-roof-load design criteria (Sintra Engineering, 2011).
- Historic annual probability estimate from Eng et al. (2017) with data from the Edmonton International Airport.
- Future annual probability estimate from Boyd et al. 2018.

Hailstorm

Projected climate change	Increased summer storm intensity
Impact event description	Hailstorm producing hail stones of 45 mm (“golf ball” sized hail) or greater in diameter
Potential consequences	• 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
Proxy indicator / threshold	A hailstorm with 45 mm diameter or greater hailstones

Historic value	Near Future (2030s)	Distant future (2060s)
Major hailstorm in 2019 caused more than $4 million in damages	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
25%	*25%*	*4*	*4*
		Final Consequence Score	*3.2*
		Final Risk Score	*12.8*

Data notes:

- Threshold from Eng. Et al (2017) represents a severe hailstorm capable of damaging, deforming or breaking most building cladding and roofing materials (e.g., Marshall et al., 2002), and causing damage to exposed vehicles (e.g., Hohl et al., 2002;).
- Annual probability estimates from Eng et al. (2017) with data from multiple sources, including news media, published literature, and ECCC severe storms logs for events where “golf ball” or larger diameter hail and associated impact damage were confirmed.
- The localized and short duration nature of hailstorms makes it difficult to accurately predict future changes in frequency with meaningful confidence.

High winds

Projected climate change	Increased summer storm intensity
Impact event description	A windstorm with gusts of greater than 110km per hour
Potential consequences	• 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
Proxy indicator / threshold	A windstorm with gusts of greater than 110km per hour

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
Not modelled	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
15%	*38%*	*3*	*4*
		Final Consequence Score	*2.9*
		Final Risk Score	*11.5*

Data notes:

- Threshold from Eng. Et al (2017) based on data from Environment and Climate Change Canada (ECCC) for wind warning criteria
- Annual probability estimates from Eng et al. (2017) with data from nearby weather stations at Namao CFB Edmonton, Edmonton City Centre, and Edmonton International Airport.

Tornado

Projected climate change	Increased summer storm intensity
Impact event description	An EF (Enhanced Fujita) 3+ tornado with wind speeds between 218 to 266 km per hour and potential for "severe damage"
Potential consequences	• 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
Proxy indicator / threshold	An EF3+ tornado

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
Significant tornado events include an EF4 tornado in 1987 (Edmonton), and EF3 in 2000 (Pine Lake)	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
0.3%	*0.3%*	*1*	*1*
		Final Consequence Score	*4.5*
		Final Risk Score	*4.5*

Data notes:

- Annual probability estimates from Eng et al. (2017) with data from Canada's national tornado database and climatology, as described by Cheng et al. (2013).
- No studies exist which could provide guidance on future projected tornado activity in Central Alberta and the Spruce Grove area.

Lighting strikes

Projected climate change	Increased summer storm intensity
Impact event description	Occurrence of lightning strikes within the City with the potential to contact and cause harmful effects to people, infrastructure and the environment.
Potential consequences	• 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
Proxy indicator / threshold	*One year with greater than 60 hours of lightning activity*

Historic value	Near Future (2030s)	Distant future (2060s)
2016 was a record lightning year with 95 hours of lightning activity	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
17%	*22%*	*3*	*4*
		Final Consequence Score	*2.3*
		Final Risk Score	*9.2*

Data notes:

- Threshold value from Eng. Et al (2017) represents a year with very high thunderstorm activity.
- Historical annual probability estimates from Eng et al. (2017) with data from Edmonton International Airport
- Future annual probability estimate from Boyd et al. 2018.
- The localized and short duration nature of thunderstorms and lightning makes it difficult to accurately predict future changes in frequency with meaningful confidence. There is evidence that increasing temperatures may result in stronger thunderstorms (Diffenbaugh et al., 2013).

Wildland fire

Projected climate change	Reduced summer precipitation, increased summer temperatures
Impact event description	Wildland urban interface fire
Potential consequences	• Power outage and disruption to city operations and services • Damage to property and infrastructure • Loss of recreation assets and opportunities – social impact • Increased costs and municipal resources required
Proxy indicator / threshold	Wildfire penetrates the municipal boundary causing damage to structures or property

Historic value	Near Future (2030s)	Distant future (2060s)
No known historic event causing damage to structure or property. Estimate one event every 10 years impacting wildland areas[2]	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
< 1%	*1.3%*	*1*	*1*
		Final Consequence Score	*1.9*
		Final Risk Score	*1.9*

Data notes:

- Historic annual probability estimate from personal communication with Cory Klebanosky (Assistant Deputy Fire Chief, City of Spruce Grove).
- Future annual probability based on the 33% increase in occurrence of a large wildfires within 100km of the City of Edmonton estimated in Eng et al. (2017)
- The warmer and drier climate projected for Spruce Grove by the 2060s 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, increasing wildfire smoke in the region (De Groot et al., 2013; Flannigan et al., 2019)

[2] Based on historical occurrence (personal comms with Cory Klebanosky)

Wildfire smoke

Projected climate change	Reduced summer precipitation, increased summer temperatures
Impact event description	Smoke from wildfires
Potential consequences	• Negative health outcomes related to smoke inhalation and poor air quality • Impacts exacerbated for vulnerable populations • Poor air quality at civic facilities, potential disruption of services
Proxy indicator / threshold	One year with greater than 9 days (216 hours) of wildfire smoke from nearby fires

Historic value	Near Future (2030s)	Distant future (2060s)
One year (2018) since 1953 with greater than 216 hours of wildfire smoke	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
2%	*3%*	*1*	*2*
		Final Consequence Score	*4*
		Final Risk Score	*8*

Data notes:

- Historic annual probability based on internal data from Environment and Climate Change Canada - number of smoke hours per year in the Edmonton area (1953-2020).
- Future annual probability estimate from Eng et al. (2017) with data from the Canadian Wildland Fire Information System – National Fire Database (NRCan 2017), based on a 33% increase in wildfire activity in central Alberta.
- The warmer and drier climate projected for Spruce Grove by the 2060s 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, increasing wildfire smoke in the region (De Groot et al., 2013; Flannigan et al., 2019).

Increased space cooling demand

Projected climate change	Increased summer temperatures and extreme heat
Impact event description	Increased demand for space cooling
Potential consequences	• Increased space cooling and building operating costs to municipality • Costs to retrofit and upgrade buildings and facilities • Increased space cooling costs for businesses and residents • Impacts exacerbated for vulnerable populations (low income)
Proxy indicator / threshold	*Cooling Degree Days in any given year being greater than or equal to 282*

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
50 CDDs	*132 CDDs*	*282 CDDs*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
4%	*43%*	*2*	*4*
		Final Consequence Score	*2.3*
		Final Risk Score	*9.1*

Data notes:

- Cooling Degree Days (CDD) are equal to the number of degrees Celsius a given day's mean temperature is above 18 °C. For example, if the daily mean temperature is 21 °C, the CDD value for that day is equal to 3. If the daily mean temperature is below 18 °C, the CDD value for that day is set to zero.
- For context, the historical summer value of cooling degrees in Medicine Hat, Alberta, from 1976-2005, is 200 (Climate Atlas of Canada, 2021)
- Historic and future climate projections from PCC, 2021.

Outbreak of invasive tree species

Projected climate change	Fewer cold days in winter
Impact event description	Invasive tree species outbreak (Emerald Ash Borer)
Potential consequences	• Negative impacts to local trees and forests, including tree death • Increased operational pest management costs and tree management costs • Loss of urban tree canopy, which cannot be immediately replaced
Proxy indicator / threshold	The coldest minimum temperature in any given year does not drop below -30°C

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
-35.4°C	*-31.7°C*	*-27.6°C*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
8%	*65%*	*3*	*5*
		Final Consequence Score	*2*
		Final Risk Score	*10*

Data notes:

- Historic and future climate projections from PCC, 2021.
- Threshold value based on the extreme cold temperature threshold required to kill Emerald Ash Borer larvae. Emerald Ash Borer was an invasive species identified as a potential future concern for the Edmonton Metropolitan Region (Diamond Head Consulting, 2019). Future invasions from this species become more likely if there are fewer very cold days in winter.

Reduced winter recreation

Projected climate change	Warmer winter temperatures
Impact event description	A shorter, more variable season for winter recreation activities that are dependent on cold, snow and ice
Potential consequences	• Increased difficulty in maintaining outdoor ice rinks, leading to increased maintenance costs and/or poorer quality skating conditions • Reduced snow accumulation leads to poorer quality cross country skiing conditions • Impacts exacerbated for vulnerable populations (low income) who cannot participate in organized sports
Proxy indicator / threshold	*Less than or equal to 88 winter days (a day with a minimum temperature less than or equal to -5 °C) in any given year*

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
130 days	*108 days*	*88 days*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
4%	*54%*	*2*	*5*
		Final Consequence Score	*1.8*
		Final Risk Score	*9.2*

Data notes:

- The threshold value (*-5°C*) is based on the optimal conditions for ice skating and Nordic skiing (see Dickau et al., 2020 for an example).
- Historic and future climate projections from PCC, 2021.

Freeze-thaw cycles

Projected climate change	Warmer average temperatures in fall and spring
Impact event description	Temperatures fluctuate above and below freezing
Potential consequences	• Infrastructure damage and associated maintenance costs • Hazardous walking and driving conditions – safety concern
Proxy indicator / threshold	*68 freeze-thaw cycles in any given year*

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
89 cycles	*78 cycles*	*68 cycles*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
92%	*45%*	*5*	*4*
		Final Consequence Score	*2.0*
		Final Risk Score	*8.0*

Data notes:

- Historic and future climate projections from PCC, 2021.

Cold stress in winter

Projected climate change	Warmer winter temperatures, fewer extreme cold days
Impact event description	A very cold day with below -30°C
Potential consequences	• Injuries and fatalities related to cold exposure • Impacts for vulnerable populations, including the young, elderly, disabled and long-term sick, as well people experiencing homelessness or living in poor-quality homes.
Proxy indicator / threshold	One very cold day with temperatures -30°C or less

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
8 days	*4 days*	*1 day*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
40%	*18%*	*4*	*3*
		Final Consequence Score	*1.7*
		Final Risk Score	*5.0*

Data notes:

- Historic and future climate projections from PCC, 2021.
- For context, Lethbridge, Alberta historically (1976-2005) has about 4 very cold days per year, and that is decreasing to 1 (0.7) in the near future (2060s).

Water supply shortage

Projected climate change	Changes to weather conditions both locally and upstream could change water flow patterns in the North Saskatchewan river (e.g., due to reduced snowpack, hotter summer temperatures, etc.).
I Impact event description	Extreme low flow conditions in the North Saskatchewan River endangering water supply
Potential consequences	• At risk water supply, with potential water restrictions • Impacts to aquatic ecosystems • Reduced water quality, increased need for treatment and filtration
Proxy indicator / threshold	North Saskatchewan River flow rate of 25 m^3 per second

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
In the past 100 years there were two times when flow volumes fell below the 25 m^3/s threshold	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
2%	*5%*	*1*	*3*
		Final Consequence Score	*3.9*
		Final Risk Score	*11.8*

Data notes:

- Historic annual probability estimate from Eng et al. (2017) with data from the Water Survey of Canada Hydrometric data for Edmonton (daily discharge).
- Future annual probability estimate from Boyd et al. 2018.
- Threshold based on the flow rate below which the water treatment plant intakes may not be able to reliably and sustainably draw water from the river.
- In response to projected climate changes, the seasonal pattern of river flow will shift. River flows in June to August will be, on average, lower than in the past. As a warming climate amplifies the hydrological cycle, the range of river levels will expand, with larger departures from a shifting baseline of higher winter flows and lower summer flows (Kerr, et al., 2019).

Increased water demand

Projected climate change	Hotter summer temperatures, more extreme heat and drier summer conditions
Impact event description	Increased demand for and consumption of potable water
Potential consequences	• Increased operating costs to municipality • Increased utility costs for businesses and residents
Proxy indicator / threshold	Mean maximum summer temperature of 26.2°C [corresponding to a 22% increase in water use]

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
21.9°C	*24°C*	*26.2°C*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
9%	*81%*	*3*	*5*
		Final Consequence Score	*2.0*
		Final Risk Score	*10.0*

Data notes:

- Threshold value based on a projected increase in potable water demand of 5.2% per degree Celsius increase in mean maximum daily temperature (Water Research Foundation, 2013).
- Historic and future climate projections from PCC, 2021.

Multi-year drought

Projected climate change	Reduced summer precipitation, increased summer temperatures
Impact event description	Two or more consecutive years of anomalously low moisture during the frost-free period
Potential consequences	• Stress on natural systems • Impacts to and loss of local trees and forests • Damage to sporting fields and outdoor facilities • Increased operational costs for the City • Damage to green infrastructure
Proxy indicator / threshold	Palmer Drought Severity Index (PDSI) value of -2 or below

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
1998-2005 drought affected much of western Canada	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
10%	*80%*	*3*	*5*
		Final Consequence Score	*3.3*
		Final Risk Score	*16.7*

Data notes:

- Threshold values based on impacts associated with the 1998-2005 drought that affected much of western Canada. The PDSI incorporates critical drought related factors such as the period of time between precipitation events, as well as the effects of increased temperatures on evapotranspiration (Bonsal et al., 2013). During the drought year of 2002, crop losses alone were in the billions of dollars on the Prairies, with zero farm income in Alberta (Wheaton et al., 2008).
- Historic and future annual probability estimates from Eng et al. (2017) with data from Bonsal et al. (2013)

River flooding

Projected climate change	Increased precipitation in spring, and increased heavy rainfall
Impact event description	Elevated flow conditions in the North Saskatchewan River (NSR) resulting in damage to the Water Treatment Plant in Edmonton
Potential consequences	• Disruption of drinking water supply
Proxy indicator / threshold	North Saskatchewan River flow rate of 5,800 m^3 per second

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
5,800 m^3 per second is the largest volume ever recorded on the NSR at Edmonton during the 1915 flood	*Not modelled*	*Not modelled*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
0.6%	*1.5%*	*1*	*1*
		Final Consequence Score	*4.5*
		Final Risk Score	*4.5*

Data notes:

- Historic annual probability estimate from Eng et al. (2017) with data from the Water Survey of Canada Hydrometric data for Edmonton (daily discharge).
- Future annual probability estimate from Boyd et al. 2018.
- Threshold based on the flow rate above which the water treatment plant at Rossdale in Edmonton would sustain damage and be unable to reliably provide water
- In response to projected climate changes, the seasonal pattern of river flow will shift. River flows in June to August will be, on average, lower than in the past. As a warming climate amplifies the hydrological cycle, the range of river levels will expand, with larger departures from a shifting baseline of higher winter flows and lower summer flows (Kerr, et al., 2019).

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Increased ground level ozone

Projected climate change	Increases in the mean maximum summer temperature
Impact event description	Ground level ozone, an air pollutant, will increase as the mean maximum summer temperature increases
Potential consequences	• Acute and chronic mortality • Increased incidence of acute respiratory symptom days, asthma symptom days, and respiratory emergency room visits
Proxy indicator / threshold	*Changes to the mean maximum summer temperature: Acute and chronic mortality will increase by 3.1 individuals per 100,000 population per degree Celsius increase in average maximum summer temperature.*

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
22.0	*24.0*	*26.2* *Estimated increase in acute and chronic mortality by 13 individuals per 100,000*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
14%	*38%*	*3*	*4*
		Final Consequence Score	*2.0*
		Final Risk Score	*8.0*

Data notes:

- Ozone concentrations are assumed to increase by 2.9 parts per billion volume per degree Celsius increase in daily maximum summer temperature (Boyd et al., 2020).

Appendix A2. Climate impacts with positive consequences (*opportunities)*

Increased summer recreation season

Projected climate change	Warmer weather in spring and fall
Impact event description	Longer recreation season for summer outdoor recreation activities
Potential consequences	• Increased quality of life for residents • Longer tourism season • Increased use of active transportation methods such as bicycles • Increased summer festivals and events
Proxy indicator / threshold	*Frost-Free Season equal to or greater than 168 days (5.5 months) in length*

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
128 days	*149 days*	*168 days*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
1%	*47%*	*1*	*4*
		Final Consequence Score	*3.0*
		Final Risk Score	*12.0*

Data notes:

- The Frost-Free Season is the length of time (number of days) during which there are no freezing temperatures (Climate Atlas of Canada, 2021).
- Historic and future climate projections from PCC, 2021.
- For context, the length of the frost-free season in Lethbridge, Alberta, in the 1976-2005 time period was 133 days.

Reduced space heating demand

Projected climate change	Higher average temperatures in fall, winter, and spring
Impact event description	Reduced demand for indoor space heating
Potential consequences	• Reduced space heating and building operating costs to municipality • Reduced space heating costs for businesses and residents
Proxy indicator / threshold	*Heating Degree Days (HDDs) in any given year being less than or equal to 4171*

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
5473 HDDs	*4791 HDDs*	*4171 HDDs*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
6%	*45%*	*3*	*4*
		Final Consequence Score	*2.0*
		Final Risk Score	*8.0*

Data notes:

- Heating Degree Days (HDD) are equal to the number of degrees Celsius a given day's mean temperature is below 18 °C. For example, if the daily mean temperature is 12 °C, the HDD value for that day is equal to 6 °C. If the daily mean temperature is above 18 °C, the HDD value for that day is set to zero.
- Historic and future climate projections from PCC, 2021.
- For context, the historical summer value of heating degree days in Lethbridge, Alberta, from 1976-2005, was 4574

Longer construction season

Projected climate change	Warmer spring and fall temperatures
Impact event description	Longer construction season
Potential consequences	• Increased efficiency of summer construction projects such as road repairs and underground utility work (more projects complete, more opportunities) • Economic benefits for local businesses
Proxy indicator / threshold	*Frost-Free Season equal to or greater than 168 days (5.5 months) in length*

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
128 days	*149 days*	*168 days*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
1%	*47%*	*1*	*4*
		Final Consequence Score	*3.8*
		Final Risk Score	*15.3*

Data notes:

- The Frost-Free Season is the length of time (number of days) during which there are no freezing temperatures (Climate Atlas of Canada, 2021).
- Historic and future climate projections from PCC, 2021.
- For context, the length of the frost-free season in Lethbridge, Alberta, in the 1976-2005 time period was 133 days.

Increased agricultural productivity

Projected climate change	Warmer spring, summer and fall temperatures
Impact event description	Warmer growing season for plants and crops
Potential consequences	• Increased economic benefits for local agriculture (increased yield potential and crop varieties) • Increased quality of life for local residents (increased yield potential and crop varieties)
Proxy indicator / threshold	*Annual Corn Heat Units (CHU) of greater than or equal to 2400*

Historic value (1976-2005)	Near Future (2030s)	Distant future (2060s)
2127 CHU	*2673 CHU*	*3252 CHU*

Annual probability		Likelihood score	
Historic	Future	Historic	Future
15%	*99%*	*3*	*5*
		Final Consequence Score	*2.0*
		Final Risk Score	*10.0*

Data notes:

- Historic and future climate projections from PCC, 2021.
- Corn Heat Units are an agricultural metric that takes account of both temperatures that are too cold (less than 10 degrees C during the day) and too hot (more than 30 degrees C during the day) to grow corn. Due to this 'double bounded' effect, it is a useful way to explore the overall potential change in agricultural productivity in the future.
- Threshold value based on the number of Corn Heat Units (2400) required for corn to reach maturity (Alberta Agriculture, 2014).
- Note: The benefits of warmer average temperatures could be offset by dry conditions and/or insufficient access to water

Appendix A3. Climate Impacts Reference List

Alberta Agriculture and Rural Development. 2014. The Potential for Grain Corn in Alberta.

Bonsal, B. R., Aider, R., Gachon, P., & Lapp, S. 2013. An assessment of Canadian prairie drought: Past, present, and future. Climate Dynamics, 41(2), 501–516. Available at: http://doi.org/10.1007/s00382-012-1422-0

Boyd, R., Eyzaguirre, J., Poulsen, F., Siegle, M., Thompson, A., Yamamoto, S., Osornio-Vargas, Erickson, A., and Urcelay, A. (2020). Costing Climate Change Impacts on Human Health Across Canada. Prepared by ESSA Technologies Ltd. For the Canadian Institute for Climate Choices

Boyd, R., Zukiwsky, J., Tang, J., and Butler, L. 2018. Climate Change Vulnerability and Risk Assessment for City of Edmonton.

Cheng, C., Li, G., and Auld, H. 2011. Possible Impacts of Climate Change on Freezing Rain Using Downscaled Future Climate Scenarios: Updated for Eastern Canada. Atmosphere-Ocean 49(1): 8-21.

Cheng, V., Arhonditsis, G., Sills, D., Auld, H., Shephard, M., Gough, W., and Klaassen, J. 2013. Probability of Tornado Occurrence across Canada. Journal of Climate 26(23): 9415-9428.

Climate Atlas of Canada. 2021. Available at: www.climateatlas.ca

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.

Dickau, M., Matthews, D., Guertin, E., and Seto, D. 2020. Projections of declining outdoor skating availability in Montreal due to global warming.

Diffenbaugh, N., Scherer, M., and Trapp, R. 2013. Robust increases in severe thunderstorm environments in response to greenhouse forcing. PNAS, October 8, 2013, vol. 110, no. 41, p.16361–16366.

Diamond Head Consulting, 2019, Invasive Species and Pest Vulnerability Study – Edmonton Metropolitan Region. Consultant Report prepared for All One Sky Foundation, Calgary AB

Eng, S., Shippee, N., Switzman, H., Auld, H., and Comer, N. et al. 2017. Projected Future Climate Hazards and Impacts – Research and Primer (City of Edmonton).

Environment and Climate Change Canada (ECCC). 2021. Criteria for Public Weather Alerts. Available at: https://www.canada.ca/en/environment-climate-change/services/types-weather-forecasts-use/public/criteria-alerts.html#freezingRain.

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

Hohl, R, Schiesser, H., and Knepper, I. 2002. The use of weather radars to estimate hail damage to automobiles: an exploratory study in Switzerland. Atmospheric Research, Vol. 61, p. 215–238.

Kerr, S., Andreichuk, Y., Bedoya, M., and Sauchyn, D. (2019) The impact of climate change on water security in the Edmonton Metropolitan Region: A meta-analysis of existing knowledge and information

Marshall, Timothy P., Richard F. Herzog, Scott J. Morrison, and Steven R. Smith. 2002. Hail Damage Threshold Sizes for Common Roofing Materials. 21st Conf. on Severe Local Storms, San Antonio, TX, 3.2, 4 pp

Natural Resources Canada (NRCan). 2017.Canadian Wildland Fire Information System – Datamart. National Fire Database. Available at: http://cwfis.cfs.nrcan.gc.ca/datamart/metadata/nfdbpoly

Natural Resources Canada: emerald ash borer fact sheet (n.d.) Available at: https://www.nrcan.gc.ca/forests/fire-insects-disturbances/top-insects/13395

Prairie Climate Centre (PCC). 2021. Summary of downscaled climate projections for the City of Spruce Grove.

Sintra Engineering. 2011. "Snow Covered Roofs Collapse." Spring 2011 Newsletter.

Water Research Foundation. 2013. Changes in Water Use Under Regional Climate Change Scenarios. Available at: https://www.waterrf.org/system/files/resource/2019-05/4263_1.pdf

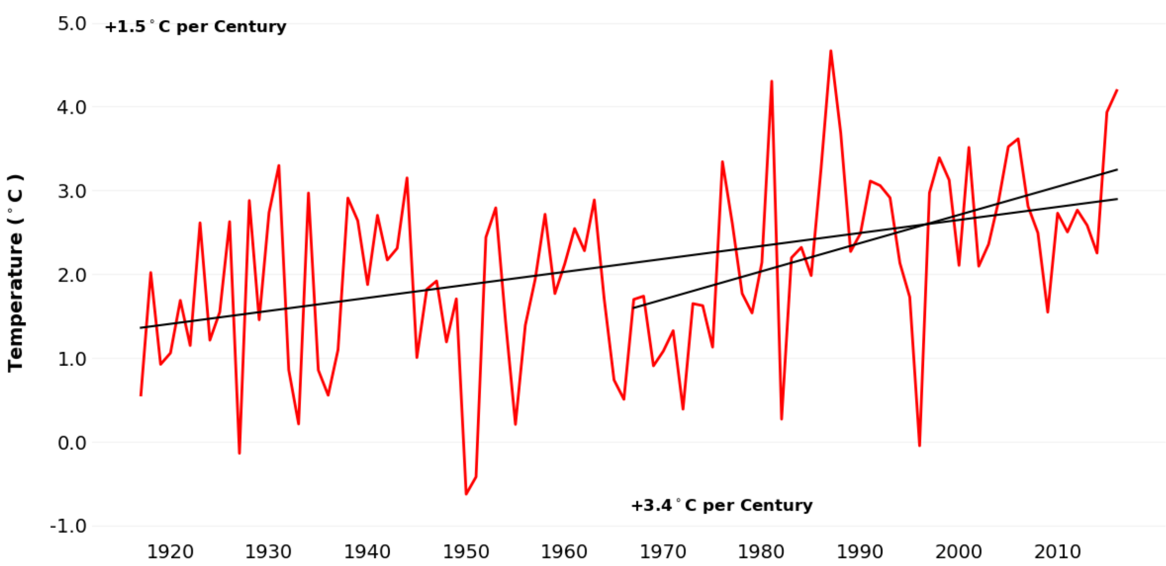
Wheaton, E., Kulshreshtha, S., Wittrock, V., and Koshida, G. (2008). Dry times: hard lessons from the Canadian drought of 2001 and 2002. The Canadian Geographer 52(2), 242–262.

APPENDIX B: CLIMATE CHANGE PROJECTIONS FOR SPRUCE GROVE

Appendix B1: Historic climate record

Temperature records from the Spruce Grove area show increasing trends in both precipitation and temperature. Mean annual temperature over the past century (1917-2016) has increased at a rate of +1.5°C per century, and the rate of warming observed over the last 50 years is higher still at +3.4°C per century (Figure 1). 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, and 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.

Figure 1: Mean annual temperature in Spruce Grove area (1917-2016)



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.

Appendix B2: Future climate projections

Table 9 below provides a summary of variables and indicators important for understanding how the climate will change in Spruce Grove in the future[3]. The table shows 30-year averages for the baseline period (1976-2005), the near future (2021-2050) and the distant future (2051-2080) under a high emissions scenario (RCP 8.5), as described in Section 3.1.2 . Definitions of all climate variables are provided on the following page.

[3] Climate projections for Spruce Grove compiled by the Prairie Climate Centre, using data from the Climate Atlas of Canada

Table 9: Detailed summary of climate projection variables for Spruce Grove

Climate variable	Baseline (1976-2005)	Near future (2006-2050)			Distant future (2051-2080)		
		(10th percentile)	Mean	(90th percentile)	(10th percentile)	Mean	(90th percentile)
Warmer Winters							
Coldest Minimum Temperature	**-35.4°C**	*-36.8°C*	**-31.7°C**	*-26.9°C*	*-32.5°C*	**-27.6°C**	*-22.6°C*
Very Cold Days (-30° C)	**8**	*0*	**4**	*9*	*0*	**1**	*4*
Winter Days (-15° C)	**57**	*25*	**42**	*61*	*14*	**29**	*46*
Mild Winter Days (-5° C)	**130**	*88*	**108**	*128*	*67*	**88**	*111*
Icing Days (max temp ≤0° C)	**89**	*57*	**76**	*96*	*44*	**64**	*83*
Frost Days (temp drops below 0°C)	**191**	*152*	**168**	*183*	*129*	**146**	*163*
Freeze-thaw cycles (number)	**89**	*63*	**78**	*93*	*55*	**68**	*83*
Heating Degree Days	**5473**	*4284*	**4791**	*5292*	*3703*	**4171**	*4652*
Freezing Degree Days	**1359**	*722*	**1053**	*1395*	*501*	**787**	*1103*
Hotter Summers							
Warmest Maximum Temperature	**30.9°C**	*30.3°C*	**33.3°C**	*36.3°C*	*32.7°C*	**35.7°C**	*38.7°C*
Heatwaves (3+ days +30° C)	**0.4**	*0*	**1.3**	*3*	*1.2*	**3.2**	*5.4*
Very Hot Days (temp reaches 30° C)	**3**	*2*	**10**	*20*	*9*	**24**	*41*
Summer Days (≥25° C)	**28**	*30*	**49**	*68*	*53*	**74**	*96*
Tropical Nights (Nighttime ≥20° C)	**0**	*0*	**0**	*0*	*0*	**2**	*4*
Date of Last Spring Frost	**May 12**	*Apr. 18*	**May 2**	*May 17*	*Apr 7*	**Apr. 23**	*May 8*
Date of First Fall Frost	**Sep. 20**	*Sep. 17*	**Oct. 2**	*Oct. 19*	*Sep. 24*	**Oct. 11**	*Oct. 28*
Frost Free Season (days)	**128**	*128*	**149**	*170*	*145*	**168**	*190*
Cooling Degree Days	**50**	*58*	**132**	*208*	*163*	**282**	*421*
Growing Degree Days (5°C)	**1466**	*1617*	**1834**	*2052*	*1984*	**2249**	*2536*
Growing Degree Days (10°C)	**683**	*781*	**958**	*1136*	*1065*	**1286**	*1524*
Growing Degree Days (15°C)	**183**	*221*	**346**	*467*	*410*	**574**	*758*
Corn Heat Units	**2127**	*2314*	**2673**	*3048*	*2845*	**3253**	*3669*
Precipitation changes							
Wet Days	**134**	*117*	**135**	*153*	*117*	**135**	*153*
Dry Days	**231**	*211*	**229**	*247*	*212*	**230**	*247*
Heavy Precipitation Days (10mm)	**9.6**	*5.8*	**10.6**	*15.5*	*6.3*	**11.5**	*17*
Heavy Precipitation Days (20mm)	**2.2**	*0.4*	**2.5**	*4.7*	*0.6*	**2.9**	*5.4*
Max 1-Day Precipitation (mm)	**32**	*20*	**34**	*51*	*21*	**36**	*55*
Max 3-Day Precipitation (mm)	**46**	*29*	**49**	*73*	*30*	**52**	*77*
Max 5-Day Precipitation (mm)	**57**	*36*	**61**	*91*	*38*	**64**	*95*

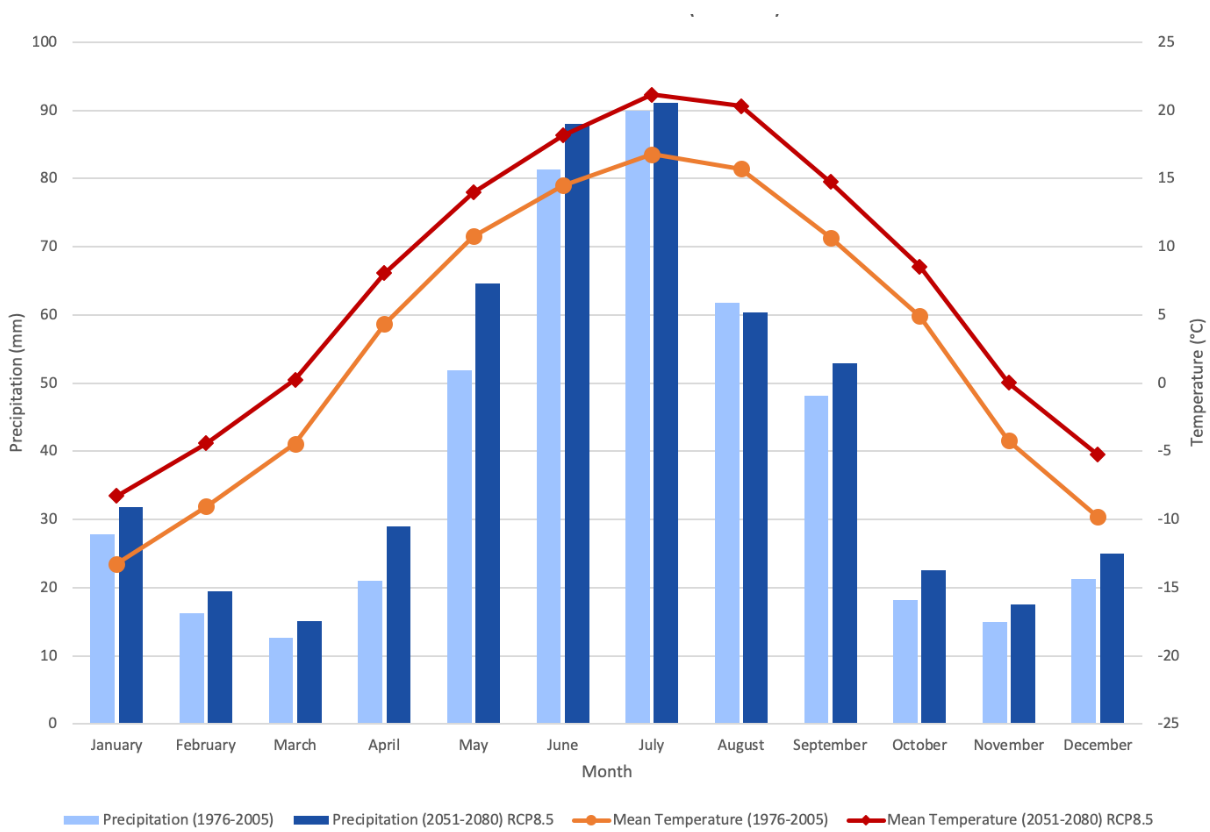
Table 10: Climate variable definitions

Climate variable	Definition
Coldest Minimum Temperature	The very coldest temperature of the year
Very Cold Days (-30° C)	A day with a minimum temperature less than or equal to -30 °C
Winter Days (-15° C)	A day with a minimum temperature less than or equal to -15 °C
Mild Winter Days (-5° C)	A day with a minimum temperature less than or equal to -5 °C
Icing Days (max temp ≤0° C)	A day on which the daily maximum temperature is less than or equal to 0 °C
Freeze-thaw cycles	A freeze-thaw cycle occurs when the daily maximum temperature is higher than 0 °C and the daily minimum temperature is less than or equal to -1 °C
Heating Degree Days (HDD)	An index of the number of degrees Celsius a given day's mean temperature is below 18 °C. For example, if the daily mean temperature is 12 °C, the HDD value for that day is equal to 6
Freezing Degree Days	Freezing degree days (FDD) is an index of below freezing temperatures. If a day's mean temperature is -21 °C, for example, it increases the annual FDD value by 21
Frost Days	A day in which the coldest temperature of the day is lower than 0 °C
Warmest Maximum Temperature	The highest temperature of the year
Heatwaves	The number of heat waves per year (at least three days in a row reach or exceed 30 °C)
Very Hot Days (30° C)	A day when the temperature rises to at least 30 °C
Summer Days (≥25° C)	A day when the temperature rises to at least 25 °C
Tropical Nights	A night when the lowest temperature does not go below 20 °C
Date of Last Spring Frost	The date of the last spring frost, marking the beginning of the growing season
Date of First Fall Frost	The date of the first fall frost, which marks the approximate end of the growing season for frost-sensitive crops and plants
Frost Free Season (days)	The length of the growing season, during which there are no freezing temperatures
Cooling Degree Days (CDD)	An index of the number of degrees Celsius a given day's mean temperature is above 18 °C. For example, if the daily mean temperature is 21 °C, the CDD value for that day is equal to 3
Growing Degree Days	An index of the annual sum of the number of degrees Celsius that each day's mean temperature is above a specified base temperature. Different base temperatures (5, 10 and 15 °C) are used to capture results for organisms that demand different amounts of heat
Corn Heat Units	An index of growing season heat available to grow corn, derived from daily maximum and minimum temperatures. The starting date is the last day of three consecutive days with a mean daily temperature greater than or equal to 12.8 °C; the ending date is the first date with a minimum temperature less than or equal to -2.0 °C.
Wet Days	The number of days in a year with rain/snow.
Dry Days	The number of days in a year without rain/snow.
Heavy Precipitation Days (10mm)	A day on which at least a total of 10 mm of rain or frozen precipitation falls.
Heavy Precipitation Days (20mm)	A day on which at least a total of 20 mm of rain or frozen precipitation falls.
Max 1-Day Precipitation (mm)	The maximum precipitation that falls in single calendar day.
Max 3-Day Precipitation (mm)	The maximum total precipitation that falls over a consecutive three-day period.

Max 5-Day Precipitation (mm)	The maximum total precipitation that falls over a consecutive five-day period.

Select climate graphics

Figure 2: Climograph of monthly temperature and precipitation in Spruce Grove between 1976-2005 and 2051-2080 (RCP 8.5)

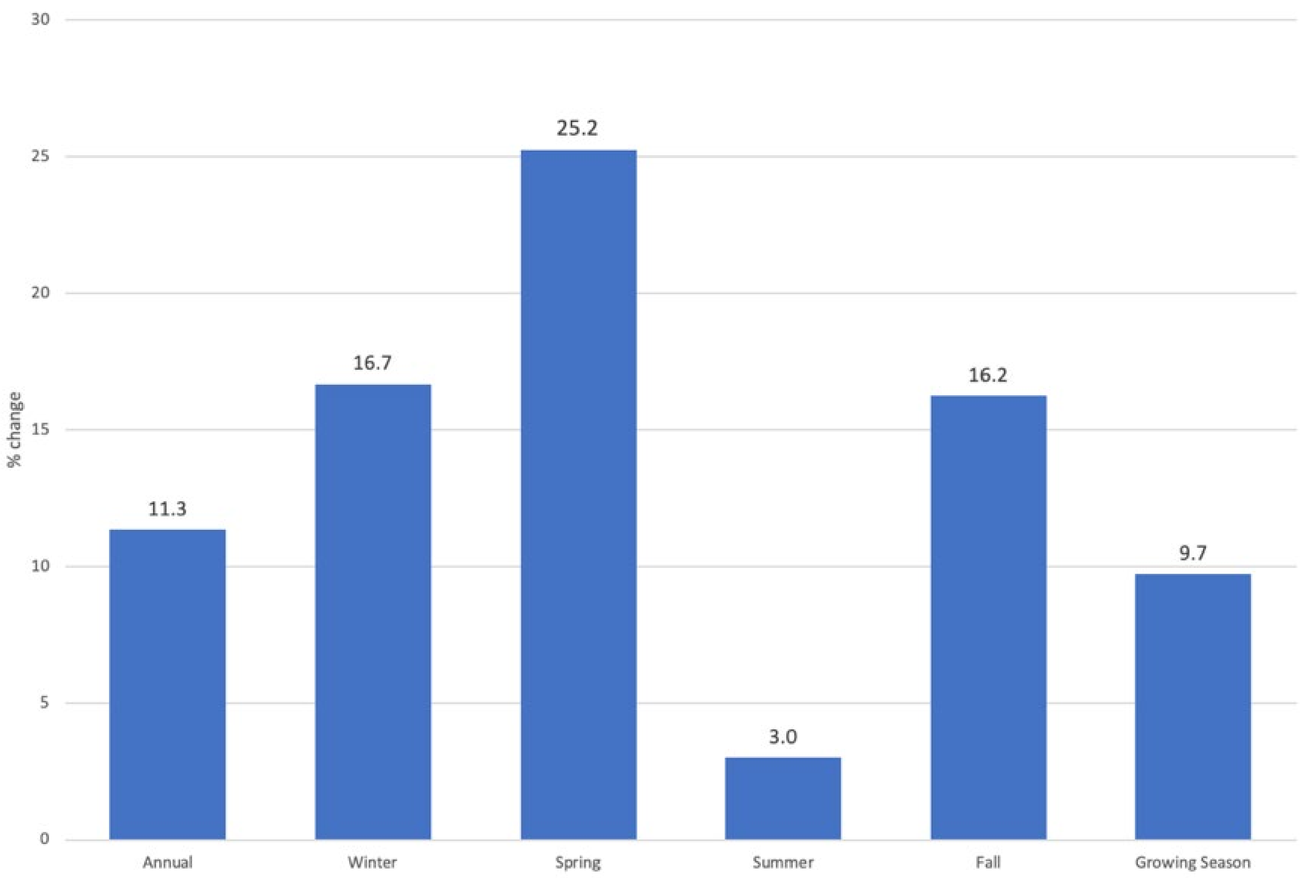


The climograph shows the average monthly mean temperature (°C) and precipitation (mm) for two different time periods: 1976-2005 and 2051-2080. Models project an increase in the average mean temperature for every month of the year during the time period 2051-2080, with the greatest increases occurring in the winter months. Models also project an increase in average total precipitation for each month except for August.

Projected changes in seasonal precipitation

Mean annual precipitation is projected to increase by 11% by the 2060s, from 465mm historically to 518mm. The largest increases in precipitation are projected for the spring (March, April, May) at 25%.

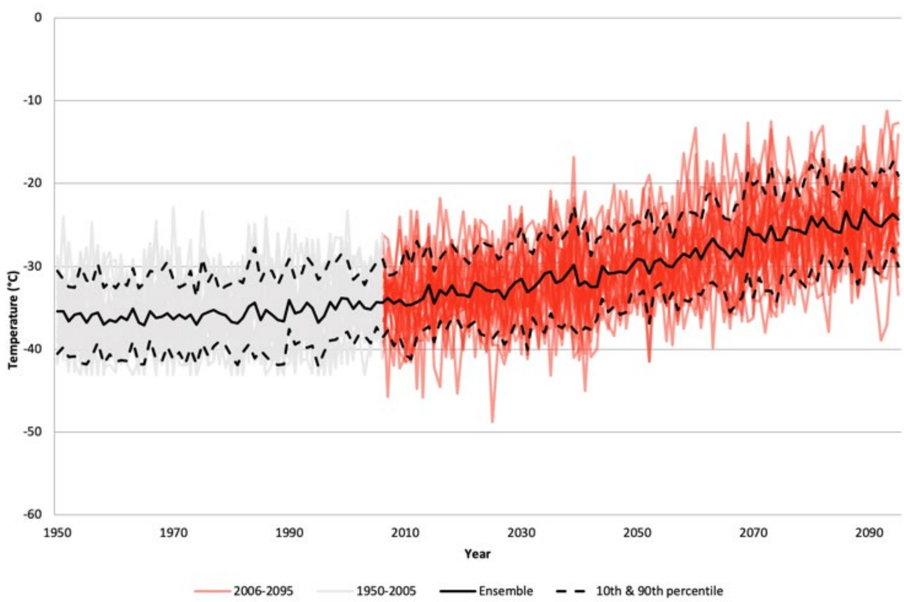
Figure 3: Percent Change in Precipitation in 2051-2080 vs 1976-2005 (RCP 8.5)



Cold temperatures

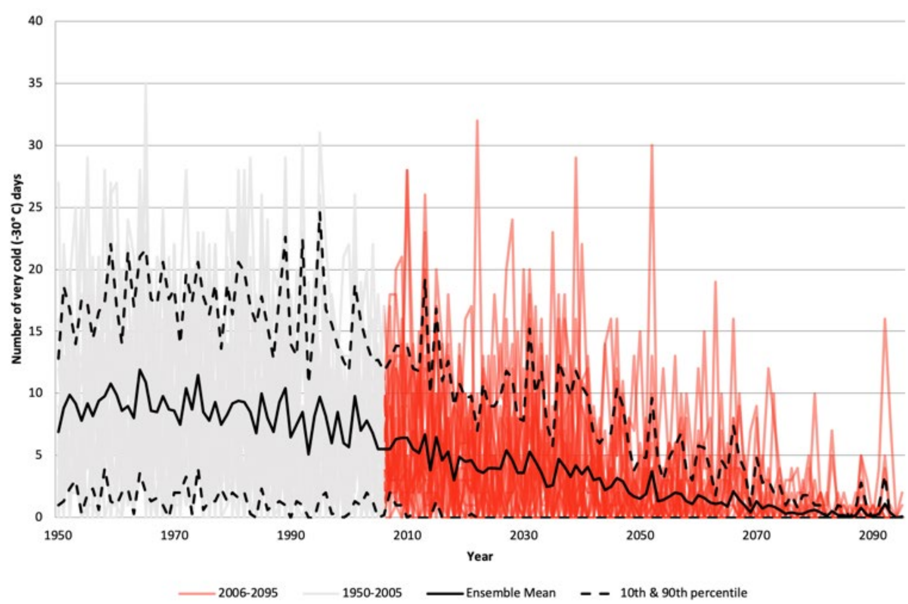
Spruce Grove winters are projected to get shorter and warmer. Climate models project the average coldest temperature of the year to be almost 8°C warmer in 2060s (-27.6°C) compared to the historic value (-35.4°C).

Figure 4: Annual Coldest Minimum Temperature (°C) 1950-2095 (RCP 8.5)



The average number of days that reach -30°C each year is projected to decrease in Spruce Grove as well. Models show an average of only 1 day per year that reaches -30° C in the 2060s compared to an average of 8 per year historically.

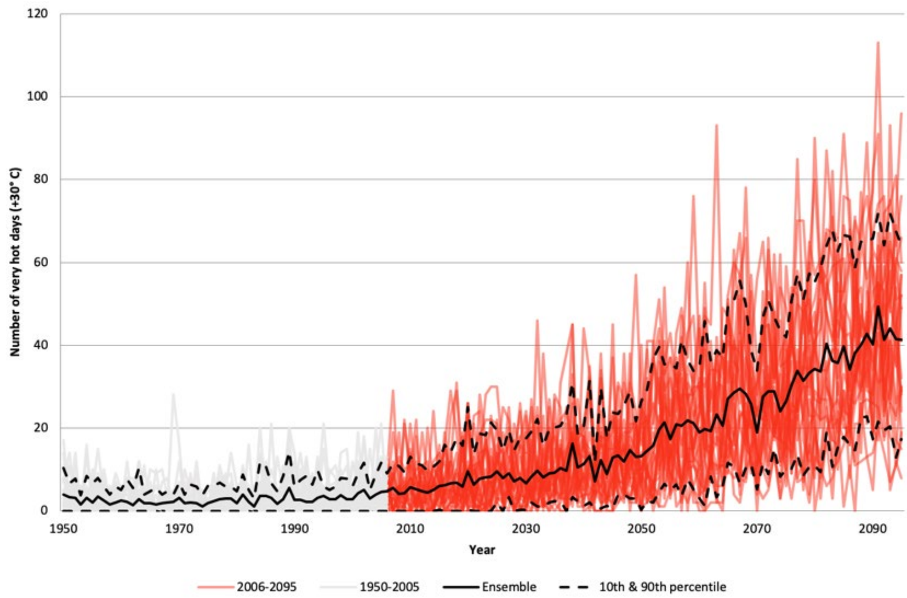
Figure 5: Number of Very Cold (-30°C) Days 1950-2095 (RCP 8.5)



Hot temperatures

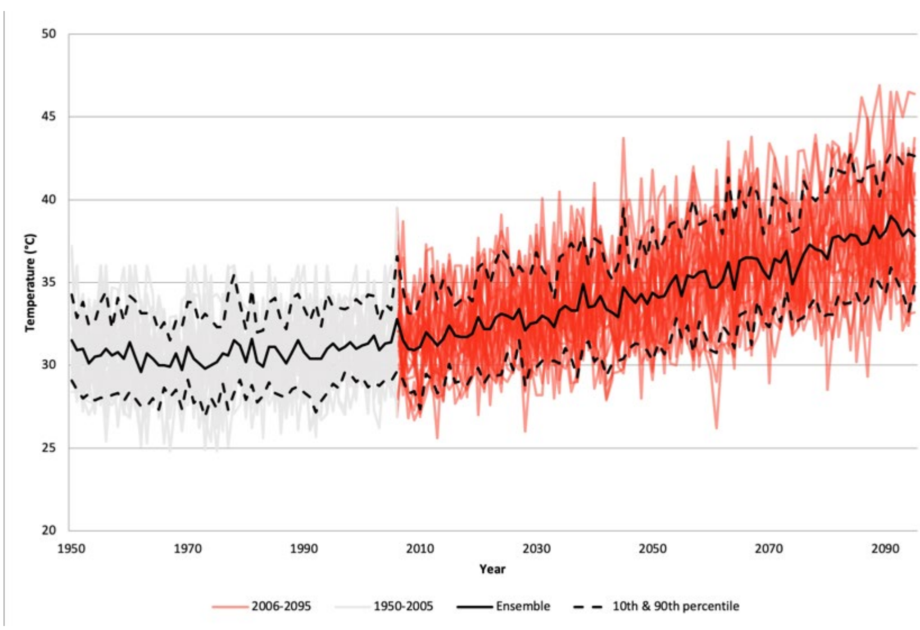
Climate models project summers to get hotter in Spruce Grove. The annual number of days that are projected reach +30°C in the future (2060s) will become much more common, with an average of 24 days per year in the future compared to 3 days historically. This will lead to Spruce Grove experiencing heatwaves or extended periods of very warm weather.

Figure 6: Number of Very Hot Days (-30°C) 1950-2095 (RCP 8.5)



The hottest temperature experienced each year is also projected to increase. The average annual hottest day is projected to increase from 30.9°C historically, to 35.7°C in the 2060s. The City will very likely experience hotter temperatures in the future that have not been experienced before in the region.

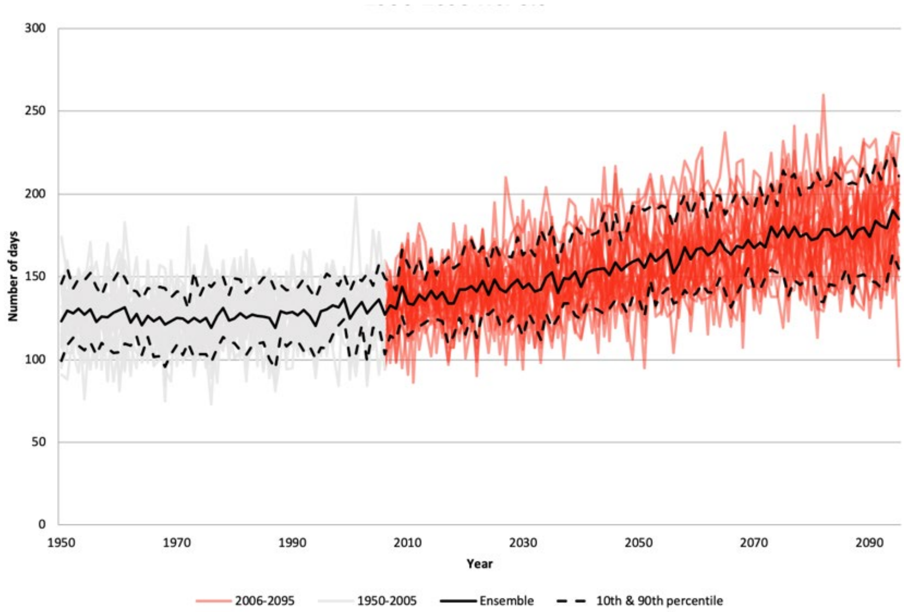
Figure 7: Annual Hottest Maximum Temperature (°C) 1950-2095 (RCP 8.5)



Agriculture and food growing

Climate models project that Spruce grove will experience a longer frost-free season (also known as growing season), and therefore also a shorter winter season, in the future due to climate change. On average, the annual length of the frost-free season will be 40 days longer in the future (2051-2080) compared to the historic value (1976-2005). A longer growing season provides a longer window for plants and crops to grow.

Figure 8: Length of Frost Free Season (days) 1950-2095 (RCP 8.5)



APPENDIX C: WORKSHOP PARTICIPANTS FOR RISK AND OPPORTUNITY ASSESSMENT

The following staff members from the City of Spruce Grove attended the climate change Vulnerability and Risk Assessment Workshop on June 21, 2021.

1. Kevin Stener, Director - Public Works
2. Bill Ruether, Drainage Supervisor - Public Works
3. Janine Peter, Director - Community Social Development
4. Darren Flynn, Supervisor - Municipal Infrastructure
5. Darcy Bryant, Supervisor - Utilities
6. Carol Bergum, Director - Planning and Development
7. Ken Luck, Acting Director - Culture and Recreation Services
8. Mark Hussey, Director - Engineering
9. Robert Kosterman, Fire Chief
10. Robert Hayder, Manager - Asset Management
11. Gordon Andrews, Supervisor – Roads
12. Dan Howarth, Advisor - Insurance and Risk Management
13. Erin Rutherford, Manager - Community Social Development
14. Karla Gould, Specialist - Economic Development
15. Dave Walker, Director - Economic & Business Development
16. Caitlin van Gaal, Advisor - Environment

17. Filip Dundur, Water Modeling Manager, EPCOR Water

18. Jeff Zukiwsky, All One Sky Foundation (Facilitator)
19. Sarah Prescott, All One Sky Foundation (Facilitator)

APPENDIX D: RESULTS OF PUBLIC ENGAGEMENT OPPORTUNITIES

Appendix D1: Webinar – Spring 2021

An online webinar was held on May 27, 2021. The webinar was both an opportunity for citizens to learn more about the Climate Change Action Plan process, and to provide their comments, questions and ideas about the plan.

The online webinar was advertised on the Spruce Grove Connect website, on Spruce Grove social media, and in the local newspaper. The webinar was attended by eleven people.

Respondents were posed four questions at the end of the webinar and their answers were stored on an online whiteboard below, two of which related to climate change adaptation. The responses to these questions are noted below:

What do you hope our city does to prepare for climate change?

- Continuous studies and projections, since climate events are changing rapidly
- Would like the city to be very aware of climate action grants from other levels of Government to initiate GHG emission reduction targets
- I would like the city to stop allowing developers to develop on wetlands and set improved criteria for raw land development
- Protect natural forested areas and environmentally sensitive areas
- Encourage the development community to look to building net zero GHG housing forms
- I would like the city to increase density requirements for all development (key pieces of land need to be conserved)
- I hope the city will consider the opinions and input of individuals who do not believe there is a climate crisis, but who are willing to work towards energy efficiency and a cleaner environment
- Take a reasonable, tempered approach
- Protect water tables and agricultural land by identifying key land to not develop
- Establishing transition to carbon neutrality programs
- Save agricultural land and encourage micro agriculture in city limits, to grow local
- Plant only native plants on public lands
- Plant fruit trees in public parks and facilitate community gardens in new developments, in land that is allocated during the development phase, not after
- Develop community halls in new developments, to develop more community level activity

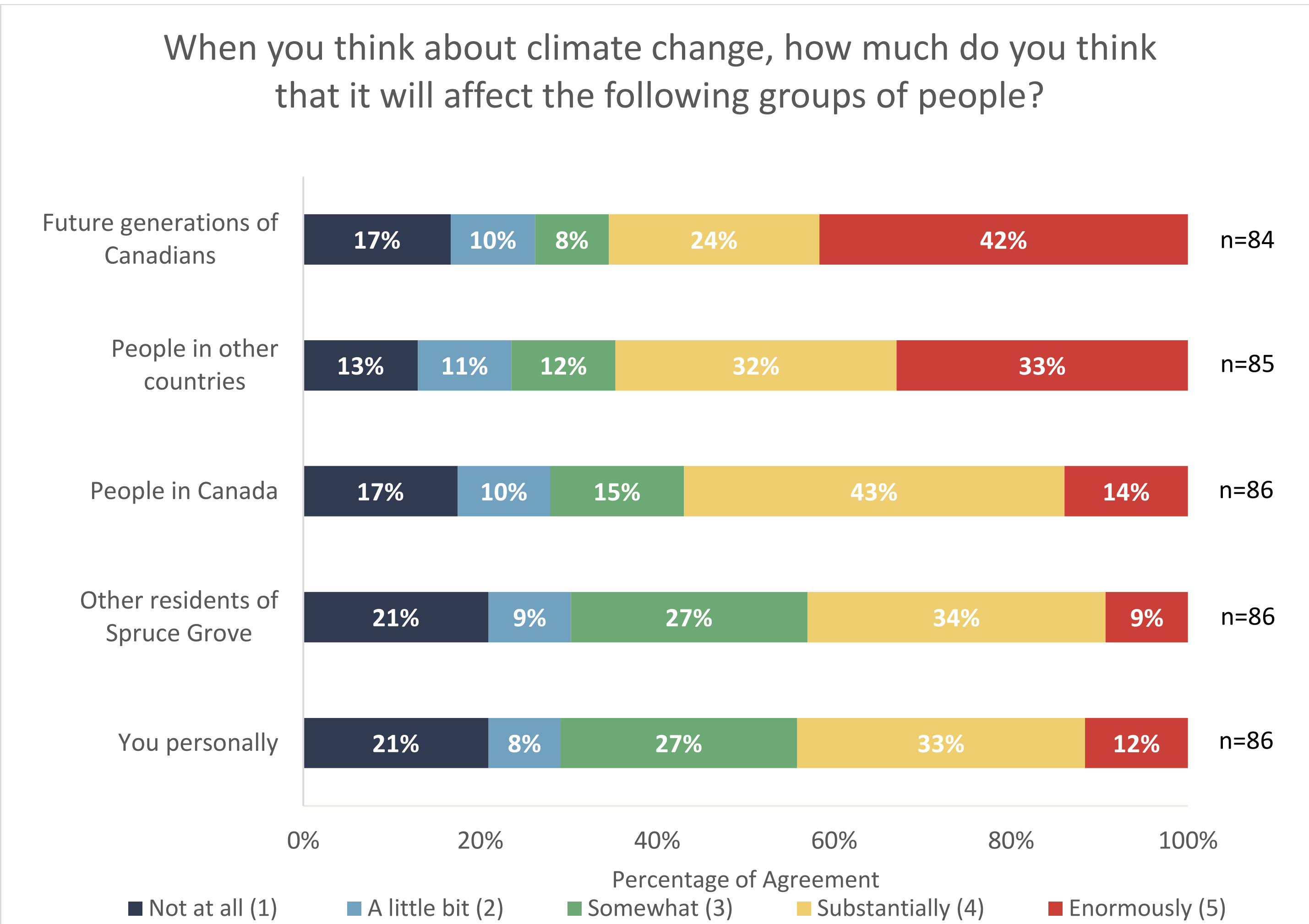
What can the City do to help you in Climate Resilience & Adaptation?

- Offer technical assistance for people looking to add solar to homes and grant programs
- Provide toolkits of residential and business adaptation to give people ideas about how to adapt homes and businesses
- Update building codes to include climate resiliency components
- I would appreciate a guide or document that would help me to access the vulnerabilities of my home and what is available to mitigate potential problems
- Require electric vehicle infrastructure to be built in commercial developments

- Encourage local food production – community chickens and gardens can produce a lot of food

Appendix D2: Online Survey – Spring 2021

An online survey was open from May 10 to June 8, 2021. The survey was advertised on the Spruce Grove Connect website, on Spruce Grove social media, and in the local newspaper. A total of 22 questions were asked: some relating to climate adaptation, some relating to climate mitigation, and a few demographic questions about the survey takers. Climate mitigation related responses are described in the Greenhouse Gas Mitigation Technical Report. The following figures show the responses to all questions related to climate adaptation, as well as responses to the demographic questions.



<u>Can you tell us why you answered the way that you did?</u>

- Climate change affects everyone and is getting worse
- Climate change impacts our oceans and the air we breathe
- Climate change induces extreme weather events (e.g., floods, wildfires, air and water pollution) that will have disastrous effects on humanity

- Changing weather patterns damage our economy (e.g., building quality, insurance, etc.)
- We need to be more proactive rather than reactive towards climate change
- We need to develop more sustainable recycling programs
- Overpopulation and overconsumption will not allow us to support future generations
- Climate change is not real
- Changing weather patterns are a natural phenomenon
- Climate change is just a political agenda
- Spruce Grove and Alberta will not be affected significantly by climate change
- People will be able to adapt to climate change though technological advancements

Local climate projections

According to recent climate predictions, Spruce Grove can expect to see some of the following changes in their local climate both now and into the future:

- More **heavy rainfall** events
- **Hotter, drier** summers
- Warmer temperatures in all seasons
- Warmer winters with **fewer cold days**
- More **extreme weather** (hail, wind, etc.)

These changes could affect Spruce Grove in a variety of ways

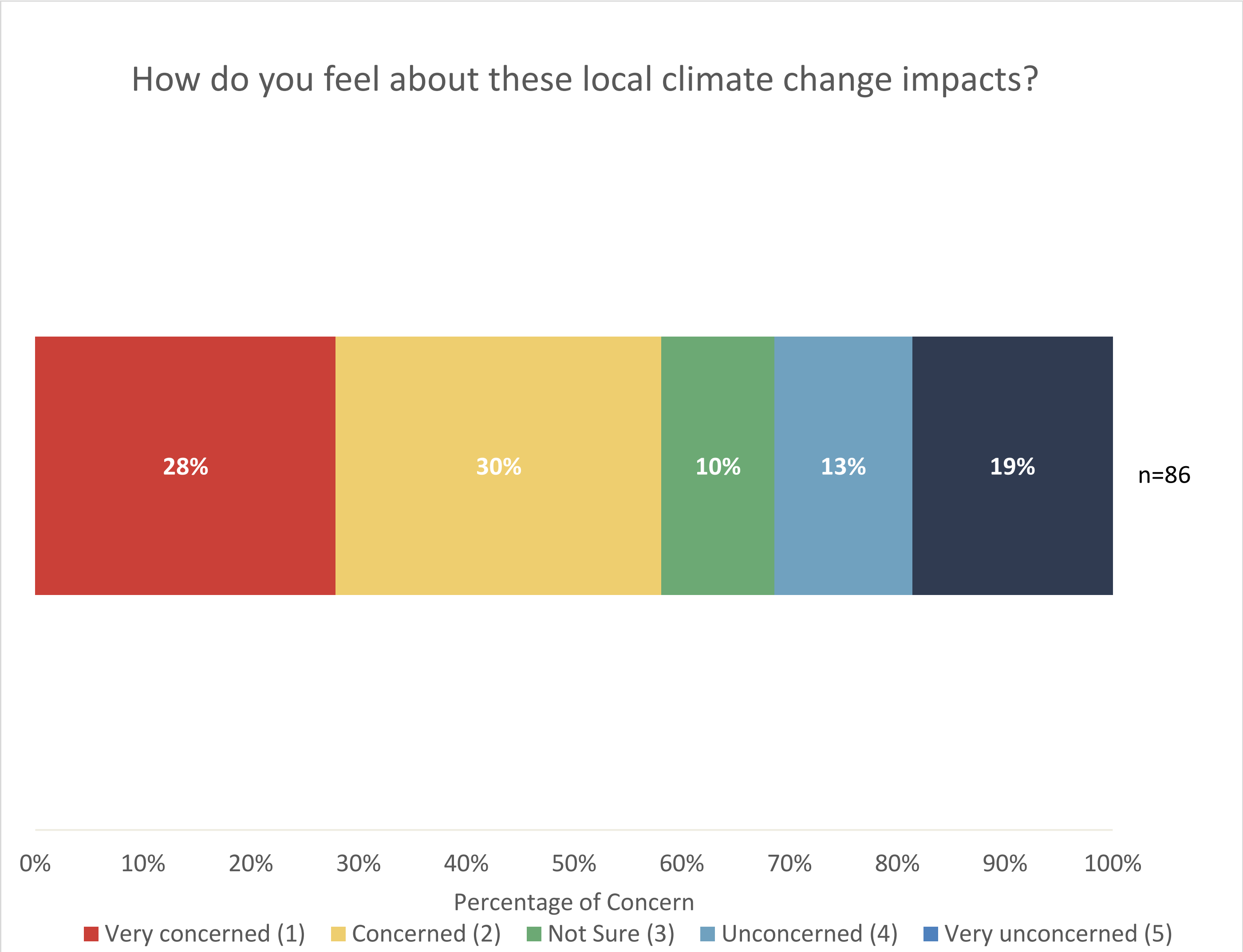
A few negative examples include:

- Increased chance of **urban flooding in the spring**, due to more rainfall, especially rain that falls during intense storms
- Increased chance of **water shortages in the summer**, due to higher demand for water, especially on very hot days
- Higher chance of **freezing rain** during fall, winter, and spring, due to more days with temperatures that are just above freezing. This could result in power outages, more needs for road maintenance, and tree damage.
- **More thunderstorms** in the summer, which will **increase damage** from hail, intense winds, and lightning strikes

A few positive examples include:

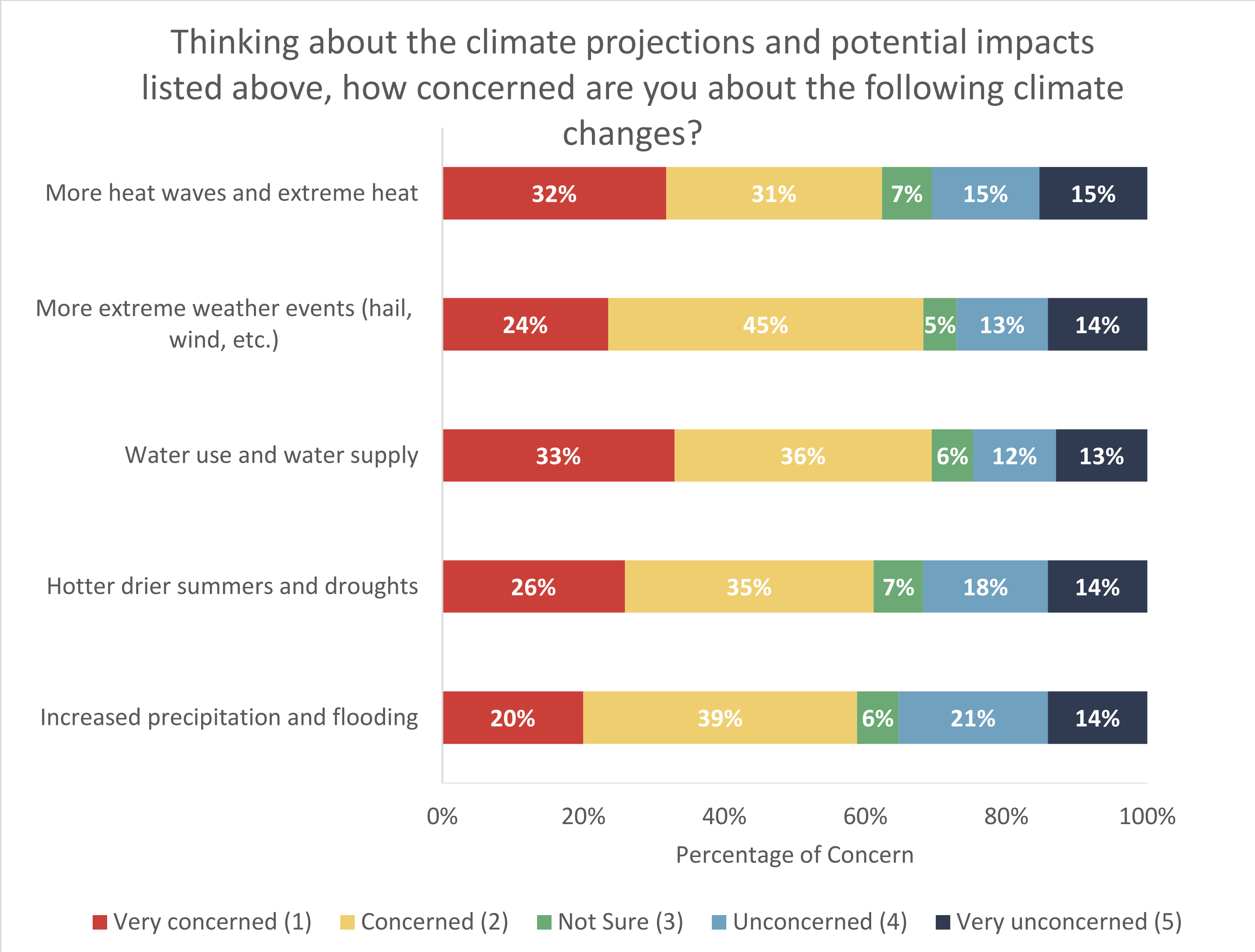
- A **longer construction season** and a **longer growing season**, due to a longer period of time without freezing temperatures at night
- More opportunities for **spring recreation**, due to warmer spring temperatures, and a longer **summer recreation season**
- Lower winter **heating costs**, due to warmer average winter temperatures

Changes to local weather patterns in **other parts of Canada** and **other parts of the world** will also affect life in Spruce Grove. For example, a crop failure due to flooding somewhere in the United States could affect crop prices and food availability here. However, these effects are difficult to predict. For this project, our city is focusing on **preparing for the direct effects** that changes to long term local weather patterns will have on our city.



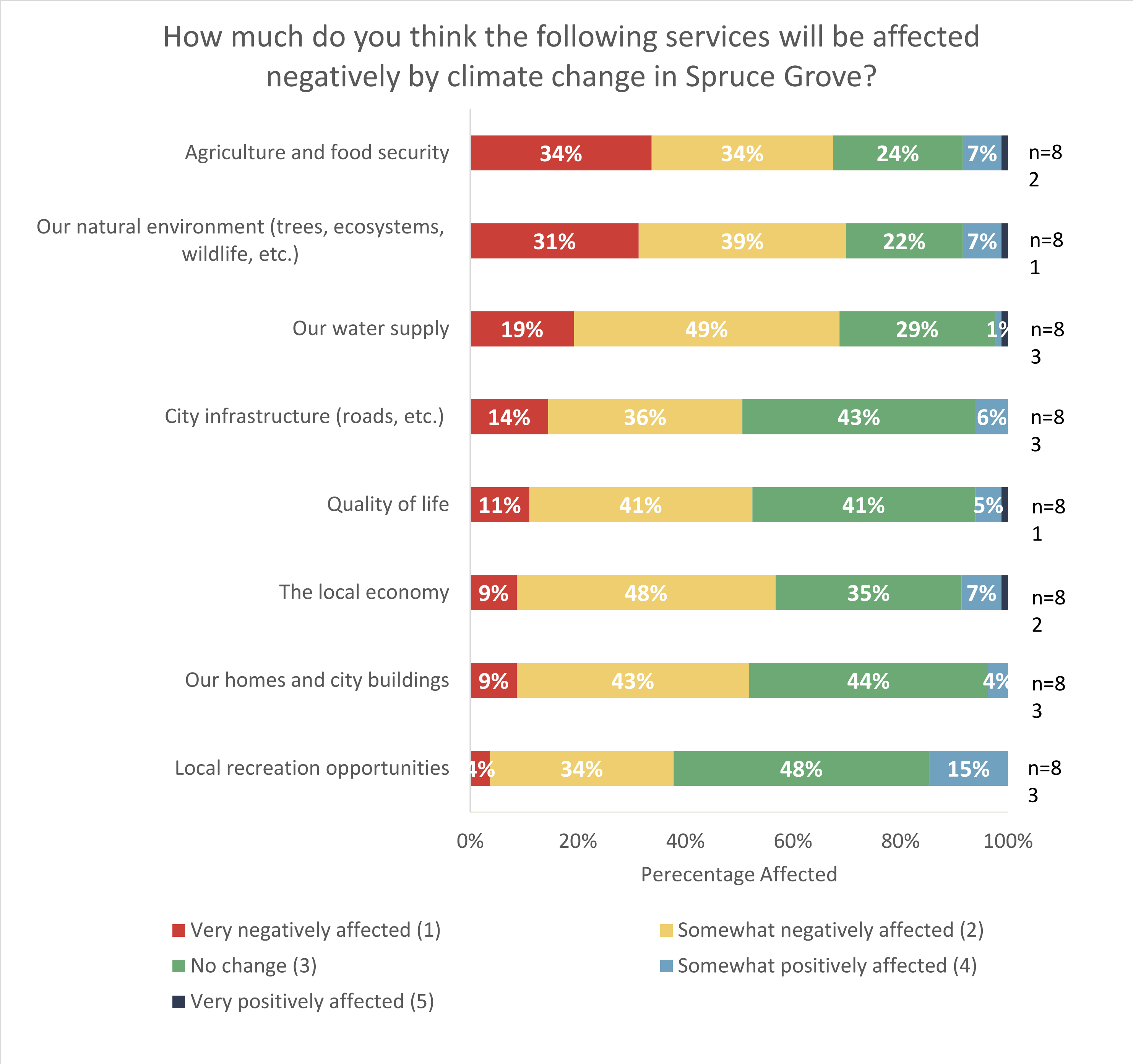
<u>Why did you answer this way?</u>

- Climate change is happening and will increase in intensity
- Climate change affects our crops, homes, and livelihoods
- Climate change will increase water shortages
- Extreme weather events are unpredictable, dangerous, and expensive
- Humans are resilient and will adapt to climate change
- Climate change is beneficial (e.g., warmer winters, drier summers) for Canada
- Climate change is natural and is not affected by emissions or human activities



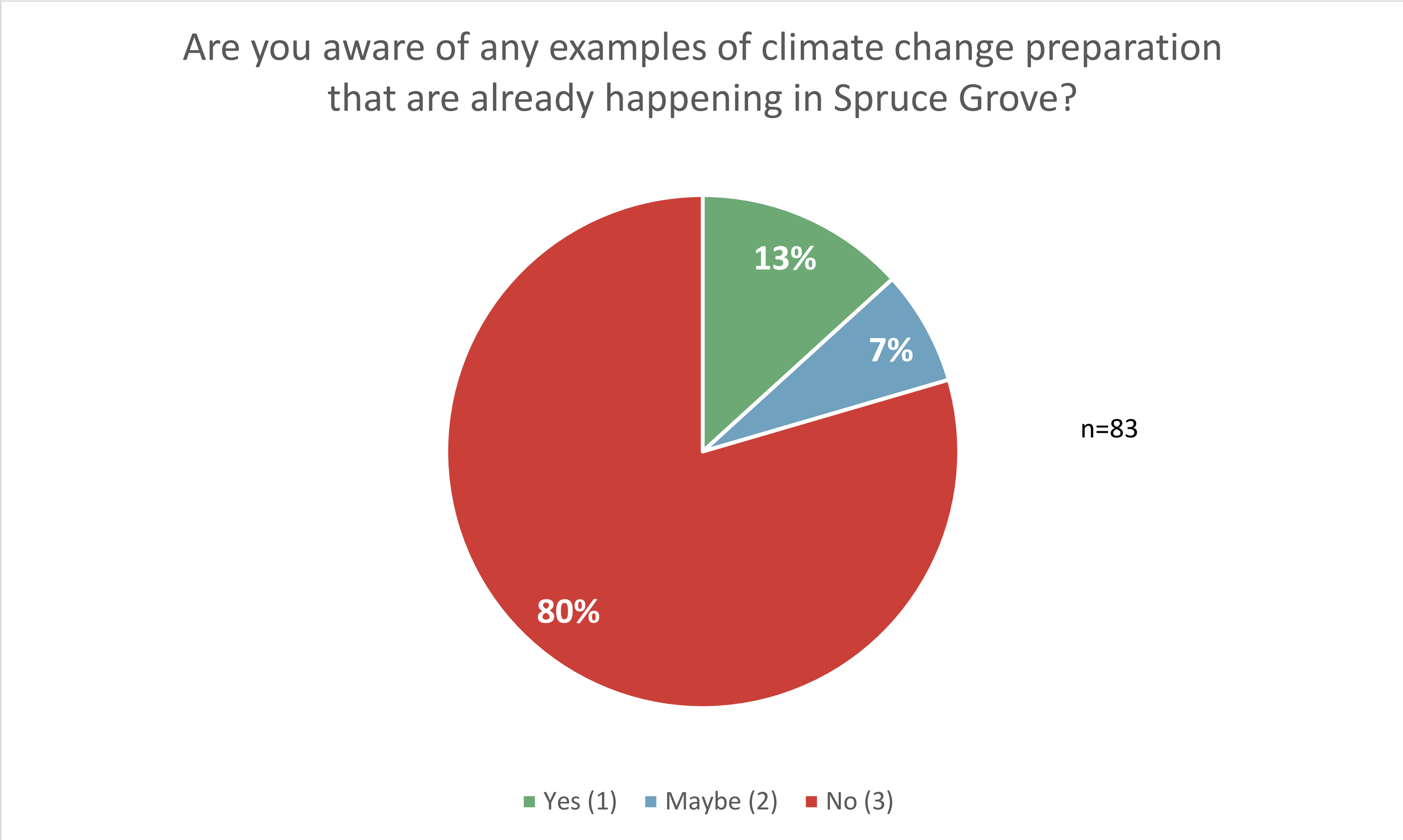
<u>Why did you answer this way?</u>

- Science and fact prove that climate change is real
- Extreme weather causes damages that are expensive to insure
- Extreme weather puts our livelihoods at risk
- Our population will die if our environment can no longer support us
- Extreme weather is unchangeable, so we need to build less in vulnerable areas (e.g., floodplains, muskegs, etc.)
- Climate change is normal, and we will adapt
- Spruce Grove won't change the planet



<u>Why did you answer this way?</u>

- Extreme weather increases costs
- Climate change is real
- Climate change negatively impacts our food, water, health, economy, roads, and building infrastructure
- Increased CO_2 levels will green the planet and improve food security and agriculture
- Climate change is gradual and can easily be adapted
- Weather happens



<u>If so, can you describe what those actions are?</u>

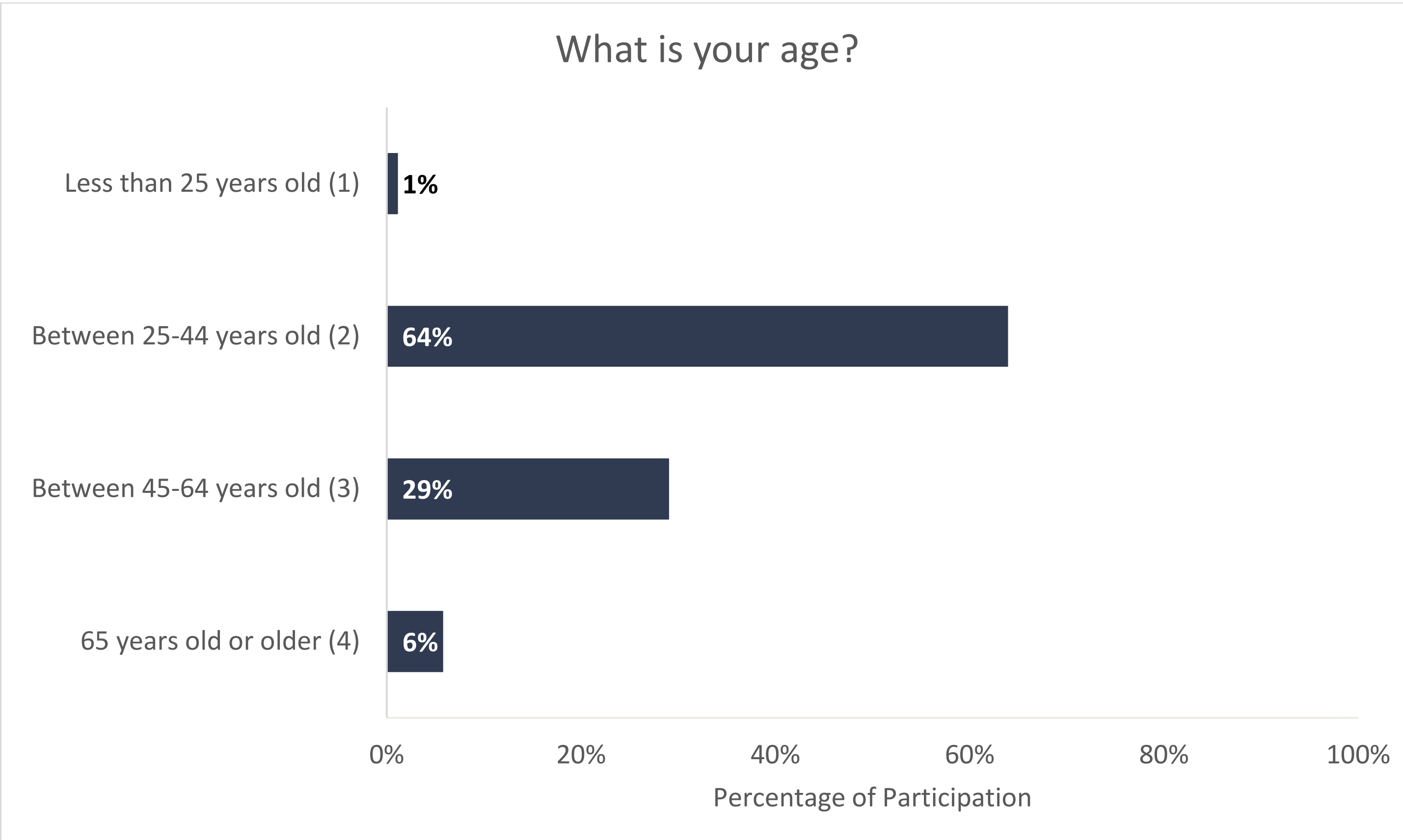
- Weekly waste pickup is preferred
- A climate plan with no tangible actions
- Electrical systems (Solar panels, lightning protection, Sensors to turn off lights in unused rooms)
- Water management systems (stormwater charges to water bills, pond systems for snow/rainwater containment, rain barrels, floodplains, water restrictions)
- Natural beautification of Spruce Grove
- A study needs to be done to support electric vehicles
- There are none

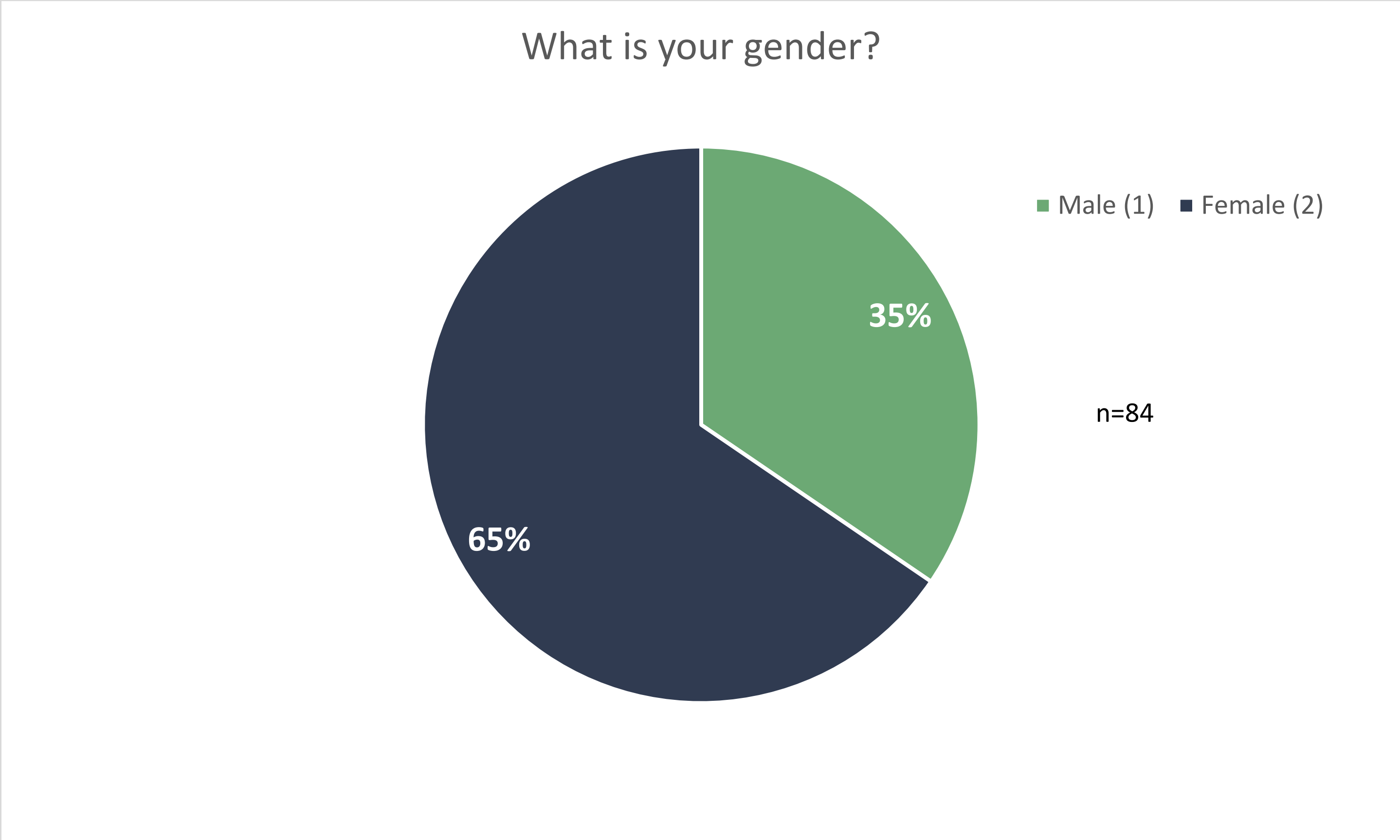
<u>In your opinion, what are the most important actions the city should take to reduce the potential negative effects of weather changes due to climate change on Spruce Grove residents?</u>

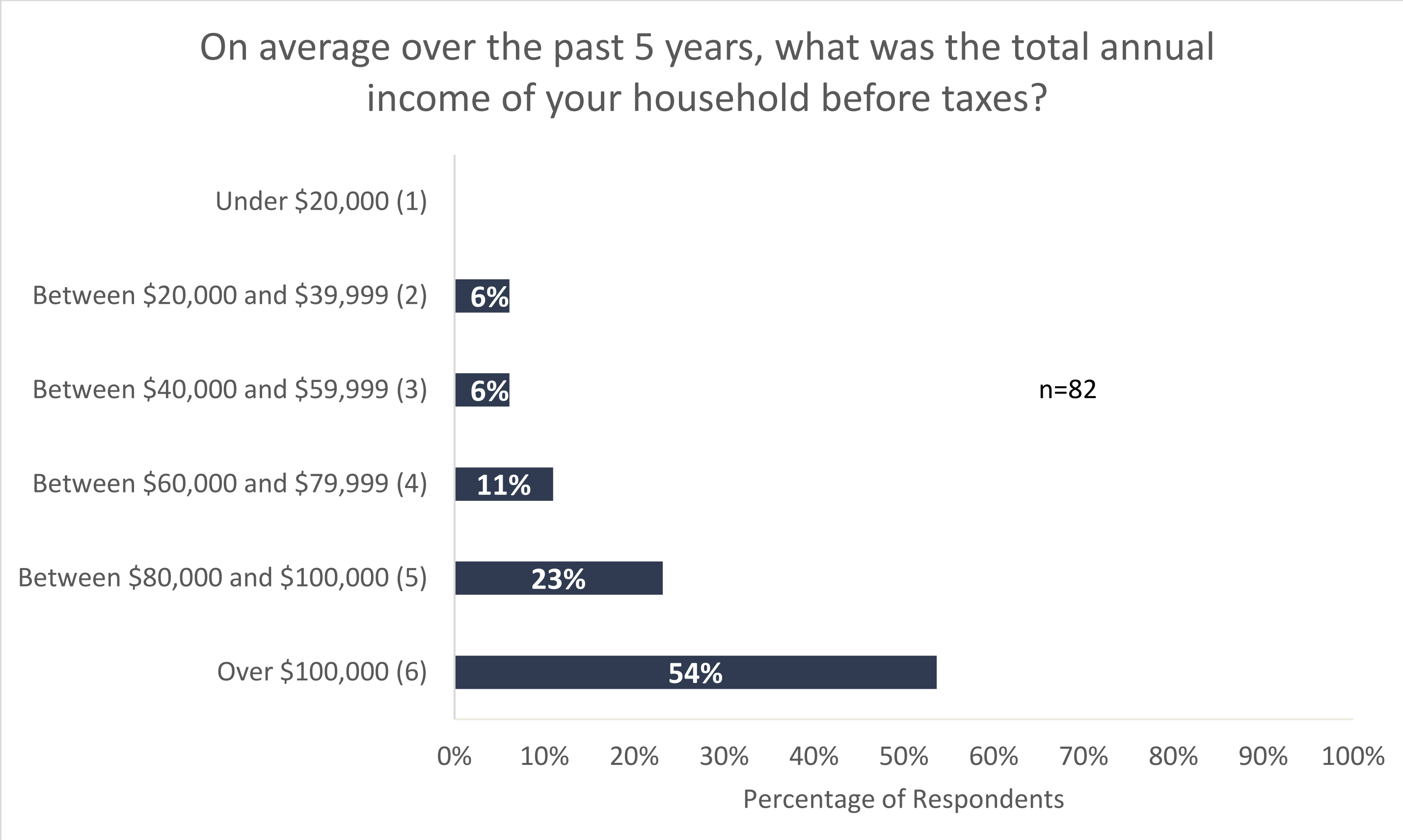
- Improve water and sewer systems (run-off systems, storm water retention ponds, road drainage, flood preparation)
- Promote green incentives (electric vehicles, solar panels, green energy municipal infrastructure, energy literacy workshops, ban plastic, reduce garbage collection, less reliance on oil and gas, net zero buildings, plant trees, recycle)
- Create a data map using climate change projections and prioritize projects based on data
- Build new weather resistant infrastructure (wind resistant building exteriors, drought resistant landscaping)
- Development permits that meet a set of climate change criteria

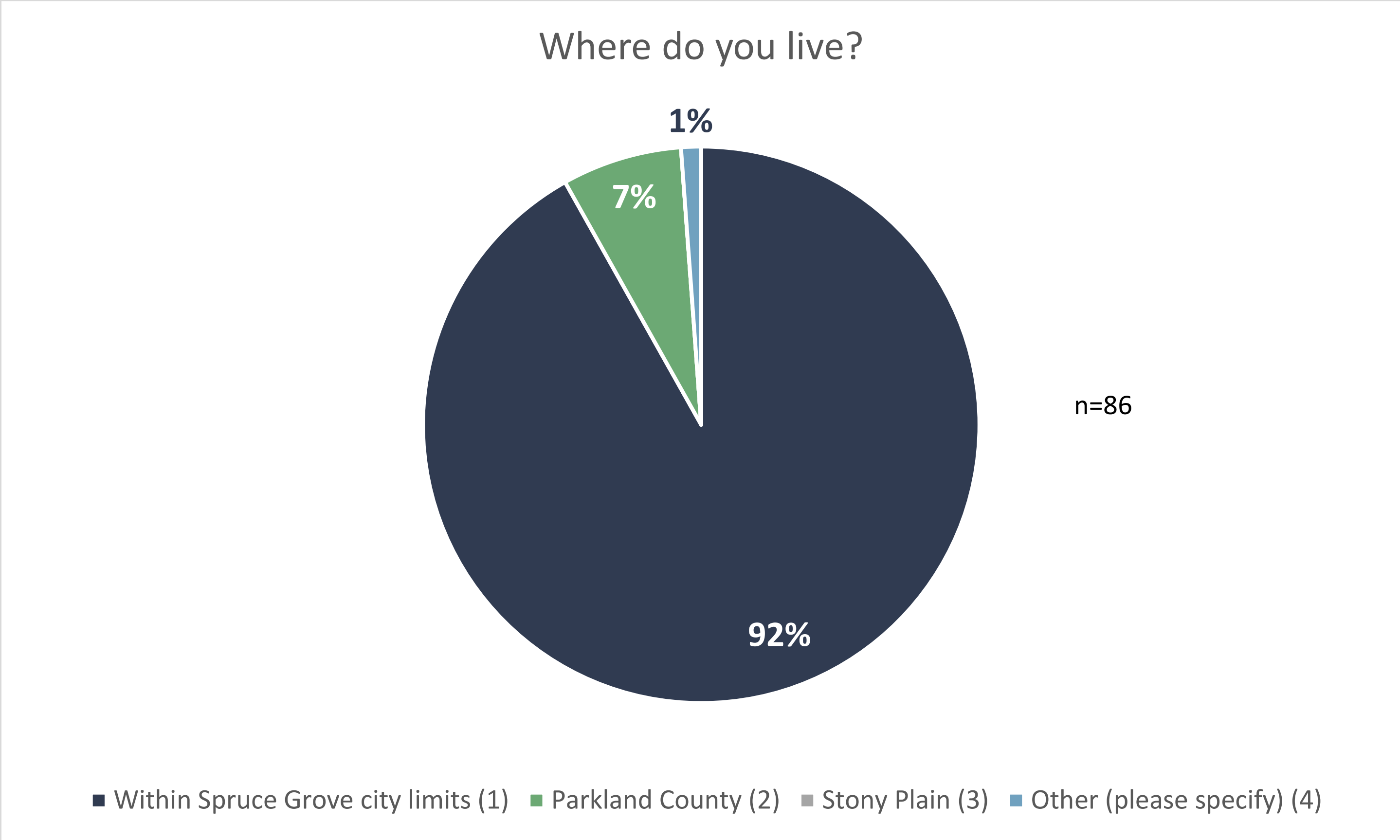
- Anti-idling bylaw
- More education, communication, and participation
- Anything that makes economic sense
- No actions necessary
- Climate change isn't real

The following charts displays demographic statistics of the participants of this survey.




What is your gender?
Male (1)
Female (2)
35%
65%
n=84


On average over the past 5 years, what was the total annual income of your household before taxes?
Under $20,000 (1)
Between $20,000 and $39,999 (2)
6%
Between $40,000 and $59,999 (3)
6%
n=82
Between $60,000 and $79,999 (4)
11%
Between $80,000 and $100,000 (5)
23%
Over $100,000 (6)
54%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Respondents


Where do you live?
1%
7%
92%
n=86
Within Spruce Grove city limits (1)
Parkland County (2)
Stony Plain (3)
Other (please specify) (4)

ALL ONE SKY FOUNDATION is a not-for-profit, charitable organization established to help vulnerable populations at the crossroads of energy and climate change. We do this through education, research and community-led programs, focusing our efforts on adaptation to climate change and energy poverty. Our vision is a society in which ALL people can afford the energy they require to live in warm, comfortable homes, in communities that are resilient and adaptive to a changing climate.

www.allonesky.ca

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