THE RESILIENCE INSTITUTE

Climate Risk Assessment Report

January 18, 2024

Municipality of Jasper

MUNICIPALITY OF JASPER

Prepared by the Resilience Institute in partnership with Associated Engineering
and the Prairie Adaptation Research Collaborative

Associated STRATEGIC ADVISORY SERVICES

PARC

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Gratitude

We are grateful for the opportunity to partner with the Municipality of Jasper on this important step towards climate resilience. This project was funded by the Government of Alberta through the Municipal Climate Change Action Centre's Climate Resilience Capacity Building Program. The Municipal Climate Change Action Centre is a partnership of Alberta Municipalities, Rural Municipalities of Alberta, and the Government of Alberta.

Our journey in assessing Jasper's climate risks was made possible thanks to the open engagement and generous guidance of numerous people in the community. Your stories, concerns, and ideas for addressing local climate threats are reflected in this report.

With gratitude,
Henry Penn, PhD, Research Fellow
Laura Lynes, LLM, President/CEO

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Introduction

On behalf of the Resilience Institute and our partners on this project, the **Prairie Adaptation Research Collaborative** and **Associated Engineering**, we are pleased to provide Municipality of Jasper with a **Climate Risk Assessment Report.** A suite of tools including PowerPoint slides and a Summary Document to communicate with various audiences can be provided in the future at the community's request.

This report is based on the best available knowledge at the time of our partnership. It is important to note that ***climate change is an evolving circumstance*** that could impact risks to your community.

It is our recommendation that the scoring and impact statements in this report (and appendices) be revisited on an annual or biennial basis to ensure that the rationale is **still relevant in the context of current circumstances.** We would be happy to provide additional guidance to how this might be done.

What is Climate Resilience and Why is it Critical?

Adaptation

Deliberate actions by communities in response to current or expected climate change impacts, which moderate potential harm or take advantage of beneficial opportunities. Actions can include monitoring, research, and other information gathering, education, and capacity building, changes to infrastructure, creating new policies and regulations, developing economic, and other incentives, and ensuring governance takes into account climate change.

Resilience

The ability of a community to prepare for, resist, respond to, and recover from the impacts of climate change in a timely and efficient manner, with minimum damage and disruption to the environment, and the social well-being and economic vitality of the community. Resilience and adaptive capacity are strongly linked. Thus, different groups within the community will be relatively more or relatively less resilient to climate phenomena, depending on their adaptive capacity.

Mitigation

An action that will reduce or prevent GHG emissions, such as using renewable energies like wind and solar, making buildings, vehicles and equipment more energy efficient, and walking or cycling from time to time instead of using a car. It can also include planting trees to absorb and store carbon dioxide from the atmosphere.

Climate and weather refer to separate things. **Weather describes atmospheric conditions** (such as temperature, humidity, precipitation, wind, cloudiness) in a place or region in the **short-term** – usually, hour-to-hour, day-to-day, and even weeks to months.

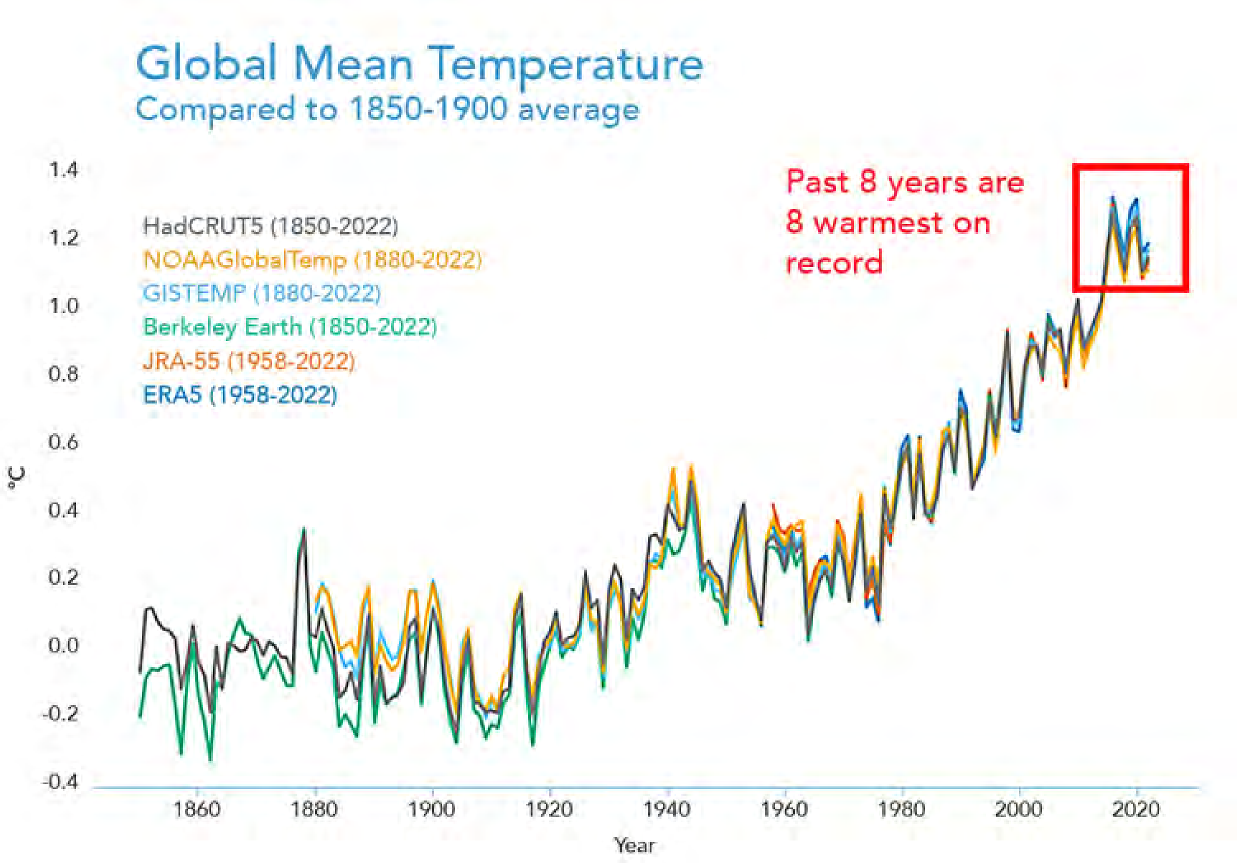
Climate refers to the average of weather conditions over 30 years or more. When describing southern Alberta as typically windy, you are describing an aspect of its climate. Weather can change dramatically in a place or region from day-to-day (e.g., hot and dry one day, followed by cold, wet conditions the next day). Climate, in contrast, changes more slowly since it represents the average weather over the long-term.

Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C above 1850-1900 in 2011-2020.

Widespread and rapid changes in the atmosphere, ocean, cryosphere, and biosphere have occurred. Human-caused climate change is already affecting many weather and climate extremes in every region across the globe.

This has led to widespread adverse impacts and related losses and damages to nature and people. Every increment of global warming will intensify multiple and concurrent hazards.

For any given future warming level, many climate-related risks are higher, and projected long-term impacts are up to multiple times higher than currently observed. Climatic and non-climatic risks will increasingly interact, creating compound and cascading risks that are more complex and difficult to manage.



Global mean temperature in 2022 was 1.15°C above the 1850-1900 average. The years 2015 to 2022 were the eight warmest in the instrumental record back to 1850. 2022 was the 5th or 6th warmest year.

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 GHGs and to protect and enhance **carbon sinks.** This uncertainty is captured using 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 GHGs 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 a high baseline emission scenario associated with higher levels of global warming.

The Scope of this Assessment

The risk assessment examines the impacts of climate change on built, natural, and social/cultural systems. These are referred to as systems because they are interacting and interrelated, so are considered collectively.

The scope of the risk assessment is defined along four boundary conditions:

Climate-Related Hazards

The assessment is largely confined to climate-related hazards that have direct impacts on Jasper and are within the Municipality's control and influence. Within these boundaries, a community-wide approach is adopted, that considers impacts to municipal and private property, the local economy, the health and lifestyle of residents, social equity, and natural capital, as well as impacts within Jasper's boundaries that may impact regional economic systems.

Chronic and Acute Stresses

In terms of climate-related hazards, both slow-onset (chronic) stresses and sudden-onset (acute) discrete events are within scope. The latter tend to be short duration events, that typically last minutes, hours, days, or weeks. These will generally occur irrespective of climate change – though their frequency, intensity, or distribution may alter because of climate change. Examples include windstorms, heavy snowfall events, freezing rain events, wildfire, and temperature extremes. Slow-onset stresses, in contrast, are caused entirely by climate change, with impacts unfolding gradually, building up over longer time frames – decades or more. Examples of slow-onset impacts include warming trends in air and surface water temperatures and ecosystem shifts.

RCP8.5 Scenario

Projections of future climate change are available for a range of GHG emissions, concentrations, and radiative forcing scenarios referred to as *representative concentrations pathways* (RCPs). When assessing climate-related risks it is prudent to consider the greatest plausible change scenario relative to the present, which in practice means working with projected changes for the region under the RCP 8.5 scenario, i.e., the most conservative scenarios. The primary justification for using RCP 8.5 is that it means no risks are missed during the risk assessment. Uncertainties relating to whether the future unfolds along RCP 8.5 or along a different, lower emission RCP, are managed during the adaptation planning and implementation phase.

Time Horizon

The risk assessment completed by Associated considers impacts arising from projected climate and associated environmental changes out to a future, 30-year time period centered around the 2050s. In some instances, climate hazards are discussed using PARC data projected to the end of the century and included in Appendix C.

Key Findings

Daily mean temperatures in every season are expected to increase over this century (based on PARC data). This will result in warmer temperatures in every season of the year, and could impact residents and visitors ability to recreate safely.

Jasper can expect to have zero days with a mean daily temperature of minus 30°C or colder by the end of century (based on PARC data). Extreme cold days, and extreme cold periods are projected to reduce.

Jasper is projected to experience a significant reduction in freeze-thaw days over the next 30 years, the result of which is a shorter winter season.

The number of extreme rainfall events is expected to increase, alongside a general increase in rainfall (not snow), including freezing rain.

Wildfire risk will continue to be significant and compounded by dramatic annual variability in both drought and rainfall patterns, alongside increased annual and seasonal temperatures.

Next Steps

The following section provides recommendations for steps towards climate resilience for built, natural, social, and economic systems, as well as the following overarching steps:

Develop a Climate Change Adaptation Action Plan specifically targeting both the high risks as identified in this assessment, and those risks that are significant to residents, departments and businesses. Ideally, municipal staff, members of the Jasper Park Chamber of Commerce, Tourism Jasper, and other community organizations, should work collaboratively to co-create a plan towards greater resilience that can realistically be implemented. Inclusion of regional partners such as the Town of Hinton, Parks Canada, and Indigenous groups should also be considered as momentum builds for adaptation.

Identify and support the implementation of early adaptation actions as well as onger-term actions that have "co-benefits" and can be incorporated into existing processes and funding sources. Considering the following:

- Targets and indicators to drive action and accountability, to be communicated publicly.
- Roles and responsibilities to carry out each of the actions including partnerships with community groups.
- Identification of existing initiatives and resources best suited to drive and align each of the actions.
- Develop a timeline and resource plan for implementation of the actions.

Built System

- Create an inventory of cooling infrastructure and amenities throughout the Municipality and region. Use findings to inform future investments and plans. The addition of cooling equipment (AC or heat pumps) should be seriously considered in the development of new or retrofits of existing buildings.
- Cooling spaces could include the use of shade trees and should include spaces and cooling centers that visitors can escape the heat. Minimising in-community deforestation should also be considered during future development projects.
- Explore non-combustion-based forms of backup power (e.g., on-site renewables, batteries), including residential energy generation options. And, create an inventory of where backup power can be installed and temporary generators that can be shared.
- Maintain ongoing dialogue between the Municipality, Parks Canada, and utility companies concerning changing risks to power infrastructure. Honest and open dialogue about concerns, challenges, and vulnerabilities will support resilience planning efforts for all parties.
- Review the existing asset management studies and incorporate consideration of climate impacts relating to short- and long-range funding needs, asset risk, and level of service considerations, into future revisions and asset management plans.
- Review evacuation plans and identify ways to reduce the number of vehicles on the road, and other obstacles, to reduce congestion on the limited road infrastructure. Identify thresholds for when roads are closed due to poor conditions (like freezing rain) and communicate the potential for closures early.
- Review findings from this Assessment with Jasper Park Chamber of Commerce and Tourism Jasper, and incorporate report findings when updating existing Municipal plans and/or pursuing new infrastructure developments.
- Work with Parks Canada to develop early warning systems (time lapse cameras, water level measurements) to protect infrastructure and keep people away from hazards, including sudden changes in snow stability and glaciers if there is a risk of significant ice breaks or water releases.

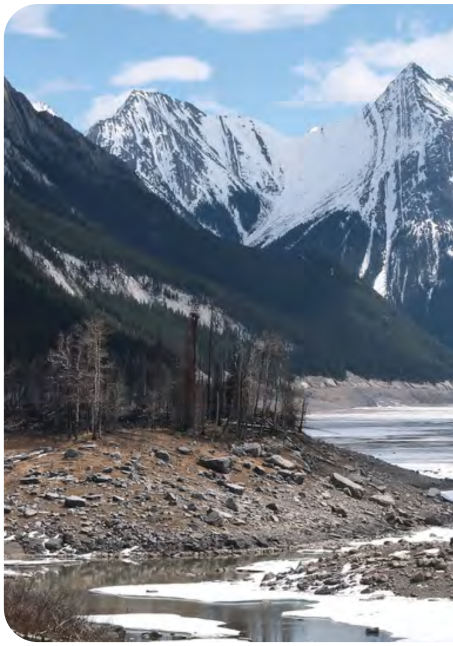
Natural System

- Investigate ways to conserve water to reduce demands on the natural environment. Partnerships with Jasper Tourism and tourism companies could play an important role in supporting water conservation efforts.
- Continue to share information and revise messaging with both residents and the visiting public, on the increased and changing risks of wildlife/human interactions and ways to reduce encounters.
- Collaborate with water users and interest groups (e.g., residents, commercial sector, environmental groups) to create dialogue on water conservation and sharing.

Social System

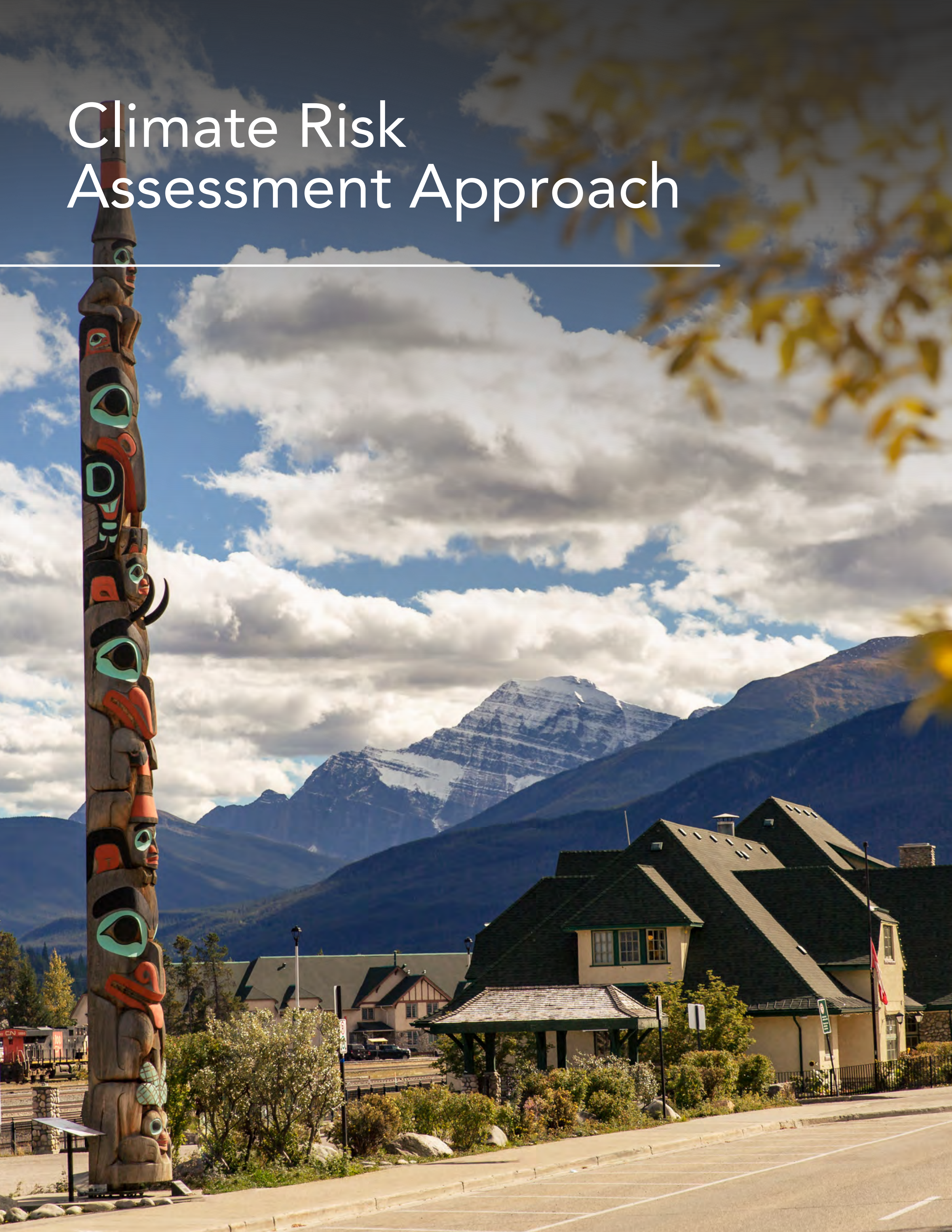
- Create opportunities for people to access cooling and clean air spaces, with special consideration for vulnerable populations (e.g., the elderly, people with medical conditions, unhoused).
- Explore increasing publicly accessible, outdoor cooling amenities (e.g., water misters, spray parks, water fountain/bottle filling stations, shade structures) to make it safer, and more comfortable to spend time outside in hotter conditions.
- Assess what standard operating procedures (SOPs) are in place for extreme heat or wildfire smoke conditions for outdoor workers. Consider incorporating the option for working alternative hours (i.e., limited work during peak heat hours). Update or develop procedures based on the findings from this assessment.
- Share information with the public on how to avoid heat related illnesses and ensure there is adequate resources to respond to people in distress.
- Complete a public education campaign on climate risks and emergency preparedness. Share information on evacuation plans and resources that could be accessed if residents and visitors are displaced.

Economic System (Tourism)



- Increase outdoor cooling amenities (e.g., water misters, water fountain/bottle filling stations, shade structures) to make it more comfortable to spend time outside, even despite the extreme heat.
- Complete market research to better understand perceptions of Jasper as an appealing tourist destination in the face of climate change. For example, the impacts of wildfire smoke, wildfire danger, and changing precipitation on visitor experience.
- Engage with tourism operators to educate them on findings from this report and encourage them to adapt their business practices to address climate risks and contribute to the overall resilience of Jasper.

Climate Risk Assessment Approach



Determining Climate Risk: Methodology

Risk is evaluated as the **product of likelihood of the hazard, events, or condition that could occur, and the level of the consequence of the impact.** In terms of climate risk, our approach is to develop an understanding of how the variability of climate patterns impact the built, natural, and societal/cultural systems. We then describe each as systems to recognize the interconnected and tangled nature of each impact relative to one or multiple others.

The purpose of a risk assessment is to identify as many potential risks as possible, not just the highest risks, so that subsequent adaptation actions are focused along **a spectrum of short, medium and long term actions** that address both those highest risks and those of greatest concern to your community.

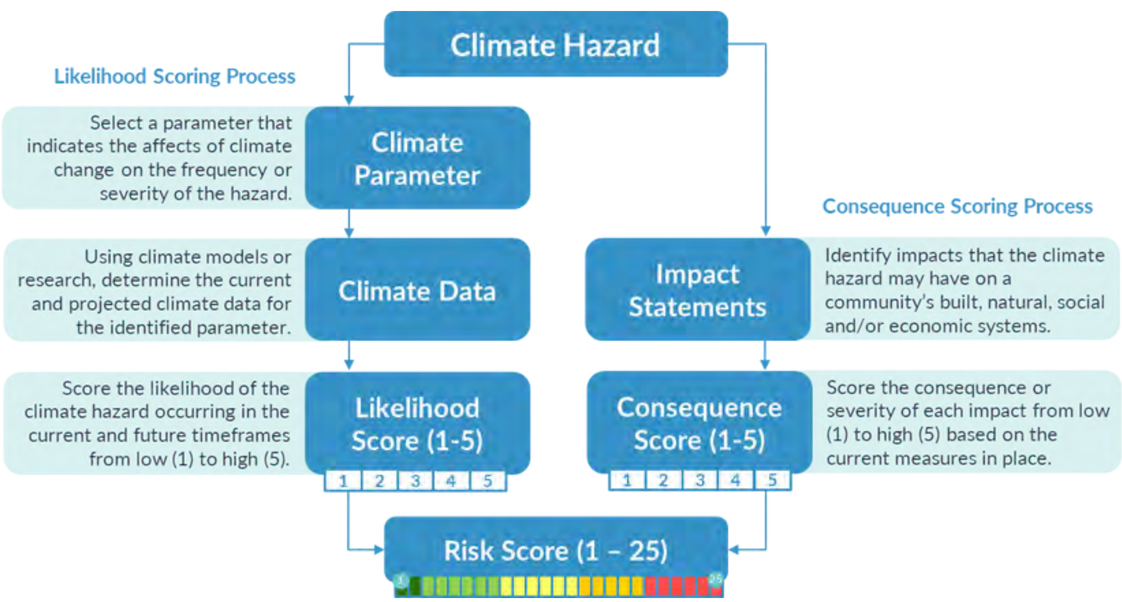
Our project partners at **Associated Engineering's Strategic Advisory Services** have used a blended approach to the risk assessment process used for this project which is based on the **ISO 31000's principles of risk management.** The principles follow a systematic cycle of actions to create and protect the value of the community. Their approach to the climate risk assessment methodology also aligns with 'good practice' methodology including:

Public Infrastructure Engineering Vulnerability Committee (PIEVC) High Level Screening Guide (HLSG) developed by Engineers Canada and assumed by the Institute for Catastrophic Loss Reduction (ICLR), the Climate Risk Institute (CRI) and Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ).

International Standards Organization (ISO) guideline 14092: ***Adaptation to Climate Change – Requirements and guidance on adaptation planning for local governments and communities***, and with the Intergovernmental Panel on Climate Change's (IPCC) latest conceptualization of climate risk assessment methods.

The risk assessment begins by assigning **likelihood** and **consequence scores** for each hazard The scores are then multiplied to get a risk score for each potential impact. The steps are summarized below:

1. **Identify climate hazards applicable for the study area**
2. **Analyse the likelihood of each hazard, or how frequently a hazard may occur**
   - Identify a climate parameter from available climate data which is representative of the frequency and/or severity of each hazard (e.g., number of days above 30 °C, 24 hour 100-year rainfall (mm/hr)). There could be multiple parameters to describe a hazard, but only one is selected to represent the relative change in the hazard over time due to climate change.
   - Collect climate data for a high emissions scenario looking at historic and future (2050s) timeframes and calculate the projected increase or reduction of the likelihood of each hazard. Climate models do not capture all climate hazards, such as forest fire or hail, and therefore alternative data sources (research, national monitoring indices) are used, along with experience and good practice.
   - Agree on a baseline likelihood score (1 to 5) according to historic data and community conversations around the experiences with the hazard.
   - Assign a future likelihood score (1 to 5) according to the calculated change in parameter likelihood.
3. **Analyze the consequences of each hazard** (how severe the impacts will be on the community)
   - Identify the various impacts of each hazard to the built, natural, social, and economic systems within the scope of the assessment.
   - Co-develop with community input consequence scores (1 to 5) for each impact considering severity such as cost of impacts, duration of interruption, significant of health impacts, or resources to respond.
4. **Calculate the baseline and future risk score for each hazard and impact** by multiplying the corresponding likelihood score and consequence scores are summarized below:



Climate Risk Assessment Process Flow Chart

Source: Associated Engineering's Strategic Advisory Services; see appendix D for more details.

Determining Climate Hazards

Selected climate hazards were chosen according to their relevance to the community and project scope at the time of the assessment. Climate hazards are **weather-related, hydrometeorological events** which can cause harm, and may also be referred to as **extreme weather events.**

In terms of climate-related hazards, both **slow-onset (chronic) stresses** and **sudden-onset (acute) discrete events** are discussed in this assessment. The latter tend to be short duration events, that typically last minutes, hours, days, or weeks. These will generally occur irrespective of climate change – though their frequency, intensity, or distribution may alter because of climate change. Examples include windstorms, heavy snowfall events, freezing rain events, wildfire, and temperature extremes. **Slow-onset stresses, in contrast,** are caused entirely by climate change, with impacts unfolding gradually, building up over longer time frames – decades or more. Examples of slow-onset impacts include **warming trends** in air and surface, water temperatures, drought and **ecosystem shifts.**

The assessment considers impacts arising from projected climate and associated environmental changes over at 30-year time period centered around the **2050s**. Projections of future climate change are available for a range of greenhouse gas emissions, concentrations, and radiative forcing scenarios – *Representative Concentrations Pathways* (RCPs).

When assessing climate-related risks it is prudent to consider the greatest plausible change scenario relative to the present, which in practice means working with projected changes for the region under the **RCP 8.5** scenario, i.e., the most conservative of global "limited climate policy" scenarios. The primary justification for using **RCP 8.5** is that it means no risks are missed during the risk assessment. Uncertainties relating to whether the future unfolds along **RCP 8.5** or along a different, lower emission RCP, are managed during the adaptation planning and implementation phase.

Some climate hazards are not adequately captured in global climate models (GCMs) due to spatial scale of the hazard (e.g., hail events) or due to the complexity of the hazard (e.g., forest fire being influenced by multiple factors such as moisture deficit, temperature, winds, etc.).

Where appropriate, additional resources from research or federal datasets are used to inform the relative change in the likelihood or frequency of the hazard over time.

Determining Climate Hazards

Climate Hazard	Parameter	Data Source
Drought	Standardized precipitation evapotranspiration index (SPEI 12)[1]	PARC[2]
Lightning	Annual average number of days with lightning[3]	ECCC[4]; Paquin et al. (2014)[5]
Localized Flooding	15 min 25-year rainfall (mm/hr)	Climate Data[6]
River/Creek Flooding	24 hour 100-year rainfall (mm/hr)	Climate Data[6]
Wildfires	Annual average area burned (ha) within region	Wang et al. (2022)[7]
Wildfire Smoke	Annual average area burned (ha) within region	Wang et al. (2022)[7]
Hail	Annual severe summer hail days	Brimelow et al. (2017)[8]
Freezing Rain	Change in ice accretion (2020-2050)	ECCC[9]
High Winds	Change in annual hourly wind pressure (1/50) (2020-2050)	ECCC[9]
Heavy Snow	Annual winter precipitation (mm)	PARC[2]
Extreme Heat	Annual days above +30°C	PARC[2]
Extreme Cold	Days below -15 °C	PARC[2]
Freeze-Thaw Cycles	Annual # of freeze-thaw events	Canadian Climate Atlas[10]
Eco-region Shift	Biodiversity shift[11]	AdaptWest[12]
Landslides	24 hour 100-year rainfall (mm/hr)	Climate Data[6]
Avalanches	Professional judgement based on research	Bellaire, et al. (2016)[13]
Glacial Recession	Freezing degree days	Canadian Climate Atlas[10]; Science Daily[14]

1 Values range from -5 to 5, with higher numbers indicating higher levels of moisture; a reduction in value indicates an increase in drought conditions.

2 Prairie Adaptation Research Collaborative (PARC) supplied data

3 While no projected values are available, research points towards a slight increase in lightning frequency.

4 Environment and Climate Change Canada (ECCC) (2019), Lightning Activity in Canadian Cities. https://www.canada.ca/en/environment-climate-change/services/lightning/statistics/activity-canadian-cities.html

5 Dominique Paquin, Ramón de Elía & Anne Frigon (2014) Change in North American Atmospheric Conditions Associated with Deep Convection and Severe Weather using CRCM4 Climate Projections, Atmosphere-Ocean, 52:3, 175-190, DOI: 10.1080/07055900.2013.877868

6 Climate Data for a Resilient Canada: climatedata.ca Short-duration Rainfall IDF Data, Version 3.30 (2022-10-31)

7 Wang, Xianli, Tom Swystun, and Mike D. Flannigan (2022). Future wildfire extent and frequency determined by the longest fire-conducive weather spell. Science of the total environment 830 (2022): 154752.

8 Brimelow et al. (2017). The changing hail threat over North America in response to anthropogenic climate change. Nature Climate Change, DOI: 10.1038/nclimate3321

9 Environment and Climate Change Canada (ECCC), Climate-Resilient Buildings and Core Public Infrastructure - An Assessment of the Impact of Climate Change on Climatic Design Data In Canada - Annex 1.2. https://publications.gc.ca/collections/collection_2021/eccc/En4-415-2020-eng.pdf

10 Climate Atlas of Canada: climateatlas.ca

11 Eco-region maps project a shift in ecoregion in the area.

12 AdaptWest – A Climate Adaptation Conservation Planning Database for North America: adaptwest.databasin.org

13 Bellaire, S., Jamieson, B., Thumlert, S., Goodrich, J., and Statham, G. (2016).Analysis of long-term weather, snow, and avalanche data at Glacier National Park, B.C., Canada. Cold Regions Science and Technology. Analysis of long-term weather, snow and avalanche data at Glacier National Park, B.C., Canada - ScienceDirect

14 Science Daily (2005). Most of Arctic's Near-surface Permafrost to Thaw by 2100. Science News. https://www.sciencedaily.com/releases/2005/12/051220085054.htm

Change in Climate Hazard Likelihood

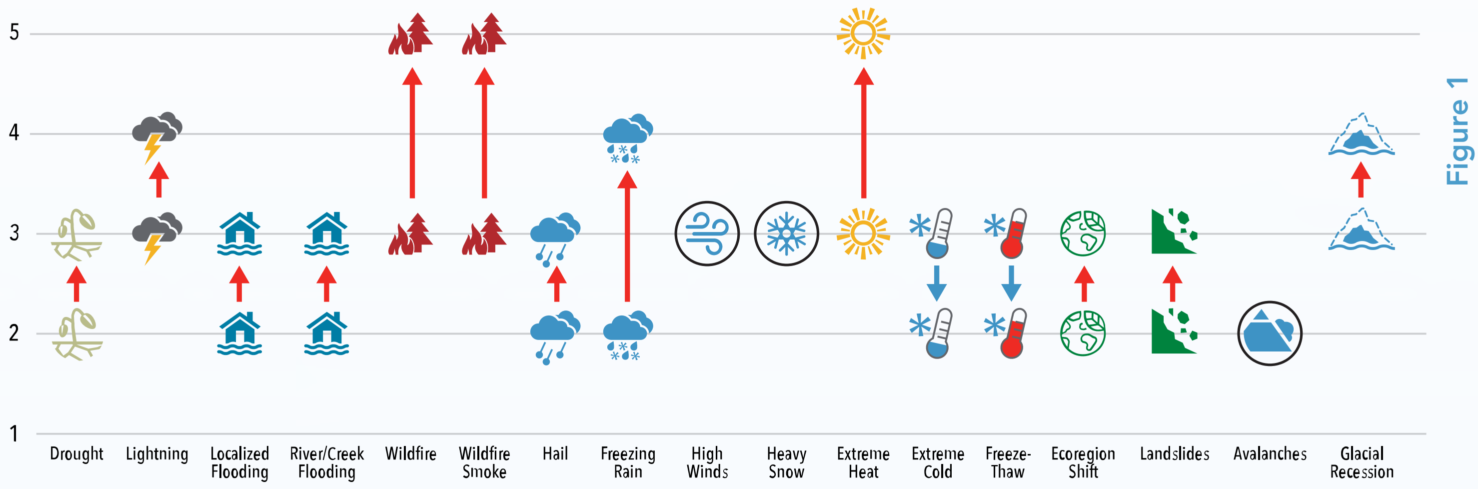


Figure 1: Change in Climate Hazard Likelihood (historic baseline to 2050). Looking at the assessment holistically across all systems, the climate hazards presenting very high risks to the Municipality in the 2050s are wildfire, freezing rain, glacial recession, extreme heat, and wildfire smoke.

Some Final Key Takeaways

- The likelihood of hazardous or extreme events associated with wildfires and wildfire smoke, freezing rain and extreme heat occuring will increase over the next 30 years.
- Though climate projections indicate that there is little to no changes in the frequency or significance (i.e. the likelihood) of heavy snow events expected over the next 30-years, the timing of when precipitation fall is highly unpredictable. As news stories from around the world have been sharing – annual snow and rain could fall in the matter of days rather than spread out over the calendar year.
- Tourism operators that depend on snow, as Marmot Basin, can could face shorter winter seasons due to precipitation falling as rain – or not falling at all.
- Ongoing and continuing glacial recession could create diverse impacts for the Municipality and tourism businesses, including reducing the availability or quality of drinking water, impacting access for glacier tours or viewing for tourists, and contributing to a drying landscape and droughts.

Understanding Climate Hazard Risk

Climate Impact Consequence

Not all impacts have the same severity of consequence and therefore each impact is assessed individually through the risk assessment process. Different criteria are used to assess impacts to built, natural, social, and economic systems as shown in the consequence rubric, with a high or more severe consequence scored a **5** and a lower severity a score of **1** (see Appendix D). Recognizing that some impacts affect multiple systems, consequences were scored looking at multiple criteria where necessary. The final consequence score given indicates the highest consequence score across all criteria for the considered impact.

Consequence scores were co-assigned with community input considering the level of consequence that is expected to be seen from the climate hazard given the current understanding of the hazard.

Assessing Impact Likelihood

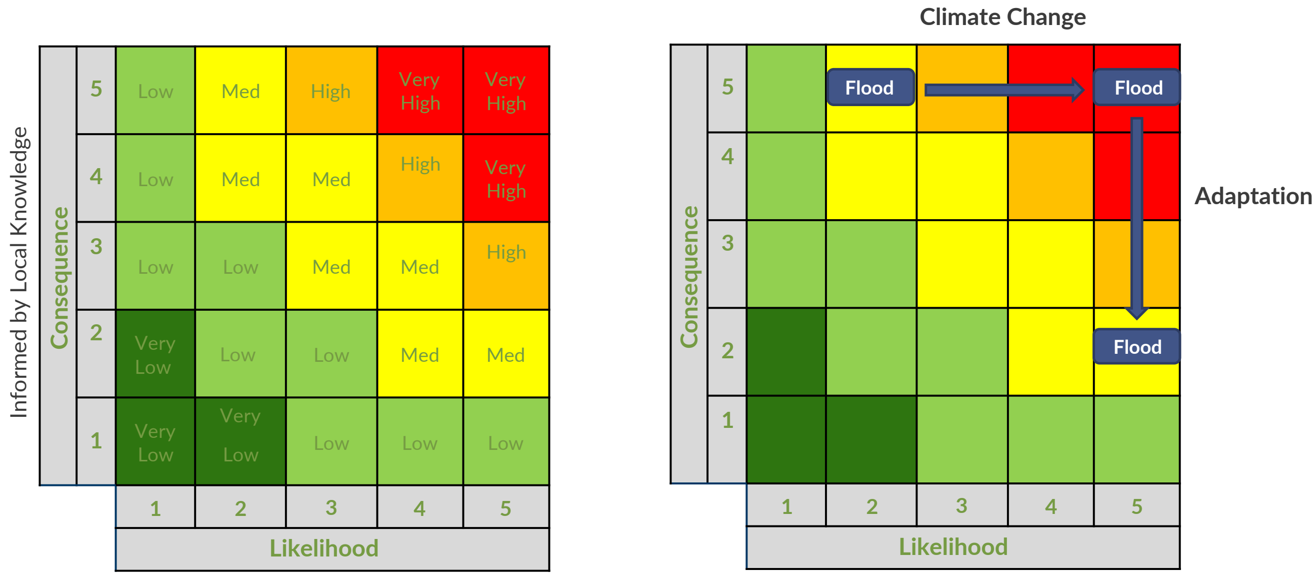
Likelihood scores were assigned for the **historic and future (2050s) time horizons** according to climate parameter trends, with increasing/decreasing values reflecting increasing/decreasing occurrence or severity over the time horizon. Climate projections consider a high-emissions scenario, with the earth reaching **2 degrees of global warming in the mid to late 2050s.** Translation into likelihood scores normalizes the various climate change trend measures into a common numerical ranking. These scores allow for both **qualitative** (collective judgement) and **quantitative** (data informed) translations into likelihood score values. In alignment with **PIEVC Protocol** for climate risk methodology, a baseline approach was used to assign the historic likelihood scores based on feedback in workshops to date with the following assumptions:

A historic likelihood score of 2 **...indicates that, while the climate hazard may be occurring, it does not cause recurring issues or significant concern for the community at this time;**

A historic likelihood score of 3 **...indicates that the climate hazard is already a problem for the community and impacts have been experience a number of times in the recent past.**

A single climate parameter was selected for each hazard to represent the change in likelihood. Some hazards such as high winds, heavy snow, and forest fires are complex with several contributing factors not captured within available climate modelling and projections. In these cases, a climate parameter was selected that was considered to **most represent the hazard in context of the impacts.**

Where representative climate parameters or projected data were unavailable, scores were assigned based on available research, studies and good practice.



Climate Risk Assessment Heat Map

Source: Associated Engineering's Strategic Advisory Services; see appendix D for more details.

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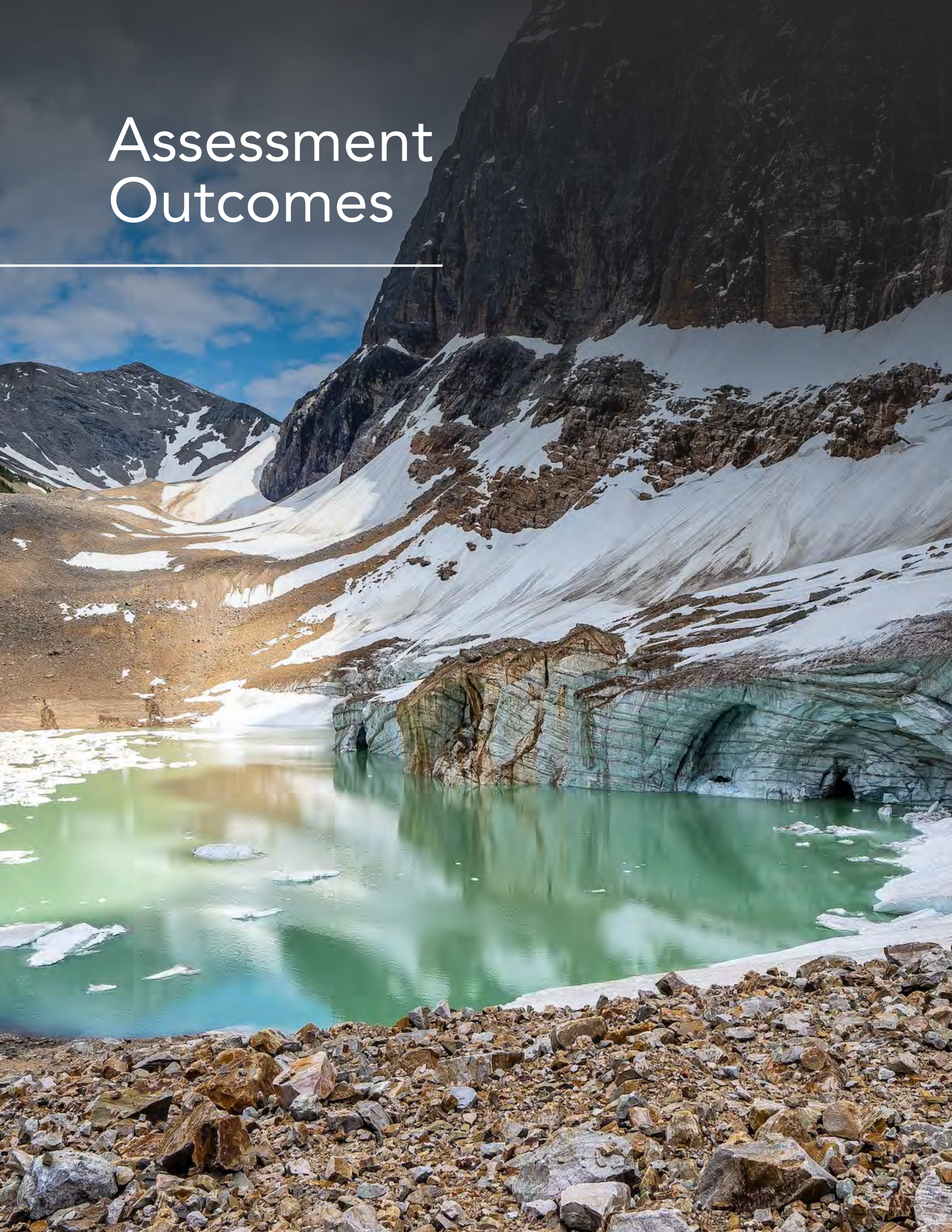
Community Engagement Process

1. **Initial engagement** with community leaders to agree scope.
2. **Desktop review** of existing community plans and assessments, and any local data sources.
3. **Engagement with community leaders** to confirm scope, discuss desktop review, and agree on climate hazards.
4. **Climate data modelled** and project data calculated.
5. **Draft risk likelihood scores calculated** and shared with community leaders.
6. **Draft risk consequence rubric created** and initial impact statements drafted, and shared with community leaders.
7. **In-person visits to the community** for discussions with diverse members of the community. **Meetings held.**
8. Additional **virtual discussions with individual community members** held for those unable to attend in person meetings (optional).
9. **Likelihood scores, consequence rubric, and impact statements** agreed to based on community feedback.
10. **Draft scoring of impact statement consequences** sent to community for review.
11. **Review of feedback** on draft impact statement consequence scores by project team.
12. **Draft final report** shared with community leaders.
13. **Final report** submitted.

Assessment Outcomes



Key Findings and Recommendations

"Jasper broke an 80-year-old record Friday, recording a high temperature of 9.0 C beating the old record of 8.9 C."

Global News, December 23, 2023

This climate risk assessment considers the impacts on different 'systems' that make up the Municipality of Jasper. Importantly, community resilience benefits from considering climate hazards as a system too, and one where singular climate hazards are interconnected. For the Municipality of Jasper, many hazards will see an increase in how likely they are to occur between historical data and 2050s projections.

The largest shifts in hazard likelihood are for wildfires, wildfire smoke, precipitation (including winter precipitation events based on PARC data), and extreme heat (days above 30°C). Glacial recession is particularly noted by Associated's risk assessment. There are also significant implications for flooding as will be discussed. However, many of the risks and potential impacts of these climate hazards are driven by an overarching increase in extreme heat likelihood. Within in this assessment, TRI consider's extreme heat as a key driver, and the trunk of the climate hazard tree, with all other climate hazards associated as branches.

Extreme Heat

Daily mean temperatures in every season are expected to increase over this century. Figure 2 (below) shows that while daily mean temperatures will increase throughout the year, the greatest increase will be in summer. In the 1950s daily mean temperatures for summer months (June to August) were on average around 10°C. Based on PARC data, by the 2090s, this average is expected to increase to 16°C; an almost 40% increase in summer daily mean temperatures.

The health impacts of extreme heat were identified as a very high risk. Extreme heat can result in heat-related illnesses (e.g., heat stroke) and even death in some cases. Elders, children, people who are pregnant, and people with medical conditions are all vulnerable populations at greatest risk of heat-related discomfort and medical issues. During the community engagement, it was noted that there are many people without access to air conditioning (AC). People in Jasper enjoy spending time outdoors, and they recognized that extreme heat is the number one risk to social systems is critical.

Spending time in nature and enjoying outdoor recreation is the core offering of Jasper tourism. The increase in days above 30°C may result in less people spending time outdoors and enjoying the natural environment. Extreme heat related health emergencies and impacts to vegetation/wildlife can make the area less appealing thus reduce the enjoyment and tourism quality.

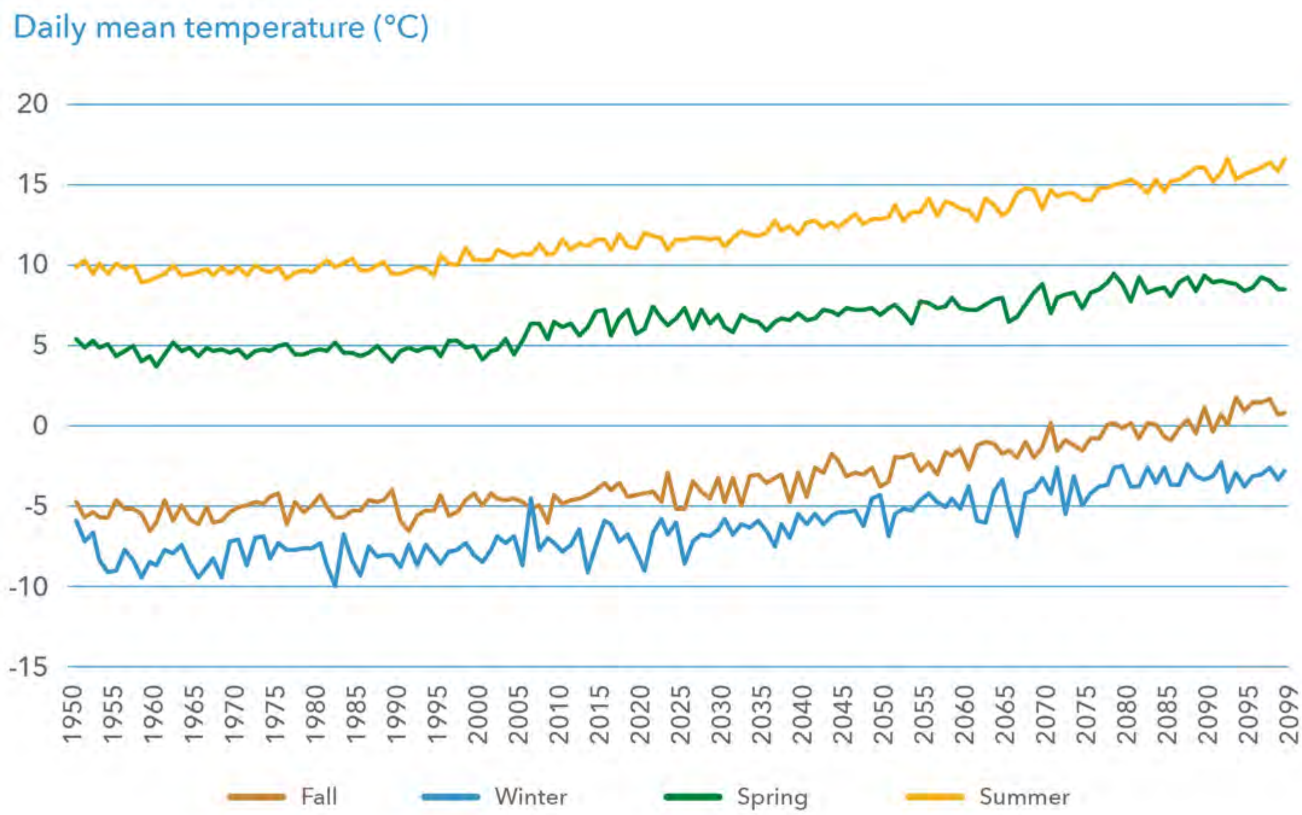


Figure 2

Figure 2: Seasonal daily mean temperatures (°C) each year for historical (1950s) to future projections (2099). Data provided by PARC, and not included in Associated's risk assessment.

Alongside a projected general warming trend, the number of hot days and consecutively hot days are expected to increase (see Figure 3 and Figure 4). Extreme or hot days are described as days with a daily mean temperature of 30°C or more. Note that this is the average temperature of the whole day, not just the hottest time of a day.

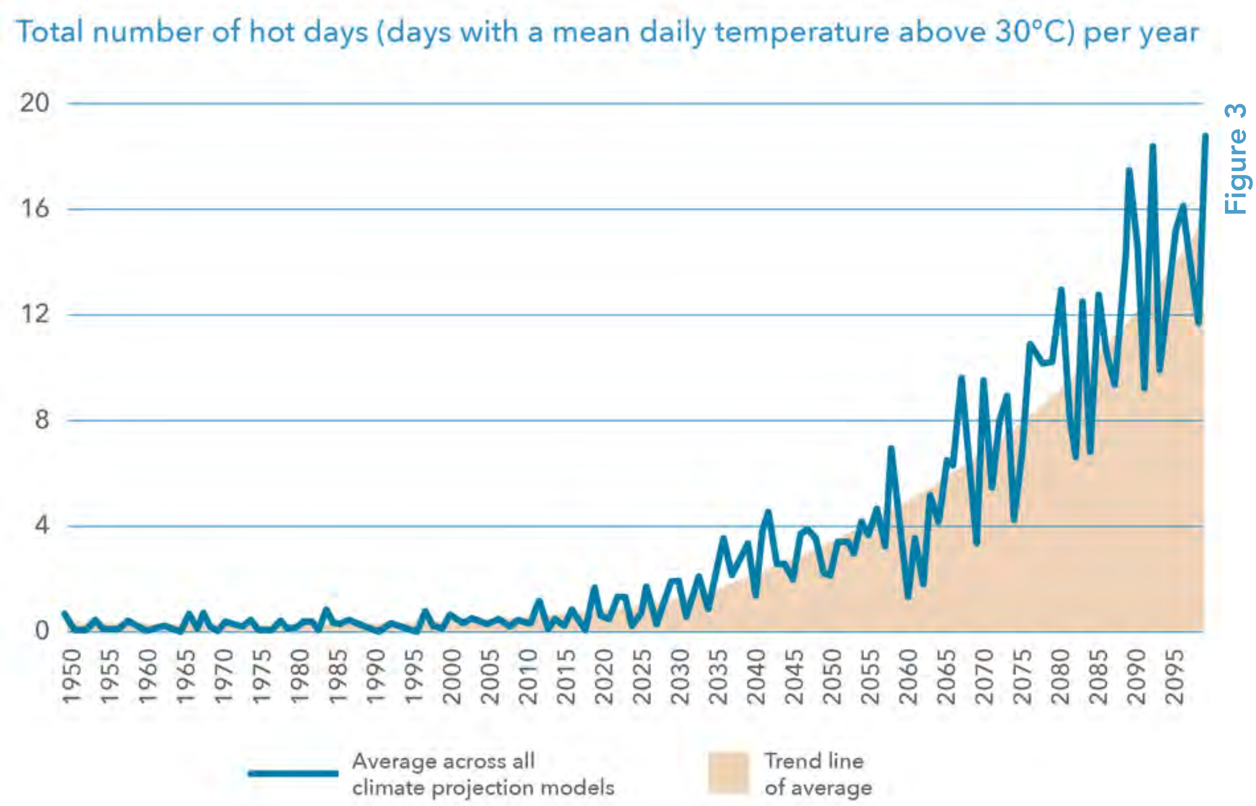
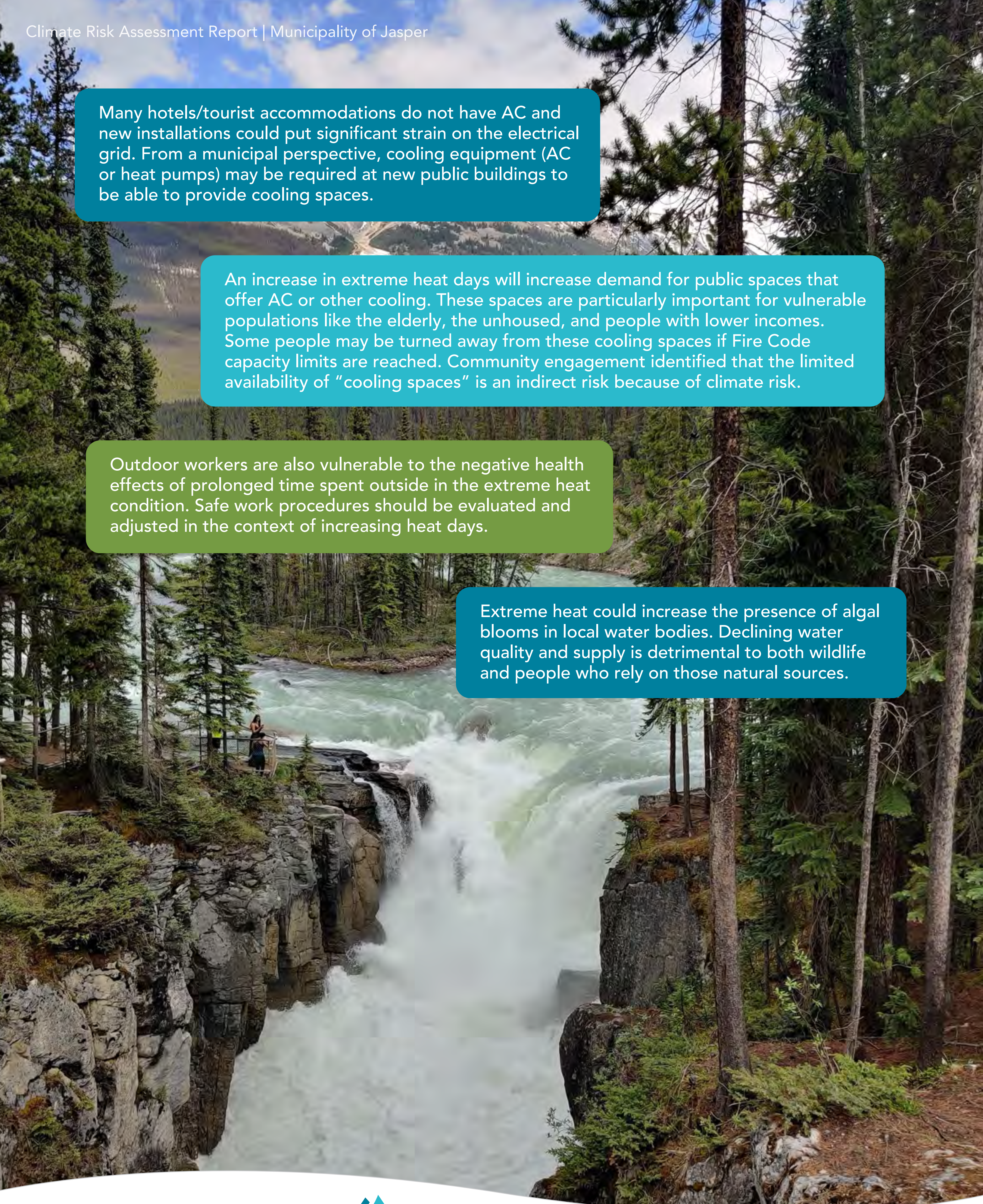


Figure 3: The total number of hot days (days with a daily mean temperature of 30°C or more) per year. In the 1950s each year would, on average, have one hot day. By the end of the century this number is expected on average to reach twenty-one hot days. (Data provided by PARC)



Many hotels/tourist accommodations do not have AC and new installations could put significant strain on the electrical grid. From a municipal perspective, cooling equipment (AC or heat pumps) may be required at new public buildings to be able to provide cooling spaces.

An increase in extreme heat days will increase demand for public spaces that offer AC or other cooling. These spaces are particularly important for vulnerable populations like the elderly, the unhoused, and people with lower incomes. Some people may be turned away from these cooling spaces if Fire Code capacity limits are reached. Community engagement identified that the limited availability of "cooling spaces" is an indirect risk because of climate risk.

Outdoor workers are also vulnerable to the negative health effects of prolonged time spent outside in the extreme heat condition. Safe work procedures should be evaluated and adjusted in the context of increasing heat days.

Extreme heat could increase the presence of algal blooms in local water bodies. Declining water quality and supply is detrimental to both wildlife and people who rely on those natural sources.

Animals are on the move

Extreme heat can also result in heat stroke, death, inability to forage, and/or reduced weight gain for wildlife, and changes in behaviour as they try to adapt. Changes could include different habitat range, active hours (e.g., hunting/grazing during cooler periods), and/or more frequent human-animal interactions when seeking alternative food and water sources. Community members have already observed more bear activity and wildlife encounters, so awareness of the potential for more interactions is very important.

Around the globe they are moving to higher regions and hunting patterns are changing in response to prey also moving. Reasons for this include seeking food and water as climate change is impacting growing seasons and viability, and heat stress. For the protection of residents, visitors, and animals, the Municipality should ensure it updates its policies to reflect this risk.

"We ended up with this persistent high pressure bringing a lot of consistent warm air especially for the month of August."

Jasper Fitzhugh, Sep 6, 2022

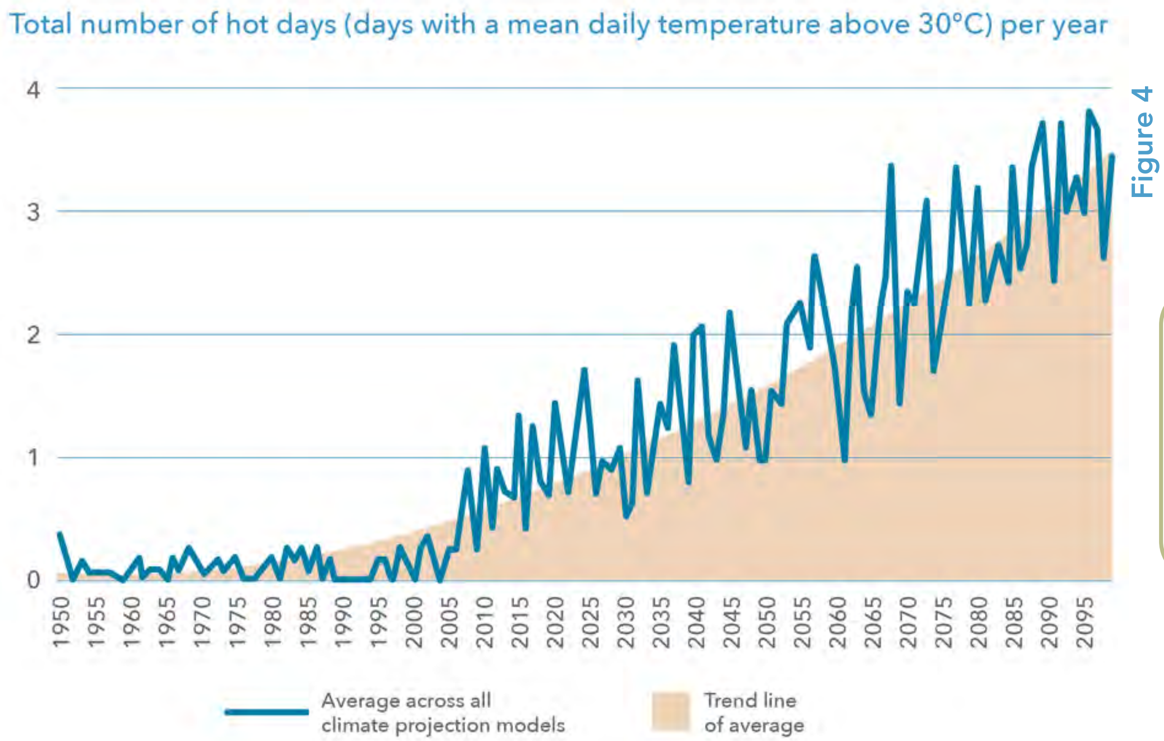


Figure 4: The total number of consecutive hot days (days with a daily mean temperature of 30°C or more) per year. In the 1950s each year would, on average, have zero consecutive hot days. By the end of the century this number is expected on average to reach four consecutive hot days i.e. periods of three hot days back-to-back. (Data provided by PARC)

Spending time in nature and enjoying outdoor recreation is the core offering of Jasper tourism. The increase in days above 30°C may result in less people spending time outdoors and enjoying the natural environment. Extreme heat related health emergencies and impacts to vegetation/wildlife can make the area less appealing thus reduce the enjoyment and tourism quality.

Up until this point, recreation spaces and amenities (e.g., sports fields, pathways, campsites) have not been designed with future heat extremes in mind. While Jasper is fortunate to have natural cooling via the forest, this alone is insufficient to provide relief to those spending time outdoors during peak heat. Vulnerable populations (children, elderly) may require cooling supports (e.g., misters) beyond what the ecosystem can naturally offer.

Glaciers and Jasper

Glacial melt can lead to ponded water on the surface of the glacier and can enlarge into a dam-like feature. Release of this melt water could behave like a dam break event with a sudden release of water flowing into surrounding areas. Infrastructure on the downstream side of a glacier may be damaged or flooded due to this melt. In extreme cases, the rapid release of water has the potential to damage houses, wipe out transportation infrastructure, and pose serious public health and safety concerns. Engagement did not identify specific pieces of infrastructure that are at-risk due to glacial recession. However, roadways that support tourism to the Columbia Icefield and Mount Edith Cavell would likely be one of the first built assets to be affected given their proximity to the glaciers.

A large ice break and water release was seen in the area as recently as 2012. The Ghost Glacier collapsed, dropped ice into the Cavell Tarn, and caused massive waves that washed up a parking lot. Floodwaters were released and travelled kilometers downstream, damaging natural and built infrastructure along the way.

Glaciers serve as an important raw water source for both the Municipality and downstream communities. The miette valley (west to the Park border) is the main recharge zone for the Municipality's aquifer Glaciers contribute to groundwater volume as well as surface water baseflow. Baseline water supply will decline as glaciers recede and are not replenished at the same rate. In the long term, this could lead the Municipality to require other raw water sources. The Municipality has not had to implement mandatory water restrictions up to this point. However, it was noted that if restrictions were required, commercial use would be of greater concern than residential use due to the scale of water needs (commercial use accounts for 70% of water use in the municipality).

Glacier tours are an important part of Jasper's tourism industry. The Columbia Icefield is a major tourism draw, with international tourists booking well (years) in advance. Glacial recession will impact the scale and quality of the glaciers and has the potential to permanently disrupt this type of tourism. For example, there could be a decline in registrations for the Columbia Icefield Adventure, fewer visits to the Skywalk, and lower food and beverage sales. The Glacier View Lodge could also see lower occupancy or be forced to reduce rates if there is less attraction to staying in the Icefield (i.e., views are not as nice as people have become accustomed to).

Freezing Rain

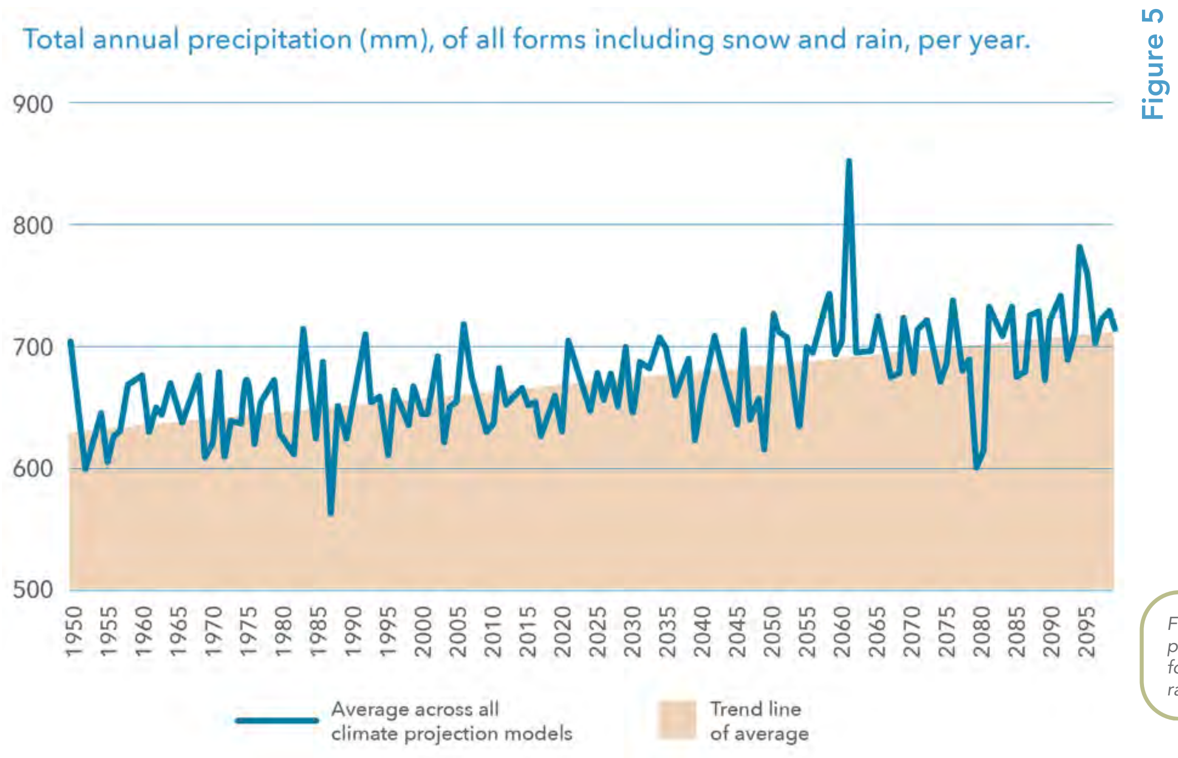


Figure 5: Total annual precipitation (mm), of all forms including snow and rain, per year.

The community engagement noted that there are three roads that offer ingress/egress. Highway 93 (from Banff) was noted as a particularly important corridor, and that dangerous conditions or road closures could lead to traffic delays and challenges reaching tourism sites. When Highway 93 is closed for avalanche control (typically 2-3 days' notice), it can more than double the travel time between Jasper and Banff/Calgary. There is also concern that there is insufficient local organization to coordinate the use of alternative routes.

Freezing rain can result in dangerous driving conditions. These hazardous driving conditions could lead to a large-scale collision or incident, potentially resulting in injury or death for many. Visitors could be concerned about the safety of roadways and avoid Jasper due to these dangerous conditions. The roads may need to be closed in certain cases of freezing rain to reduce the risk of driving during dangerous conditions.

Freezing rain can create dangerous road/sidewalks conditions. There is also a risk that visibility will be reduced, depending on the intensity of the rain. These factors may lead to an increase in vehicle collisions, and/or damage to transportation infrastructure (e.g., signage). Health care facilities could also see additional slip-related injuries.

A Note On Flooding

"The highly variable rain rates and enormous spatial variability makes determination of mean precipitation difficult, let alone how it will change as the climate changes"

Intergovernmental Panel on Climate Change (IPCC)

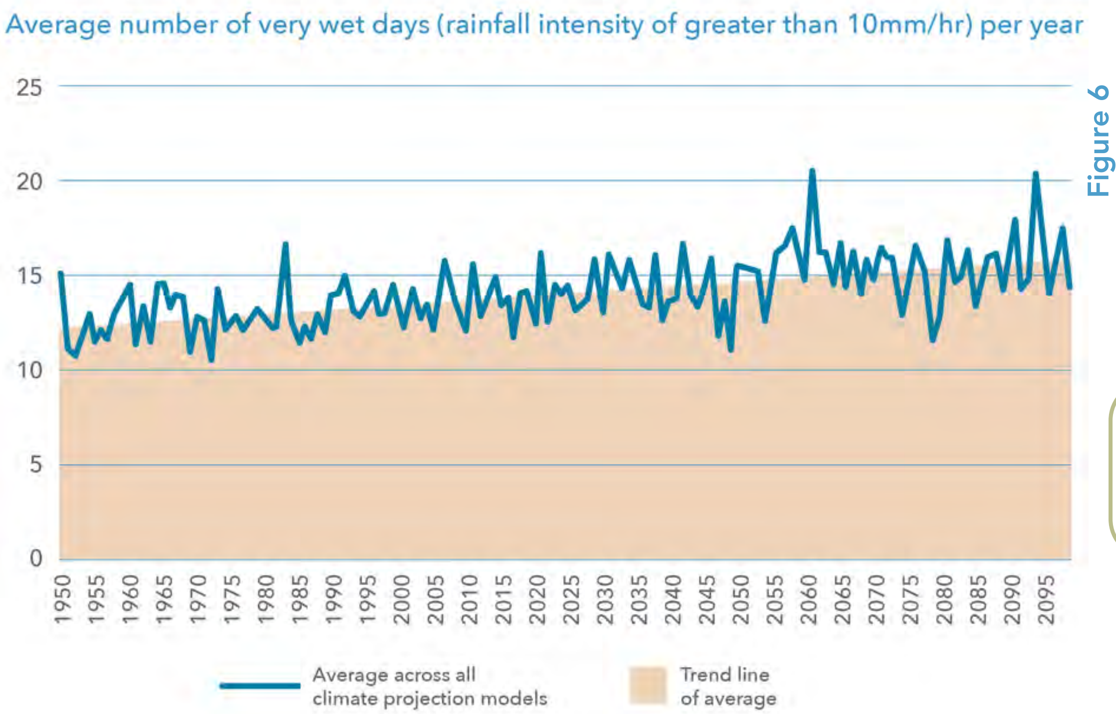


Figure 6: Average number of very wet days each year for the Municipality of Jasper. A very wet day is characterised as having a rainfall event with a rainfall intensity of greater than 10mm per hour. Data provided by PARC and is separate from data used in Associated's risk assessment

Municipal leadership and Jasper residents shared the challenges associated with localised, or overland, flooding. This type of flooding is caused, in most instances, by rainfall of an intensity greater than the capacity of the stormwater management system's ability to absorb and distribute it. This information is provided in addition to Associated's risk assessment to directly address a community concern. Figure 6 shows an approximate 10-15% increase in very wet days over the years before the end of the century, but with the following conditions:

- Precipitation in general is quite difficult to predict due to its variability and geographical spread. Figure 6 shows the average number of very wet days each year as a mean across all climate models used in this report. Also included in the graph are the most extreme and most conservative model projections. While a general trend of increasing very wet days is true for all models, there is certainly the expected amount of variability in precise numbers.
- Precipitation for the Municipality of Jasper is projected to increase annually over the next 30 years, but with some seasonal variation included. For example, the increase in winter precipitation is greater than that for summer.
- Very wet days are projected to increase by 10-15% annually, which means that Jasper's rainfall with increase generally overall, but characterised by more frequent significant and/or rainfall events that increase the risk of localised flooding.

[15] https://archive.ipcc.ch/ipccreports/tar/wg1/276.htm#:~:text=The%20highly%20variable%20rain%20rates,change%20as%20the%20climate%20changes

Wildfires & Wildfire Smoke

An online community engagement survey, facilitated by the Municipality of Jasper, was used to support this project. Results showed that respondents were most concerned with wildfire out of all climate risks. However, discussions with the Municipality of Jasper and Parks Canada noted that the public may be more fearful than warranted due to strong fire management practices in place. A draft consequence score of "5" was originally proposed for this hazard, but it was reduced to a "4" after reviewing the extensive work already being done to reduce the impact of wildfire.

A wildfire in the municipality could damage infrastructure, which may require significant repairs or full replacement depending on the extent of the damages. Community member homes and other private property could be impacted damaged or destroyed. Critical (water treatment, medical, etc.) and less critical buildings and facilities (library, school) are also at risk.

With the recent wildfire experienced in 2023, the risk of power outages was a recurring theme throughout discussions with community members, mainly the inability to keep critical infrastructure in service. The backup power that some facilities have currently (e.g., wastewater treatment plant and emergency services building) may be insufficient if there is an extended outage (i.e., backup generators may only be able to supply electricity for days, not weeks). Municipal staff feel that they are prepared to keep critical water and sewer services operational. Parks Canada did not identify wildfire-related power outages are as a priority impact because they view that utility companies have responded appropriately during previous fire events. Community members spoke about their experiences with previous utility outages even though if is not impacted by wildfire.
Lost of habitat due to wildfire could induce local ecosystems change. While ecosystems will adapt, the length of time to recover and the types of species that will stay in the area will depend on the extent of damage.

Water quality will decline with soil erosion, ash, and contamination from fire fighting agents. Chemicals from fire retardant can increase chemical levels in soil and water, such as phosphate, nitrate, and nitrite. Wildlife would have negative health impacts associated with consumption of contaminated water.

Wildfires in the region could result in residents being displaced from their homes, either temporarily or permanently. The length of time and number of residents displaced will depend on the extent of the fire. A large-scale evacuation would require a corresponding amount of emergency housing and transportation logistics, with additional supports made available for vulnerable populations. The stress of fire damaging or destroying property, the need to evacuate, and fear for the health and safety of loved ones may negatively impact mental health. The community expressed that there is chronic stress/fear associated with previous fires and growing pine beetle populations that exacerbates risk.

During the community engagement, it was noted that wildfires pose a risk of creating a long-term negative perception of Jasper as a tourist destination. International tourists often book trips years in advance, so media coverage of wildfires can impact the long-term economic performance of the area. Demand for camping may drop off if sites are inaccessible or there is an increase in fire bans. Visitors may also be concerned about last minute trip cancellations or mandatory evacuations. As Jasper prides itself for outdoor activities throughout the year, poor air quality from fire smoke would reduce interest in these activities as well as events closure or postponement. The investment of time and resources to various events and activities will be reduced, thus reducing the economic and social opportunities.

Interviews with the Parks Canada staff revealed that there are already extensive FireSmart practices underway, two firefighting teams based in Jasper, and proactive monitoring done to reduce wildfire risk and respond when needed. Parks Canada is the sole authority for the FireSmart program and updates Jasper residents throughout the year. These actions reduce the potential consequence of a wildfire on Jasper. Parks Canada expressed that the actual risk of fire is less than the public perception. Regardless, the long-term success of Jasper's tourism sector will be affected by people's thoughts, feelings, and impressions of wildfire risk which should be considered in education and communication.

Increased and/or prolonged exposure to wildfire smoke could impact the respiratory wellbeing of residents, particularly for those who are elderly or with certain medical conditions (e.g., asthma). Due to the recent wildfire event, the community expressed high concerns for future recurring events. The community noted that smoke events will never be just isolated to Jasper, and smoke will remain a top concern in the community due to its impact on health and daily life.

A note on lightning

Conversation with community members identified that that 2022 Chetamon fire was started by a lightning strike. Some tourism operators were also identified as being at a higher risk from lightning events. Information is provided here separate to the risk assessment.

Data present in this assessment draws a distinction between number of days in a year when a lightning strike could occur versus the intensity of any lightning event. The same is true for hailstorms, and equally wind events such as tornadoes.

The number of days in a year is a measure of the frequency of lightning or hail events. Whereas intensity is the rate in terms of number of hailstones and lightning strikes per minute. Challengingly, this latter type of data is rare, and so not incorporated in this assessment.

In general, the shorter the duration and greater the intensity, the more difficult it is to monitor and model, and thus there also is very little known abut tornadoes in a changing climate. Models do not simulate tornadoes or generate tornado data. Understanding of risk likelihood for this assessment are made from other conditions (temperature and air pressure gradients) that are associated with these intense storms.

Extreme Cold & Freeze-Thaw Days

- Municipal leadership and community members identified that Jasper is experiencing more extreme cold days (described in this report as days with a mean daily temperature of minus 30°C or colder) and that periods of extreme cold are lasting longer.
- The local Fitzhugh reported on Jan 14, 2020, that at 9 a.m. it was -44.8 degrees Celsius in Jasper with a wind chill of -52°C.
- The previous coldest January 14 was in 2005 at -35.7°C, and similar cold periods occurred in 2022.
- Municipality of Jasper plans for temperatures in Jasper to fluctuate between minus 40°C and plus 40°C on an annual basis.

- This information is provided separate to the risk assessment provided by Associated.

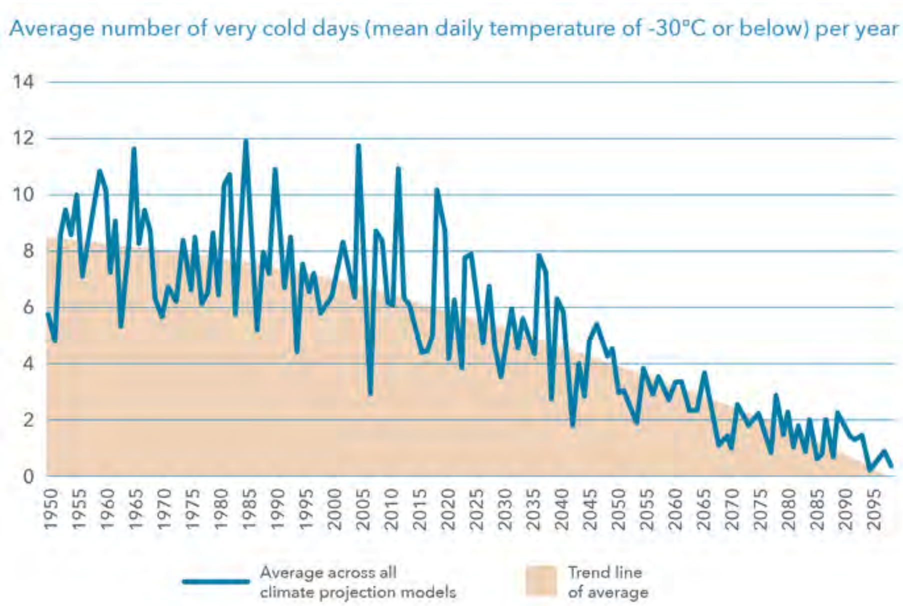


Figure 7

Figure 7: Average number of very cold days (mean daily temperature of minus 30°C or below) per year.

> *"Freeze Thaw cycles causes most infrastructure damage and failures."*
> Municipality of Jasper

- Based on the PARC climate projection data, Figure 5 shows that by the end of the century, Jasper can expect to have zero days with a mean daily temperature of minus 30°C or colder.
- In the 1950s, the average year would expect to have 8-9 extreme cold days.
- 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 minus 1 °C.
- Municipal leadership staff, particularly Public Works identified that freeze-thaw cycles are a significant risk to public infrastructure. This is especially true for energy and water infrastructure.

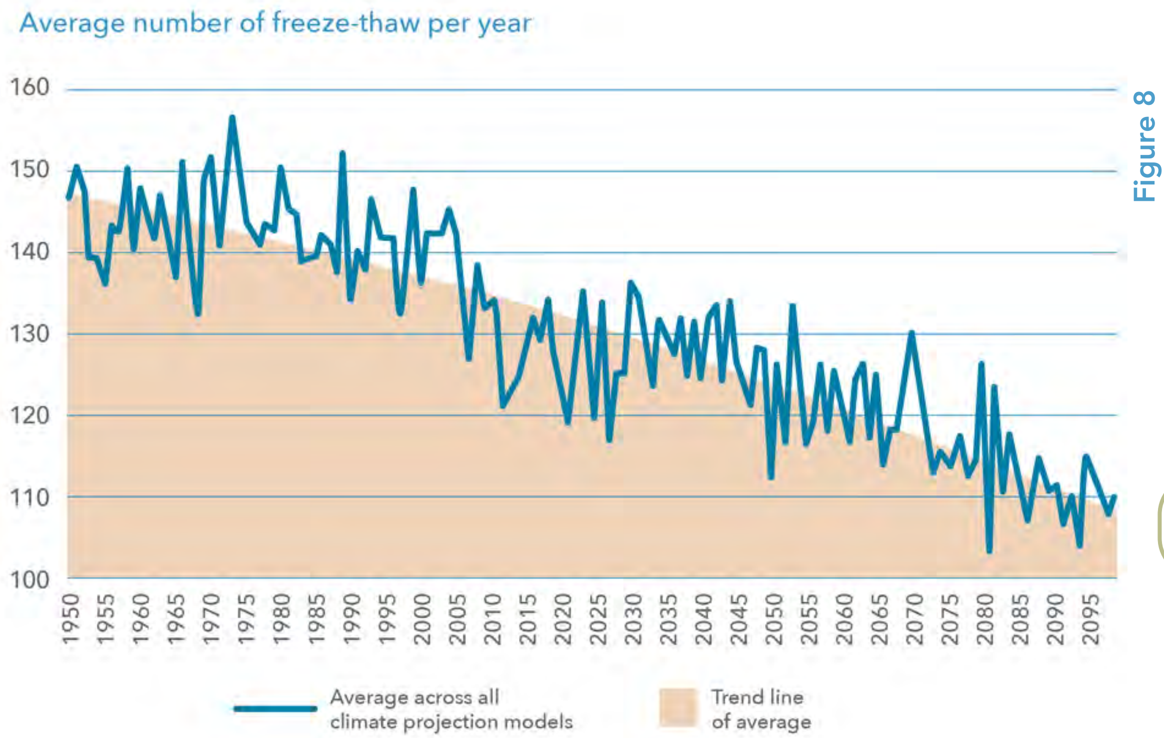


Figure 8: Average number of freeze-thaw days per year based on PARC data

- Over the next 30-to-75-year, Jasper is projected to experience a 13% reduction in freeze-thaw days. Additional data from PARC is used in this determination.
- For both extreme cold and freeze-thaw days, it is important to understand, that the climate projection data used in this assessment is based on daily averages, that are then (in some instances) averaged over years.
- While this will capture general trends, it will not account for the extremes and erratic events that are also to projected to occur within a changing climate.
- As the data has shown it is very possible to experience a significant extreme cold spell, lasting many days, within a general reducing cold weather trend.
- Information provided here for context, and is outside of the risk assessment provided by Associated.

Appendix A: Glossary of Climate Change Terms

Addressing Climate Change

There are two complementary courses of action to address climate change. Good climate change planning includes **both mitigation and adaptation strategies.**

Mitigation

One course of action targets the causes of climate change and seeks to **reduce the amount of greenhouse gases** (GHGs) that are released to the atmosphere as the result of human activities; for example, by reducing energy consumption in our homes or vehicles, or reducing the GHG-intensity of the energy we use. This is called climate mitigation.

Adaptation

A second course of action targets the impacts of climate change and seeks to **enhance our resilience** to changing climate conditions, enabling us to **better cope with and manage risks**, as well as take advantage of opportunities that arise. This is commonly referred to as climate adaptation.

Key Terms and Concepts

Adaptation (actions)

Deliberate actions by communities in response to current or expected climate phenomena, which moderate potential harm or take advantage of beneficial opportunities. Actions can include monitoring, research, and other information gathering, education and capacity building, changes to infrastructure, creating new policies and regulations, developing economic and other incentives, and ensuring governance takes into account climate change. Adjusting to actual or expected climate impacts to reduce negative effects on people, society, infrastructure, and the environment.

Adaptive capacity

The capability of a community to moderate potential harm, to take advantage of opportunities, or to cope with the consequences from current and expected climate phenomena. The adaptive capacity of individuals, households and communities is determined by their access to, and control over, human (e.g., awareness of climate risks), social (e.g., healthcare), physical (e.g., irrigation infrastructure), natural (e.g., reliable raw water supply) and financial (e.g., savings) resources.

Adaptation planning

The collection of participatory activities and steps undertaken to moderate potential harm or to take advantage of beneficial opportunities from climate phenomena.

Climate

Climate and weather refer to separate things. Weather describes atmospheric conditions (such as temperature, humidity, precipitation, wind, cloudiness) in a place or region in the short-term – usually, hour-to-hour, day-to-day, and even weeks to months. For example, Medicine Hat may have a particularly hot day, wet week, or warm winter. Climate refers to the average of weather conditions over 30 years or more. When describing southwest Alberta as typically windy, you are describing an aspect of its climate. Weather can change dramatically in a place or region from day-to-day (e.g., hot, and dry one day, followed by cold, wet conditions the next day). Climate, in contrast, changes more slowly since it represents the average weather over the long-term.

Climate change

A change in climate (average weather patterns) that lasts for an extended period. Climate change includes significant changes in average annual and average seasonal temperature or precipitation patterns in, say, central Alberta, that persist for decades or longer. Climate change also refers to long-term changes in the variability of climate. Climate change arises from human activity (i.e., greenhouse gas emissions) that alters the composition of the atmosphere, over and above what would be expected with natural climate variability.

Climate extremes

Weather extremes viewed over seasons (e.g., drought or heavy rainfall over a season), or longer periods. Weather extremes are individual events that are unusual in their occurrence (at a minimum, the event lies in the upper or lower tenth percentile of the distribution) or have destructive potential, like tornadoes, strong wind gusts, short-duration high-intensity rainfall events, etc.

Climate phenomenon (also called climate parameters)

An atmospheric condition or related hydrologic process that results in a specific set of generally known, or characterizable, impacts. Climate phenomena include both (rapid onset) shocks, such as heat waves, drought, lightning strikes, freezing rain, tornados, strong winds, heavy snow, hail, low flows in rivers, short duration intense rainfall, flooding, and (slow onset) stresses, such as changes to seasonal temperatures and rainfall patterns. Climate change may affect the character, magnitude and likelihood of specific climate phenomena occurring in a place.

Climate variability

Average weather patterns show variation within short timeframes (e.g., a month, a season, one or more years). For example, this year may be significantly drier than an average year in Alberta, whilst the preceding couple of years may have been slightly wetter than the average year. Climate variability refers to these deviations – or anomalies – from the average. The term "natural climate variability" refers to variability in the climate that is not attributable to, or influenced by, any activity related to humans.

Co-benefits

The added benefits of adaptation, over and above the benefits of moderating potential harm or exploiting potential opportunities that arise from current and expected climate conditions. For example, the increased use of distributed energy technologies to provide electricity not only reduces a community's vulnerability to power outages by diversifying supply, but it also reduces emissions of greenhouse gases (contributes to climate mitigation goals) and increases job opportunities (contributes to economic development goals). Co-benefits can often be at least as equally important as the direct benefits of adaptation.

Community

A group of Indigenous people who are linked by social ties, share a common identify and geographical locations or settings, and on this basis, engage in joint action. People who are, or perceive themselves to be, affected by a decision, strategy, or process. A community partner can be an individual, an organization or a group within an organization. Community partners can change at different stages in a process.

Consequence

The result or effect from climate impacts to people, society, infrastructure, or the environment.

Exposure

Exposure refers to people, livelihoods, buildings, infrastructure, cultural assets, environmental resources, and services, etc. being in places where they could be affected by climate phenomena. Communities in semi-arid regions, for example, may be exposed to drought and water shortages.

Greenhouse gas

A greenhouse gas (GHG) is a compound found in the Earth's atmosphere – for example, carbon dioxide, methane, water vapor, and other human-made gases. These gases allow solar radiation to enter the atmosphere and strike the Earth's surface, warming it. Some of this energy is reflected towards space. A portion of this reflected energy, however, bounces off the GHGs, and becomes trapped in the atmosphere in the form of heat. The more GHG molecules there are in the atmosphere, the more outgoing energy is trapped, and the warmer the Earth will become.

Hazard

A climate phenomenon that has the potential for causing harm to a community. A special type of hazard that is (at least partially) caused by climatic drivers, e.g., drought, high winds, extreme heat, etc. A potential source of harm.

Impacts

Adverse or beneficial effects on communities. For this Guide, impacts result only when a community is exposed to a climate phenomenon, to which that community has inherent vulnerabilities. An estimate of the harm that could be caused by an event or hazard.

Likelihood

The probability or chance of a hazard occurring, and how this likelihood changes in the future due to climate change.

Livelihoods

The capacity (capabilities, resources, and activities) of a community and its residents to generate and sustain their means of living, enhance their well-being, and the well-being of future generations. Livelihood resources include human, natural, social, physical, and financial capital. Livelihood activities include agriculture, trading, formal employment, etc.

Maladaptation

Maladaptation describes adaptation actions taken to reduce vulnerability to climate change that increase, rather than decrease, the vulnerability of a community. Maladaptation may occur when actions increase the vulnerability of people, groups, or sectors, increase GHG emissions, increase inequity in the community, decrease incentives to adapt, or place limits on the ability of future generations to adapt.

Mitigation

An action that will reduce or prevent GHG emissions, such as using renewable energies like wind and solar, making buildings, vehicles, and equipment more energy efficient, and walking or cycling from time to time instead of using a car. It can also include planting trees to absorb and store carbon dioxide from the atmosphere.

Sensitivity

The degree to which people, livelihoods, buildings, infrastructure, cultural assets, environmental resources, and services, etc. could be affected, either adversely or beneficially, if exposed to climate phenomena. For example, newer buildings constructed to the latest code will be less sensitive to strong winds or heavy snow loads than older structures in need of repair. Furthermore, the elderly and people suffering chronic respiratory and cardiovascular illness are more sensitive to heat stress than healthy adults.

Representative Concentration Pathway (RCP)

RCPs represent models that predict how concentrations of GHGs in the atmosphere will change in the future because of human activities. There are four RCPs (2.6, 4.5, 6.0 and 8.5) with a higher value representing higher GHG concentrations in 2100.

Resilience

The ability of a community to prepare for, resist, respond to, and recover from the impacts of climate phenomena in a timely and efficient manner, with minimum damage and disruption to the environment, and the social well-being and economic vitality of the community. Resilience and adaptive capacity are strongly linked. Thus, different groups within the community will be relatively more or relatively less resilient to climate phenomena, depending on their adaptive capacity.

Risk

A combination of likelihood and consequences of an adverse event or condition occurring. The expected consequences for people, livelihoods, buildings, infrastructure, cultural assets, environmental resources, and services, etc. of exposure to specific climate phenomena. Risk is thus a function of the likelihood of a climate phenomenon occurring in a place and the resulting impacts. In some instances, risk is categorized as:

Acute Risk: Rapid onset or event-driven risks such as high wind or intense rainfall events.

Chronic Risk: Slow onset risks and long-term shifts in climate patterns such as seasonal temperatures and precipitation changes, or species migration.

Vulnerability

The propensity or predisposition of people, livelihoods, buildings, infrastructure, cultural assets, environmental resources, and services, etc. to be affected by specific climate phenomena. Vulnerability is a function of the nature and magnitude of the climate phenomenon to which people, livelihoods, etc. are exposed, their sensitivity to that phenomenon, and their adaptive capacity. Exposure of vulnerable people, livelihoods, buildings, infrastructure, cultural assets, environmental resources, and services, etc. to climate phenomena gives rise to impacts.

Weather

Short term day-to-day changes in atmospheric conditions like temperature and precipitation.

Appendix B: Project Timeline

February 2023	Application to MCCAC approved & contracts signed.
March	Project kick-off meeting with the Municipality of Jasper.
June	Consequence scoring rubric and draft impact statements memo shared with Municipality of Jasper for review and comment.
July	Virtual presentation to Municipality of Jasper Council.
August	Likelihood scoring memo shared with Municipality of Jasper for review and comment.
September	Project Open House in Jasper alongside meetings with Municipality of Jasper leadership.
October/November	Additional and virtual community engagement held, including with Jasper Tourism and Parks Canada .
January 2024	Draft final climate risk assessment report shared with Municipality of Jasper for comment and review.

Appendix C: Climate Projections, Raw Data by Prairie Adaptation Research Collaborative

Data files provided separately by TRI.

Appendix D: Climate Risk Assessment by Associated Engineering

Appendix E: Fully Scored Risk Assessment

The Resilience Institute (TRI) is a national charity based in Alberta. Our team works locally and globally with diverse partners to minimize the suffering caused by climate impacts.

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An atmospheric condition or related hydrologic process that results in a specific set of generally known, or characterizable, impacts. Climate phenomena include both (rapid onset) shocks, such as heat waves, drought, lightning strikes, freezing rain, tornados, strong winds, heavy snow, hail, low flows in rivers, short duration intense rainfall, flooding, and (slow onset) stresses, such as changes to seasonal temperatures and rainfall patterns. Climate change may affect the character, magnitude and likelihood of specific climate phenomena occurring in a place.

Climate variability

Average weather patterns show variation within short timeframes (e.g., a month, a season, one or more years). For example, this year may be significantly drier than an average year in Alberta, whilst the preceding couple of years may have been slightly wetter than the average year. Climate variability refers to these deviations – or anomalies – from the average. The term "natural climate variability" refers to variability in the climate that is not attributable to, or influenced by, any activity related to humans.

Co-benefits

The added benefits of adaptation, over and above the benefits of moderating potential harm or exploiting potential opportunities that arise from current and expected climate conditions. For example, the increased use of distributed energy technologies to provide electricity not only reduces a community's vulnerability to power outages by diversifying supply, but it also reduces emissions of greenhouse gases (contributes to climate mitigation goals) and increases job opportunities (contributes to economic development goals). Co-benefits can often be at least as equally important as the direct benefits of adaptation.

Community

A group of Indigenous people who are linked by social ties, share a common identify and geographical locations or settings, and on this basis, engage in joint action. People who are, or perceive themselves to be, affected by a decision, strategy, or process. A community partner can be an individual, an organization or a group within an organization. Community partners can change at different stages in a process.

Consequence

The result or effect from climate impacts to people, society, infrastructure, or the environment.

Exposure

Exposure refers to people, livelihoods, buildings, infrastructure, cultural assets, environmental resources, and services, etc. being in places where they could be affected by climate phenomena. Communities in semi-arid regions, for example, may be exposed to drought and water shortages.

Greenhouse gas

A greenhouse gas (GHG) is a compound found in the Earth's atmosphere – for example, carbon dioxide, methane, water vapor, and other human-made gases. These gases allow solar radiation to enter the atmosphere and strike the Earth's surface, warming it. Some of this energy is reflected towards space. A portion of this reflected energy, however, bounces off the GHGs, and becomes trapped in the atmosphere in the form of heat. The more GHG molecules there are in the atmosphere, the more outgoing energy is trapped, and the warmer the Earth will become.

Hazard

A climate phenomenon that has the potential for causing harm to a community. A special type of hazard that is (at least partially) caused by climatic drivers, e.g., drought, high winds, extreme heat, etc. A potential source of harm.

Impacts

Adverse or beneficial effects on communities. For this Guide, impacts result only when a community is exposed to a climate phenomenon, to which that community has inherent vulnerabilities. An estimate of the harm that could be caused by an event or hazard.

Likelihood

The probability or chance of a hazard occurring, and how this likelihood changes in the future due to climate change.

Livelihoods

The capacity (capabilities, resources, and activities) of a community and its residents to generate and sustain their means of living, enhance their well-being, and the well-being of future generations. Livelihood resources include human, natural, social, physical, and financial capital. Livelihood activities include agriculture, trading, formal employment, etc.

Maladaptation

Maladaptation describes adaptation actions taken to reduce vulnerability to climate change that increase, rather than decrease, the vulnerability of a community. Maladaptation may occur when actions increase the vulnerability of people, groups, or sectors, increase GHG emissions, increase inequity in the community, decrease incentives to adapt, or place limits on the ability of future generations to adapt.

Mitigation

An action that will reduce or prevent GHG emissions, such as using renewable energies like wind and solar, making buildings, vehicles, and equipment more energy efficient, and walking or cycling from time to time instead of using a car. It can also include planting trees to absorb and store carbon dioxide from the atmosphere.

Sensitivity

The degree to which people, livelihoods, buildings, infrastructure, cultural assets, environmental resources, and services, etc. could be affected, either adversely or beneficially, if exposed to climate phenomena. For example, newer buildings constructed to the latest code will be less sensitive to strong winds or heavy snow loads than older structures in need of repair. Furthermore, the elderly and people suffering chronic respiratory and cardiovascular illness are more sensitive to heat stress than healthy adults.

Representative Concentration Pathway (RCP)

RCPs represent models that predict how concentrations of GHGs in the atmosphere will change in the future because of human activities. There are four RCPs (2.6, 4.5, 6.0 and 8.5) with a higher value representing higher GHG concentrations in 2100.

Resilience

The ability of a community to prepare for, resist, respond to, and recover from the impacts of climate phenomena in a timely and efficient manner, with minimum damage and disruption to the environment, and the social well-being and economic vitality of the community. Resilience and adaptive capacity are strongly linked. Thus, different groups within the community will be relatively more or relatively less resilient to climate phenomena, depending on their adaptive capacity.

Risk

A combination of likelihood and consequences of an adverse event or condition occurring. The expected consequences for people, livelihoods, buildings, infrastructure, cultural assets, environmental resources, and services, etc. of exposure to specific climate phenomena. Risk is thus a function of the likelihood of a climate phenomenon occurring in a place and the resulting impacts. In some instances, risk is categorized as:

Acute Risk: Rapid onset or event-driven risks such as high wind or intense rainfall events.

Chronic Risk: Slow onset risks and long-term shifts in climate patterns such as seasonal temperatures and precipitation changes, or species migration.

Vulnerability

The propensity or predisposition of people, livelihoods, buildings, infrastructure, cultural assets, environmental resources, and services, etc. to be affected by specific climate phenomena. Vulnerability is a function of the nature and magnitude of the climate phenomenon to which people, livelihoods, etc. are exposed, their sensitivity to that phenomenon, and their adaptive capacity. Exposure of vulnerable people, livelihoods, buildings, infrastructure, cultural assets, environmental resources, and services, etc. to climate phenomena gives rise to impacts.

Weather

Short term day-to-day changes in atmospheric conditions like temperature and precipitation.

Appendix B: Project Timeline

February 2023	Application to MCCAC approved & contracts signed.
March	Project kick-off meeting with the Municipality of Jasper.
June	Consequence scoring rubric and draft impact statements memo shared with Municipality of Jasper for review and comment.
July	Virtual presentation to Municipality of Jasper Council.
August	Likelihood scoring memo shared with Municipality of Jasper for review and comment.
September	Project Open House in Jasper alongside meetings with Municipality of Jasper leadership.
October/November	Additional and virtual community engagement held, including with Jasper Tourism and Parks Canada .
January 2024	Draft final climate risk assessment report shared with Municipality of Jasper for comment and review.

Appendix C: Climate Projections, Raw Data by Prairie Adaptation Research Collaborative

Data files provided separately by TRI.

Appendix D: Climate Risk Assessment by Associated Engineering

REPORT

Municipality of Jasper

MUNICIPALITY OF
JASPER

Climate Risk Assessment

DECEMBER 2023

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GLOSSARY

Term	Definition
Acute Risks	Rapid onset or event-driven risks such as high wind or intense rainfall events.
Adaptation (to climate change)	Adjusting to actual or expected climate impacts to reduce negative effects on people, society, infrastructure, and the environment.
Chronic Risks	Slow onset risks and long-term shifts in climate patterns such as seasonal temperatures and precipitation changes, or species migration.
Climate	The weather of a place averaged over a period of time, typically 30 years.
Climate Change	Significant changes in global temperature, precipitation, wind patterns and other measures of climate that occur over several decades or longer.
Climate Parameters	Climate variables or indices that influence the hazard, e.g., a high intensity, short duration rainfall event.
Climate Hazard	A special type of hazard that is (at least partially) caused by climatic drivers, e.g., drought, high winds, extreme heat, etc.
Consequence	The result or effect from climate impacts to people, society, infrastructure or the environment.
Greenhouse Gas (GHG)	A gas that absorbs and emits radiant energy causing the greenhouse effect, which warms the atmosphere and changes the climate. The primary greenhouse gases are water vapour, carbon dioxide, methane, nitrous oxide and ozone.
Hazard	A potential source of harm.
Impact	An estimate of the harm that could be caused by an event or hazard.
Likelihood	The probability or chance of a hazard occurring, and how this likelihood changes in the future due to climate change.
Mitigation (of climate change)	Human interventions to reduce the sources and enhance the sinks, or absorption, of GHGs.
Representative Concentration Pathway (RCP)	RCPs represent models that predict how concentrations of GHGs in the atmosphere will change in the future as a result of human activities. There are four RCPs (2.6, 4.5, 6.0 and 8.5) with a higher value representing higher GHG concentrations in 2100.
Resilience	The capacity of a system, community, or society exposed to hazards to minimize damages by responding or changing to reach and maintain an acceptable level of functioning and structure.
Risk	A combination of likelihood and consequences of an adverse event or condition occurring.
Weather	Short term day-to-day changes in atmospheric conditions like temperature and precipitation.

1 INTRODUCTION

This report provides the details of the climate risk assessment (CRA) for the Municipality of Jasper (the Municipality) funded by the **Municipal Climate Change Action Centre's (MCCAC) Climate Resilience Capacity Building Program**. The intent of the CRA is to support the community in identifying and planning for climate hazards such as high intensity rainfall, extreme heat, and severe storms. Action and implementation planning was outside the scope of this assessment and should be considered as next steps by the community to build on the results of this report.

Associated Engineering's Strategic Advisory Group (Associated) worked in collaboration with The Resilience Institute (TRI) to conduct the climate risk assessment (CRA). The CRA focuses on the built (i.e., buildings and infrastructure), natural (i.e., wildlife and the land), social/cultural (i.e., health and wellbeing), and economic/tourism systems that are present within Jasper.

Associated's scope for the CRA is as follows:

- Identify climate hazards relevant to the community.
- Research climate data projections and other data sources as necessary to determine the historic and future likelihood of the locally relevant climate hazards.
- Co-facilitated meetings on the Municipality's perspective on priority climate hazards and consequences.
- Calculate the community's risks from these hazards based on the likelihood of a climate impact occurring and the severity of the consequence.
- Develop high level considerations for adapting to the highest risks.
- Support TRI in engagement by preparing materials, co-facilitating discussions and integrating community feedback into the risk assessment.

1.1 Participatory Approach

A participatory approach was used throughout the project to integrate community perspectives and knowledge into the CRA. This included staff from the Municipality of Jasper, Parks Canada, Tourism Jasper and community members at large. Understanding local experiences with climate impacts and what most concerns people about the future helps to produce a well-rounded CRA that is specific to the community. There are two key stages where local knowledge and input informed the project:

- **Identification of relevant climate hazards and current likelihood:** Representatives from TRI and Associated held an open house and used an online survey to gather community feedback. This broad engagement, as well as meetings with municipal staff, helped the project team identify the climate hazards that are of greatest concern. Discussions provided insight on which climate hazards are already being experienced and causing impacts.
- **Climate impact statements and consequence scoring:** TRI completed meetings with Parks Canada and Tourism Jasper staff to review climate impact statements. These conversations helped provide an understanding of the severity of consequences from climate impacts.

1.2 Acknowledgment

We would like to acknowledge the **Municipality of Jasper staff, Parks Canada and Tourism Jasper representatives, and community members** whose insights were critical in the creation of this report. The project team appreciates their shared knowledge for the purpose of including local perspectives in this community project.

2 SCOPE OF CLIMATE RISK

This section provides a discussion on the boundaries that shaped the assessment and discussion. The boundaries defined the systems of the community, geographical boundaries, and climate parameters to help develop the climate impact scenarios that were used for risk assessments.

2.1 Community Systems

It is best practice in climate risk assessments to evaluate potential impacts on different “systems” that make up a community. Built, natural, and social/cultural systems are usually included in CRAs, with economic systems considered in some situations (outside the scope of this assessment). These are referred to as systems because they are interacting and interrelated so are considered collectively. This approach allows for a holistic consideration of the consequences of climate change and is particularly valuable for identifying impacts that may be less obvious (e.g., physical damage to infrastructure is more straightforward and visible than health impacts or changes in activities).

The risk assessment examines the impacts of climate change on the built, natural, social, and economic/tourism systems (see **Figure 2-1**).

Figure 2-1 Systems Impacted by Climate Change

The scope of the risk assessment is defined along four boundary conditions:

2.2 Geographical Boundaries (or Spatial Scope)

The assessment is largely confined to climate-related hazards that have direct impacts within Jasper’s boundaries and are within the Municipality’s control and influence. Within these boundaries, a community-wide approach is adopted, that considers impacts to private property, the local economy, the health and lifestyle of residents, social equity, and natural capital, as well as impacts within Jasper’s boundaries that may impact regional economic/tourism systems.

2.3 Types of Climate-Related Impacts

In terms of climate-related hazards, both slow-onset (chronic) stresses and sudden-onset (acute) discrete events are within scope. The latter tend to be short duration events, that typically last minutes, hours, days, or weeks. These will generally occur irrespective of climate change—though their frequency, intensity, or distribution may alter because of climate change. Examples include windstorms, heavy snowfall events, freezing rain events, wildfire, and temperature extremes. Slow-onset stresses, in contrast, are caused entirely by climate change, with impacts unfolding gradually, building up over longer time frames—decades or more. Examples of slow-onset impacts include warming trends in air and surface water temperatures and ecosystem shifts.

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. This uncertainty is captured using 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 a high baseline emission scenario associated with higher levels of global warming. The mean annual temperature for Jasper, for example, is projected to average +6.4°C in the future (2051-2080), an increase of 3.9°C from its average value over the baseline period (1971-2000) (ClimateData.ca).

2.4 Future Climate Scenarios

Projections of future climate change are available for a range of greenhouse gas emissions, concentrations, and radiative forcing scenarios—or Representative Concentrations Pathways (RCPs). When assessing climate-related risks it is prudent to consider the greatest plausible change scenario relative to the present, which in practice means working with projected changes for the region under the RCP 8.5 scenario, i.e., the most conservative of global "limited climate policy" scenarios (see the text box). The primary justification for using RCP 8.5 is that it means no risks are missed during the risk assessment. Uncertainties relating to whether the future unfolds along RCP 8.5 or along a different, lower emission RCP, are managed during the adaptation planning and implementation phase.

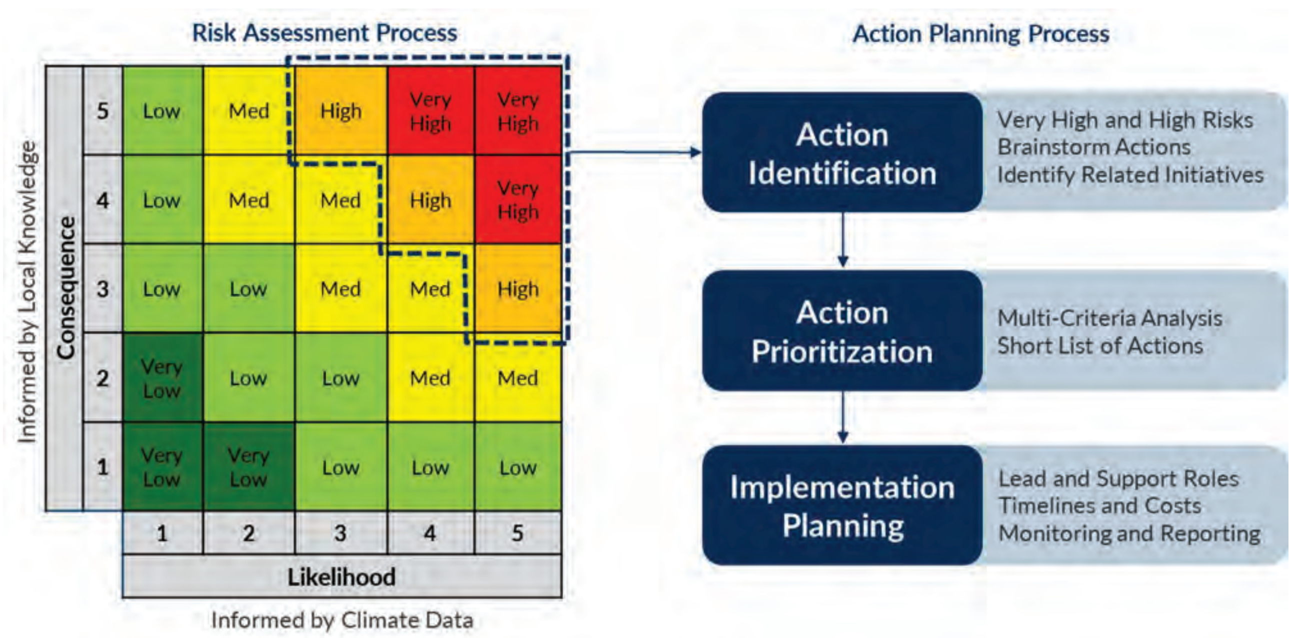
2.5 Time Horizon

The assessment considers impacts arising from projected climate and associated environmental changes out to a future, 30-year time period centered around the 2050s. **Section 3.3** specifies the time periods considered for each climate hazard based on available data sources.

3 RISK ASSESSMENT METHODOLOGY

Risk is evaluated as the product of **likelihood** of the hazard, events, or condition that could occur, and the level of the **consequence of the impact.** In terms of climate risk, we develop an understanding of how the variability of climate patterns impact the built and natural environment, and in turn, how this impacts the society and economy. **The purpose of a risk assessment is to identify the highest risks so that subsequent adaptation actions are focused on these highest risks.** This is illustrated in **Figure 3-1** below. The scope of this project is centered on the risk assessment and does not include action planning.

Figure 3-1 Climate Adaptation Risk Assessment and Planning Overview



3.1 International Standards for Risk Assessment

The risk assessment process used for this project is based on the **ISO 31000's principles of risk management**. The principles follow a systematic cycle of actions to create and protect the value of community assets. **Figure 3-2** illustrates the process starting from integration of organizational activities that requires the collaboration of groups, using a structured approach to assess risk that is customized for the appropriate context. The discussion is also inclusive and dynamic, drawing from evidence-based information. Finally, the risk management process identifies a continual improvement through learning and experience.

Figure 3-2 Principals of Risk Management (ISO 31000)

The approach to the climate risk assessment methodology also aligns with 'good practice' methodology including:

- **Public Infrastructure Engineering Vulnerability Committee (PIEVC) High Level Screening Guide (HLSG)** developed by Engineers Canada and assumed by the Institute for Catastrophic Loss Reduction (ICLR), the Climate Risk Institute (CRI) and Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ).
- **"*Climate Resilience Express – Community Climate Adaptation Planning Guide*"** (https://mccac.ca/app/uploads/CRE_Planning-Guide_Final.pdf), which was developed by All One Sky Foundation for the Municipal Climate Change Action Centre and the Climate Resilience Capacity Building Program.
- **International Standards Organization (ISO) guideline 14092**: Adaptation to Climate Change—Requirements and guidance on adaptation planning for local governments and communities, and with the Intergovernmental Panel on Climate Change's (IPCC) latest conceptualization of climate risk assessment methods.

3.2 Risk Assessment Process

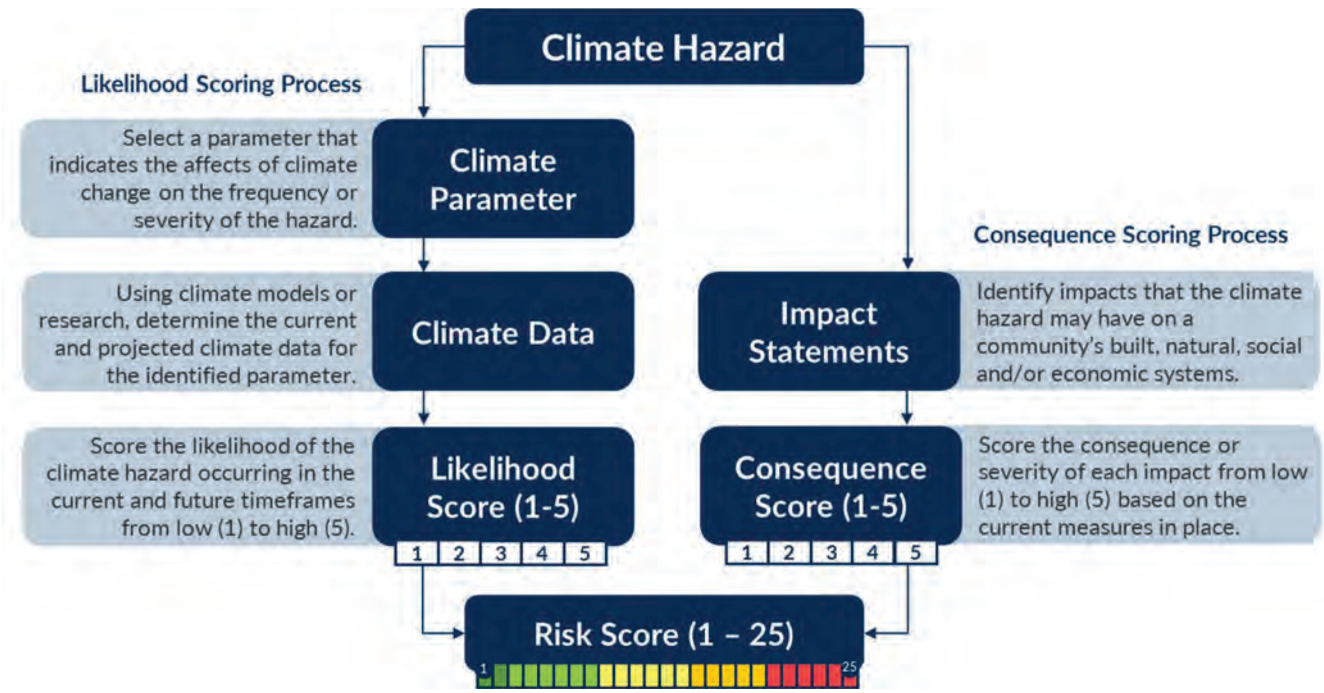
As mentioned above, risk is a product of likelihood and consequence. The steps are summarized in **Figure 3-3** and outlined below:

1. Identify **climate hazards** applicable for the study area (e.g., extreme heat, wildfire smoke or heavy rainfall. However, sea level rise is not appropriate for this site.)
2. Analyse the **likelihood** of each hazard (how frequent a hazard may occur)
    a. Identify a **climate parameter** from available climate data which is representative of the frequency and/or severity of each hazard (e.g., Number of days above 30 °C, 24 hour 100-year rainfall (mm/hr)). There could be multiple parameters to describe a hazard but only one is selected to represent the relative change in the hazard over time due to climate change.
    b. **Collect climate data** for a high emissions scenario looking at historic and future (2050s) timeframes and calculate the projected increase or reduction of the likelihood of each hazard. Climate models do not capture all climate hazards, such as forest fire or hail, and therefore alternative data sources (research, national monitoring indices) are used, along with experience and good practice.

c. Assign a **baseline likelihood score** (1 to 5) which indicates the historical and current frequency or severity of the hazard according to historic data and conversations with the Municipality around the experiences with the hazard.
d. Assign a **future likelihood score** (1 to 5) which indicates the projected frequency or severity of the hazard in the 2050's according to the calculated change in parameter likelihood.

3. Identify the various **impacts** of each hazard to the built, natural, and social systems within the scope of the assessment.
4. Assign a **consequence score** (1 to 5), with the community's input, to each impact considering severity such as cost of impacts, duration of interruption, significance of health impacts, etc.
5. Calculate the **baseline and future risk score** for each hazard and impact by multiplying the corresponding likelihood score and consequence score.

Figure 3-3 Risk Assessment Process



3.3 Risk Assessment Assumptions & Limitations

Key assumptions and limitations in the risk assessment methodology include:

Hazard Identification

- Climate hazards were chosen according to relevance to Jasper and project scope at the time of the assessment. The Municipality could consider the impacts from additional climate hazards as appropriate when more in-depth adaptation planning is conducted.

Likelihood

- A single climate parameter was selected for each hazard to represent the change in likelihood. Some hazards such as high winds, heavy snow, and forest fires are complex with several contributing factors not captured within available climate modelling and projections. In these cases, a climate parameter that was considered to most represent the hazard in context of the impacts was selected.
- Data for a nearby location (i.e., Hinton, Edson) was used where climate data was unavailable specifically for Jasper.
- Time periods considered for historic climate data varied across climate hazards depending on available data.
  - Data supplied by Prairie Adaptation Research Collaborative (PARC) (drought, heavy snow, extreme heat, extreme cold) is understood to span 1976-2005.
  - Data derived from Intensity-Duration-Frequency (IDF) curves for localized flooding and river/creek flooding spans 1963-1994.
  - Data from the Canadian Climate Atlas (freeze-thaw, glacial recession) spans 1976-2005.
  - Data for wildfires and wildfire smoke spans 1981-2010.
  - Data for hail spans 1971-2000.
  - Data for lightning spans 1999-2018.
  - Data for ecoregion shift spans 1969-1990.
- Likelihood scores for freezing rain and high winds looked at the projected percent change in parameter between 2020 and 2050.
- Time periods considered for future (2050s) climate data varied across climate hazards depending on available data.
  - Data supplied by PARC (drought, heavy snow, extreme heat, extreme cold) is understood to span 2035-2065.
  - Data derived from IDF curves for localized flooding and river/creek flooding spans 2051-2080.
  - Data from the Canadian Climate Atlas (freeze-thaw, glacial recession) spans 2021-2050.
  - Data for wildfires, wildfire smoke, hail, and ecoregion shift spans 2041-2070.
- Where representative climate parameters or projected data were unavailable, scores were assigned based on available research, studies, and good practice.
- Research on the impacts of climate change on avalanches seems inconclusive regarding the impact on likelihood. For this reason, avalanche likelihood score was maintained between baseline and future scores.

Consequence

- Consequence scores were assigned with the Municipality's input considering the level of consequence that is expected to be seen from the climate hazard given the current understanding of the hazards and the current systems (built, natural, social, and economic/tourism). It is possible that realized consequences could be more or less severe than anticipated in scoring because this assessment is based on the best available information at the time but is not a guarantee of what will happen in the future.

Risk Classification

- Risks were classified from very low to very high using a standard risk matrix scored from 1 to 25. High and very high risks are used as the priority for action planning.

3.4 Relevant Hazards

Climate hazards are weather-related, hydrometeorological events which can cause harm, and may also be referred to as extreme weather events. There are multiple climate hazards, but some are only applicable to specific locations such as sea level rise along the coasts. The climate hazards identified to be applicable to Jasper are listed and described in **Table 3-1**.

Table 3-1 Climate Hazard Descriptions

Hazard	Description
Drought	A prolonged period of abnormally low rainfall, leading to a shortage of water.
Lightning	Occurrence of natural electrostatic discharges of short duration and high voltage within clouds, or between clouds and the ground.
Localized Flooding	Rapid increases in water level, particularly in low lying areas and along drainage networks, seen during periods of short-duration high-intensity rainfall or rapid melting of snow or ice. Also know as pluvial flooding.
River/Creek Flooding	River water levels exceeding the top of bank and spilling onto surrounding lands typically driven by longer duration heavy rainfall. Also know as fluvial flooding.
Wildfires	A large, destructive fire that spreads quickly over forests or grasslands.
Wildfire Smoke	A mix of gases and fine particles from burning trees and plants, buildings and other material.
Hail	Pellets of frozen rain which fall as showers.
Freezing Rain	Rain that freezes on impact with the ground or solid objects.
High Winds	A period of abnormally strong, sustained winds.
Extreme Heat	Summertime temperatures that are much hotter and/or humid than average.
Extreme Cold	Winter temperatures that are much colder than average
Heavy Snow	A period of intense, sustained snowfall.
Freeze-Thaw Cycle	The fluctuation of air temperature between freezing and non-freezing temperatures.
Ecoregion Shift	A change in the climatic conditions of an area, affecting the health and presence of native ecoregions (ecological features and plant and animal communities).
Avalanches	A mass of snow, ice, and rocks falling rapidly down a mountainside
Glacial Recession	A shrink in glacier size because more material melts, evaporates, or erodes than is replenished

3.5 Climate Likelihood Scoring

Likelihood scores were assigned for the historic and future (2050s) time horizons according to climate parameter trends, with increasing/decreasing values reflecting increasing/decreasing occurrence or severity over the time horizon. **Climate projections consider a high-emissions scenario, with the earth reaching 2 degrees of global warming in the mid to late 2050s.**

Historic likelihood scores are assigned using feedback solicited during meetings and workshops. A historic (baseline) likelihood score of either 2 or 3 is assigned based on community experiences with the hazard up to present day. This approach is used to capture local knowledge and experience with climate hazards that may not be reflected in scientific datasets. The likelihood score is selected based on the following criteria:

- A historic **likelihood score of 2** indicates that, while the climate hazard may be occurring, it does not cause recurring issues or significant concern for the community at this time;
- A historic **likelihood score of 3** indicates that the climate hazard is already a problem for the Municipality and impacts have been experienced a number of times in the recent past.

From there, a future likelihood score is calculated according to the percent increase or decrease of the assessed climate parameter over time. Community feedback is not used to inform future likelihood because this assessment used specific climate data portals and research to evaluate the likelihood of certain conditions.

The scoring rubrics for likelihood are shown in **Tables 3-2** and **3-3** below.

Table 3-2 Likelihood Rubric, Baseline of 2 (Hazard Not a Current Concern)

Likelihood Score (L)	Historic Likelihood	Future Likelihood
1	↑	10-100% reduction in frequency of intensity with reference to Baseline Mean
2	Seldom occurs in current climate	Baseline mean conditions or a change in frequency or intensity of +/-10% with reference to baseline mean
3	↓	10-40% increase in frequency or intensity with reference to Baseline Mean
4		40-70% increase in frequency or intensity with reference to Baseline Mean
5		70-100% increase in frequency or intensity with reference to Baseline Mean

Table 3-3 Likelihood Rubric, Baseline of 3 (Hazard a Current Concern)

Likelihood Score (L)	Historic Likelihood	Future Likelihood
1	↑	50-100% reduction in frequency of intensity with reference to Baseline Mean
2		10-50% reduction in frequency of intensity with reference to Baseline Mean
3	Often occurs in current climate	Baseline mean conditions or a change in frequency or intensity of +/-10% with reference to the baseline mean
4	↓	10-50% increase in frequency or intensity with reference to Baseline Mean
5		50-100% increase in frequency or intensity with reference to Baseline Mean

3.6 Impact Statements

Climate hazards can have multiple types of impacts such as financial damages, increased operational needs, deterioration of health both physical and mental, interruption to key services, or temporary evacuations, to name a few. By looking at the impacts to each system (built, natural, social, and economic/tourism), a broad and holistic understanding of the impacts is developed. The list of impact statements is informed by those that are commonly experienced in communities with similar climate projections and supplemented with local knowledge and experience. Some sample impact statements showing the different types of impacts across the systems are provided in **Figure 3-4**.

Figure 3-4 Sample Impact Statements

Hazard	System	Impact Statement
Extreme Heat	Built	Power outages due to overheated electrical systems
	Natural	Increase in algae blooms affecting water quality
	Social/Cultural	Health risks for outdoor workers
	Economic/Tourism	Reduced desirability of outdoor tourism activities

3.7 Consequence Scoring

Not all impacts have the same severity of consequence and therefore each impact is assessed individually through the risk assessment process. Different criteria are used to assess impacts to built, natural, social, and economic/tourism systems as shown in the consequence rubric, with a high or more severe consequence scored a 5 and a lower severity a score of 1 (see **Table 3-4**).

Table 3-4 Consequence Scoring Rubric

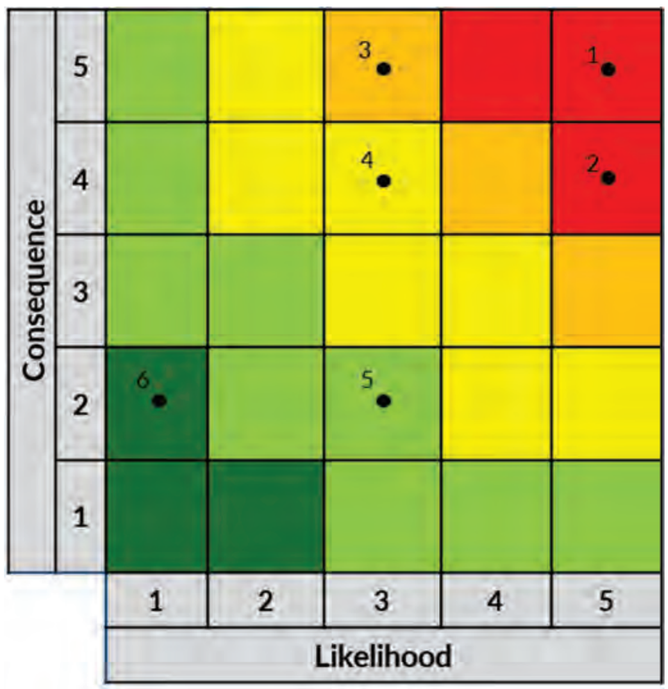
System	Very Low - 1	Medium - 3	Very High - 5
Natural	▪**Minimal or no environmental disruption or damage** to landscape, water resources, trees, and other natural infrastructure. ▪**Affected resources recover full functionality within days**, e.g., plants and wildlife only marginally affected.	▪**Isolated but eventually reversible damage** to wildlife, habitat or and ecosystems, or **short-term disruption** to environmental amenities. ▪**Full restoration of function possible** but could takes months or 1-2 years.	▪**Widespread and irreversible damage** to wildlife, habitat and ecosystems, or **long-term damage, disruption** to environmental amenities. ▪**Full restoration of function is not possible or could take decades.** Ecoregions experience a **permanent shift,** with more invasive species, loss of medicinal plants & other valued species.
Built	▪**Little or no expected additional financial costs** to the Municipality. ▪**Minimal or no impact on operations** and delivery of services. ▪Community members' reaction is minimal - **little to no erosion of trust** in community administration.	▪Cost of damages **within Municipality's funding capacity.** ▪**Operation and services temporarily interrupted for weeks** before backlog is cleared. ▪Community members' **reaction is moderate** - negative views of community administration is held by **several** community members.	▪**Cost of damages far exceeds the Municipality's funding capacity.** ▪**Operation and services severely interrupted** - additional resources required to clear backlog taking **months.** ▪Community members' **reaction is significant** - negative views of community administration is **widespread.**
Social	▪**Minimal disruption to daily life**, minimal or no change in community cohesion ▪**Minimal health effects** ▪**No self-evacuations or displacement**	▪**Week-long disruption to daily life** with temporary feelings of fear and anxiety, moderate erosion of community cohesion ▪**Moderate health effects** with some injuries or illnesses ▪Small areas of municipality seeing **temporary self-evacuations/ displacement**	▪**Months long disruption to daily life** (e.g., inability to access schools, recreation) with widespread psychological effects and erosion of community cohesion ▪Significant and **widespread** health effects including **fatalities, injuries, or illnesses** ▪Large areas of municipality requiring temporary evacuations, with **some permanent displacement**
Economic/ Tourism	▪Disruption of tourism activities **for a day to a week in non-peak season** ▪Little to no damage to tourist infrastructure (natural or built) ▪Minimal public perception of the municipality as unsafe or unappealing due to the hazard	▪Disruption of tourism activities for a **day to a week in peak season or weeks to months in non-peak season** ▪Moderate damage to tourist infrastructure (natural or built) ▪Public perception of the municipality as less safe or slightly unappealing due to the hazard	▪Disruption of tourism activities for **weeks to months in peak season** ▪Significant damage to tourist infrastructure (natural or built) ▪Significant public perception of the municipality as unsafe or unappealing due to the hazard

3.8 Risk Scoring

Using the likelihood and consequence scoring, the final **risk score** for each impact statement falls on a scale between **0 and 25** (refer to **Figure 3-5**):

- Between 0 and 2 are considered very low risk (**dark green**);
- Between 3 and 7 are considered low (**light green**);
- Between 8 and 14 are considered medium risk (yellow);
- Between 15 and 19 are considered high risk (**orange**); and
- Between 20 and 25 are considered very high risk (**red**) items.

Figure 3-5 Sample Risk Matrix



Typically, the **very high** and **high risks** are the focus area for adaptation action planning in the next phase (not part of the current project scope). As progress is made, the medium risks can then be considered. Often the low and very low risks are accepted, and actions may not be taken. The risk tolerance of a community may vary and therefore more or less risks may be considered as part of adaptation action planning.

4 RISK ASSESSMENT RESULTS

4.1 Change in Climate Hazard Likelihood

Risk is driven by both the consequence of different climate hazards and their likelihoods. Changes in likelihoods drive a large portion of risk, as rare events become more common.

Many hazards will see an increase in how likely they are to occur between historical data and 2050. **The largest shifts in likelihood are for wildfires, wildfire smoke, hail, extreme heat (days above +30°C), and glacial recession.** Of the hazards explored in this assessment, the number of **extreme cold days (below -15 °C)** and **freeze thaw cycles** are projected to see a decrease in likelihood between historical data and 2050. Projections show fewer avalanches at lower elevations but more at higher elevations with wetter snow. When these events are considered together, there is a minimal change in likelihood overall. The climate parameters assessed and their corresponding likelihood scores are shown in **Table 4-1**. The change in climate hazard likelihood scores is summarized in **Figure 4-1**.

Table 4-1 Climate Hazard Parameters and Likelihood Scores

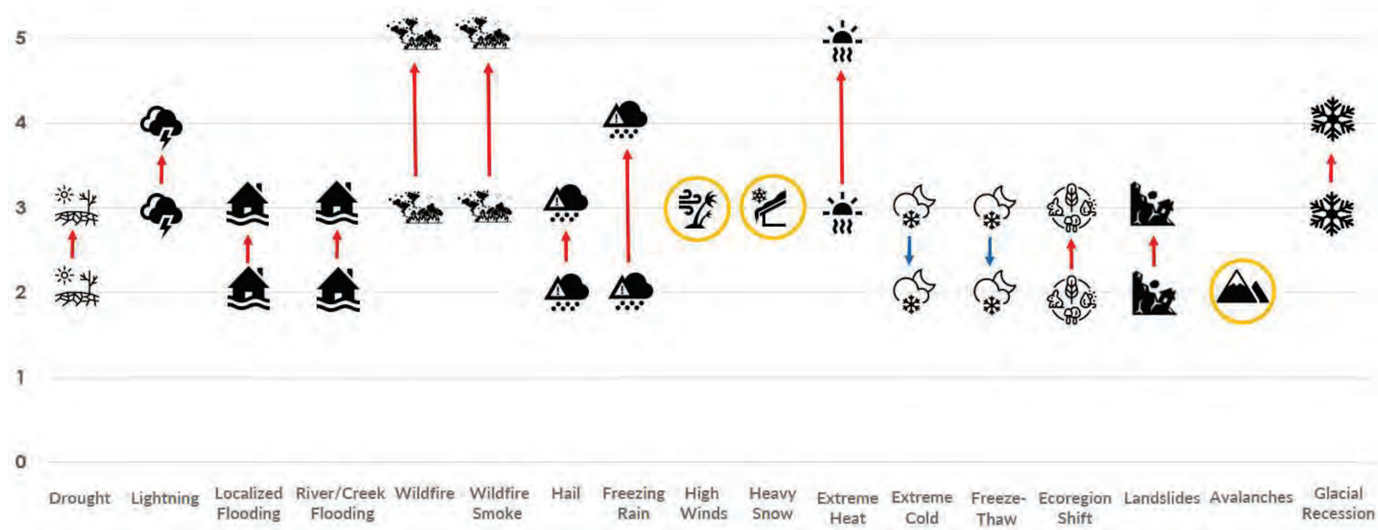
Climate Hazard	Parameter	Historic Value	Future Value	% Change	Historic Likelihood	Future Likelihood	Data Source
Drought	Standardized precipitation evapotranspiration index (SPEI 3)[1]	0.71	0.53	-25%	2	3	PARC[2]
Lightning	Annual average number of days with lightning[3]	40.2	-	-	3	4	ECCC[4]; Paquin, et al. (2014)[5]
Localized Flooding	15 min 25-year rainfall (mm/hr)	56.2	72	28%	2	3	Climate Data[6]
River/Creek Flooding	24 hour 100-year rainfall (mm/hr)	3.6	4.6	28%	3	4	Climate Data[6]
Wildfires	Annual average area burned (ha) within region	189,251	734,294	288%	3	5	Wang, et al. (2022)[7]
Wildfire Smoke	Annual average area burned (ha) within region	189,251	734,294	288%	3	5	Wang, et al. (2022)[7]
Hail	Annual severe summer hail days	1.25-1.5	1.9	26%	2	3	Brimelow, et al. (2017)[8]

[1] Values range from -5 to 5, with higher numbers indicating higher levels of moisture; a reduction in value indicates an increase in drought conditions.
[2] Prairie Adaptation Research Collaborative (PARC) supplied data
[3] While no projected values are available, research points towards a slight increase in lightning frequency.
[4] Environment and Climate Change Canada (ECCC) (2019), *Lightning Activity in Canadian Cities*. https://www.canada.ca/en/environment-climate-change/services/lightning/statistics/activity-canadian-cities.html
[5] Dominique Paquin, Ramón de Elía & Anne Frigon (2014) Change in North American Atmospheric Conditions Associated with Deep Convection and Severe Weather using CRCM4 Climate Projections, Atmosphere-Ocean, 52:3, 175-190, DOI: 10.1080/07055900.2013.877868
[6] Climate Data for a Resilient Canada: climatedata.ca Short-duration Rainfall IDF Data, Version 3.30 (2022-10-31)
[7] Wang, Xianli, Tom Swystun, and Mike D. Flannigan (2022). *Future wildfire extent and frequency determined by the longest fire-conducive weather spell*. Science of the total environment 830 (2022): 154752.
[8] Brimelow et al. (2017). *The changing hail threat over North America in response to anthropogenic climate change*. Nature Climate Change, DOI: 10.1038/nclimate3321

Climate Hazard	Parameter	Historic Value	Future Value	% Change	Historic Likelihood	Future Likelihood	Data Source
Freezing Rain	Change in annual ice accretion (2020-2050)	-	-	40%	2	4	ECCC[9]
High Winds	Change in annual hourly wind pressure (1/50) (2020-2050)	-	-	9%	3	3	ECCC[9]
Heavy Snow	Annual winter precipitation (mm)	102.89	104.42	1%	3	3	PARC[2]
Extreme Heat	Annual days above +30°C	0.4	5.1	1175%	3	5	PARC[2]
Extreme Cold	Days below -15 °C	59.41	40.82	-31%	3	2	PARC[2]
Freeze-Thaw Cycles	Annual # of freeze-thaw events	120	104.6	-13%	3	2	Canadian Climate Atlas[10]
Ecoregion Shift	Biodiversity shift[11]	-	-	-	2	3	AdaptWest[12]
Landslides	24 hour 100-year rainfall (mm/hr)	3.6	4.6	28%	2	3	Climate Data[6]
Avalanches	Professional judgement based on research	-	-	-	2	2	Bellaire, et al. (2016)[13]
Glacial Recession	Freezing degree days	1116	857.8	-23%	3	4	Canadian Climate Atlas[10]; Science Daily[14]

[9] Environment and Climate Change Canada (ECCC), *Climate-Resilient Buildings and Core Public Infrastructure - An Assessment of the Impact of Climate Change on Climatic Design Data In Canada - Annex 1.2.* https://publications.gc.ca/collections/collection_2021/eccc/En4-415-2020-eng.pdf
[10] Climate Atlas of Canada: climateatlas.ca
[11] Eco-region maps project a shift in ecoregion in the area.
[12] AdaptWest – A Climate Adaptation Conservation Planning Database for North America: adaptwest.databasin.org
[13] Bellaire, S., Jamieson, B., Thumlert, S., Goodrich, J., and Statham, G. (2016). Analysis of long-term weather, snow, and avalanche data at Glacier National Park, B.C., Canada. *Cold Regions Science and Technology*. Analysis of long-term weather, snow and avalanche data at Glacier National Park, B.C., Canada - ScienceDirect
[14] Science Daily (2005). *Most of Arctic's Near-surface Permafrost to Thaw by 2100*. Science News. *https://www.sciencedaily.com/releases/2005/12/051220085054.htm*

Figure 4-1 Change in Climate Hazard Likelihood (historic baseline to 2050)



4.2 Results by System

Risk scores for each of the **152 climate impact statements** (**Appendix A**) were calculated by multiplying the likelihood score (1 to 5) by the consequence scores (1 to 5), where the highest possible risk score is 25. Looking at the assessment holistically across all systems, the climate hazards presenting **very high risks** to the Municipality in the 2050s are **wildfire, freezing rain, glacial recession, extreme heat, and wildfire smoke.** A summary of some of the highest risk impacts of these hazards is shown in **Table 4-2**.

Table 4-2 Climate Impact Statements –Top Hazards

Top Hazards	Top Impacts
	Wildfire • Risk of a Jasper developing a poor reputation within the international tourism market • Damage to buildings and community member homes • Power outages cause disruptions, especially for essential services
	Freezing Rain • Increased risk of automobile accidents and injuries/death • Slow traffic flow, making tourism opportunities less appealing
	Glacial Recession • Physical damage to infrastructure and the built environment • Reduced water supply • Glacier-related tourism is less appealing
	Extreme Heat • Health impacts or death, especially for vulnerable populations (chronic health conditions, elderly, children) • Reduced participation in outdoor recreation • Increased wildlife/human interactions as animals seek out water and food sources
	Wildfire Smoke • Serious health implications, especially for those with respiratory problems • Impacts on tourism sector due to less interest in outdoor activities

Results are summarized in the following sections according to each system: Built, Natural, Social, and Economic/Tourism:

a. Risk matrix for each system including all impacts (very low to very high)
b. Summary table of very high risks for each system
c. Description of very high risks for each system
d. High level insights to guide future adaptation planning for the area

Each impact statement within the risk matrices is labeled with the **hazard name** and a **unique impact statement ID for that hazard**. For example, wildfire has 17 impact statements which are named from Wildfire (A) to Wildfire (Q). Extreme heat has 11 impact statements which are named from Extreme Heat (A) to Extreme Heat (K). A full table of results across all impact statements is provided in **Appendix A**.

4.2.1 Built System

Built systems are man-made structures and facilities and may be owned by the Municipality or its residents. These encompass all constructed elements, including roadways, pathways, the Fitness Centre, the Aquatic Centre, the Activity Centre, the Jasper Library and Cultural Centre, and essential facilities (e.g., water treatment plant).

A total of **51 impacts** to the built system were assessed and are shown in **Figure 4-2** below. The majority of the impacts are a medium risk (yellow) with extreme heat, wildfires, freezing rain, and glacial recession standing out as very high risks. **Table 4-3** provides details on the 6 risks which were found to be very high for the built system.

Figure 4-2 Climate Risk Matrix – Built System

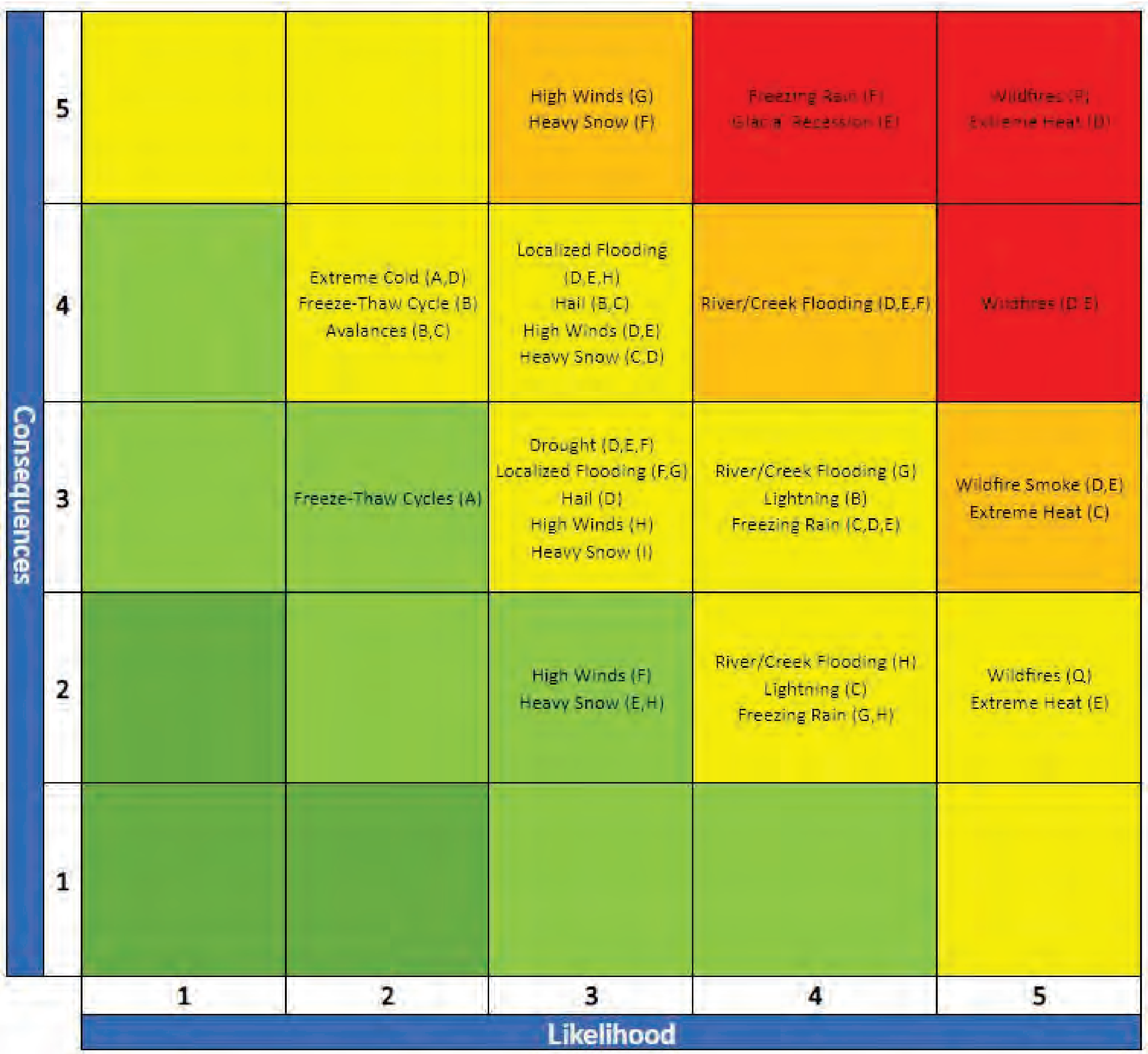


Table 4-3 Very High Risk Climate Impacts – Built System

Hazard (Impact ID)	Impact
Wildfires (P)	Power outages for critical facilities/services
Wildfires (D)	Damage to private property
Wildfires (E)	Damages to buildings and facilities
Extreme Heat (D)	Demand for "cooling spaces" exceeds supply and additional investment is required
Freezing Rain (F)	Road traffic accidents and transportation delays, including active transportation
Glacial Recession (E)	Damage to or flooding of infrastructure on downstream side of glacier (ice breakage or large release)

Wildfires

The community engagement survey supporting this project found that the community is most concerned with wildfire out of all climate risks. However, discussions with the Municipality of Jasper and Parks Canada noted that the public may be more fearful than warranted due to strong fire management practices in place. A draft consequence score of "5" was originally proposed for this hazard, but it was reduced to a "4" after hearing about the extensive work already being done to reduce the impact of wildfire.

A wildfire in the municipality could damage infrastructure, which may require significant repairs or full replacement depending on the extent of the damages. Community member homes and other private property could be impacted damaged or destroyed. Critical (water treatment, medical, etc.) and less critical buildings and facilities (library, school) are also at risk.

With the recent wildfire experienced in 2023, the risk of power outages was a recurring theme throughout the engagement, mainly the inability to keep critical infrastructure in service. The backup power that some facilities have currently (e.g., wastewater treatment plant and emergency services building) may be insufficient if there is an extended outage (i.e., backup generators may only be able to supply electricity for days, not weeks). Municipal staff feel that they are prepared to keep critical water and sewer services operational. Parks Canada did not identify wildfire-related power outages are as a priority impact because they view that utility companies have responded appropriately during previous fire events.

Community members spoke about their experiences with previous utility outages even though it is not impacted by wildfire. Their past experience made aware of their vulnerabilities that can be impacted by multiple climate hazards.

Extreme Heat

An increase in extreme heat days will increase demand for public spaces that offer air conditioning (AC) or other cooling. These spaces are particularly important for vulnerable populations like the elderly, the unhoused, and people with lower incomes. Some people may be turned away from these cooling spaces if Fire Code capacity limits are reached. Community engagement identified that the limited availability of "cooling spaces" is an indirect risk because of climate risk.

Many hotels/tourist accommodations do not have AC and new installations could put significant strain on the electrical grid. From a municipal perspective, cooling equipment (AC or heat pumps) may be required at new public buildings to be able to provide cooling spaces.

Freezing Rain

Freezing rain can create dangerous road/sidewalks conditions. There is also a risk that visibility will be reduced, depending on the intensity of the rain. These factors may lead to an increase in vehicle collisions, and/or damage to transportation infrastructure (e.g., signage). Health care facilities could also see additional slip-related injuries.

The community engagement noted that there are three roads that offer ingress/egress. Highway 93 (from Banff) was noted as a particularly important corridor, and that dangerous conditions or road closures could lead to traffic delays and challenges reaching tourism sites. When Highway 93 is closed for avalanche control (typically 2-3 days' notice), it can more than double the travel time between Jasper and Banff/Calgary. There is also concern that there is insufficient local organization to coordinate the use of alternative routes.

Glacial Recession

Glacial melt can lead to ponded water on the surface of the glacier and can enlarge into a dam-like feature. Release of this melt water could behave like a dam break event with a sudden release of water flowing into surrounding areas. Infrastructure on the downstream side of a glacier may be damaged or flooded due to this melt. In extreme cases, the rapid release of water has the potential to damage houses, wipe out transportation infrastructure, and pose serious public health and safety concerns. Engagement did not identify specific pieces of infrastructure that are at-risk due to glacial recession. However, roadways that support tourism to the Columbia Icefield and Mount Edith Cavell would likely be one of the first built assets to be affected given their proximity to the glaciers.

A large ice break and water release was seen in the area as recently as 2012. The Ghost Glacier collapsed, dropped ice into the Cavell Tarn, and caused massive waves that washed up a parking lot. Floodwaters were released and travelled kilometers downstream, damaging natural and built infrastructure along the way.

4.2.2 Natural System

Natural systems referred to the biotic and abiotic features of Jasper. This includes riparian areas, forests, grasslands, landscaping, animals, aquatic life, and natural water features (rivers, streams, wetlands) which exist **in or around the Municipality**.

A total of **33 impacts** to the natural systems were assessed and are summarized in **Figure 4-3** below. There are 3 very high-risk hazards, a result of climate data and community engagement assigning high likelihood and consequence scores to extreme heat, glacial recession, and wildfires. **Table 4-4** provides details these very high risks.

Figure 4-3 Climate Risk Matrix – Natural System

Consequences \ Likelihood	1	2	3	4	5
5		Avalanches (A)	Ecoregion Shift (A,B,C)	Glacial Recession (A)	Extreme Heat (B)
4			Drought (A) High Winds (A,B) Heavy Snow (A)	River/Creek Flooding (B) Glacial Recession (B,C,D)	Wildfires (A)
3			Drought (C) Localized Flooding (B) Hail (A) High Winds (C) Heavy Snow (B)	River/Creek Flooding (C) Lightning (A) Freezing Rain (B)	Wildfire Smoke (B,C)
2			Drought (B) Localized Flooding (C)	Freezing Rain (A)	Wildfires (B) Wildfire Smoke (A)
1			Localized Flooding (A)	River/Creek Flooding (A)	Extreme Heat (A)

Table 4-4 Very High Risk Climate Impacts – Natural System

Hazard (Impact ID)	Impact
Extreme Heat (B)	Increased heat stress for wildlife and aquatic populations
Glacial Recession (A)	Reduction of raw water supply (surface water baseflow and groundwater)
Wildfires (A)	Damage to terrestrial habitat

Extreme Heat

Extreme heat could increase the presence of algal blooms in local water bodies. Declining water quality and supply is detrimental to both wildlife and people who rely on those natural sources. Extreme heat can also result in heat stroke, death, inability to forage, and/or reduced weight gain for wildlife, and changes in behaviour as they try to adapt.

Changes could include different habitat range, active hours (e.g., hunting/grazing during cooler periods), and/or more frequent human-animal interactions when seeking alternative food and water sources. Community members have already observed more bear activity and wildlife encounters, so awareness of the potential for more interactions is very important.

Glacial Recession

Glaciers serve as an important raw water source for both the Municipality and downstream communities. Glaciers contribute to groundwater volume as well as surface water baseflow. Baseline water supply will decline as glaciers recede and are not replenished at the same rate. In the long term, this could lead the Municipality to require other raw water sources. The Municipality has not had to implement mandatory water restrictions up to this point. However, it was noted that if restrictions were required, commercial use would be of greater concern than residential use due to the scale of water needs (commercial use accounts for 70% of water use in the municipality).

Wildfires

During the community engagement, it was noted that Parks Canada has an established FireSmart program and two local firefighting teams.

Lost of habitat due to wildfire could induce local ecosystems change. While ecosystems will adapt, the length of time to recover and the types of species that will stay in the area will depend on the extent of damage.

Water quality will decline with soil erosion, ash, and contamination from fire fighting agents. Chemicals from fire retardant can increase chemical levels in soil and water, such as phosphate, nitrate, and nitrite. Wildlife would have negative health impacts associated with consumption of contaminated water.

4.2.3 Social System

Social systems relate to people as they spend time in the municipality, either as residents of the community, employees, or visitors. The social system considers health (physical and mental) and safety implications, as well as any disruptions to day to day lives of citizens.

A total of **38 impacts** to the social systems were assessed and are summarized in **Figure 4-4** below. **Table 4-5** provides details on the 7 risks which were found to be very high.

Figure 4-4 Climate Risk Matrix – Social System

Consequences	Likelihood 1	Likelihood 2	Likelihood 3	Likelihood 4	Likelihood 5
5		Extreme Cold (B) Avalanches (D)	Heavy Snow (J)		Extreme Heat (F)
4		Extreme Cold (E)	High Winds (K) Ecoregion Shift (D)	River/Creek Flooding (J)	Wildfires (F,G,H) Wildfire Smoke (F) Extreme Heat (G,H)
3			Drought (G,I) Localized Flooding (I,J) High Winds (I,J) Heavy Snow (G,K)	River/Creek Flooding (I,K,L) Freezing Rain (I,M)	Wildfires (C,I,J) Wildfire Smoke (G) Extreme Heat (I)
2		Extreme Cold (C)	Drought (H) Hail (E,G)		
1			Ecoregion Shift (E,F)		

Table 4-5 Very High Risk Climate Impacts – Social System

Hazard (Impact ID)	Impact
Extreme Heat (F)	Health impacts including mortality especially for vulnerable community (elders, children, medical issues)
Wildfires (F)	Damage to (natural and built) sites of cultural heritage
Wildfires (G)	Residents displaced from their homes, temporarily or permanently
Wildfires (H)	Poor mental health & PTSD from fire events
Wildfire Smoke (F)	Serious health implications, especially for those with respiratory problems
Extreme Heat (G)	Risk to people working outdoors
Extreme Heat (H)	Risk to people indoors without air conditioning

Extreme Heat

The health impacts of extreme heat were identified as a very high risk. Extreme heat can result in heat-related illnesses (e.g. heat stroke) and even death in some cases. Elders, children, people who are pregnant, and people with medical conditions are all vulnerable populations at greatest risk of heat-related discomfort and medical issues. During the community engagement, it was noted that there are many people without access to air conditioning. People in Jasper enjoy spending time outdoors, and they recognized that extreme heat is the number one risk to social systems is critical.

Outdoor workers are also vulnerable to the negative health effects of prolonged time spent outside in the extreme heat condition. Safe work procedures should be evaluated and adjusted in the context of increasing heat days.

Wildfires

Wildfires in the region could result in residents being displaced from their homes, either temporarily or permanently. The length of time and number of residents displaced will depend on the extent of the fire. A large-scale evacuation would require a corresponding amount of emergency housing and transportation logistics, with additional supports made available for vulnerable populations. The stress of fire damaging or destroying property, the need to evacuate, and fear for the health and safety of loved ones may negatively impact mental health. The community expressed that there is chronic stress/fear associated with previous fires and a growing pine beetle populations that exacerbates risk.

Wildfire Smoke

Increased and/or prolonged exposure to wildfire smoke could impact the respiratory wellbeing of residents, particularly for those who are elderly or with certain medical conditions (e.g., asthma). Due to the recent wildfire event, the community expressed high concerns for future recurring events. The community noted that smoke events will never be just isolated to Jasper, and smoke will remain a top concern in the community due to its impact on health and daily life.

4.2.4 Economic/Tourism System

The economic/tourism system was assessed because the Municipality is within a National Park with significant tourist activity and the Municipality expressed interest in understanding the impact of climate change on the local economic and tourism environment. Impacts in this system relate to the perception of the community as a tourism destination, tourist activities that support the local economy, and quality of visitor experience.

A total of **30 impacts** to the social/cultural systems were assessed and are summarized in **Figure 4-5** below. **Table 4-6** provides details on the 9 risks which were found to be very high.

Figure 4-5 Climate Risk Matrix – Economic/Tourism System

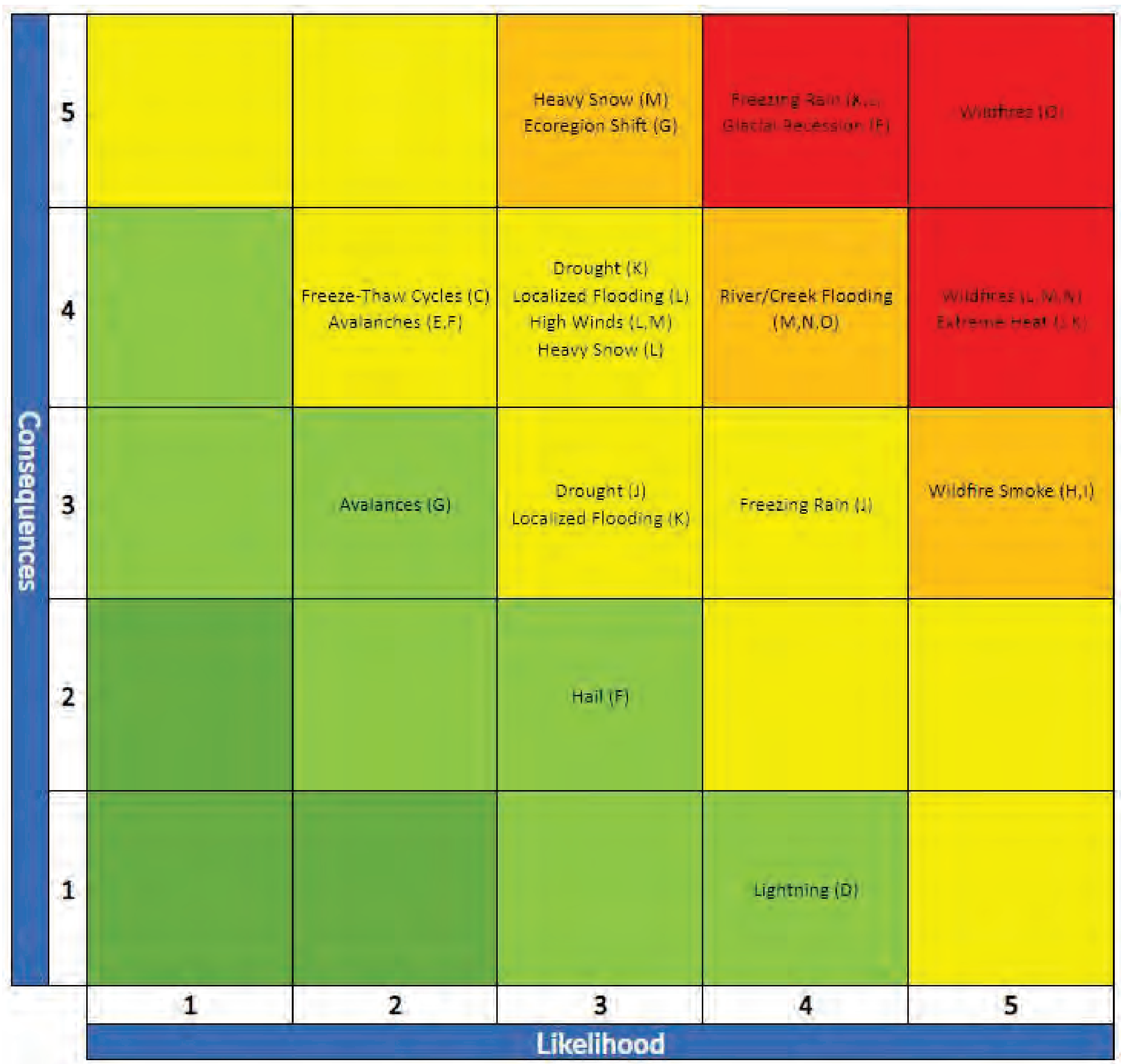


Table 4-6 Very High Risk Climate Impacts – Economic/Tourism System

Hazard (Impact ID)	Impact
Wildfires (O)	Long-term negative perception of Jasper as an international tourism destination
Wildfire (L)	Parks or camping sites are not accessible due to wildfires
Wildfire (M)	Earlier and longer fire bans decrease demand for camping
Wildfire (N)	Cancellation of or disruption to tourism operation activities
Extreme Heat (J)	Decline in use of outdoor recreation spaces
Extreme Heat (K)	Decline in participation in nature-based tourism activities
Freezing Rain (K)	Loss of reputation following a mass casualty, collision, or incident
Freezing Rain (L)	Closure of or reduced safety on key tourism transportation corridors
Glacial Recession (F)	Decreased tourism activity to visit/recreate at glaciers

Wildfires

During the community engagement, it was noted that wildfires pose a risk of creating a long-term negative perception of Jasper as a tourist destination. International tourists often book trips years in advance, so media coverage of wildfires can impact the long-term economic performance of the area.

Demand for camping may drop off if sites are inaccessible or there is an increase in fire bans. Visitors may also be concerned about last minute trip cancellations or mandatory evacuations.

As Jasper prides itself for outdoor activities throughout the year, poor air quality from fire smoke would reduce interest in these activities as well as events closure or postponement. The investment of time and resources to various events and activities will be reduced, thus reducing the economic and social opportunities.

Interviews with the Parks Canada staff revealed that there are already extensive Fire Smart practices underway, two firefighting teams based in Jasper, and proactive monitoring done to reduce wildfire risk and respond when needed. Parks Canada is the sole authority for the FireSmart program and updates Jasper residents throughout the year. These actions reduce the potential consequence of a wildfire on Jasper. Parks Canada expressed that the actual risk of fire is less than the public perception. Regardless, the long-term success of Jasper's tourism sector will be affected by people's thoughts, feelings, and impressions of wildfire risk which should be considered in education and communication.

Extreme Heat

Spending time in nature and enjoying outdoor recreation is the core offering of Jasper tourism. The increase in days above 30°C may result in less people spending time outdoors and enjoying the natural environment. Extreme heat related health emergencies and impacts to vegetation/wildlife can make the area less appealing thus reduce the enjoyment and tourism quality.

Up until this point, recreation spaces and amenities (e.g., sports fields, pathways, campsites) have not been designed with future heat extremes in mind. While Jasper is fortunate to have natural cooling via the forest, this alone is insufficient to provide relief to those spending time outdoors during peak heat. Vulnerable populations (children, elderly) in particular may require cooling supports (e.g., misters) beyond what the ecosystem can naturally offer.

Freezing Rain

Freezing rain can result in dangerous driving conditions. These hazardous driving conditions could lead to a large-scale collision or incident, potentially resulting in injury or death for many. Visitors could be concerned about the safety of roadways and avoid Jasper due to these dangerous conditions. The roads may need to be closed in certain cases of freezing rain to reduce the risk of driving during dangerous conditions.

Glacial Recession

Glacier tours are an important part of Jasper's tourism industry. The Columbia Icefield is a major tourism draw, with international tourists booking well (years) in advance. Glacial recession will impact the scale and quality of the glaciers and has the potential to permanently disrupt this type of tourism. For example, there could be a decline in registrations for the Columbia Icefield Adventure, fewer visits to the Skywalk, and lower food and beverage sales. The Glacier View Lodge could also see lower occupancy or be forced to reduce rates if there is less attraction to staying in the Icefield (i.e., views are not as nice as people have become accustomed to).

6 CONSIDERATIONS FOR FUTURE ADAPTATION PLANNING

Climate change will, and already is, affecting the region in a multitude of ways which can often feel overwhelming. The Municipality of Jasper will need to continue to respond to more severe and frequent extreme weather events, such as those described in the CRA. Based on the results of the assessment, it is recommended that the Municipality undertake the following next steps to aid in the community's resilience journey:

- **Develop a Climate Change Adaptation Action Plan** specifically targeting the highest risks as identified in this assessment. Ideally, local government staff, community organizations, knowledge holders, and citizens should work collaborative to co-create a plan that can realistically be implemented. Support the development of adaptation strategies that generate co-benefits and can be incorporated into existing processes and funding sources. Implementation planning to operationalize the action should include:
  - Targets and indicators to drive action and accountability, to be communicated publicly.
  - Roles and responsibilities to carry out each of the actions including partnerships with community groups.
  - Identification of existing initiatives and resources best suited to drive and align each of the actions.
  - Develop a timeline and resource plan for implementation of the actions.
- **Continue and expand on the work already underway.** The community's existing policies and procedures provide a strong foundation to build upon. The expansion of these initiatives could include:
  - Adjusting to accommodate future climate conditions,
  - Broadened to consider multiple climate hazards and maximize benefits, or
  - Reprioritized to target the highest risks as identified in this plan.

Below are some potential actions to consider for future climate adaptation planning for each of the impacted systems. The considerations provided are only for the "very high" risks identified in this CRA and is not an exhaustive list. As previously mentioned, it is recommended that the Municipality undertakes a more in-depth climate adaptation exercise to further identify and prioritize actions continuing to integrate community input.

6.1.1 Built System

High level adaptation considerations for built systems:

- Create inventory of cooling infrastructure and amenities throughout the municipality and region. Use findings to inform future investments and plans. The addition of cooling equipment (AC or heat pumps) needs to be seriously considered in the development of new buildings or retrofits of existing.
- Create inventory of where backup power can be installed and temporary generators that can be shared. Explore non-combustion-based forms of backup power (e.g., on-site renewables, batteries).
- Maintain ongoing dialogue between the Municipality, Parks Canada, and utilities as it relates to risks to power infrastructure. Honest and open information sharing about concerns, challenges, and vulnerabilities will support resilience planning efforts for all parties.
- Review the existing asset management studies and incorporate consideration of climate impacts relating to short- and long-range funding needs, asset risk, and level of service considerations, into future revisions and asset management plans. Incorporate findings from this assessment in asset management practices moving forward (e.g., building ventilation will require more maintenance due to increased smoke events).

- Review evacuation plans and identify ways to reduce the number of vehicles on the road so as to reduce congestion on the limited road infrastructure. Identify thresholds for when roads are closed due to poor conditions (like freezing rain) and communicate the potential for closures early.
- Review and incorporate findings from this assessment when updating municipal plans and pursuing new developments.
- Work with Parks Canada to develop early warning systems (time lapse cameras, water level measurements) to protect infrastructure and keep people away from glaciers if there is a risk of significant ice breaks or water releases.

6.1.2 Natural System

The following are considerations in adaption for natural systems:

- Investigate ways to conserve water, thereby reducing demands on the natural environment and leaving more water available for and animals and wild and cultivated plans.
- Share information with the public on the increased risk of wildlife/human interactions and ways to reduce encounters.
- Collaborate with water users and interest groups (residents, commercial sector, environmental groups) to create dialogue on water conservation and sharing.

6.1.3 Social System

Social/cultural systems are another consideration in climate adaptation:

- Create opportunities for people to access cooling and clean air spaces, with special consideration for vulnerable populations (e.g., the elderly, people with medical conditions, unhoused).
- Explore increasing publicly accessible, outdoor cooling amenities (e.g., water misters, spray parks, water fountain/bottle filling stations, shade structures) to make it more comfortable to spend time outside, even despite the extreme heat.
- Assess what standard operating procedures (SOPs) are in place for extreme heat or wildfire smoke conditions for outdoor workers. Consider incorporating the option for working alternative hours (i.e., limited work during peak heat hours). Update or develop procedures based on the findings from this assessment.
- Share information with the public on how to avoid heat related illnesses and respond to people in distress.
- Complete a public education campaign on climate risk and emergency preparedness. Share information on evacuation plans and resources that could be accessed if residents are displaced.

6.1.4 Economic/Tourist System

Adaptation considerations for the economic/tourism system include:

- Complete market research to better understand perceptions of Jasper as an appealing tourist location in the face of climate change.
- Engage with tourism operators to educate them on findings from this report and encourage them to update their business practices to address/reduce risk.
- Increase outdoor cooling amenities (e.g., water misters, water fountain/bottle filling stations, shade structures) to make it more comfortable to spend time outside, even despite the extreme heat.
- Understand government trigger points to issue travel advisories/restrictions to the region.

CLOSURE

The objective of this climate risk assessment is to identify and prioritize the potential impacts climate change may have within the Municipality of Jasper. This will help guide the Municipality's climate adaptation action planning to focus on the highest risks to the built, natural, social, and economic/tourism systems.

The services provided by Associated Engineering Alberta Ltd. in the preparation of this report were conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions. No other warranty expressed or implied is made.

Respectfully submitted,

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Appendix E: Fully Scored Risk Assessment

APPENDIX - RISK ASSESSMENT RESULTS BY SYSTEM

This Appendix provides the detailed results of the risk assessment for all impact statements. These include all climate impact risks ranked from "Very High" to "Very Low" to show the breadth of consequences assessed. The intent of the risk assessment was to identify the highest risks, so the climate impacts are displayed in descending order to highlight which climate impacts pose the greatest risk in the future.

Table A-1 Risk Score Details for 2050s – Built System

Future Likelihood Score	Consequence Score	Future Risk Score	Hazard	Climate Impact / Consequence
5	5	25	Extreme Heat (D)	Need for cooling spaces
5	5	25	Wildfires (P)	Power outages for critical facilities/services
4	5	20	Freezing Rain (F)	Road traffic accidents and transportation delays, including active transportation
4	5	20	Glacial Recession (E)	Damage to or flooding of infrastructure on downstream side of glacier (ice breakage or large release)
5	4	20	Wildfires (D)	Damage to private property
5	4	20	Wildfires (E)	Damages to buildings and facilities
4	4	16	River/Creek Flooding (D)	Damage to private property
4	4	16	River/Creek Flooding (E)	Damage to buildings and facilities
4	4	16	River/Creek Flooding (F)	Flooding of/damage to roads (access/egress, community services)
5	3	15	Wildfire Smoke (D)	Increased wear on filtration systems & AC units
5	3	15	Wildfire Smoke (E)	Smoke infiltrating into buildings (i.e., air tightness of buildings, type of filters on HVAC)
3	5	15	High Winds (G)	Road traffic accidents and transportation delays, including active transportation
3	5	15	Heavy Snow (F)	Road traffic accidents and transportation delays, including active transportation
5	3	15	Extreme Heat (C)	Increased usage of building mechanical systems (i.e., cooling)
3	4	12	Localized Flooding (D)	Damage to private property

Future Likelihood Score	Consequence Score	Future Risk Score	Hazard	Climate Impact / Consequence
3	4	12	Localized Flooding (E)	Damage to buildings and facilities
3	4	12	Localized Flooding (H)	Flooding of/damage to roads (access/egress, community services)
4	3	12	River/Creek Flooding (G)	Flooding of electrical infrastructure for critical services
4	3	12	Lightning (B)	Power outages for critical facilities/services
3	4	12	Hail (B)	Damage to private property
3	4	12	Hail (C)	Hail damage to buildings and facilities
4	3	12	Freezing Rain (C)	Damages to private property from fallen trees
4	3	12	Freezing Rain (D)	Damages to buildings and facilities from fallen trees or breakage of building components
4	3	12	Freezing Rain (E)	Power outages from fallen trees or ice accretion
3	4	12	High Winds (D)	Damages to private property from fallen trees
3	4	12	High Winds (E)	Damages to facilities and infrastructure from fallen trees
3	4	12	Heavy Snow (C)	Damages to private property (i.e., snow load, fallen trees)
3	4	12	Heavy Snow (D)	Damages to buildings and facilities (i.e., snow load on buildings, fallen trees)
5	2	10	Extreme Heat (E)	Damages to/increased deterioration of road & bridge materials
5	2	10	Wildfires (Q)	Widespread power outages
3	3	9	Drought (D)	Water availability during prolonged dry spells
3	3	9	Drought (E)	Increased pressure on pumps at water network
3	3	9	Drought (F)	Longer season's impact on infrastructure operations
3	3	9	Localized Flooding (F)	Flooding of electrical infrastructure for critical services
3	3	9	Localized Flooding (G)	Impacts to municipal water treatment or raw water supply
3	3	9	Hail (D)	Fallen debris and hail blocking catch basins, culverts and leading to localized flooding
3	3	9	High Winds (H)	Fallen debris blocking catch basins, culverts leading to flooding if it rains before debris cleanup
3	3	9	Heavy Snow (I)	Blockage and/or icing of catch basins leading to flooding during snow melt
4	2	8	River/Creek Flooding (H)	Impacts to municipal water treatment

Future Likelihood Score	Consequence Score	Future Risk Score	Hazard	Climate Impact / Consequence
4	2	8	Lightning (C)	Widespread power outages
4	2	8	Freezing Rain (G)	Increased salt use and sanding
4	2	8	Freezing Rain (H)	Fallen debris blocking catch basins, culverts leading to localized flooding
2	4	8	Extreme Cold (A)	Water line breaks in infrastructure above frost line
2	4	8	Extreme Cold (D)	Increased load on power and gas systems
2	4	8	Freeze-Thaw Cycles (B)	Damage to, and decreased service life of, water mains and service lines
2	4	8	Avalanches (B)	Blockage of roads and disruption of Town access/egress
2	4	8	Avalanches (C)	Damage to buildings, including residential homes, municipal buildings, and businesses
3	2	6	High Winds (F)	Power outages (i.e., downed trees near powerlines)
3	2	6	Heavy Snow (E)	Power outages from downed trees or snow load on powerlines
3	2	6	Heavy Snow (H)	Maintenance and operational costs for snow clearing
2	3	6	Freeze-Thaw Cycles (A)	Damage to, and decreased service life of, buildings and infrastructure

Table A-2 Risk Score Details for 2050s – Natural System

Future Likelihood Score	Consequence Score	Future Risk Score	Hazard	Climate Impact / Consequence
5	5	25	Extreme Heat (B)	Increased heat stress for wildlife and aquatic populations
5	4	20	Wildfires (A)	Damage to terrestrial habitat
4	5	20	Glacial Recession (A)	Reduction of raw water supply (surface water baseflow and groundwater)
4	4	16	River/Creek Flooding (B)	Damage and erosion to riverbanks and riparian areas
4	4	16	Glacial Recession (B)	Loss of viable habitat for local flora/fauna
4	4	16	Glacial Recession (C)	Formation of new glacial lakes which could fail comparable to a dam release
4	4	16	Glacial Recession (D)	Slope destabilization
5	3	15	Wildfire Smoke (B)	Increased risk of wildlife and human interactions due to decreased visibility (i.e., car accidents, wildlife accessing water sources and fleeing the fire)
5	3	15	Wildfire Smoke (C)	Vegetation die off or degradation due to air quality
3	5	15	Ecoregion Shift (A)	Increase in invasive species and pests
3	5	15	Ecoregion Shift (B)	Loss of medicinal plants and other wild crops
3	5	15	Ecoregion Shift (C)	Changes in habitat resulting in changes in wildlife in the area
3	4	12	Drought (A)	Increased tree mortality
4	3	12	River/Creek Flooding (C)	Impacts to wildlife habitats and populations
4	3	12	Lightning (A)	Lightning strikes causing wildfires
4	3	12	Freezing Rain (B)	Damage to trees/tree branches – increased clean up
3	4	12	High Winds (A)	Increased blowing dust removing topsoil
3	4	12	High Winds (B)	Damage to trees / tree branches – loss of habitat
3	4	12	Heavy Snow (A)	Damage to trees / tree branches – loss of habitat
5	2	10	Wildfire Smoke (A)	Decreased health to wildlife due to air quality
5	2	10	Wildfires (B)	Decreased water quality due to runoff from wildfire areas
2	5	10	Avalanches (A)	Loss of recreational areas (skiing, trails, camping sites)
3	3	9	Drought (C)	Reduction in water availability / drinking water supply

Future Likelihood Score	Consequence Score	Future Risk Score	Hazard	Climate Impact / Consequence
3	3	9	Localized Flooding (B)	Damage and erosion to creek banks and riparian areas
3	3	9	Hail (A)	Damage to trees and shrubs leading to debris cleanup
3	3	9	High Winds (C)	Damage to trees/tree branches – increased clean up
3	3	9	Heavy Snow (B)	Damage to trees/tree branches – increased deadfall
4	2	8	Freezing Rain (A)	Damage to trees / tree branches – loss of habitat
3	2	6	Drought (B)	Increased stress on aquatic and terrestrial ecosystems
3	2	6	Localized Flooding (C)	Impacts to wildlife habitats and populations
5	1	5	Extreme Heat (A)	Algae blooms in ponded or slow-moving water compromise water quality
4	1	4	River/Creek Flooding (A)	Increased stress on aquatic habitat
3	1	3	Localized Flooding (A)	Increased stress on aquatic habitat

Table A-3 Risk Score Details for 2050s – Social System

Future Likelihood Score	Consequence Score	Future Risk Score	Hazard	Climate Impact / Consequence
5	5	25	Extreme Heat (F)	Health impacts including mortality especially for vulnerable community (elders, children, medical issues)
5	4	20	Wildfire Smoke (F)	Serious health implications, especially for those with respiratory problems
5	4	20	Wildfires (F)	Damage to (natural and built) sites of cultural heritage
5	4	20	Wildfires (G)	Residents displaced from their homes, temporarily or permanently
5	4	20	Wildfires (H)	Poor mental health & PTSD from fire events
5	4	20	Extreme Heat (G)	Risk to people working outdoors
5	4	20	Extreme Heat (H)	Risk to people indoors without air conditioning
4	4	16	River/Creek Flooding (J)	Residents displaced from their homes, temporarily or permanently
5	3	15	Wildfire Smoke (G)	Disruption to outdoor activities/events
5	3	15	Wildfires (C)	Transportation delays and disruptions on major routes (access/egress routes)
5	3	15	Wildfires (I)	Interruptions to critical community services (i.e., schools, medical centers, seniors homes, etc.)
5	3	15	Wildfires (J)	Food insecurity due to being cut off from surrounding communities
3	5	15	Heavy Snow (J)	Health risks from isolation or inability to access services, particularly for vulnerable populations (elderly)
5	3	15	Extreme Heat (I)	Reduction in labour supply and labour (e.g., restaurant and kitchen staff, hotels, service industry)
4	3	12	Freezing Rain (I)	Injuries from falls on iced surface
4	3	12	Freezing Rain (M)	Increased strain on limited medical capacity and first responders due to injuries
4	3	12	River/Creek Flooding (I)	Increased risk of illness due to mold from flooded buildings, basements
4	3	12	River/Creek Flooding (K)	Interruptions to critical community services (i.e., schools, medical centers, seniors homes, etc.)

Future Likelihood Score	Consequence Score	Future Risk Score	Hazard	Climate Impact / Consequence
4	3	12	River/Creek Flooding (L)	Food insecurity due to being cut off from surrounding communities
3	4	12	High Winds (K)	Possible displacement from homes if roofs become damaged
3	4	12	Ecoregion Shift (D)	Negative health outcomes from vector-borne diseases
2	5	10	Extreme Cold (B)	Health impacts including mortality especially for vulnerable community (elders, children, unhoused, medical issues)
2	5	10	Avalanches (D)	Injuries or fatalities from falling snow/debris
3	3	9	Drought (G)	Deteriorating water quality & water restrictions force use of bottled water
3	3	9	Drought (I)	Public perception and reactions to water conservation
3	3	9	Localized Flooding (I)	Restricted access to, closure of trails, parks, playing fields
3	3	9	Localized Flooding (J)	Restricted access to transportation corridors (roads)
3	3	9	High Winds (I)	Restricted access to, closure of trails, parks, playing fields
3	3	9	High Winds (J)	Injuries and potential fatalities
3	3	9	Heavy Snow (G)	Increased strain on limited medical capacity and first responders due to injuries
3	3	9	Heavy Snow (K)	Food insecurity due to being cut off from surrounding communities
2	4	8	Extreme Cold (E)	Impacts on outdoor workers
3	2	6	Drought (H)	Damage to trails, parks, playing fields
3	2	6	Hail (E)	Possible displacement from homes if windows become damaged
3	2	6	Hail (G)	Increased strain on limited medical capacity and first responders due to injuries
2	2	4	Extreme Cold (C)	Decline in use of outdoor recreation spaces
3	1	3	Ecoregion Shift (E)	Economic losses due to the absence of traditional food and harvesting sources
3	1	3	Ecoregion Shift (F)	Dietary changes as traditional food sources disappear, possible health impacts

Table A-4 Risk Score Details for 2050s – Economic/Tourism System

Future Likelihood Score	Consequence Score	Future Risk Score	Hazard	Climate Impact / Consequence
5	5	25	Wildfires (O)	Long-term perception of Jasper as an international tourism destination
4	5	20	Freezing Rain (K)	Loss of reputation following a mass casualty, collision, or incident
4	5	20	Freezing Rain (L)	Closure of or reduced safety on key tourism transportation corridors
5	4	20	Extreme Heat (J)	Decline in use of outdoor recreation spaces
5	4	20	Extreme Heat (K)	Decline in participation in nature-based tourism activities
4	5	20	Glacial Recession (F)	Decreased tourism activity to visit/recreate at glaciers
5	4	20	Wildfires (L)	Parks or camping sites are not accessible due to wildfires
5	4	20	Wildfires (M)	Earlier and longer fire bans decrease demand for camping
5	4	20	Wildfires (N)	Cancellation of or disruption to tourism operation activities
4	4	16	River/Creek Flooding (M)	Closure of key tourism transportation corridors due to flooding affecting access/egress
4	4	16	River/Creek Flooding (N)	Interruptions or changes to water-based tourism
4	4	16	River/Creek Flooding (O)	Damage to tourism infrastructure (i.e., hotels) restricting capacity
5	3	15	Wildfire Smoke (H)	Town is less appealing to visit or to camp nearby during smoke events
5	3	15	Wildfire Smoke (I)	Cancellation of or disruption to tourism operation activities
3	5	15	Heavy Snow (M)	Closure of or reduced safety on key tourism transportation corridors
3	5	15	Ecoregion Shift (G)	Changes in availability of nature-based tourism activities
3	4	12	Drought (K)	Deteriorating water quality & water restrictions force operational changes or limitations.
3	4	12	Localized Flooding (L)	Disruption or closure of commercial operations.
4	3	12	Freezing Rain (J)	Cancellation of or disruption to tourism operation activities
3	4	12	High Winds (L)	Damage to hotels impacting availability
3	4	12	High Winds (M)	Cancellation of or disruption to tourism operation activities

Future Likelihood Score	Consequence Score	Future Risk Score	Hazard	Climate Impact / Consequence
3	4	12	Heavy Snow (L)	Changes to demand for skiing and snow-based recreational offerings
3	3	9	Drought (J)	Lower water levels for water-based recreation
3	3	9	Localized Flooding (K)	Interruptions or changes to tourism activities
2	4	8	Freeze-Thaw Cycles (C)	Disruptions in the use of winter recreation activities
2	4	8	Avalanches (E)	Decreased access to backcountry recreation areas or increased risk associated with backcountry recreation
2	4	8	Avalanches (F)	Closure of or reduced safety on key tourism transportation corridors
3	2	6	Hail (F)	Interruptions to nature-based tourism activities
2	3	6	Avalanches (G)	Disruption or closure of commercial operations.
4	1	4	Lightning (D)	Interruptions to nature-based tourism activities

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