Climate Risk Assessment & Adaptation Plan

for the Pincher Creek Region

June 2023

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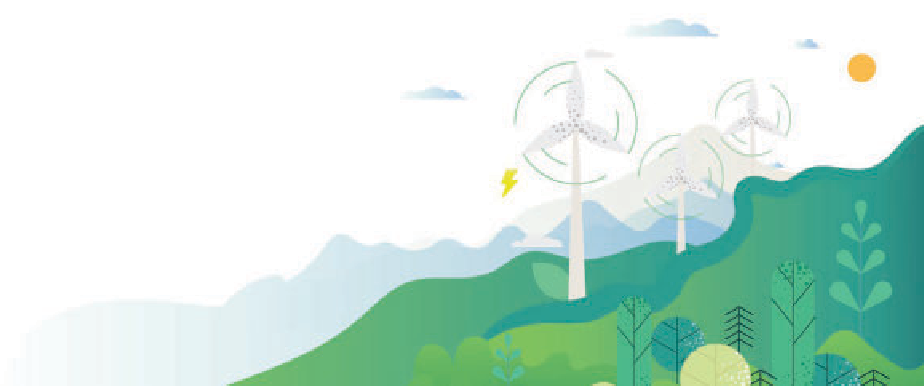

Acknowledgements

The Climate Risk Assessment and Adaptation Plan (the "Plan") was collaboratively prepared by the Town of Pincher Creek, the Municipal District (MD) of Pincher Creek, the Piikani Nation and a consulting team led by All One Sky Foundation. The Pincher Creek Climate Adaptation Project Team was instrumental in the development of the Plan; contributing time and participating throughout the planning process, and providing essential local knowledge, advice and direction to ensure the successful completion of the Plan:

- Tristan Walker, Municipal Energy Project Lead
- David Desabrais, Utilities and Infrastructure Manager, Municipal District of Pincher Creek
- Brett Wuth, Director of Emergency Management, Pincher Creek Regional Emergency Management Organization
- Andrea Hlady, Director of Family and Community Support Services, Town of Pincher Creek
- Tawnya Plain Eagle, Project Manager, Piikani Nation Lands Department

In addition, many other Town and MD staff and community members participated in and supported the process through completion of the community survey and attendance at the open houses, the risk assessment workshop and climate adaptation action planning sessions.

All One Sky Foundation managed the project and led all aspects of the community and stakeholder engagement, costs of inaction, climate impact assessment and climate adaptation planning process. The Prairie Adaptation Research Collaborative completed the climate modelling, projections and mapping for the Pincher Creek region. The Resilience Institute led the First Nations engagement.

Name	Organization	Role
Jeff Zukiwsky	All One Sky Foundation	Project Manager, Climate risk assessment and adaptation planning lead
Richard Boyd	All One Sky Foundation	Technical lead, climate change economics lead
Calvin Kwan	All One Sky Foundation	Research, community engagement and planning support
Dave Sauchyn	Prairie Adaptation Research Collaborative	Climate science lead
Soumik Basa	Prairie Adaptation Research Collaborative	Climate data acquisition
Jon Belanger	Prairie Adaptation Research Collaborative	GIS and mapping
Laura Lynes	The Resilience Institute	First Nations Engagement Lead
Amie Chaotakoongite	Avenir Creative	Creative design

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The project team acknowledges the traditional territories of the Niitsitapi (Blackfoot) and the people of the Treaty 7 region in Southern Alberta, which includes the Siksika, the Piikani, the Kainai, the Tsuut'ina, and the Stoney Nakoda First Nations, including Chiniki, Bearspaw, and Wesley First Nations. Southern Alberta is also home to the Métis Nation of Alberta Region 3.

1 Introduction

There is unequivocal evidence that Alberta has warmed over the last century and will warm further in the future[1]. Projections indicate a warmer and generally wetter future climate, with an increase in the frequency, intensity, or both, of some extreme weather events. Climate change is already altering our natural environment with observable changes related to the timing and availability of water, shifts in natural ecosystems, landscapes and species' ranges[2]. It is also negatively impacting the ability of municipalities to meet levels of service targets due to accelerated deterioration of infrastructure and reduced performance and reliability[3]. In addition, climate change is a driver of health risks related to extreme heat, wildfires and the expansion of vector-borne diseases; risks anticipated to increase as warming continues[4]. These impacts affect every aspect of our lives—our livelihoods and economy, social connectedness, culture and traditions, and general wellbeing. With further climate change anticipated this century there is a growing need for governments at all levels to understand, prioritize, and efficiently manage climate change risks.

This Plan provides a climate resilience and adaptation roadmap for the Pincher Creek region. It was developed following the participatory approach to climate adaptation planning shown in Figure 1. The Plan supports the Town of Pincher Creek (the "Town") and Municipal District (MD) of Pincher Creek to better understand the climate change risks facing residents, the economy, natural environment, and infrastructure in the region, to prioritize risks, and outlines a robust plan to adapt to these risks. Implementation of this Plan has tremendous potential to make the Pincher Creek region, economy and way of life more resilient to weather disruptions and stress, and healthier and safer for residents, now and in the future.

Encompassing the first three steps in Figure 1, this Plan is structured as follows:

Section 2	An overview of the project scope
Section 3	A summary of climate projections for the Pincher Creek region
Section 4	An overview of the community and stakeholder engagement for this project
Section 5	A summary of the economic impacts of climate change on the Pincher Creek region
Section 6	The climate impact assessment approach and results
Section 7	The Climate Adaptation action Plan for the Town and MD of Pincher Creek

1 Zhang, X., et al. (2019): Changes in Temperature and Precipitation Across Canada; Chapter 4 in Bush, E. and Lemmen, D. (Eds.). Canada's Changing Climate Report. Government of Canada, Ottawa, Ontario.
2 Bonsal, B. et al. (2019): Changes in freshwater availability across Canada; Chapter 6 in Canada's Changing Climate Report, *ibid*.
3 Brown, C., et al. (2021): Cities and Towns; Chapter 2 in Warren, F. and Lulham, N. (Eds.). Canada in a Changing Climate: National Issues Report. Government of Canada, Ottawa, Ontario.
4 Berry, P. and Schnitter, R. (Eds.). (2022). Health of Canadians in a Changing Climate: Advancing our Knowledge for Action. Government of Canada, Ottawa, Ontario.

Figure 1:

The climate adaptation planning process

Climate adaptation planning and implementation is an ongoing process.

The purpose of step 1 is to:

- Determine the scope of the planning process
- Develop a plan to engage stakeholders and residents
- Compile climate trends and projections for your community

The purpose of step 2 is to:

- Understand your communities' vulnerabilities
- Develop climate impact statements
- Conduct a climate change risk and opportunity assessment
- Determine priorities for action planning

The purpose of step 3 is to:

- Define actions to manage priority climate impacts and consequences
- Assess and prioritize actions
- Formulate a Climate Adaptation Action Plan

The purpose of step 4 is to:

- Commit funding and staff time to implement actions
- Partner with local and regional organizations
- Monitor impacts and actions
- Repeat the process every 5-10 years

Source: Climate Resilience Express: A Community Climate Adaptation Planning Guide, All One Sky Foundation and the Municipal Climate Change Action Centre [www.allonesky.ca]

2 Project Scope

Climate change impacts are widespread in scope, affecting nearly every aspect of community life, the economy, the natural environment, as well as built assets, infrastructure and municipal services. It is therefore necessary to be clear about what the climate risk assessment and adaptation planning process is to include and what it is to exclude. The scope of the exercise is summarized below:

The project is focused on consequences arising from climate-related impacts that occur directly within the **geographical boundaries** of the **MD of Pincher**

The project includes both **chronic (slow onset)** and **acute (rapid onset) climate-related impacts** with consequences for the natural environment, built environment, the regional economy, and the health and well-being of residents and visitors.

Where relevant, the climate risk assessment and adaptation plan distinguish between **impacts that affect the Town and MD of Pincher Creek differently.** The Action Plan specifies whether the action is intended for implementation by the Town, MD, or both.

It is a **high-level assessment** of risk focusing on identifying significant climate-related impacts that affect **broad categories of built and natural assets and/or aspects of the economy and well-being.** The assessment does not consider impacts to specific or individual assets or infrastructure components.

Climate projections and the climate risk assessment are based on a **"high emissions scenario"** whereby global greenhouse gas emissions and global warming continue unabated to the end of the century[5]. Under this scenario global mean temperature reaches +3°C relative to the 1976 to 2005 baseline period by the 2070s.

The risk assessment is **future –focused**, characterizing the severity of impacts anticipated to occur within the MD boundaries under projected climate conditions by the 2070s.

The Climate Adaptation Plan considers **existing and planned measures** in place to manage climate-related impacts. The goal is to identify the incremental impacts of climate change by **overlaying the climate of the future onto the Pincher Creek of today.**

The Climate Adaptation Plan identifies both current and future adaptation deficits and **actions that can be implemented in the next 10 years** to close these gaps.

5 This scenario is consistent with the representative concentration pathway (RCP) 8.5, whereby global mean temperatures are projected to reach 4.3°C [likely range of 3.2-5.4°C] above pre-industrial levels by 2081-2100.

3 Climate Projections for the Pincher Creek Region

Predicting the future is inherently uncertain. To accommodate this uncertainty, projections of future climate change consider a range of plausible scenarios. Scenarios have long been used by planners and decision-makers to analyse futures in which outcomes are uncertain. Projections of future climate change for the Pincher Creek Region were developed under a high-end emissions scenario (referred to in the climate science literature as Representative Concentration Pathway 8.5 or RCP 8.5) where no additional effort is made to curtail human factors contributing to climate change[6]. For this assessment climate projections are based on when a 3°C increase in global mean temperature is realized relative to the 1976 to 2005 historical baseline period. This is expected to occur around the 2070s.

Overall, future climate projections for Pincher Creek for the 2070s indicate the following:

- Hotter temperatures, with increases in maximum temperature, minimum temperature and the number of hot days;
- Less cold, with higher mean and minimum winter temperatures and fewer cold days;
- Drier summer conditions, with more dry days, and an increase in drought risk;
- Wetter conditions overall, with more heavy precipitation days and potential flooding; and
- A longer summer season with fewer frost days, a longer growing season with more degree days.

Table 1 provides a summary of projected changes to climate variables for the Pincher Creek region.

Table 1 — Summary of Climate Projections for the Pincher Creek Area

Variable	Historic	Future	Change
Average maximum summer temperature (°C)	20	24.3	+4.3
Number of hot days (above 30°C)	2.7	17.2	+14.5
Number of hot days (above 35°C)	0.03	2.0	+2.0
Average minimum winter temperature (°C)	-9.8	-5.7	+4.1
Very cold days (temps below -30°C)	3.4	0.3	-3.1
Number of frost days (temps below 0°C)	198	134	-64
Length of the frost-free season (days)	167	231	+64
Average annual precipitation (mm)	795	853	+58 (+7%)
Average spring precipitation (mm)	256	312	+56 (+22%)
Average summer precipitation (mm)	176	165	-11 (-6%)
Number of wet days (>10mm rainfall)	23.9	26.4	+2.5
12-Month Standardized Precipitation Evapotranspiration Index[7]	0.7	0.6	-0.1

Figure 2 through Figure 6 contain maps depicting projected changes in a selection of climate variables for the Pincher Creek region. Detailed climate projections and additional maps are provided in the companion Report – *'Climate Change Projections for Pincher Creek'*, prepared by the Prairie Adaptation Research Collaborative (PARC). Additional climate projections, as well as information on historical trends in extreme weather events, are also provided in Appendix A.

6 The number 8.5 refers to the additional warming (in Watts per square metre) anticipated under this scenario by 2100.

7 The Standardized Precipitation Evapotranspiration Index (SPEI) provides a measure of potential drought or excessive moisture conditions, with values greater than +1 being associated with excessive moisture, and values less than -1 being associated with drought.

Figure 2:

Map of projected changes in the Number of Hot Days (T > 30° C)

As shown in Figure 2, the Pincher Creek region will have an increase in the number of hot days (+30°C or higher) in the future, with 15 more hot days per year, on average, across the region by the 2070s. Lower elevation areas in the east are projected to see greater increases in the number of hot days in the future, compared to the higher elevation areas in the west towards the mountains. The Town of Pincher Creek is projected to have, on average, about 27 hot days per year in the future, compared to only five historically (1976-2005).

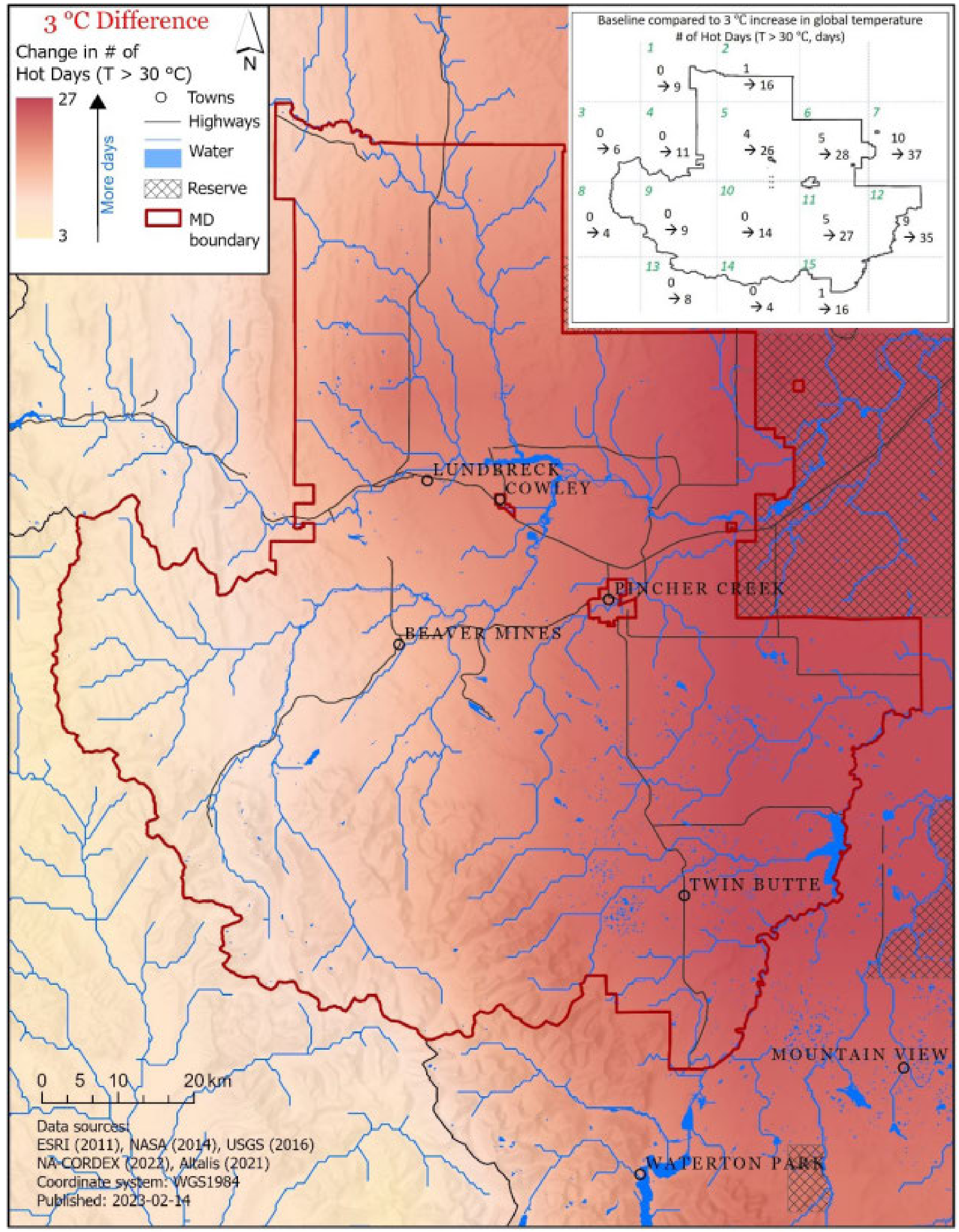


Figure 3:

Map of projected changes in the length of the frost-free season

The length of the frost-free season is projected to increase across the Pincher Creek region, with 58 - 69 extra days without frost by the 2070s (Figure 3). The Town of Pincher Creek is projected to have, on average, 66 more frost free days per year in the future relative to the 1976-2005 baseline period. The increase in the frost-free season suggests an earlier start and later end to the plant, tree and agricultural growing season in the region.

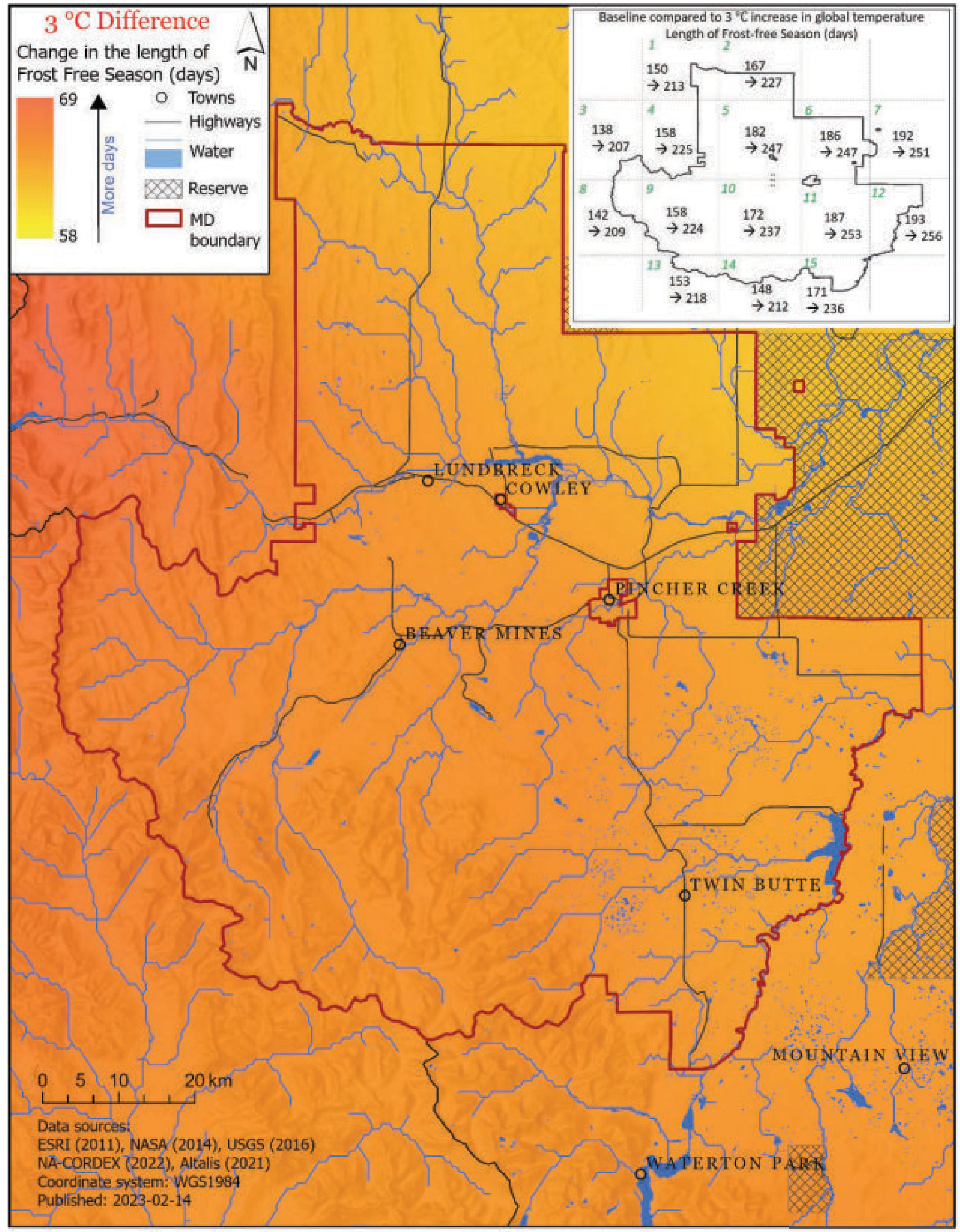


Figure 4:

Map of projected changes in summer precipitation

Climate projections show that the Pincher Creek region will have less summer (June, July and August) precipitation in the future (Figure 4). Higher elevation areas in the west and southern parts of the MD are projected to see larger reductions in summer precipitation than lower elevation areas in the northeast. By the 2070s the Town of Pincher Creek is projected to have, on average, about 9 millimetres less precipitation in the summer (a 6% reduction) relative to the 1976-2005 baseline period.

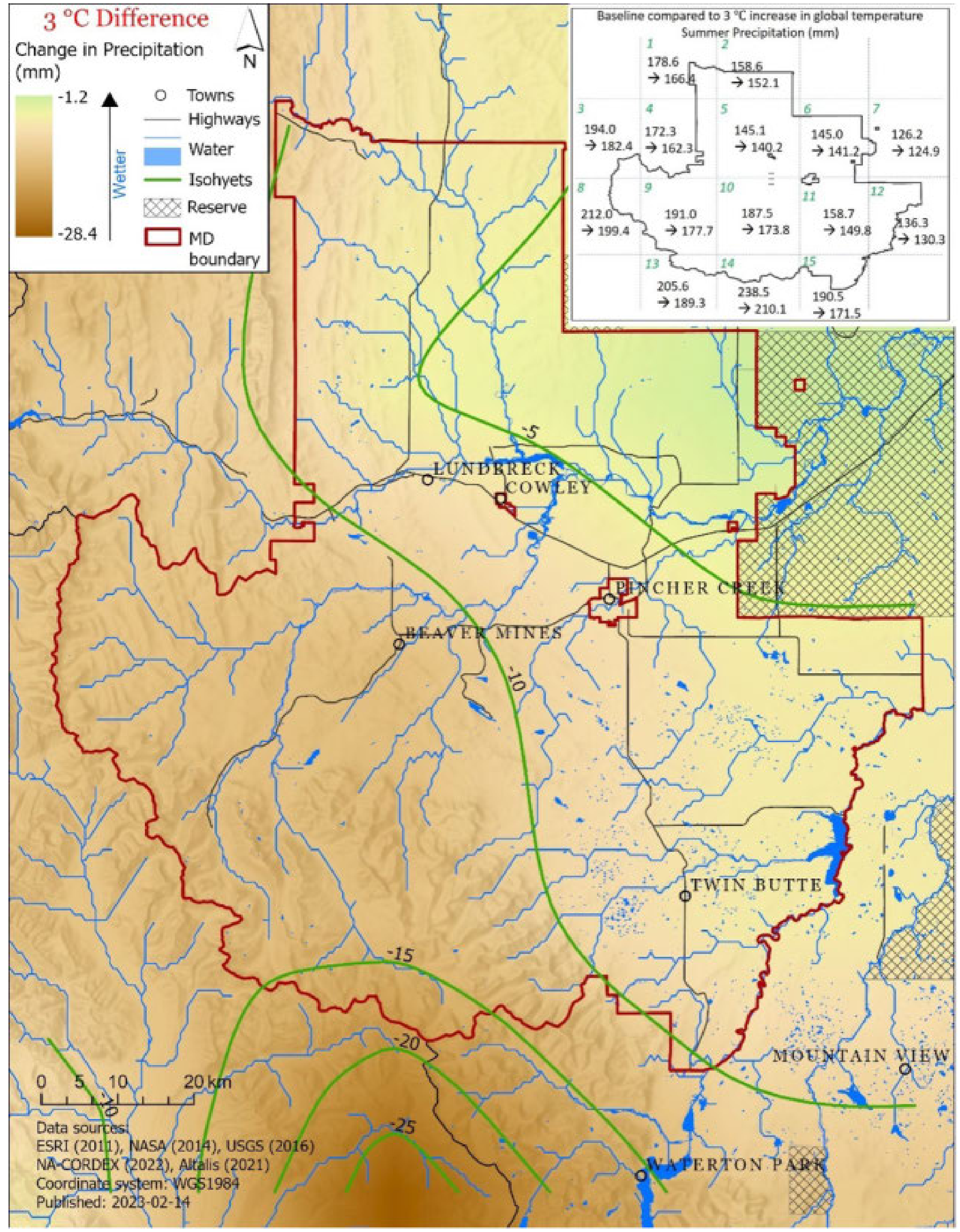


Figure 5:

Map of projected changes in spring precipitation

Precipitation in the spring (March, April and May) is projected to increase across the Pincher Creek region in the future. Lower elevation, valley bottom areas are projected to have a larger increase in spring precipitation than higher elevation areas in the west. By the 2070s the Town of Pincher Creek is projected to have, on average, about 67 millimetres more precipitation in the spring (a 30% increase) relative to the 1976-2005 baseline period.

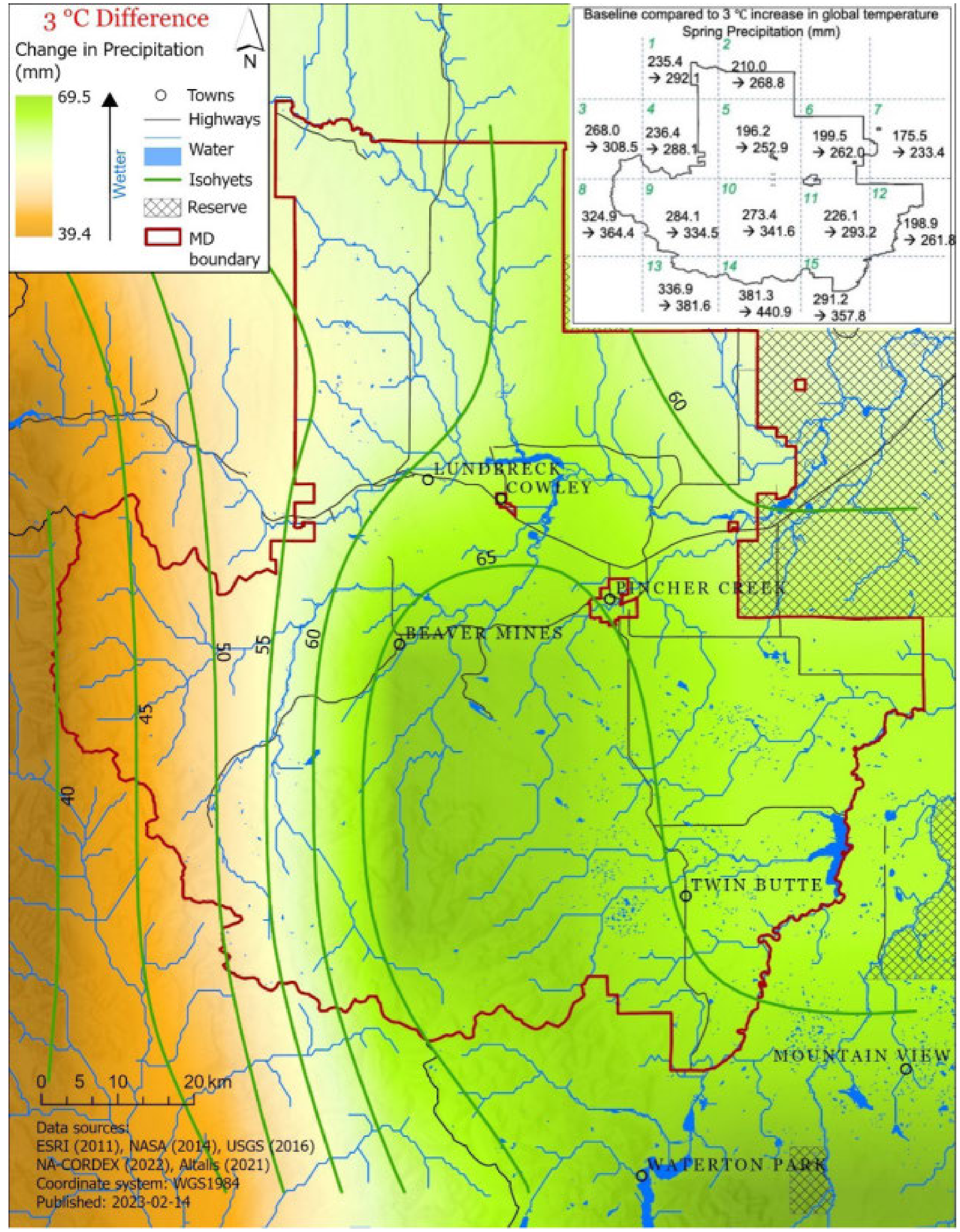
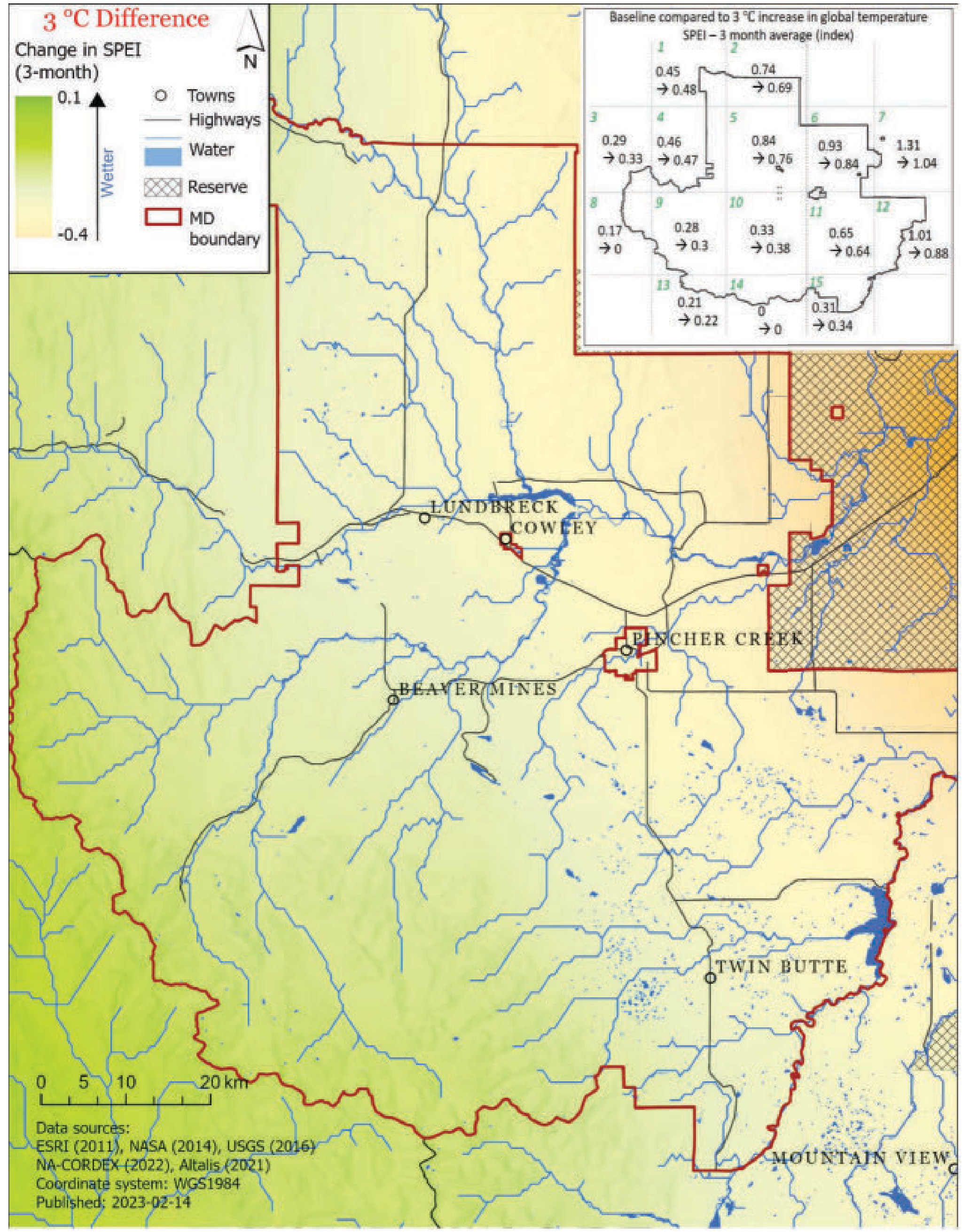


Figure 6:

Map of projected changes in meteorological drought conditions

Figure 6 shows projected changes in meteorological drought conditions in the Pincher Creek region in the future, using the Standardized Precipitation Evapotranspiration Index (SPEI). The SPEI measures potential drought or excessive moisture conditions, with values greater than +1 being associated with excessive moisture, and values less than -1 being associated with moderate-extreme drought conditions. Projected changes to the SPEI suggest that slightly drier conditions are anticipated on average in the lower elevation areas in an around the Town of Pincher Creek, Cowley, Lundbreck and Twin Butte. Moisture conditions are projected to remain relatively stable through much of the rest of the region.



4 Community and Stakeholder Engagement

Field tour with staff.

The development of this Plan is grounded in a participatory approach to climate adaptation. Not only does this provide an effective way of making climate and impact science accessible to staff and members of the community—fostering learning and capacity building—but it also enables the inclusion of local knowledge in the planning process. This increases the credibility, legitimacy and ownership of outcomes, increasing the likelihood that recommendations will be incorporated into decision-making and successfully implemented.

Town and MD Staff

This Plan was developed collaboratively with the Pincher Creek Project Team consisting of representatives from the Town, MD, Pincher Creek Regional Emergency Management Organization and Piikani Nation. In addition to the Project Team, other staff from the Town and MD contributed their expertise through participation in the climate risk assessment and adaptation action planning sessions.

Community open house.

Open Houses

A community open house was hosted on April 13th, 2023, to hear from community members about the climate change projections for the region, provisional climate risk assessment findings, and potential actions to increase regional resilience to climate change. The community open house was attended by over 30 residents, with more than 40 ideas brainstormed to manage priority climate risks in the region.

A second community open house was hosted on June 28th, 2023, to present and discuss a draft of the Climate Adaptation Plan.

Piikani Nation

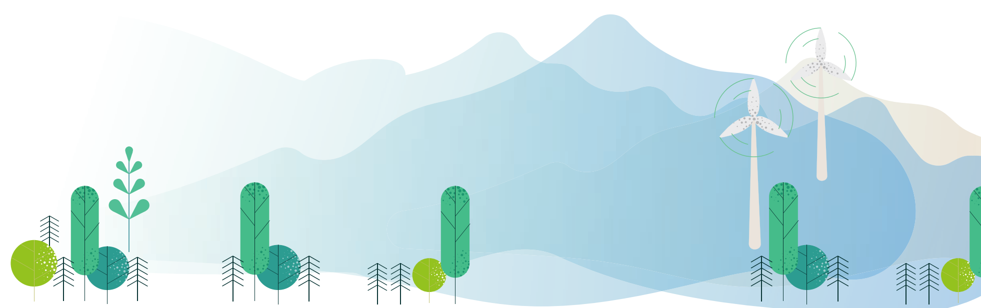
Throughout the project the Town and MD sought to engage meaningfully with the Piikani to provide an opportunity to share their perspectives on key climate risks facing region and to help identify climate adaptation actions that would benefit from collaboration between the Piikani Nation and the Town and MD. Piikani staff were hosted in Pincher Creek to share and discuss the climate risk assessment and identify opportunities for future collaboration on climate resilience. Tawnya Plain Eagle with the Piikani Lands Department was an active participant on the project team.

Community survey

An online survey – which ran from November 14 to December 26, 2022 – provided Pincher Creek residents with the opportunity to offer their thoughts on how the community might be affected by climate change in the future. The survey yielded 211 usable responses.

Overall, the survey results show that residents in the Pincher Creek region are quite concerned about the local impacts of climate change, mainly hotter temperatures, warmer winters, drier summer conditions, more severe storms, and shifting seasons and ecosystems.

The full survey results are available in Appendix B.



5 Costs of Inaction: Economic Analysis of Climate Risks

Information on the economic consequences of climate change is increasingly being demanded by decision-makers as they contemplate how to respond. A key piece of economic evidence used to make the business case for action are the costs that result from allowing climate change to continue unabated and without new adaptation. Estimates of the costs of climate change are being used by decision-makers to inform the overall scale of investment in adaptation, the prioritization of risks, and the selection, timing and sequencing of specific adaptation options, as well as the distribution of costs and adaptation benefits. An economic analysis of climate risks for the Pincher Creek region was completed to inform and provide impetus to the climate adaptation planning process. The results are summarized below.

While climate change is anticipated to bring some benefits for the Pincher Creek region, the total economic impact is projected to be overwhelmingly negative. Under the high future climate scenario, direct economic losses attributable to further climate change are estimated at **$18.3 million** and **$32.8 million** (in 2020 dollars) per year, on average, by the 2050s and 2080s, respectively. The scale and direction of projected direct economic losses varies across climate-sensitive sectors (also see Figure 7):

Losses of **$13.5 million** (2050s) to **$26.2 million** (2080s) annually from public health impacts caused by higher temperatures and periods of poor air quality (e.g., from wildfire smoke).

Losses of **$0.5 million** (2050s) to **$1.0 million** (2080s) annually from reduced worker productivity due to higher temperatures.

Losses of **$4.0 million** (2050s) to **$6.5 million** (2080s) annually from damages to transportation infrastructure and associated delays in the movement of people and freight due to high temperatures and heavy precipitation events.

Losses of **$1.6 million** (2050s) to **$2.7 million** (2080s) annually from damages to electricity transmission and distribution infrastructure due to a range of climate-related hazards.

Losses of **$0.7 million** (2050s) to **$1.9 million** (2080s) annually from damages to water, wastewater and drainage infrastructure due to heavy precipitation events and drought conditions.

Losses of **$0.8 million** (2050s) to **$1.4 million** (2080s) annually from damages to building structures and contents resulting from river and stormwater flooding.

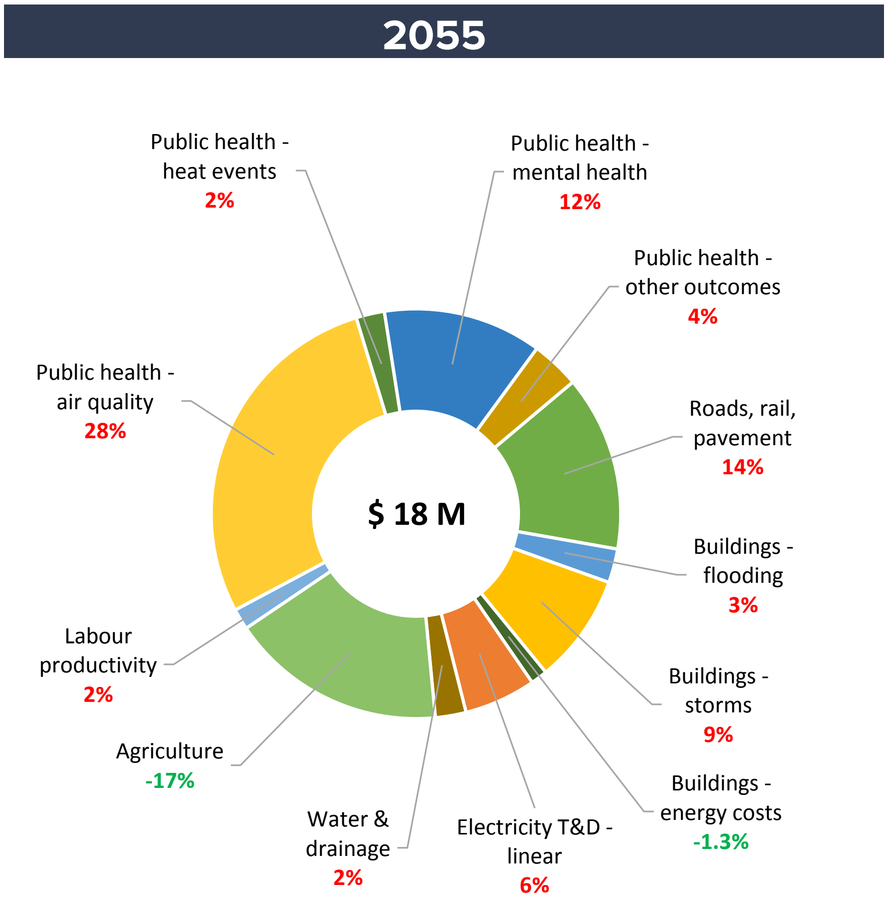
Losses of **$2.5 million** (2050s) to **$3.6 million** (2080s) annually from damages to building structures resulting from high winds, hail and freezing precipitation.

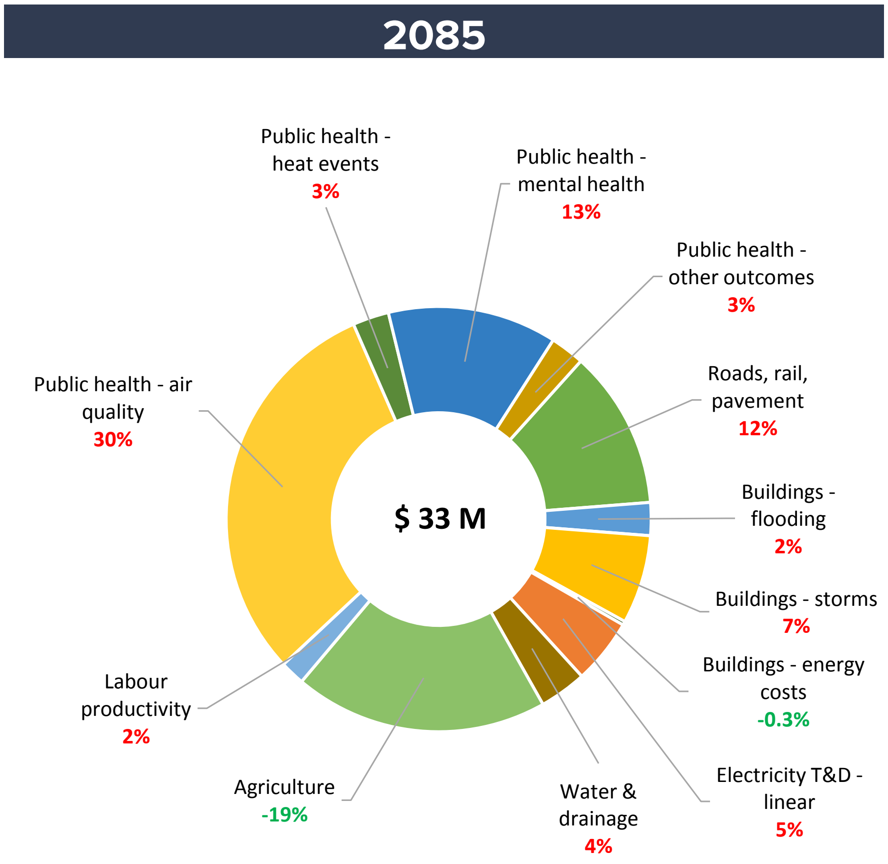
Savings of **$0.4 million** (2050s) to **$0.2 million** (2080s) annually from reduced building energy costs due to rising seasonal temperatures.

Increases in farmland values of **$4.9 million** (2050s) to **$10.4 million** (2080s) annually from rising agricultural productivity due to seasonal warming, a longer growing season and increases in total annual precipitation.

Figure 7:

Projected direct economic impacts of climate change for the Pincher Creek region in 2055 and 2085 by affected climate-sensitive sector





The direct economic losses listed above will give rise to a range of secondary or indirect costs in the wider economy as spending by affected businesses and households in the region and beyond is adversely impacted. The direct impacts of climate change on the Pincher Creek region are projected to reduce Gross Domestic Product in the wider economy by **$4.6 million** and **$6.8 million** per year, on average, by the 2050s and 2080s, respectively.

The estimated costs of climate change for the Pincher Creek region are almost certainly larger than the losses presented above. There are several key gaps in our current state-of-knowledge, including failure to account for cascading and compounding impacts across interdependent infrastructure systems and climate hazards that occur simultaneously or in close sequence, the loss of key service flows provided by infrastructure (e.g., drinking water, power, etc.), and impacts to some key climate-sensitive sectors (e.g., natural landscapes, tourism).

As noted above, estimates of the costs of climate change can be used to inform the overall scale of investment in adaptation. Building resilience and adapting municipalities to climate change has been conservatively estimated to require an annual investment of 0.26% of GDP[8], which equates to a total expenditure of about $13.6 million for the Town and MD of Pincher Creek over 10 years. Table 2 shows the estimated costs and benefits from investing this amount over the 10-year period 2025-2035, assuming the money is invested in climate resilience actions offering typical rates of return found in other economic studies of between $3-$5[9]. The corresponding benefits in present value terms (at a discount rate of 3% per year) over the useful life of the implemented actions are shown in the third column. For example, the present value benefits from a total 10-year investment of $13.6M in adaptation in the Pincher Creek region at an assumed $3 rate of return are estimated at $41M. The fourth column in the table shows the percentage reduction in the projected

8 IBC and FCM, 2020, Investing in Canada's Future: The Cost of Climate Adaptation at the Local Level, Final Report, February 2020.

9 Boyd, R. and Markandya, A., 2021, Costs and benefits of climate change impacts and adaptation; Chapter 6 in Canada in a Changing Climate: National Issues Report, (Eds.) F.J. Warren and N. Lulham; Government of Canada, Ottawa, Ontario [https://changingclimate.ca/national-issues/chapter/6-0/]

total direct costs presented above. The fifth column shows the percentage of these projected costs still being incurred even with a total 10-year investment of $13.6M in adaptation—i.e., the residual direct costs of climate change. Continuing with the same example, an adaptation investment of $13.6M at the assumed $3 rate of return is estimated to reduce projected direct costs over the lifetime of the adaptation actions by 21%, with 79% of projected costs still being incurred. It is evident from Table 2 that investing 0.26% of projected GDP in adaptation actions at typically rates of return from other economic studies ($3-$5) still leaves the Pincher Creek region exposed to significant residual losses. But what if the investment in adaptation actions was roughly tripled to 0.75% of projected GDP annually? This equates to a total investment of about $39.3M over 10-years or roughly $560 per person per year. At the same typical rates of return found in other economic studies (i.e., $3-$5), it is now evident from Table 2 that this higher level of investment in adaptation can virtually eliminate the incurrence of residual direct costs—especially if adaptation projects return close to $5 per $1 invested.

Table 2 — Simulated costs and benefits of 10-year adaptation investment strategy for the Pincher Creek region

Investment Strategy	10-year adaptation investment plan	Present value lifetime benefits of adaptation investment	Reduction in projected total direct costs (2025–2060)	Present value residual direct costs with adaptation (2025–2060)
	($2022 M)	($2022 M)		
Invest 0.26% of projected GDP				
$1 returns $3	13.6 $1,935 / person	41	**21%**	**79%**
$1 returns $4		54	**27%**	**73%**
$1 returns $5		68	**34%**	**66%**
Invest 0.75% of projected GDP				
$1 returns $3	39.3 $5,585 / person	118	**59%**	**41%**
$1 returns $4		157	**79%**	**21%**
$1 returns $5		196	**99%**	**1%**

6 Climate Risk Assessment

This section describes the process that was followed and the results of the climate risk assessment for the Pincher Creek region. The process involved four key steps:

- Defining climate impact scenarios,
- Assessing the *likelihood* of each scenario occurring in the Pincher Creek region,
- Assessing the *consequences* of each scenario, should they occur, and
- Evaluating the results to determine priorities for action planning.

The level of risk for Pincher Creek resulting from each climate impact scenario is determined by combining the outcomes of the likelihood assessment and the consequences assessment.

Each step in the climate impact assessment process is outlined below.

Define Climate Impact Scenarios

Climate impact scenarios characterize the cause-and-effect relationship, or impact chain, between climate impact-drivers, biophysical impacts, and the potential consequences of those impacts for Pincher Creek. Climate impact-drivers, as the term implies, are climate conditions (e.g., mean summer precipitation, heatwaves, hailstorms, etc.) that can result in harmful, beneficial or neutral consequences for residents, buildings or infrastructure, services, or the natural environment of Pincher Creek. Climate impact-drivers with largely negative consequences are commonly known as **climate hazards**; conversely, those with largely positive consequences are commonly known as **climate opportunities**.

Based on the results of the community survey, and discussions with the Project Team, the climate impact scenarios summarized in Table 3 were defined and included in the climate risk assessment process. Each impact scenario is described in detail in Appendix A.

Table 3 — Summary List of Climate Impact Scenarios

1	Extreme heat impacts to human health and livestock
2	Wildfire causes damage to homes and infrastructures
3	Wildfire smoke reduces air quality causing local health impacts
4	Hailstorm damages homes and infrastructure
5	Blizzard disrupts transportation
6	Windstorm damages homes and infrastructure
7	Freezing rainstorm damages trees and disrupts transportation
8	River and creek flooding causes damage to homes and properties
9	Ongoing river and creek flooding
10	Dam flooding (overtopping) occurs across the District
11	Overland flooding of homes and property in urban areas
12	Prolonged drought affecting local farmers, ranchers, wildlife and vegetation
13	Water supply shortage reduces community service levels
14	Loss of winter recreation
15	Invasive weed outbreak affecting local ranchers and farmers
16	Outbreak of invasive species or pest affecting local trees and forests
17	Vector-borne disease outbreak with public health risks
18	Changing ecosystems negatively affects wildlife and habitat

The climate impact scenarios in Table 3 result in primarily negative consequences for Pincher Creek—i.e., they can all be classified as climate hazards. A number of potential opportunities (or benefits) of climate change were also identified; for example, the region is projected to have a longer agricultural growing season with potential for new crop types and varieties to be grown, a longer construction season, and a longer summer recreation season with potential improvements in the quality of life and wellbeing of residents. In contrast to the climate hazards, however, the climate opportunities were not put through a formal assessment process. Nonetheless, the climate adaptation actions formulated in Section 7 do include measures to take advantage of potential climate opportunities identified for Pincher Creek.

Assessing Likelihood

The likelihood of each climate impact scenario being realized in the 2070s was determined using a combination of methods ranging from analysis of the historic occurrence of discrete events like heavy snowfall, modelled projections for climate variables like “the number of frost-free days”, and published research studies, as well as the professional judgment of local stakeholders and the consulting team. Where possible, the preferred approach involved using the modelled projections for climate variables to estimate the probability that specific thresholds would be exceeded in any given year, on average, during the baseline period and the 2070s. Regardless of the approach, a 1-5 likelihood score was determined for each impact scenario using the scale at Table 4. The detailed climate impact scenarios provided in Appendix A include the likelihood scores for the baseline period and the 2070s; the approach used to determine the likelihood scores is also provided.

Table 4 — Climate Impact Likelihood Scale

Score	Descriptor	Likelihood/Probability
1	Rare	Impact scenario is expected to happen less than once every 100 years (Annual chance < 1% in 2070s)
2	Unlikely	Impact scenario is expected to happen about once every 51-100 year (1% ≤ annual chance < 2% in 2070s)
3	Possible	Impact scenario is expected to happen about once every 11-50 years (2% ≤ annual chance < 10% in 2070s)
4	Likely	Impact scenario is expected to happen about once every 3-10 years (10% ≤ annual chance < 50% in 2070s)
5	Almost Certain	Impact scenario is expected to happen once every two years or more frequently (Annual chance ≥ 50% in 2070s)

Climate risk assessment workshop

Assessing Consequence

The individual consequences of a climate impact scenarios may range from negligible to catastrophic. To define the level of risk associated with each impact scenario for the Pincher Creek region it is necessary to establish the significance of resultant consequences. To these ends a consequence assessment was completed through a facilitated workshop in Pincher Creek on March 1, 2023, at which participants assigned categorical and numerical (1 to 5) values to the potential consequences of each climate impact scenario. To support the assessment, a tailored 1-5 scale for rating the consequences of each scenario for the Pincher Creek region was developed (shown in Table 5). The scale was developed to be consistent with the Region's Hazard Identification and Risk Assessment and with guidance and best practices for climate change risk assessments[10].

10 See for example: International Organization for Standardization (ISO) guideline 14092 – Climate adaptation planning for local governments and communities; All One Sky Foundation - Climate Resilience Express Community Climate Adaptation Planning Guide; and the Canadian Council of Ministers of the Environment (2021) Guidance on Good Practices in Climate Change Risk Assessment.

Table 5 — Scale of Rating for Consequences of Risks[11]

Criteria	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Health & Well-being	• Negligible impact • Not likely to result in fatalities, injuries, evacuations, psychosocial impacts, or impacts to quality of life		• Some injuries, or modest temporary impact on quality of life for some residents and vulnerable populations • Some psychosocial impacts • Modest temporary impact on quality of life for some residents and vulnerable populations		• Many serious injuries or illnesses, some fatalities, or long-term impact on quality of life for most residents and vulnerable populations • Widespread psychosocial impacts • Long-term impact on quality of life for most residents and vulnerable populations
Business / Financial	• Very minimal impact on local businesses or the economy • Financial loss equal to <1% tax impact		• Temporary impact on income and employment for a few businesses, or modest costs and disruption to a few businesses • Financial loss of between 3% and 5% tax impact		• Long-term impact on businesses and economic sectors, major economic costs or disruption • Financial loss equal to >7% tax impact
Natural Environment	• Minimal or no environmental disruption or damage		• Could cause localized and reversible damage. Quick clean up possible		• Could cause severe and irreversible environmental damage. • Full cleanup not possible
Property, Infrastructure & Municipal Services	• Not likely to result in property damage or service disruption		• Localized moderate damage (a few buildings may be destroyed) and temporary interruption of a critical municipal service		• Widespread severe damage (many buildings destroyed) • Long-term interruption of critical municipal services

11 Note: the descriptions for 2 (Low) and 4 (High) have been left blank intentionally.

Evaluate and Prioritize Risks

Following conventional risk management best practice, the outcomes of the likelihood and consequence assessments were combined in a table (known as a risk matrix) to determine an overall risk level for each climate impact scenario. The resultant risk matrix is shown in Figure 8. The matrix delineates between climate impact scenarios that pose a relatively significant threat to Pincher Creek (in the red and orange cells in the upper right corner) and those that do not (in the blue and green cells in the lower left corner). The matrix also serves to assign priorities to climate impact scenarios for adaptation planning in accordance with the criteria listed in Figure 9. Very high (red cells) and high (orange cells) rated climate impact scenarios were taken forward to adaptation action planning.

A provisional version of the risk matrix was reviewed and verified by the Pincher Creek project team and local stakeholders. Stakeholders were afforded the opportunity to review the relative position of the climate impact scenarios in the provisional matrix and make well-reasoned arguments to adjust their location if they judged a scenario—when viewed collectively with all scenarios—to have been either over or under-rated in comparison to one another. The provisional risk matrix was also presented at the first community open house (April 13, 2023). Members of the community generally supported the risk ratings with few comments received suggesting any changes.

Figure 8:

Climate Risk Matrix for Pincher Creek

Consequence	Rare (1)	Unlikely (2)	Possible (3)	Likely (4)	Almost Certain (5)
Very high (5)					
High (4)		River and creek flooding	Wildfire Drought Water shortage		
Medium (3)		Overland flood	Dam flooding Invasive weed outbreak Vector-borne disease Changing ecosystems	Extreme heat Loss of winter recreation	Wildfire smoke
Low (2)			Hailstorm	Invasive species outbreak Blizzard	Windstorm Freezing rain Ongoing flooding
Very Low (1)					

Likelihood

After the evaluation process was completed and all climate impacts were finalized, the last step of the impact assessment was to determine which climate impact scenarios should be considered for action planning. Figure 9 provides the decision-making framework that was used to prioritize scenarios based on where they fell in the matrix. In general, very high (red) and high (orange) rated impact scenarios should be considered for action planning.

Figure 9:

Decision Criteria for Action Planning

Label	Decision
Very high priority	Adaptation actions should be developed in the near-term to reduce risks or take advantage of opportunities.
High priority	Adaptation actions should be developed in the near- medium-term, to reduce risks or take advantage of opportunities.
Medium Priority	Adaptation actions may be developed, particularly where low-cost options are available that provide other social, economic or environmental benefits.
Low Priority	No action required at this time beyond monitoring and consideration as part of regular reviews.
Very low priority	No action required at this time beyond monitoring and consideration as part of regular reviews.

7 Building the Adaptation Action Plan

It was not practical to address all potential impacts of climate change through this Climate Adaptation Plan. The value of the impact assessment was to focus the efforts of the adaptation plan on the highest risks facing the region. Informed by the results of the climate risk assessment, the next step in the approach to adaptation planning involves: identifying actions to manage priority climate impacts and consequences to acceptable levels; evaluating and prioritizing those actions; and identifying how, when and by whom the prioritized actions will be implemented. The outcomes of this process are encapsulated in the Adaptation Action Plan for the Pincher Creek region. This Plan provides a roadmap for the Town of Pincher Creek and MD of Pincher Creek to enhance resilience and adapt to projected changes in the local climate.

Identifying and Evaluating Actions

The climate adaptation actions outlined below were informed by:

- The **community survey**, which included questions about support for climate adaptation and resilience actions, and open-ended question asking for the most important actions Pincher Creek should take to increase resilience to climate change, which garnered 143 responses. Overall, the most popular suggestions included enhancing education and awareness, emergency management and preparedness, environmental protection, and upgrading infrastructure (see Figure 30 in Appendix A).
- The **community open house** (April 13, 2023) where more than 40 ideas were brainstormed to manage priority climate risks for the region.
- **Action planning sessions** with MD and Town staff. Action planning sessions were hosted with staff from the Town and MD of Pincher Creek, the Piikani Nation, and other regional stakeholders. These sessions were focused on five climate adaptation themes (Health and wellbeing, Disaster resilience, Infrastructure, Parks and Environment and Economy) and with the goal of answering the following questions:
    1. What is regions climate adaptation vision and goals?
    2. How are the Town and MD currently managing each priority climate impact?
    3. Do current actions need to be modified or improved?
    4. What additional actions can be implemented by the Town and MD to better manage impacts?

In addition to inputs from staff, members of the community and other stakeholders, the consulting team provided ideas for adaptation actions drawing from their knowledge of how other municipalities across Alberta and beyond are managing climate change impacts.

Prioritizing Actions

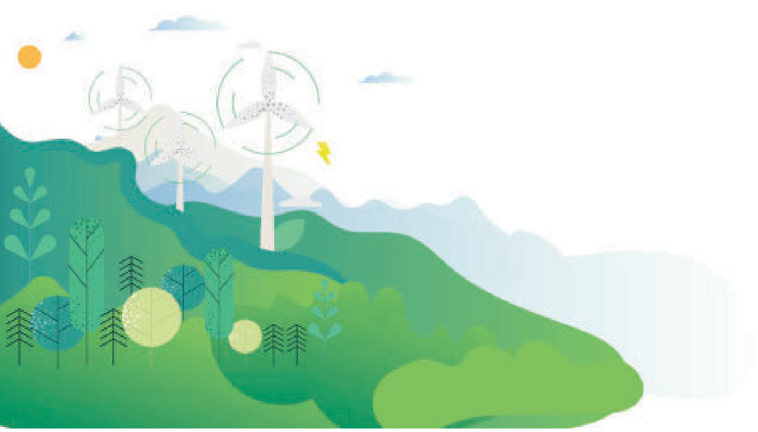
Potential climate adaptation actions identified through the above process were consolidated and then evaluated using a multi-criteria, cost-benefit framework. This assessment is intended to support the prioritization of cost-efficient adaptation actions. A benefit-cost ratio for each action is calculated based on all potential benefits and all relevant costs needed to deliver those benefits, with those actions with the highest ratio assigned higher priority. Details of the prioritization process and the results are provided in Appendix C.

The Adaptation Action Plan

The Climate Adaptation Plan for the Pincher Creek region is presented below. The Plan represents a set of actions recommended for implementation within the next 10 years to increase community and regional resilience to the anticipated impacts of climate change.

The Action Plan is guided by the following vision for climate resilience and adaptation in the region:

> **Vision**
>
> Our region is safe and resilient for all to enjoy responsibly



The Action Plan contains **35 recommended climate adaptation actions** organized according to five themes and corresponding goals:

Health & Wellbeing

Goal: People and communities remain safe and healthy in the face of climate change and continue to enjoy a high quality of life

Disaster Resilience

Goal: Pincher Creek is prepared to respond and recover from climate-related events and disasters

Infrastructure

Goal: Pincher Creek's capital assets are resilient and adapted to the future climate

Parks & Environment

Goal: Improve and adapt our parks and natural assets and protect wildlife and ecosystems

Economy

Goal: The regional economy and local businesses are climate-ready and resilient

The **type of action** is defined based on the following action type categories:

Action Types	
Partnership	Establish new or strengthen existing partnerships with key stakeholders (both internal and external)
Plan	Plans or strategies to either establish new direction, or embed climate resilience into existing plans or strategies
Policy	Establishing or updating rules and regulations through a policy, guideline or standard
Program	Develop a new or strengthen an existing program to advance climate resilience
Project	Implement projects to advance climate resilience, such as asset improvements
Research	Conduct research to better under risks and/or the effectiveness of actions
Education	Develop and disseminate educational information to support climate resilience

The **level of urgency** for each action is defined as high, medium or low, depending on the timeline by which the action should be implemented. High urgency actions should be implemented in the near-term to address more immediate threats that the region is more vulnerable to.

Urgency	
High	Implemented in the next 2 years
Medium	Implemented in the next 3-5 years
Low	Implemented in the next 5-10 years

This is a collaborative climate adaptation plan between the Town and MD of Pincher Creek. The responsibility for implementation of each action is defined:

Responsibility	
Town	Actions to be implemented by the Town only
MD	Actions to be implemented by the MD only
Both collaboratively	Actions to be implemented collaboratively by the Town and MD
Both separately	Actions to be implemented by the Town and MD separately

Individual actions identify what residents can do to support community resilience and/or protect your health and wellbeing and your assets

Action recommendations are provided below, organized by theme and ordered by the actions ranking within the cost-benefit analysis (CBA) (see Appendix C for details).

Health and Wellbeing

Goal

People and communities remain safe and healthy in the face of climate change and continue to enjoy a high quality of life

Action HW 1	Support Community Gardening
Description	To improve local food security, support residents and local organizations to establish gardens, greenhouses and/or create a community garden. Support could include financing or incentives.
Action type	Program
Urgency	Low
CBA score (rank)	3.09 (9)
Responsibility	Both separately
Individual action	Plant your own garden and grow food.

Action HW 2	Install outdoor water features
Description	Install new outdoor water features around the Town and Hamlets within the MD, including water stations and fountains along pedestrian paths and parks
Action type	Project
Urgency	Low
CBA score (rank)	2.75 (15)
Responsibility	Both separately
Individual action	Take actions to protect your health during extreme heat events including proper hydration, particularly during strenuous outdoor activities.

Action HW 3	Upgrade the spray park
Description	Upgrade the spray park with features, such as benches and shade structures, to promote participation by all community members (including seniors) as a way to cool down during extreme heat.
Action type	Project
Urgency	Medium
CBA score (rank)	2.43 (18)
Responsibility	Town
Individual action	Take actions to protect your health during extreme heat events including staying cool and proper hydration.

Action HW 4	Purchase temporary shading structures
Description	Temporary shading structures could include tents, shelters or canopies. Shade structured should be deployed during extreme heat events, and at prominent community gathering spots.
Action type	Project
Urgency	Low
CBA score (rank)	2.38 (19)
Responsibility	Town
Individual action	Take actions to protect your health during extreme heat events which include planning outdoor activities for cooler days, or in cooler locations, which have shaded areas. Consider purchasing your own shade structures (tent, tarp, etc.) to stay cool when you want to be outdoors on a hot day.

Action HW 5	Install permanent shade structures
Description	Permanent shading structures should be installed in high traffic areas across the Town and MD to provide protection from extreme heat. High traffic areas may include at parks, along pathways, and outside municipal buildings and facilities. Permanent shade structures should be incorporated into future projects and developments.
Action type	Project
Urgency	Medium
CBA score (rank)	2.12 (25)
Responsibility	Both separately
Individual action	Take actions to protect your health during extreme heat events which include planning outdoor activities for cooler days, or in cooler locations, which have shaded areas.

Action HW 6	Adjust recreation programming during heat and smoke events
Description	Adjust recreation programming and direct resources differently during extreme heat and smoke events. For example, promote outdoor water activities during extreme heat and indoor activities during wildfire smoke. This could involve adjusting staff schedules and re-allocating resources.
Action type	Policy
Urgency	High
CBA score (rank)	2.03 (26)
Responsibility	Both separately
Individual action	Adjust your recreation activities during heat and smoke events to protect your health. For extreme heat, schedule activities in the coolest part of the day or recreation indoors. During smoke events, limit outdoor activities and strenuous physical activities as much as possible or recreation indoors.

Disaster Resilience

Goal

Pincher Creek is prepared to respond and recover from climate-related events and disasters

Action DR 1	Update Land Use Bylaws to enhance flood protection
Description	Update Land Use Bylaws to enhance flood protection, including by updating the defined flood risk areas and development regulations. The Land Use Bylaws should reference the Pincher Creek Flood Hazard Study (2020) and associated mapping and consider increasing development restrictions to account for the uncertainty associated with climate change, for example by using the 1:200-year flood elevation (i.e., a flood that has a 0.5% chance of occurring each year).
Action type	Plan
Urgency	Medium
CBA score (rank)	3.99 (2)
Responsibility	Both Separately
Individual action	Go to the Alberta flood maps website and check to see if your property is in a flood hazard area: https://floods.alberta.ca/. It is possible to 'Switch to Draft Studies View' to see flood inundation maps up to 1:1,000-year flood event (i.e., a flood that has a 0.1% chance of occurring each year).

Action DR 2	Develop a heat alert response plan
Description	Develop a heat alert response plan and incorporate into the Regional Emergency Management Plan. The heat alert response plan should include: an overview of potential health risks posed by extreme heat in the region; identification of at-risk populations and locations; An alert protocol and triggers for activation of extreme heat response; a communications plan; and identification of long-term preventive actions, including existing buildings and facilities that may be appropriate cooling centres.
Action type	Plan
Urgency	High
CBA score (rank)	3.78 (3)
Responsibility	Both Collaboratively
Individual action	Take actions to protect your health during extreme heat events: Follow local weather forecasts and alerts[12]; find an air conditioned space; know the signs of heat illness; stay cool; stay hydrated; visit neighbours, friends and older family members. [Reference: https://www.canada.ca/en/health-canada/services/publications/healthy-living/infographic-staying-healthy-heat.html]

Action DR 3	Develop a smoke alert response plan
Description	Develop a smoke alert response plan and incorporate into the Regional Emergency Management Plan. The smoke alert response plan should include: an overview of potential health risks posed by wildfire smoke; identification of at-risk populations and locations; an alert protocol and triggers for activation of wildfire smoke response; a communications plan; and identification of long-term preventive actions, including existing buildings and facilities that may be appropriate clean air centres.
Action type	Plan
Urgency	Medium
CBA score (rank)	3.78 (3)
Responsibility	Both Collaboratively
Individual action	Take actions to protect your health during wildfire smoke events. To ensure you have clean air in your home, recirculate air through your HVAC system, purchase a good quality air filter and ensure you have a functioning carbon monoxide alarm. If you can't maintain clean air inside your home, be aware of locations in your community where you can find clean air. [Reference: https://www.canada.ca/en/health-canada/services/publications/healthy-living/how-prepare-wildfire-smoke.html]

12 Heat alerts are issues for the Pincher Creek area when two or more consecutive days of daytime maximum temperatures are expected to reach 32°C or warmer, and nighttime minimum temperatures are expected to fall to 16°C or warmer. Source: Government of Canada, Criteria for public health alerts: https://www.canada.ca/en/environment-climate-change/services/types-weather-forecasts-use/public/criteria-alerts.html

Action DR 4	Develop a homeowner climate change vulnerability assessment toolkit
Description	Develop and publish a toolkit to help residents to assess their home, property and personal risk and resilience to climate change impacts. The toolkit should help them understand actions they can take to support resilience, including access to grants and funding.
Action type	Education
Urgency	High
CBA score (rank)	3.26 (7)
Responsibility	Both collaboratively
Individual action	Understand how to protect your home and property from climate change impacts. Explore the City of Calgary Climate Ready Home Guide: www.calgary.ca/environment/climate/climate-ready-home-guide

Action DR 5	Develop a Drought Response Plan that considers climate change
Description	Prolonged drought and water supply shortage should be considered in the Regional Emergency Management Plan, including response planning and other information to support emergency management of water supply shortage.
Action type	Plan
Urgency	Medium
CBA score (rank)	2.90 (12)
Responsibility	Both collaboratively
Individual action	Do your part to conserve water. Water saving tips are available on the Town of Pincher Creek website: http://www.pinchercreek.ca/docs/files/Water%20Saving%20Ideas%20Summer%202017.pdf

Action DR 6	Enhance emergency preparedness education and communication
Description	Enhance emergency preparedness education and communication for residents regarding climate-related emergencies and evacuations. Enhanced communication could be via the Town and MD websites, social media, and/or other forms and include information about the local impacts of climate change and preparedness measures.
Action type	Education
Urgency	High
CBA score (rank)	2.78 (14)
Responsibility	Both collaboratively
Individual action	Visit www.getprepared.ca to learn more about how to ensure your family is prepared for climate-related emergencies.

Action DR 7	Conduct research to understand future wind patterns
Description	Climate projections obtained through this project do not model changes in extreme weather, and specifically wind. Windstorms were identified as a medium priority risk; however, the region's hazards are exacerbated by high winds, and minimal local information is available about the future trajectory of wind patterns. A wind research project would allow for a better understanding of trends and more accurate future projections of wind patterns and potential risks, allowing the region to better prepare for climate-related impacts. A partnership with a university research centre, using the Pincher Creek region as a case study, may be appropriate.
Action type	Research
Urgency	Medium
CBA score (rank)	2.59 (16)
Responsibility	Both collaboratively
Individual action	

Action DR 8	Develop a plan for enhanced fire department response capabilities
Description	Develop a plan, working with Pincher Creek Emergency Services Commission to meet the increased demand on emergency services generated by climate change. This includes increased medical calls for heat-related emergencies and increased wildland fire responses within the region. The plan should evaluate the increased needs of the organization to meet the higher call volumes. Future requirements of buildings, equipment and staffing should also be identified and assessed.
Action type	Plan
Urgency	High
CBA score (rank)	2.57 (17)
Responsibility	Both Collaboratively
Individual action	

Action DR 9	Update development legislation with FireSmart revisions
Description	Update the Intermunicipal Development Plan, Municipal Development Plans, Land Use Bylaws, and Area Structure Plans as recommended in the Wildfire Mitigation Strategy and FireSmart Canada recommendations. Recommended revisions to protect new developments from wildfire risk include identifying wildfire hazard as a development constraint, requiring wildfire risk assessments, requiring FireSmart construction materials, and requiring FireSmart landscaping and vegetation management.
Action type	Policy
Urgency	High
CBA score (rank)	2.20 (24)
Responsibility	Both collaboratively
Individual action	Help reduce the risk of wildfire to your home and neighbourhood and help firefighters to defend your home by following the recommendations in the FireSmart Homeowner's Manual: https://open.alberta.ca/publications/9781460121436

Action DR 10	Conduct forest fuel treatments and vegetation management
Description	Conduct forest fuel treatments and vegetation management to create a buffer between structures and flammable forests and vegetation to reduce the intensity and rate of spread of wildfires, as recommended in the Wildfire Mitigation Strategy. Focus on priority high and extreme fire hazard areas.
Action type	Research
Urgency	High
CBA score (rank)	1.65 (28)
Responsibility	Both collaboratively
Individual action	Help reduce the risk of wildfire to your home and neighbourhood and help firefighters to defend your home by following the recommendations in the FireSmart Homeowner's Manual: https://open.alberta.ca/publications/9781460121436

Action DR 11	Retrofit designated emergency reception centres
Description	Buildings identified for use as emergency reception centres should meet guidelines for emergency centres and should be suitable as clean air and cooling centres to address wildfire smoke and extreme heat events[13]. Important retrofits include upgrading heating, ventilation and air conditioning (HVAC) systems as necessary to ensure they can handle cooling loads and are equipped with air filers (MERV rating of 13 or more), and backup power generation. These centres should also have accessibility features and a variety of amenities and services available for the community (e.g., water, food, medical supplies, communications equipment, etc.).
Action type	Project
Urgency	High
CBA score (rank)	1.59 (29)
Responsibility	Both collaboratively
Individual action	

13 For additional information see: Health Canada: Guidance for Cleaner Air Spaces during Wildfire Smoke Events; CSA C282:19: Emergency electrical power supply for buildings; Health Canada: Health Facilities Preparation for Extreme Heat Recommendations for Retirement and Care Facility Managers; US Centre for Disease Control: The Use of Cooling Centres to Prevent Heat-Related Illness. ANSI/ASHRAE Standard 62.1-2019: Ventilation for Acceptable Indoor Air Quality.

Infrastructure

Goal

Pincher Creek's capital assets are resilient and adapted to the future climate

Action IF 1	Develop a climate resilient procurement policy
Description	Update procurement policies to require consideration of climate change impacts and adaptation in all future projects and developments including in bids, tenders and projects related to, for example, buildings, land development, stormwater management, water supply, roads and pathways. Projects should also include a lifecycle assessment of the operations and maintenance costs (energy, repairs etc.) and return on investment.
Action type	Policy
Urgency	High
CBA score (rank)	4.31 (1)
Responsibility	Both Separately
Individual action	When considering a major renovation or construction project at your home, think about how to make your home and property more resilient in the process and hire contractors that can support you.

Action IF 2	Research climate resilient building materials and infrastructure
Description	Conduct research to understand and analyze climate resilient building materials and infrastructure (roads, etc.) appropriate for the Pincher Creek region. Apply the results of this research to modify educational materials for residents, and to update municipal development policies and legislation.
Action type	Research
Urgency	Low
CBA score (rank)	2.90 (12)
Responsibility	Both Collaboratively
Individual action	Understand how to protect your home and property from climate change impacts by using climate resilience building materials. See the City of Calgary Climate Ready Home Guide for details: www.calgary.ca/environment/climate/climate-ready-home-guide

Action IF 3	Upgrade municipal buildings to provide better protection from extreme heat
Description	Upgrades could include: upgrading heating, ventilation and air conditioning (HVAC) systems as necessary to ensure they can handle increased cooling loads over time; the installation of air- or ground-source heat pumps; whole building fans; shaded external spaces and cooling stations; enhanced insulation; energy efficient windows and/or glazing; green roofs; vegetative cooling such as trees and shrubs; and/or connection to emergency power in the event of a power outage[14].
Action type	Project
Urgency	Medium
CBA score (rank)	1.41 (30)
Responsibility	Both Separately
Individual action	For information and resources about how to better protect your home from extreme heat, see: Institute for Catastrophic Loss Reduction - Protect your home from extreme heat: https://www.iclr.org/wp-content/uploads/2020/07/ICLR_Extreme-heat_2020.pdf; or City of Calgary - Climate ready home handout for extreme heat: https://www.calgary.ca/content/dam/www/uep/esm/documents/esm-documents/Climate-Ready-Home_Handout_Extreme-Heat.pdf

14 For additional information see: US Green Building Council (n.d.). Designed for enhanced resilience. LEED Pilot Credit IPpc99; US Green Building Council (n.d.). Heat Island Reduction. LEED v4 Sustainable Sites. US Green Building Council (2020). RELi 2.0. Rating Guidelines for Resilient Design and Construction; or 2030 Palette. Sustainable design principles for vegetative cooling, heat island mitigation, and building sites.

Action IF 4	Upgrade and enhance flood mitigation infrastructure
Description	Evaluate, upgrade and enhance flood mitigation infrastructure to provide protection from the 1:100 historic flood (Pincher Creek) at minimum. And consider protection from the 1:200-year flood event where feasible. Upgrades or enhancements could include increased dike infrastructure and/or enhanced capacity of upstream areas such as reservoirs. The purchase of temporary flood mitigation solutions (tiger dams) for rapid deployment should also be considered.
Action type	Project
Urgency	Low
CBA score (rank)	1.27 (33)
Responsibility	Both Collaboratively
Individual action	

Action IF 5	Install a solar covering on the Town water reservoir
Description	Install solar panels on the Town water reservoir to reduce evaporation and conserve water, and to act as a renewable energy source. This could be in the form of floating solar panels or fixed piles in the reservoir. Power generated can be used to offset the usage of all municipal facilities through net metering.
Action type	Project
Urgency	Low
CBA score (rank)	1.14 (34)
Responsibility	Town
Individual action	

Parks & Environment

Goal

Improve and adapt our parks and natural assets and protect wildlife and ecosystems

Action PE 1	**Develop a Natural Asset Inventory and Management Plan**
Description	Develop an inventory of natural assets across the Pincher Creek region to understand the extent and current state of natural assets, including trees and wetlands. Based on the inventory, a management plan should be developed to ensure trees and wetlands are resilient to climate impacts, and how natural assets can be used to support climate adaptation. Investigate the use of 'shelter belts' to protect from wind and blowing snow, and for ground stabilization.
Action type	Plan
Urgency	Medium
CBA score (rank)	3.78 (3)
Responsibility	Both collaboratively
Individual action	As a property owner in the region, consider the natural assets that exist on your property, their current state, and how you can increase resilience of your natural assets to climate change.

Action PE 2	Develop a water sharing agreement between that Town and MD
Description	The Town and MD should develop a partnership and water sharing agreement to share water and collaborate on the supply of water in times of scarcity. Collaborative water management should be considered in future land use planning and development and incorporated into the Intermunicipal Development Plan.
Action type	Partnership
Urgency	Low
CBA score (rank)	3.56 (6)
Responsibility	Both collaboratively
Individual action	

Action PE 3	Develop a Source Water Protection Plan
Description	Develop a Source Water Protection Plan to protect long-term drinking water quality and quantity and consider the impacts of climate change. A Source Water Protection Plan should link to existing plans and policies such as drinking water safety plans, municipal development plans, etc.[15]
Action type	Plan
Urgency	Medium
CBA score (rank)	3.26 (7)
Responsibility	Both collaboratively
Individual action	

15 Reference: Alberta Water Council Guide to Source Water Protection Planning: https://open.alberta.ca/dataset/dfb9347c-52cb-4b56-b13c-824edf43ec69/resource/d4367d4c-8ddf-4a13-8b92-a801c8d893d7/download/aep-guide-to-source-water-protection-planning-protecting-sources-of-drinking-water-in-alberta.pdf

Action PE 4	Develop a Water Conservation, Efficiency and Productivity Plan
Description	The Water Conservation, Efficiency and Productivity Plan should outline a strategy to manage water demand such that supplies are sustainable into the future, and without adversely impacting the local economy, lifestyles or well-being of residents. The Plan should include an overview of water sources and water use in the region, future water demand projections considering projected climate change, and concrete actions focused on water conservation and efficiency goals. The Plan should consider for example water reuse and stormwater use[16], and be integrated into existing policies and Bylaws where possible.
Action type	Plan
Urgency	Medium
CBA score (rank)	2.92 (11)
Responsibility	Both collaboratively
Individual action	Do your part to conserve water. Water saving tips are available on the Town of Pincher Creek website: http://www.pinchercreek.ca/docs/files/Water%20Saving%20Ideas%20Summer%202017.pdf

Action PE 5	Update the Water Utility Bylaw with an improved water pricing structure
Description	Update the Water Utility Bylaw to include an increasing block rate pricing structure for water consumption whereby a higher rate is paid for larger volumes of water consumption.
Action type	Policy
Urgency	Medium
CBA score (rank)	2.38 (20)
Responsibility	Both separately
Individual action	Do your part to conserve water. Water saving tips are available on the Town of Pincher Creek website: http://www.pinchercreek.ca/docs/files/Water%20Saving%20Ideas%20Summer%202017.pdf

16 Reference: Public health guidelines for water reuse and stormwater use: https://open.alberta.ca/publications/public-health-guidelines-water-reuse-stormwater-use

Action PE 6	Enhance support for watershed planning and protection
Description	Enhance support for watershed planning and protection focused on the preservation of natural landscapes to provide flood protection to the Pincher Creek region. Support could include increased collaboration with the Oldman Watershed Council, advocacy and/or partnerships with intergovernmental organizations, farmers, and ranchers to support land stewardship.
Action type	Partnership
Urgency	Low
CBA score (rank)	2.31 (21)
Responsibility	Both collaboratively
Individual action	

Action PE 7	Develop a tree planting program
Description	Develop a tree planting program with the goal of enhancing urban forests to support climate adaptation. Tree can provide cooling benefits, shade and windbreaks, and have many other co-benefits such as greenhouse gas emissions reduction; habitat restoration; increasing biodiversity; cleaning air and water; and enhancing wellbeing. This program should support the *Natural Asset Inventory and Management Plan* and include volunteer component that encourages residents to plant trees on public and private property.
Action type	Program
Urgency	Low
CBA score (rank)	1.80 (27)
Responsibility	Both separately
Individual action	Plan climate-resilient trees on your property. Plant deciduous trees on the south, east and west sides of your house to provide shade use coniferous (evergreen) trees planted in a row to protect against high winds. When planting trees, remember to avoid overhead power lines and planting trees near the foundation of your house. The FireSmart Guide to Landscaping provides a comprehensive list of tree species, including their Hardiness zone, sun/shade preferences and water use requirements: https://firesmartcanada.ca/wp-content/uploads/2022/01/328254-PIP-Landscape-low-res.pdf

Action PE 8	Enhance irrigation infrastructure
Description	Enhance irrigation infrastructure at municipal buildings and outdoor facilities (e.g., sports fields), to protect natural assets from drought. Consider options for water reuse and stormwater use[17].
Action type	Project
Urgency	Medium
CBA score (rank)	1.39 (31)
Responsibility	Both separately
Individual action	Consider ways to improve irrigation on your property including options to capture and reuse water, for example through the use of rain barrels or cisterns.

Action PE 9	Enhance environmental monitoring
Description	The Town and MD should work collaboratively to enhance monitoring of environmental assets and conditions in the region, including water quality and quantity in rivers, creeks and wetlands, snowpack, weather and soil conditions. Enhanced monitoring should be done in collaboration with Alberta Environment and Protected Areas and Environment and Climate Change Canada and be designed to fill gaps in existing monitoring. Monitoring priorities should be based on results from the *Natural Asset Inventory and Management Plan* to support an improved understanding of the current state of natural assets in the region. Environmental monitoring results should be analyzed and shared with the public.
Action type	Project
Urgency	Low
CBA score (rank)	0.80 (35)
Responsibility	Both collaboratively
Individual action	Get involved as a citizen scientist to support environmental monitoring. See: the Alberta Citizen Science Community of Practice: https://www.citscialberta.com/

17 Reference: Public health guidelines for water reuse and stormwater use: https://open.alberta.ca/publications/public-health-guidelines-water-reuse-stormwater-use

Economy

Goal The regional economy and local businesses are climate-ready and resilient

Action EC 1	Provide climate resilience education materials to farmers and ranchers
Description	Conduct research and provide education materials to farmers and ranchers about climate resilience. For example, drought tolerant crops and livestock management practices, climate-resilient crops and farming practices, as well as disaster management and emergency preparedness practices.
Action type	Education
Urgency	Low
CBA score (rank)	3.09 (9)
Responsibility	MD
Individual action	Ranching and farming are climate sensitive economic sectors. As a rancher or farmer, you should continue to stay informed about how the climate is changing, the impacts of climate change, and climate resilient practices.

Action EC 2	Develop a Tourism & Recreation Master Plan
Description	A Tourism and Recreation Master Plan should be developed for the region to provide long-term and sustainable strategy for the development of recreation and tourism-related programs, assets and services. The Plan should assess the current state of tourism and recreation and include an inventory of tourism and recreation assets and strengths, and recommendations for programs, events, parks, infrastructure, and services, including camping areas, hiking and biking trails, signage, parking, river and lake access, etc.
Action type	Plan
Urgency	Medium
CBA score (rank)	2.24 (22)
Responsibility	Both collaboratively
Individual action	

Action EC 3	Improve accessibility to outdoor recreation
Description	Improve accessibility to parks and outdoor recreation amenities and areas, including for example: developing and improving parking areas; installing informational signage; and installing lighting for night-time use. Include a focus on improving access to lakes, rivers and other water features during the summer months to provide cooling options and improve wellbeing.
Action type	Project
Urgency	Low
CBA score (rank)	2.22 (23)
Responsibility	Both separately
Individual action	During extreme heat events, plan your outdoor recreation activities in cooler locations such as lakes, rivers and other water features, and during cooler times of the day (morning and evening).

Action EC 4	Enhance marketing of the Pincher Creek region
Description	Enhance marketing and promotion of the Pincher Creek region to support climate adaptation. For example, focus on the benefits of summer, fall and spring recreation opportunities, as traditional winter sports become less viable. In the winter, emphasize alternative recreation opportunities which do not rely on snow or ice, including indoor activities. Through marketing and promotion, including a focus on the high quality of life within the region as a way to attract amenity migrants, entrepreneurs and businesses, and to promote long-term living in the region.
Action type	Education
Urgency	High
CBA score (rank)	1.38 (32)
Responsibility	Both collaboratively
Individual action	

Implementation and Updating the Plan

The Climate Adaptation Plan provides a 'shopping-list' of recommended actions to increased climate resilience in the Pincher Creek region. The most important step of the climate adaptation planning process is implementation of the plan. Several actions can be implemented quickly with minimal investment, whereas other actions have longer-term timeframes and require a higher level of investment. External funding sources may be needed and should be leveraged where possible.

It is recommended that the Pincher Creek Climate Adaptation Team, consisting of representatives from the Town, MD and Piikani Nation, be maintained and continue to meet regularly to support action implementation. Additional staff to support coordination and implementation will also be needed. Public participation and communication should continue to be a key aspect of climate resilience efforts in the region – helping residents understand climate projections, impacts and adaptation actions.

The Climate Adaptation Plan should be evaluated regularly—at least every **5-10 years**—to ensure it remains effective and relevant. The evaluation should consider:

- Lessons learned from the implementation of actions, both in terms of whether actions have been implemented as intended and the effectiveness of implemented actions in achieving the intended results.
- New research and scientific information on climate projections and impacts, which may affect the understanding of risks and opportunities facing the community.
- Changes to community goals, or changes to social, economic, or environmental conditions, which likewise may affect the understanding of risks and opportunities facing the community.

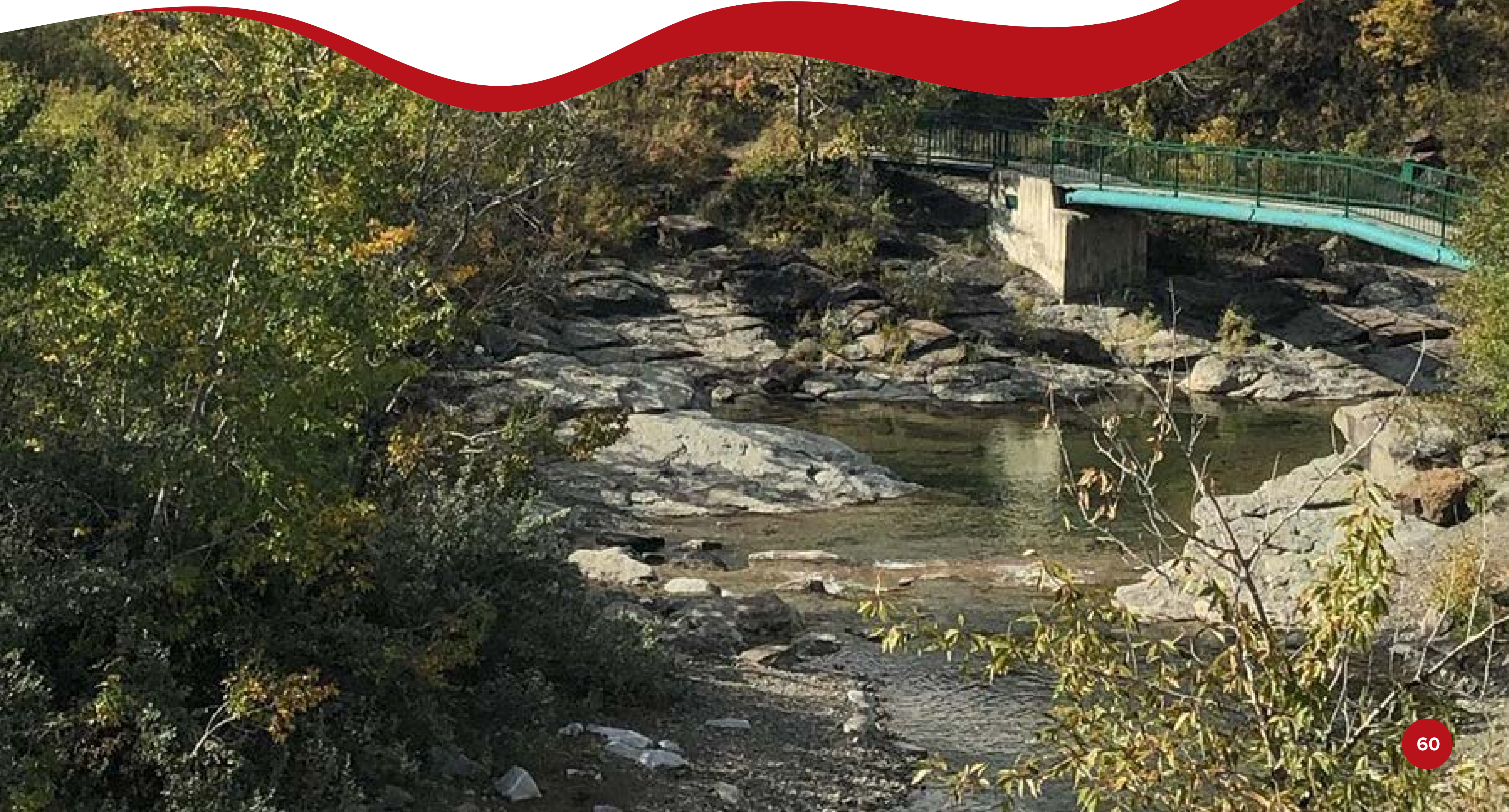
Keeping the Plan updated may only involve a few minor adjustments, or it may require revisiting some of the steps in the planning process and preparing a new Action Plan.

Implementation recommendations

In addition to the 35 climate adaptation action recommendations, the following additional recommendations are provided to support implementation:

ID	Action	Description
IM 1	Dedicate staff time and resources	The Pincher Creek Climate Adaptation Team, consisting of representatives from the Town, MD and Piikani Nation, should be maintained and continue to meet regularly to support action implementation. A climate adaptation implementation 'champion' should be identified and supported.
IM 2	Commit annual funding	Funding should be committed annually to support implementation activities, including funding for monitoring and evaluation of action implementation. Grant funding should be sought to support implementation projects where possible.
IM 3	Monitor and evaluate implementation results	The Climate Adaption Action Plan should be monitored and evaluated on a regular basis and should be updated every 5-10 years.

Appendix A: Climate Impact Scenarios



1) Extreme Heat Impacts to Human Health and Livestock

Description	Multiple days of extreme heat causes negative impacts to human health
Climate Driver(s)	Hotter temperatures
Threshold	28 hot days in a year where temperatures reach +30°C
Historic Likelihood Score	**2 (Unlikely)**
Future Likelihood Score	**4 (Likely)**
Potential Consequences	• Injuries/fatalities (vulnerable populations disproportionately affected including seniors, obese individuals, and those with chronic health conditions) • Increased space cooling costs • Reduced participation in outdoor activities • Increased water demand for both irrigation and drinking • Negative health impacts to livestock
Consequence Score	**3 (Moderate)**
Risk Score	**High**

Notes

Climate driver(s)

- Climate projections show more hot days (+30°C), very hot days (+35°C) and warmer maximum temperatures

Threshold

- 30°C is an approximate temperature at which health effects from extreme heat escalate cause increased morbidity and mortality for at-risk populations[18]

Historic Likelihood

- Likelihood score determined based on the Pincher Creek climate projections report.

Future Likelihood

- The number of hot days where temperatures reach +30°C are projected to increase from 5 days to 28 days in the Pincher Creek area[19].

18 See: Health Canada (2012) Heat Alert and Response Systems to Protect Public Health; or BC Provincial Heat Alert and Response System (BC HARS) (2022)
19 Data derived from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

2) Wildfire causes damage to homes and infrastructure

Description	An uncontrolled wildfire fire enters or starts in the Pincher Creek area and causes damage to homes and infrastructure
Climate Driver(s)	Hotter temperatures, drier summer conditions
Threshold	A wildfire occurs inside the boundaries of the Pincher Creek area
Historic Likelihood Score	**2 (Unlikely)**
Future Likelihood Score	**3 (Possible)**
Potential Consequences	• Injuries or fatalities • Damage to homes, buildings and infrastructure • Damage to parks and natural assets • Community evacuations and displacement • Forest/backcountry closures, reduced access to recreation • Economic disruption to forestry, agriculture and oil and gas sectors • Severe damage to Castle Mountain Resort due to the forest having only one exit
Consequence Score	**4 (High)**
Risk Score	**High**

Notes

Climate driver(s)

- Climate projections indicate an increase in summer temperatures, extreme heat, and dry conditions which contribute to wildfire risk

Threshold

- Conversations with Pincher Creek staff and survey results revealed that a wildfire event would have significant effects in Pincher Creek

Historic Likelihood

- Wildfires are relatively unlikely to occur in Pincher Creek, with higher risk areas to the west and in the mountains (Figure 9)[20]. Wildfire likelihood is higher in parts of the MD than in the Town.

Future Likelihood

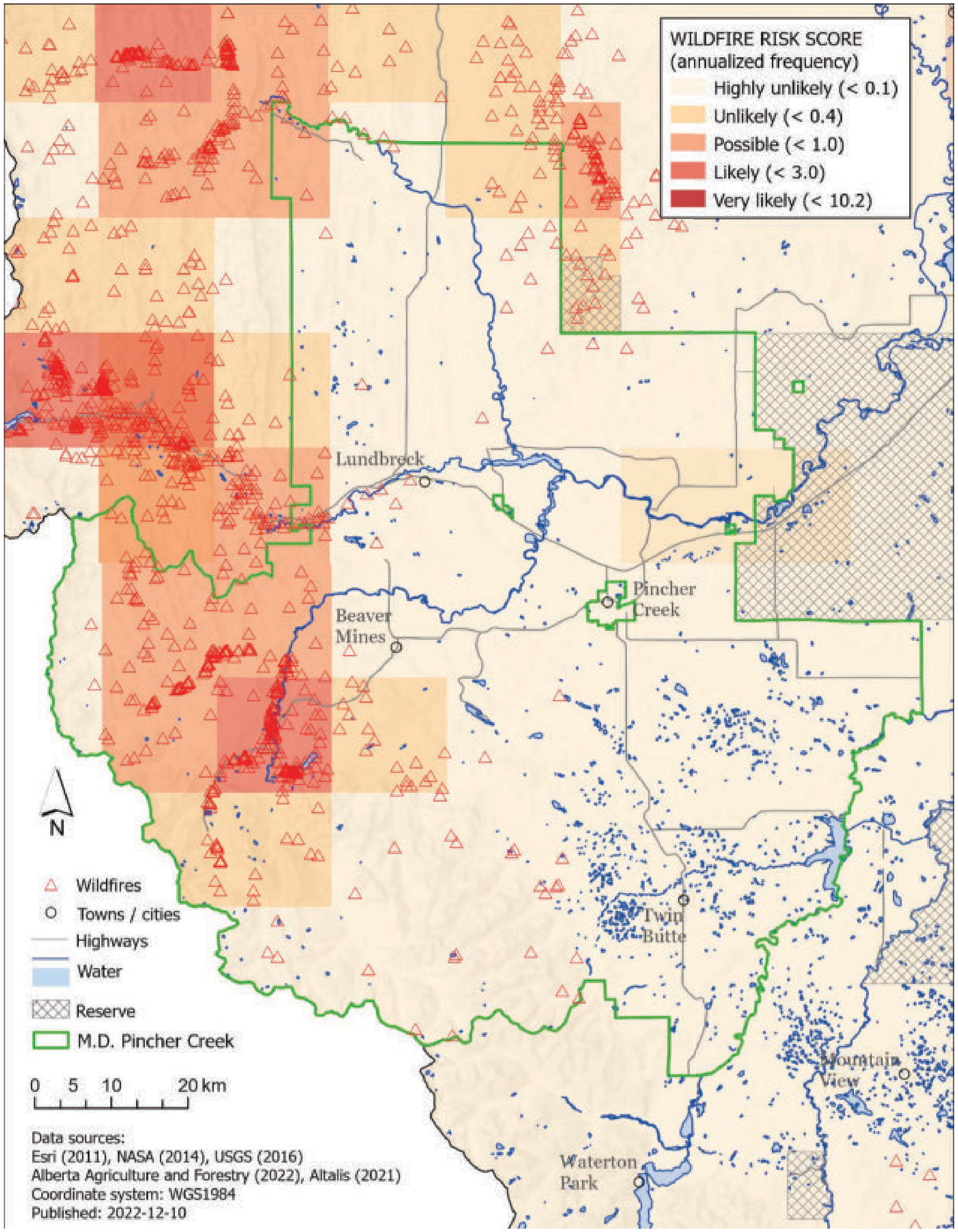
- Fire seasons are estimated to become more severe in a future warmer world. The length of the fire season is expected to increase by more than 20 days per year in the Northern hemisphere by the end of the century[21]

20 Historic likelihood defined using data from the Alberta Agriculture and Forestry - Historical Wildfire Database: https://wildfire.alberta.ca/resources/historical-data/historical-wildfire-database.aspx

21 Flannigan, M., Cantin, A. S., De Groot, W. J., Wotton, M., Newbery, A., & Gowman, L. M. (2013). Global wildland fire season severity in the 21st century. Forest Ecology and Management, 294, 54-61. https://doi.org/10.1016/j.foreco.2012.10.022

Figure 10:

Historic Wildfire Risk Map



3) Wildfire smoke reduces air quality causing local health impacts

Description	Smoke from wildfires enters the Pincher Creek area, reducing air quality and causing local health impacts
Climate Driver(s)	Hotter temperatures, drier summer conditions
Threshold	Visibility due to wildfire smoke falls below average (7km)
Historic Likelihood Score	**5 (Almost Certain)**
Future Likelihood Score	**5 (Almost Certain)**
Potential Consequences	• Health impacts (e.g., difficulty breathing, liver and kidney failure), particularly on vulnerable populations • Reduced outdoor recreation activities and quality of life (e.g., hiking, running, etc.) • Delays and/or cancellations of local events • Increased costs to install/upgrade filtration systems • Increased demand for emergency services and assistance
Consequence Score	**3 (Moderate)**
Risk Score	**High**

Notes

Climate driver(s)

- Climate projections indicate hotter maximum temperatures and more dry days

Threshold

- 7km is the average visibility from all wildfire smoke events that were recorded between 1956-2022

Historic Likelihood

- There were 233 occurrences between 1956-2022 where visibility fell below 7km due to wildfire smoke, about 3.5 occurrences per year (Figure 11) [22]

Future Likelihood

- Fire seasons are estimated to become more severe in a future warmer world. The length of the fire season is expected to increase by more than 20 days per year in the Northern hemisphere by the end of the century[23]

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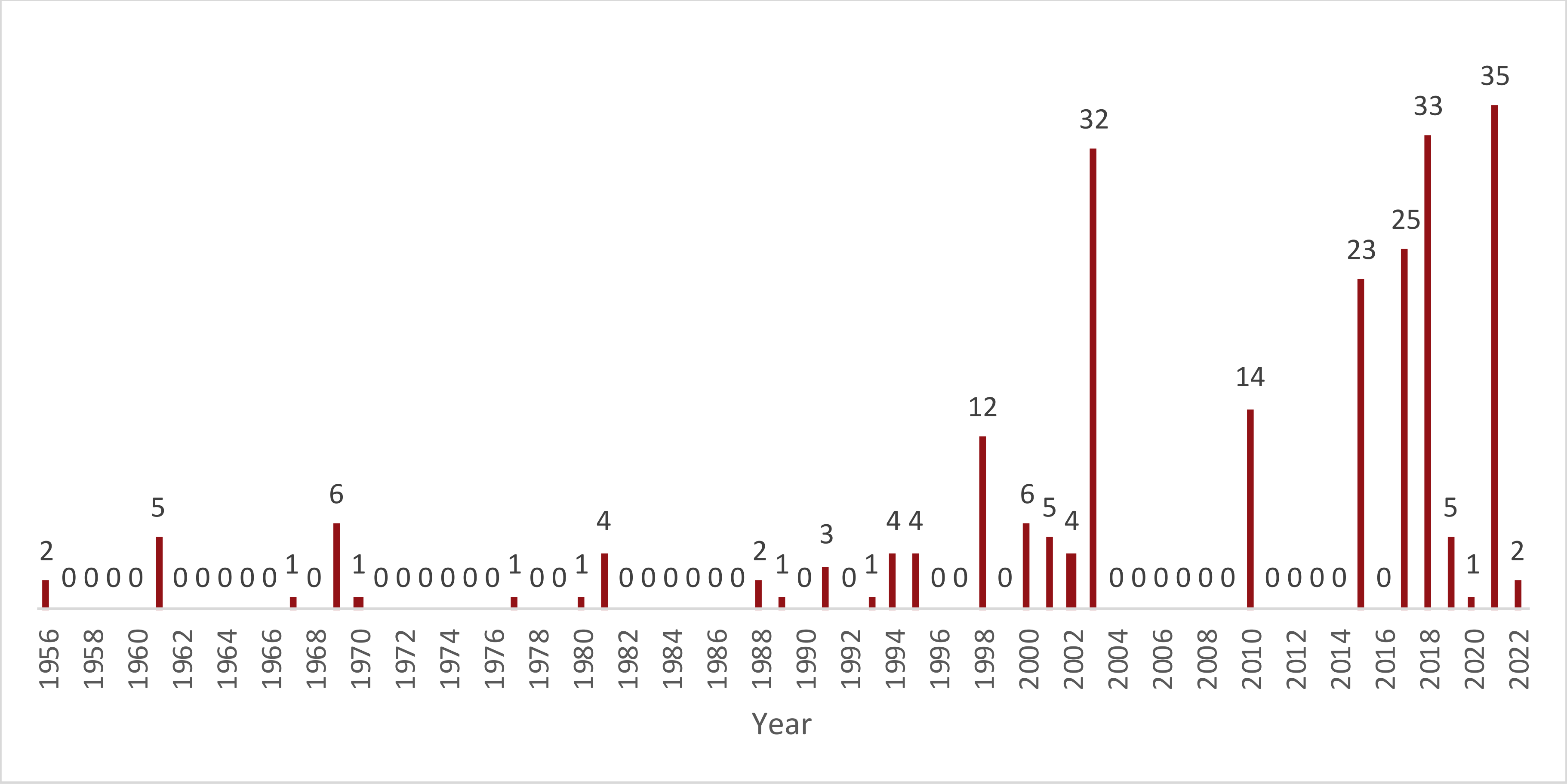
22 Data retrieved from Environment and Climate Change Canada (ECCC) (2023). Lethbridge data was used as it is the closest municipality to Pincher Creek for which information was available.

23 Flannigan, M., Cantin, A. S., De Groot, W. J., Wotton, M., Newbery, A., & Gowman, L. M. (2013). Global wildland fire season severity in the 21st century. *Forest Ecology and Management*, 294, 54-61. https://doi.org/10.1016/j.foreco.2012.10.022

Figure 11:

Historic occurrence of wildfire smoke events (visibility <7km) at Lethbridge (1956-2022)



4) Hailstorm damages homes and infrastructure

Description	A major hail event producing hailstones that reach 32mm in diameter damages homes and infrastructure in Pincher Creek
Climate Driver(s)	Severe storms
Threshold	A hailstorm with toonie-sized hailstones (32mm)
Historic Likelihood Score	**3 (Possible)**
Future Likelihood Score	**3 (Possible)**
Potential Consequences	• Evacuations / displacement • Health impacts (injuries/fatalities), particularly on vulnerable populations • Power outages • Increased cost/insurance • Increased demand for emergency services and assistance • Property damage (roofing, siding, windows, cars, etc.)
Consequence Score	**2 (low)**
Risk Score	**Low**

Notes

Climate driver(s)

- Climate projections indicate an increase in summer temperatures and extreme heat, which contribute to stronger thunderstorms that can produce large hail

Threshold

- 32mm (toonie-sized) hail incrementally damages the greatest number of roofing products[24]

Historic Likelihood

- 2 events with toonie-sized hail were recorded in Pincher Creek between 1982-2020, an average of 1 event every 19 years, or 5% annual probability[25]

Future Likelihood

- The localized and short duration nature of hailstorms makes it difficult to accurately predict future changes in frequency in the Pincher Creek area with meaningful confidence. The number of hailstorms is projected to be less frequent. However, when a hailstorm does occur, larger hail stone sizes are expected[26].

24 Marshall, T., Herzog, R., Morrison, S., & Smith, S. (2002). Hail damage threshold sizes for common roofing materials. 21st Conf. on Severe Local Storms, San Antonio, TX. Amer. Meteor. Soc. P,3. https://www.researchgate.net/publication/327022658_HAIL_DAMAGE_THRESHOLD_SIZES_FOR_COMMON_ROOFING_MATERIALS

25 Data retrieved from Environment and Climate Change Canada (ECCC) (2023).

26 Allen, J. T. (2018). Climate change and severe thunderstorms. In Oxford research encyclopedia of climate science. https://doi.org/10.1093/acrefore/9780190228620.013.62

5) Blizzard disrupts transportation

Description	A winter storm with blowing snow and wind reduces visibility
Climate Driver(s)	Severe storms, Warmer winters
Threshold	A blizzard occurs with winds of 40 km/hr or greater and widespread reductions in visibility to 400 metres or less, due to blowing snow[27]
Historic Likelihood Score	**5 (Almost Certain)**
Future Likelihood Score	**4 (Likely)***
Potential Consequences	• Health impacts (injuries/fatalities) • Impact on local events (delays/cancellations) • Disruption of transportation networks (roads, bridges, etc.) • Increased demand for emergency services and assistance • Reduced ability for emergency services to provide support/assistance
Consequence Score	**2 (Low)**
Risk Score	**Medium**

* Likelihood score was changed from 3 to 4 upon discussions with Pincher Creek staff. It was noted that blizzard events should be at least as likely as freezing rain events. Furthermore, blizzard projections are based off Lethbridge data which may not be as accurate.

Notes

Climate driver(s)

- Climate projections indicate fewer cold days and milder winters, which contribute to reduced blizzard risk

Threshold

- The criteria for a blizzard warning from Environment and Climate Change Canada is “when winds of 40 km/hour or greater are expected to cause widespread reductions in visibility to 400 metres or less, due to blowing snow, or blowing snow in combination with falling snow, for at least 4 hours”[28]

Historic Likelihood

- 64 blizzards were recorded at the Lethbridge weather station between 1953 and 2020, about 1 blizzard per year (Figure 12)[29].

Future Likelihood

- Climate projections indicate warmer temperatures which will reduce snowfall at lower elevations and may reduce the annual number of blizzard events.

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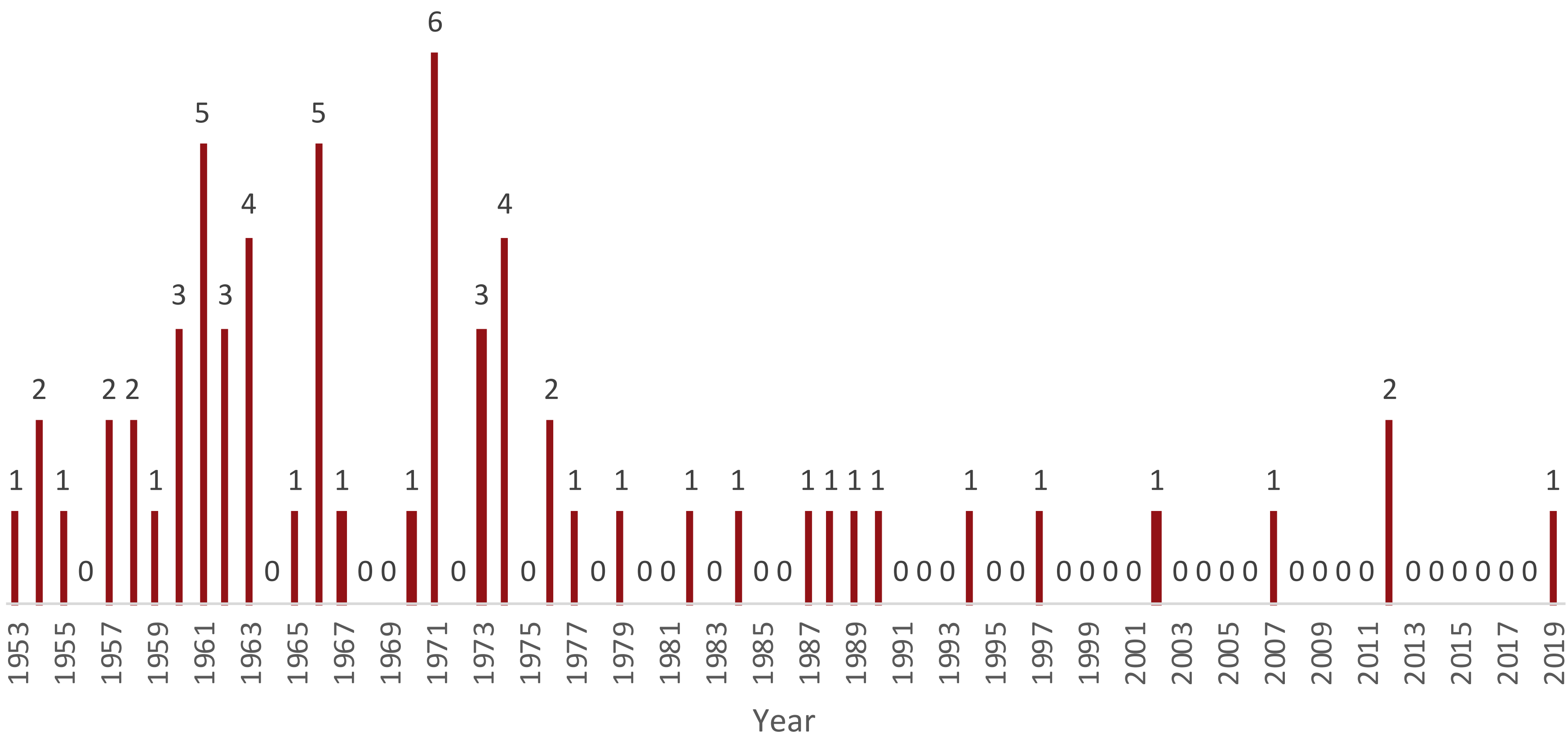
27 Based on Environment and Climate Change Canada *Criteria for public weather alerts*.

28 Environment and Climate Change Canada. (2020). *Criteria for public weather alerts*. Government of Canada. https://www.canada.ca/en/environment-climate-change/services/types-weather-forecasts-use/public/criteria-alerts.html#snowFall

29 Data retrieved from Environment and Climate Change Canada (ECCC) (2023) from the Lethbridge weather station

Figure 12:

Historic occurrence of blizzards at Lethbridge (1953 - 2020)



6) Windstorm damages homes and infrastructure

Description	A windstorm occurs damaging homes and infrastructure
Climate Driver(s)	Severe storms
Threshold	A wind warning is issued by Environment and Climate Change Canada
Historic Likelihood Score	**5 (Almost Certain)**
Future Likelihood Score	**5 (Almost Certain)**
Potential Consequences	• Health impacts (injuries/fatalities) • Power outages • Impact on local events (delays/cancellations) • Damage to parks and natural assets • Insurance and repair costs • Reduced economic activity and deterrence of new residents moving to Pincher Creek • Increased demand for emergency services and assistance • Damage to and loss of information/communications infrastructure
Consequence Score	**2 (Low)**
Risk Score	**Medium**

Notes

Climate driver(s)

- Climate projections indicate an increase in summer temperatures and extreme heat, which contribute to stronger thunderstorms that can produce high winds

Threshold

- The criteria for a wind warning is "80 km/h or more sustained wind; and/or gusts to 100 km/h or more[30]"

Historic Likelihood

- 778 wind gusts to 100km/hour or more were recorded between 1960-2022, an average of about 17 windstorms per year (Figure 13) [31]

Future Likelihood

- 50-60% of extreme wind gust events (i.e., 90km/h wind speeds or greater) are associated with warmer temperatures[32]. With warming temperatures projected across Alberta, an increase in the future likelihood of a windstorm event is anticipated

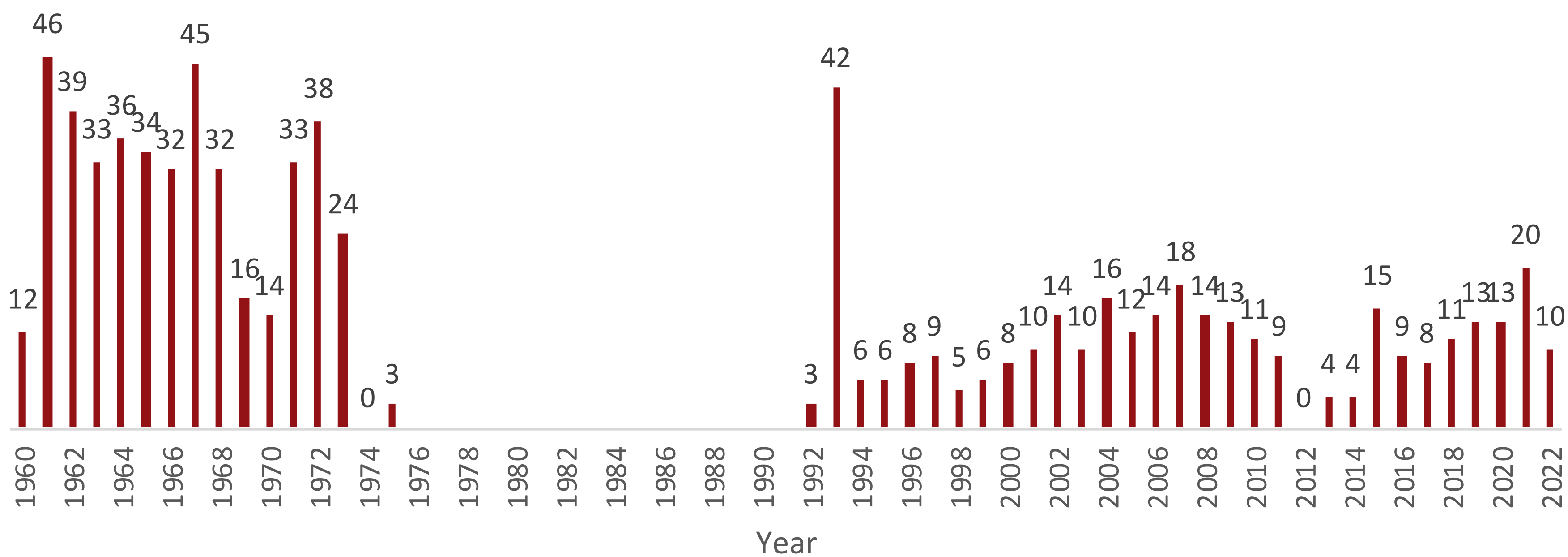
30 Environment and Climate Change Canada (ECCC). (2020. *Criteria for public weather alerts.* Government of Canada. https://www.canada.ca/en/environment-climate-change/services/types-weather-forecasts-use/public/criteria-alerts.html#snowFall

31 Data retrieved from Environment and Climate Change Canada (ECCC) (2023)

32 Cheng, C. S. (2014). Evidence from the historical record to support projection of future wind regimes: An application to Canada. *Atmosphere-Ocean*, 52(3), 232-241. https://doi.org/10.1080/07055900.2014.902803

Figure 13:

Historic windstorm frequency (gusts exceeding 100km/h) at Pincher Creek (1960-2022)[33]



33 Note: No data was recorded between the years 1976 and 1991

7) Freezing rainstorm damages trees and disrupts transportation

Description	A freezing rain event occurs damaging trees and disrupting transportation
Climate Driver(s)	Warmer winters, severe storms
Threshold	A freezing rain warning is issued by Environment and Climate Change Canada
Historic Likelihood Score	**5 (Almost Certain)**
Future Likelihood Score	**5 (Almost Certain)**
Potential Consequences	• Health impacts (injuries/fatalities) from slips, trips, and falls, particularly on vulnerable populations and livestock • Power outages • Disruption of transportation networks • Damage to parks and natural assets • Insurance and repair costs • Increased demand for emergency services and assistance • Damage to and loss of information/communications infrastructure
Consequence Score	**2 (Low)**
Risk Score	**Medium**

Notes

Climate driver(s)

- Climate projections indicate more precipitation in the winter season and milder temperatures which contribute to freezing rain risk

Threshold

- A freezing rain warning is issued by Environment Canada “when freezing rain is expected to pose a hazard to transportation or property; or when freezing rain is expected for at least two hours.”[34]

Historic Likelihood

- 86 freezing rain events were recorded between 1958-2022, about 1.3 events per year on average (Figure 14)[35]

Future Likelihood

- Freezing rain in western and central Canada – particularly in the Canadian Prairies – is projected to increase in frequency as a result of climate change[36]

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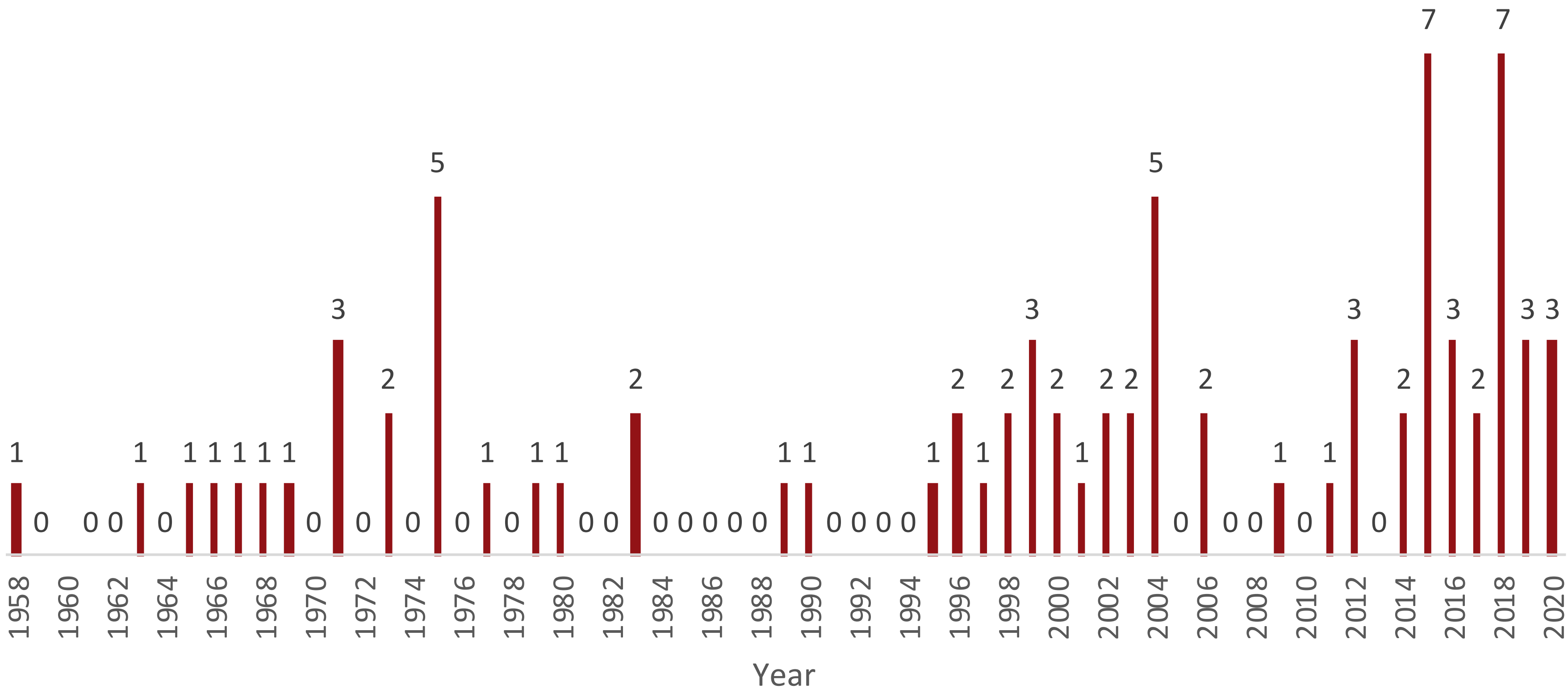
34 Environment and Climate Change Canada (ECCC). (2020. *Criteria for public weather alerts.* Government of Canada. https://www.canada.ca/en/environment-climate-change/services/types-weather-forecasts-use/public/criteria-alerts.html#snowFall

35 Data retrieved from Environment and Climate Change Canada (ECCC) (2023). Lethbridge data was used as it is the closest municipality to Pincher Creek for which information was available.

36 McCray, C. D., Paquin, D., Thériault, J. M., & Bresson, É. (2022). A Multi‐Algorithm Analysis of Projected Changes to Freezing Rain Over North America in an Ensemble of Regional Climate Model Simulations. *Journal of Geophysical Research: Atmospheres*, 127(14), https://doi.org/10.1029/2022JD036935

Figure 14:

Historic occurrence of freezing rain events at Lethbridge (1958 - 2022)



8) River and creek flooding causes damage to homes and properties

Description	Heavy rainfall causes widespread flooding of local creeks and rivers, damaging local infrastructure
Climate Driver(s)	Severe storms, more heavy rainfall events
Threshold	Pincher Creek flow rate of about 270 cubic metres per second (m^3/s), about a 1:200 year event
Historic Likelihood Score	**1 (Rare)**
Future Likelihood Score	**2 (Unlikely)**
Potential Consequences	• Flooding of basements, homes and buildings in low-lying areas, and associated impacts on wellbeing and quality of life • Flooding of parks and natural assets • Evacuations / displacement • Reduced water quality from soil erosion and increased sedimentation • Costs to repair and clean up • Overwhelming of water treatment plants and critical infrastructure
Consequence Score	**4 (High)**
Risk Score	**High**

Notes

Climate driver(s)

- Climate projections indicate increased average annual precipitation levels and wet days

Threshold

- The 1995 flood was the flood of record on Pincher Creek with a peak discharge of 271 m^3/s[37]
- Flood map showing the 1:100-year period provided at Figure 15 below

Historic Likelihood

- The 1995 flood on Pincher Creek (271 m^3/s) was estimated to be about a 200-year event (Figure 15) [38]

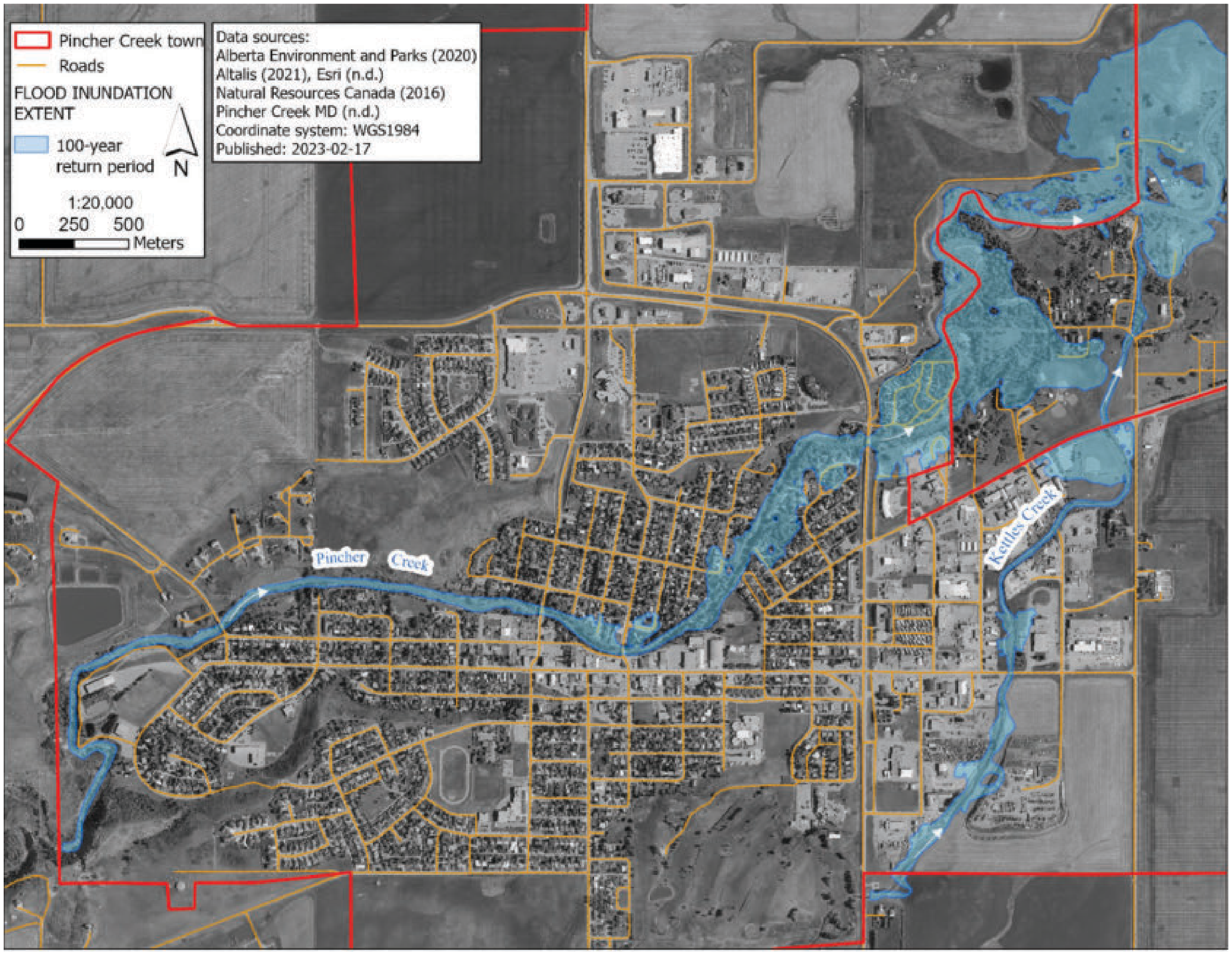
Future Likelihood

- Extreme rainfall and flooding is projected to increase as a result of climate change, and Pincher Creek is projected to have more wet days and extreme rainfall in the future[39]

37 Pincher Creek Flood Hazard Study (2020)
38 Pincher Creek Flood Hazard Study (2020)
39 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

Figure 15:

Flood map showing 100-year return period



9) Ongoing river and creek flooding

Description	Heavy rainfall causes frequent flooding of local creeks and rivers requiring an ongoing response
Climate Driver(s)	Severe storms, more heavy rainfall events
Threshold	Recurring river and creek flood events with a 1:10-year return period
Historic Likelihood Score	**4 (Likely)**
Future Likelihood Score	**5 (Almost Certain)**
Potential Consequences	• Inundation of some basements and other assets in low-lying areas • Strain on emergency response personnel and resources • Costs to repair and clean up
Consequence Score	**2 (Low)**
Risk Score	**Medium**

Notes

Climate driver(s)

- Climate projections indicate increased average annual precipitation levels and more heavy rainfall (wet days)

Threshold

- Flood map showing the 1:10-year return period on Pincher Creek provided at Figure 16 below

Historic Likelihood

- Event is expected to occur about every 10 years

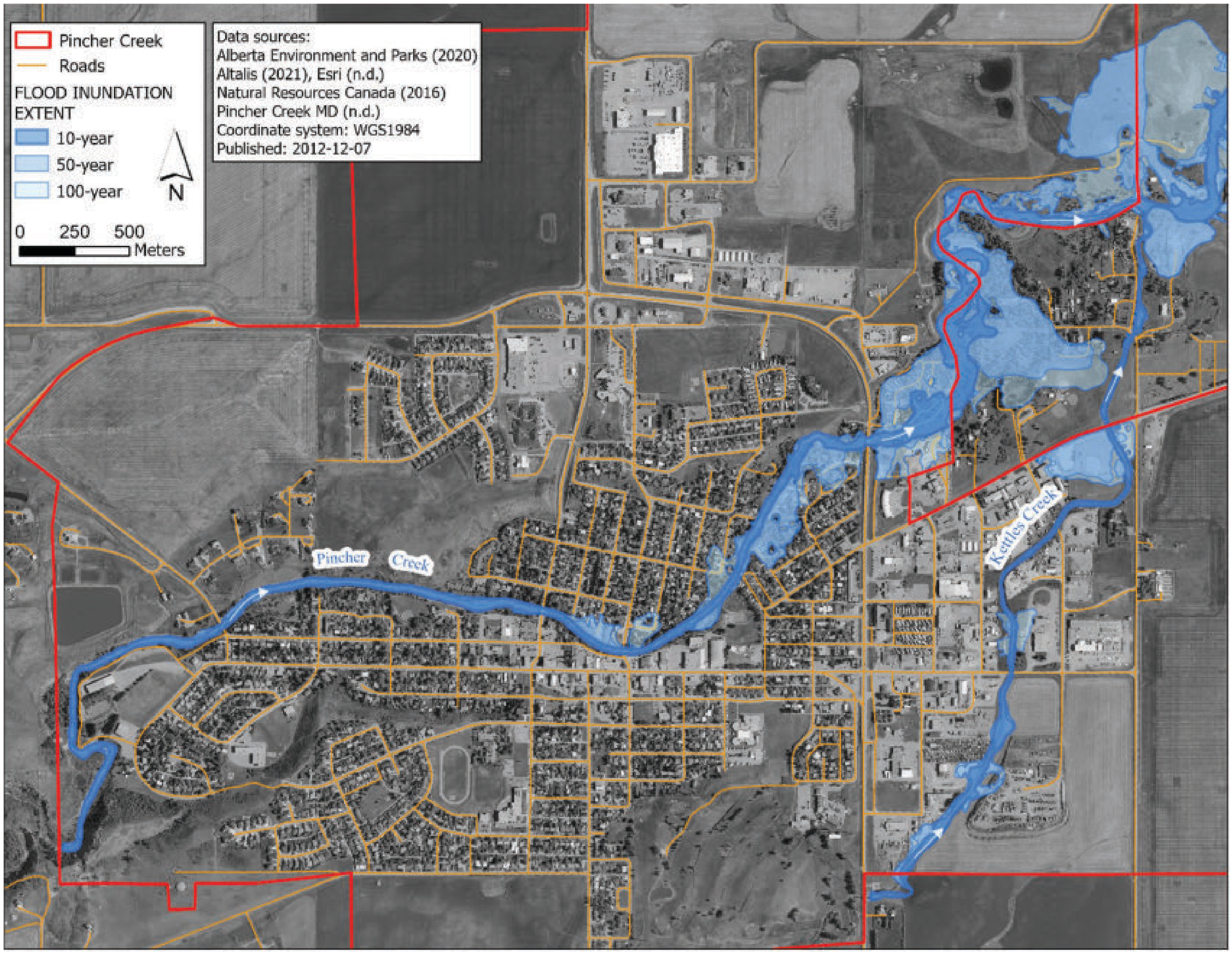
Future Likelihood

- Extreme rainfall and flooding is projected to increase as a result of climate change, and Pincher Creek is projected to have more wet days and extreme rainfall in the future[40]

40 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

Figure 16:

Flood map showing 10-year return period



10) Dam flooding (overtopping) occurs across the District

Description	Prolonged rainfall causes small dams to overtop
Climate Driver(s)	Severe storms, more heavy rainfall events
Threshold	26 very wet days per year where 10mm of precipitation falls within 24 hours
Historic Likelihood Score	**2 (Unlikely)**
Future Likelihood Score	**3 (Possible)**
Potential Consequences	• Inundation of farms and cropland, disrupting livelihoods and economic activity (especially downstream of dams) • Dam maintenance and repair costs
Consequence Score	**3 (Moderate)**
Risk Score	**Medium**

Notes

Climate driver(s)

- Climate projections indicate increased average annual precipitation levels and wet days

Threshold

- Increased precipitation and wet days may lead to increased stress on, and overtopping of smaller dams across the region

Historic Likelihood

- Likelihood score determined based on historic values from the PARC Climate Projections Report

Future Likelihood

- The future likelihood is expected to increase. The number of very wet days where 10mm of precipitation falls annually is projected to increase from 24 days to 26 days[41]

41 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

11) Overland flooding of homes and property in urban areas

Description	A heavy rainfall event occurs in Pincher Creek and damages homes and property
Climate Driver(s)	Severe storms, more heavy rainfall events
Threshold	A 1:100-year rainfall event occurs within 24-hours
Historic Likelihood Score	**1 (rare)**
Future Likelihood Score	**2 (unlikely)**
Potential Consequences	• Inundation of homes and buildings (basement flooding especially on the North side of Pincher Creek) • Damage to buildings and infrastructure (slumping on the hills impacts road networks) • Damage to parks, natural assets and other local amenities • Damage and disruption to transportation networks (roads, bridges, etc.) and culverts
Consequence Score	**3 (Moderate)**
Risk Score	**Medium**

Notes

Climate driver(s)

- Climate projections indicate increased average annual precipitation levels and wet days

Threshold

- Stormwater design standards are generally based on the 1:100-year, 24-hour rainfall event

Historic Likelihood

- The 1:100-year 24-hour rainfall event has a 1% annual probability of occurrence, and is associated with 103mm of rainfall[42]

Future Likelihood

- Considering future climate change, the 1:100-year 24-hour rainfall event has an increased annual probability of occurrence, and is associated with 119mm of rainfall (a 20% increase from the historic value)[43]

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42 Historic likelihood determined through data from the Computerized Tool for the Development of Intensity-Duration-Frequency (IDF) Curves Under Climate Change – Version 6.0. Available at: https://www.idf-cc-uwo.ca

43 Future likelihood determined through data from the Computerized Tool for the Development of Intensity-Duration-Frequency (IDF) Curves Under Climate Change – Version 6.0, using the time period 2051-2080 and SSP5.85 which is a scenario with an additional radiative forcing of 8.5 W/m3 by the year 2100. This scenario represents the upper boundary of the range of climate change scenarios described in the literature. Available at: https://www.idf-cc-uwo.ca

12) Prolonged drought affecting local farmers, ranchers, wildlife and vegetation

Description	A meteorological drought occurs affecting local farmers, ranchers, wildlife and vegetation
Climate Driver(s)	Hotter temperatures, drier summer conditions
Threshold	The Standardized Precipitation Evapotranspiration Index (SPEI) decreases to 0.59
Historic Likelihood Score	**3 (Possible)**
Future Likelihood Score	**3 (Possible)**
Potential Consequences	• Crop damages and reduced yield from crop harvests, disrupting livelihoods and economic activity (increased food prices, water restrictions, etc.) • Loss of or damage to plants, including sweetgrass and willow populations, affecting wildlife • Reduced water availability on farms and ranches (dugouts, sloughs) leading to operational constraints • Increased water demand
Consequence Score	**4 (High)**
Risk Score	**High**

Notes

Climate driver(s)

- Climate projections indicate more extreme heat, warmer maximum temperatures, and reduced summer precipitation

Threshold

- The Standardized Precipitation Evapotranspiration Index (SPEI) is a water balance index based on the monthly difference between precipitation and potential evapotranspiration[44]

Historic Likelihood

- Likelihood score based on the PARC climate projections report

Future Likelihood

- The SPEI is expected to stay relatively stable under future climate change - decreasing from 0.69 to 0.59 which is classified as “near normal”[45]

44 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek
45 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

13) Water supply shortage reduces community service levels

Description	A decrease in water levels causes a shortage reducing community access
Climate Driver(s)	Hotter temperatures, drier summer conditions
Threshold	Average annual precipitation in the summer season decreases to 165mm
Historic Likelihood Score	**2 (Unlikely)**
Future Likelihood Score	**3 (Possible)**
Potential Consequences	• Reduced water availability leading to operational constraints and decreased livelihood (e.g., water restrictions) • Impacts to water-based recreational activities (e.g., pools, spray parks, fishing, etc.) • Increased maintenance costs or damage to irrigated parks and fields • Economic impacts especially to water reliant businesses (e.g., carwashes) and farmers
Consequence Score	**4 (High)***
Risk Score	**High**

* Consequence score changed from 3 to 4 through the climate risk evaluation process

Notes

Climate driver(s)

- Climate projections indicate more extreme heat, warmer maximum temperatures, and reduced summer precipitation

Threshold

- Summer precipitation and moisture levels affect water supply and availability

Historic Likelihood

- Likelihood score based on the PARC climate projections report

Future Likelihood

- Summer precipitation is expected to decrease from 176mm to 165mm in a future time period with 3° C of global warming[46]

46 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

14) Loss of winter recreation

Description	A shorter, warmer winter season reduces opportunities for winter recreation (skating, skiing, sledding, etc.)
Climate Driver(s)	Warmer winters
Threshold	The number of frost days decreases to 134 days per year

Historic Likelihood Score	**3 (Possible)**
Future Likelihood Score	**4 (Likely)**

Potential Consequences	• Reduced quality of life from loss of winter activities and sports • Reduced tourism visitation and expenditures (Castle Mountain gets about 100,000 visits per year) • Economic disruption, particularly from the collapse of the winter skiing industry • Increased strain on indoor recreation facilities
Consequence Score	**3 (Moderate)**

Risk Score	**High**

Notes

Climate driver(s)

- Climate projections indicate less frost days and warmer winter temperatures, which contributes to fewer opportunities for winter recreation

Threshold

- A frost day is a day where temperatures are 0°C or colder. Temperatures above 0°C can lead to reduced winter snowfall and recreational opportunities

Historic Likelihood

- Likelihood score based on the PARC climate projections report

Future Likelihood

- The number of frost days is expected to decrease from 198 days to 134 days under a future time period with 3° C of global warming[47]

47 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

15) Invasive weed outbreak affecting local ranchers and farmers

Description	An outbreak of invasive weeds affects local ranchers and farmers (e.g., Hawkweed, burdock, hoary cress)
Climate Driver(s)	Changing seasons and ecosystems, hotter temperatures
Threshold	The frost-free season is extended to 231 days
Historic Likelihood Score	**2 (Unlikely)**
Future Likelihood Score	**3 (Possible)**
Potential Consequences	• Diminished crop health and yield • Increased weed management costs • Impacts to food supply for cattle, economic costs and reduced livestock health
Consequence Score	**3 (Moderate)**
Risk Score	**Medium**

Notes

Climate driver(s)

- Climate projections indicate a longer frost-free season and warmer temperatures, which contributes to the growth and survival of pests and diseases

Threshold

- The frost-free season is the approximate length of the growing season during which there are no freezing temperatures. A longer frost-free season may encourage the growth of invasive weeds[48]

Historic Likelihood

- Likelihood score based on the PARC climate projections report

Future Likelihood

- The length of the frost-free season is projected to increase from 167 days to 231 days under a future climate change, with potential increased likelihood of invasive weed outbreaks[49]

48 See: Edmonton Metropolitan Region: Managing Invasive Species and Pests in a Changing Climate
49 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

16) Outbreak of invasive species or pest affecting local trees and forests

Description	A major outbreak of invasive pests (e.g., mountain pine beetle) affects local trees and forests
Climate Driver(s)	Changing seasons and ecosystems, warmer winters
Threshold	The number of very cold days where temperatures drop to -30°C decreases to 0.3 days
Historic Likelihood Score	**1 (Rare)**
Future Likelihood Score	**4 (Likely)**
Potential Consequences	• Damage to natural infrastructure (local parks and forests) • Reduced visual quality of the landscape • Increased tree management / maintenance costs • Negative impact to native wildlife
Consequence Score	**2 (Low)**
Risk Score	**Medium**

Notes

Climate driver(s)

- Climate projections indicate less frost days and warmer winter temperatures, which may contribute to the growth and survival of some pests and diseases

Threshold

- Cold temperatures help keep invasive species and pest populations in check[50]. Fewer cold days may lead to expansion of invasive species and pest populations

Historic Likelihood

- Likelihood score based on the PARC climate projections report

Future Likelihood

- The number of very cold days is expected to decrease from 3.4 days to 0.3 days per year under climate change[51]. Fewer cold days may lead to better overwintering survival rates for some invasive species and pest populations and increased likelihood of an outbreak

50 See: Edmonton Metropolitan Region: Managing Invasive Species and Pests in a Changing Climate
51 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

17) Vector-borne disease outbreak with public health risks

Description	A major outbreak of vector-born invasive pests (e.g., Lyme disease)
Climate Driver(s)	Warmer temperatures, longer frost-free season
Threshold	The frost-free season is extended to 231 days
Historic Likelihood Score	**2 (Unlikely)**
Future Likelihood Score	**3 (Possible)**
Potential Consequences	• Risk of mortality, morbidity, especially due new unknown vector-borne diseases that could emerge • Impacts to recreational access and disruption to livelihoods and economic activity (reduced tourism)
Consequence Score	**3 (Moderate)**
Risk Score	**Medium**

Notes

Climate driver(s)

- Climate projections indicate a longer frost-free season and warmer temperatures

Threshold

- The frost-free season is the approximate length of the growing season during which there are no freezing temperatures. A longer frost-free season will contribute to increased risk of some vector-borne diseases including Lyme disease[52]

Historic Likelihood

- Likelihood score based on the PARC climate projections report

Future Likelihood

- The length of the frost-free season is projected to increase from 167 days to 231 days under a future climate change, with potential increased likelihood of vector-borne diseases outbreak such Lyme disease[53]

52 See for example: Health Canada (2019). Increased risk of tick-borne diseases with climate change. Available at: https://www.canada.ca/en/public-health/services/reports-publications/canada-communicable-disease-report-ccdr/monthly-issue/2019-45/issue-4-april-4-2019/article-2-increased-risk-tick-borne-diseases-climate-change.html; or Prairie Climate Centre (2022) Lyme disease under climate change. Available at: https://climateatlas.ca/lyme-disease-under-climate-change

53 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

18) Changing ecosystems negatively affects wildlife and habitat

Description	Changing ecosystems negatively affects habitat quality and wildlife populations
Climate Driver(s)	Warmer temperatures, longer frost-free season, changing seasons and ecosystems
Threshold	The frost-free season is extended to 231 days
Historic Likelihood Score	**2 (Unlikely)**
Future Likelihood Score	**3 (Possible)**
Potential Consequences	• Changes in wildlife species distribution and composition in the Pincher Creek area • Loss or reduction in habitat for some wildlife species • Impacts to recreation use and quality of life (changes to visual quality of the landscape)
Consequence Score	**3 (Moderate)**
Risk Score	**Medium**

Notes

Climate driver(s)

- Climate projections indicate warmer temperatures and drier conditions overall in the Pincher Creek area. This climate will be more favourable for grassland ecosystem types, and regional ecosystems are projected to shift northward and upslope across Alberta as the climate warms (Figure 17)[54]

Threshold

- The frost-free season is the approximate length of the growing season during which there are no freezing temperatures[55]. A longer frost-free season is altering the composition of ecosystems across Alberta

Historic Likelihood

- Likelihood score based on the PARC climate projections report

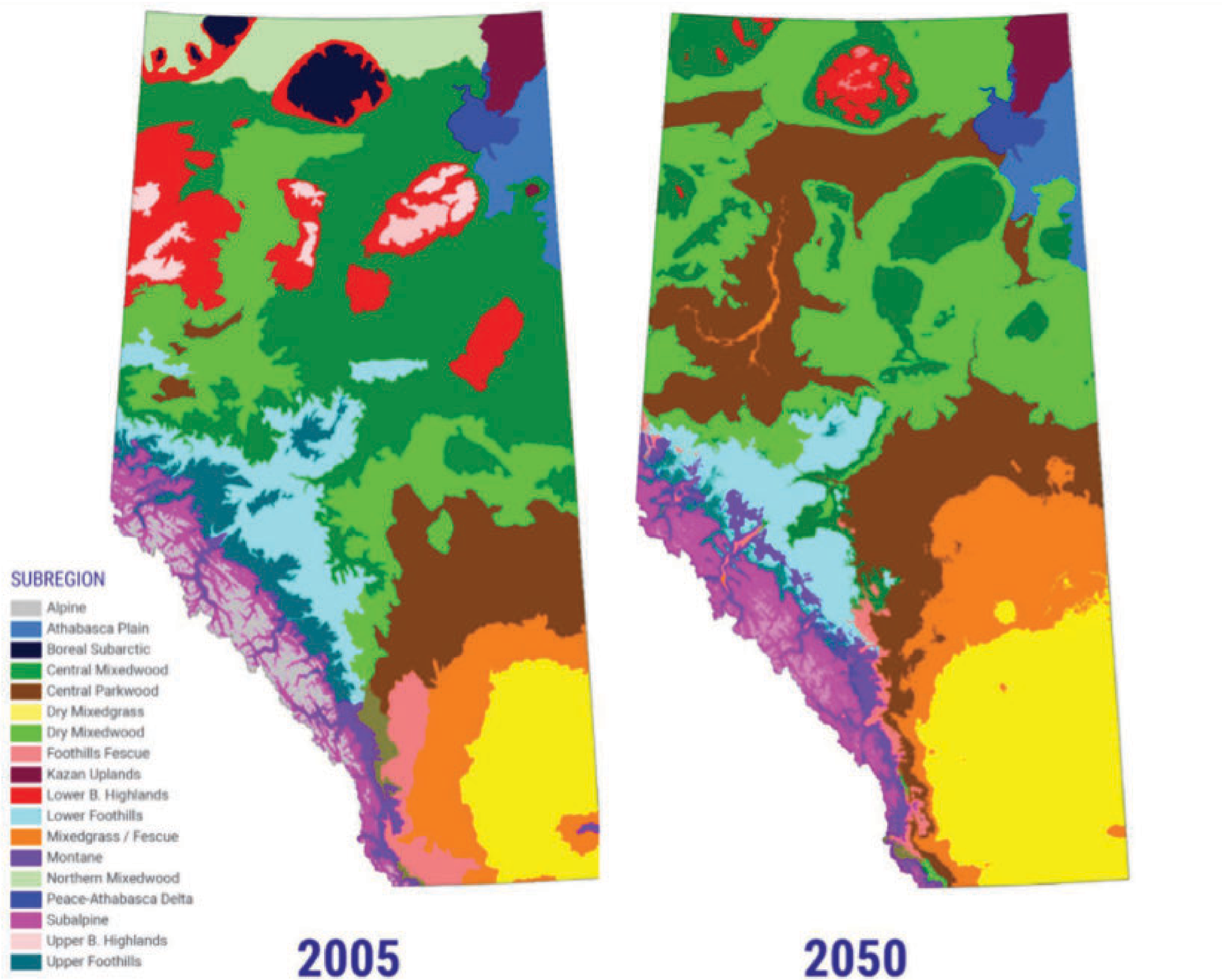
Future Likelihood

- The length of the frost-free season is projected to increase from 167 days to 231 days under a future climate change, with potential to alter local ecosystems and affect wildlife and habitat[56]

54 Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Alberta Biodiversity Monitoring Institute, Edmonton, AB
55 Threshold obtained from the definition of a frost-free season from the Prairie Climate Centre (2022)
56 Data from the Prairie Adaptation Research Collaborative (2023) - Climate Change Projections for Pincher Creek

Figure 17:

Map showing projected changes to Ecoregions in Alberta (2005 – 2050)



Appendix B: Complete Survey Results & Analysis

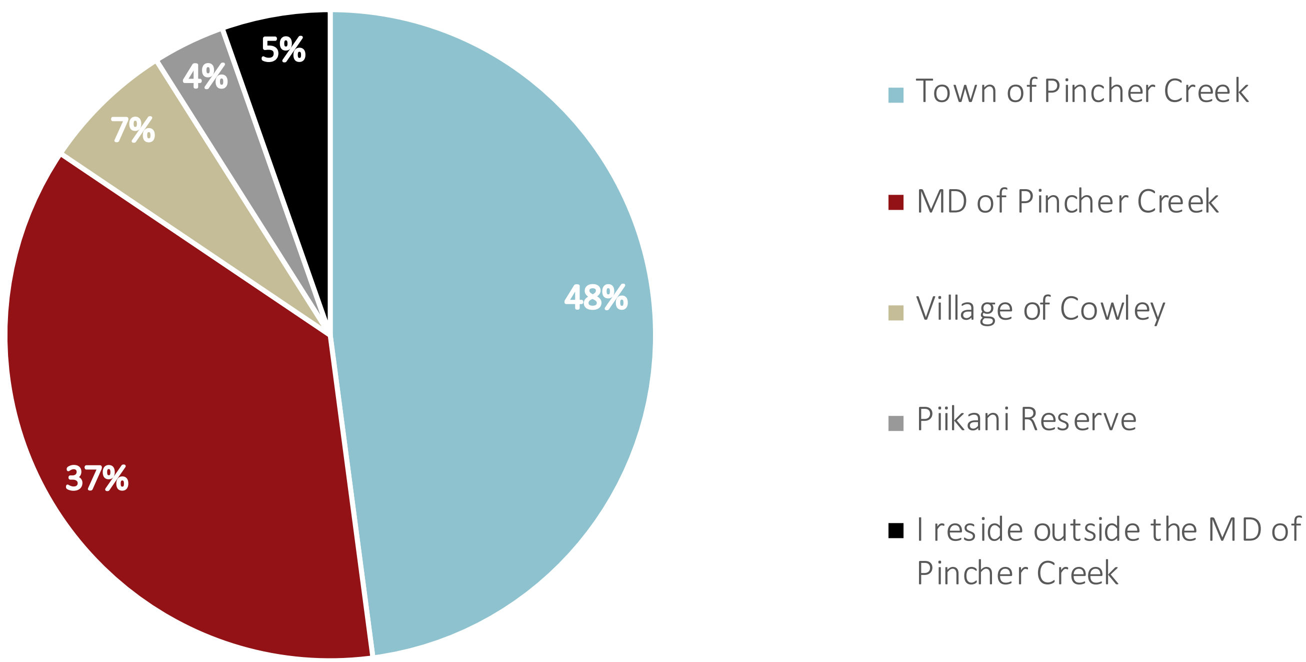
Survey Demographics

Place of residence

Results showed that the vast majority of survey respondents (48%) resided in the Town, followed by the MD (37%) (Figure 18). The remaining places of residence had a relatively equal distribution of survey respondents, ranging from 5-7%.

Figure 18:

Primary place of residence of survey respondents

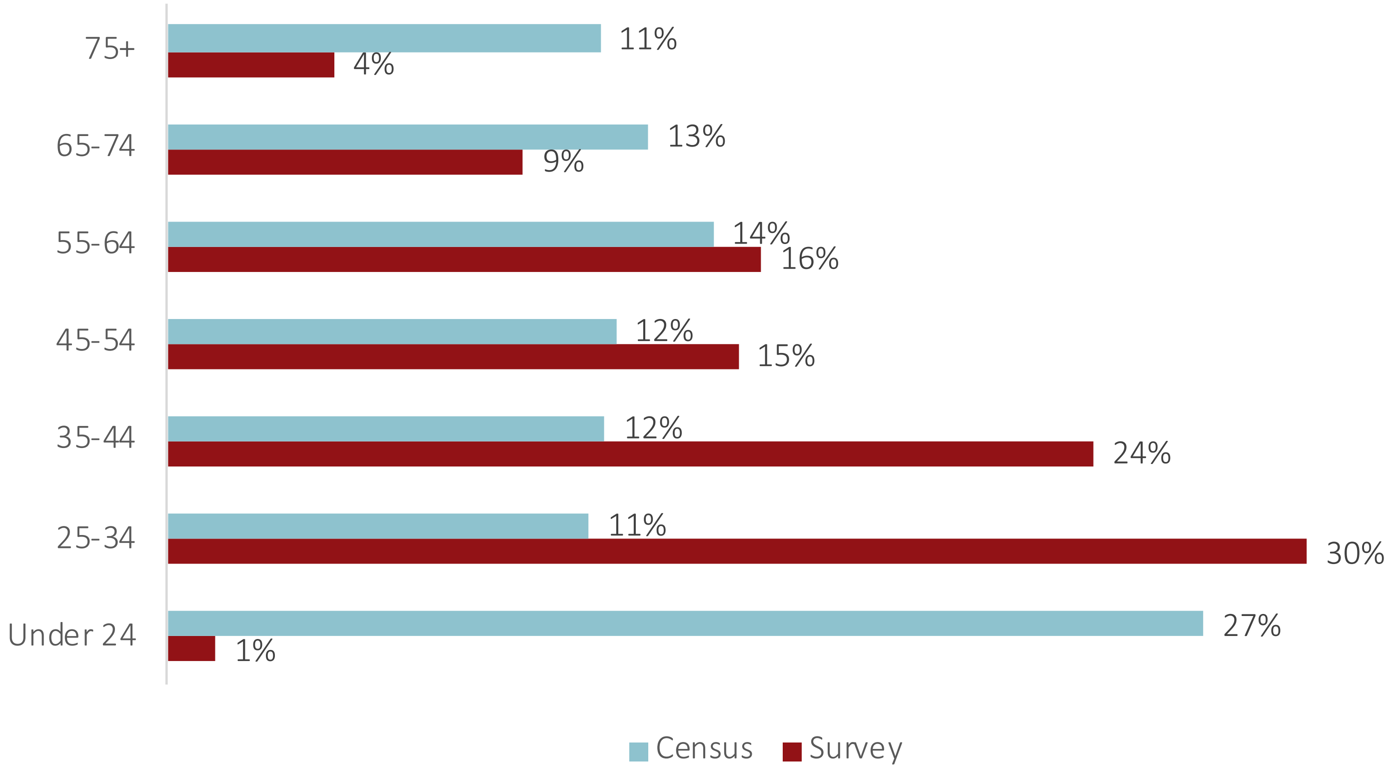


Place of residence

Figure 19 illustrates that most participants are relatively younger (under 35), with the 25-34 age category having the largest representation (30%). This finding is consistent with the overall population, although the largest age category (27%) consists of individuals under 24 years of age.

Figure 19:

Comparison of age categories between survey results and the population

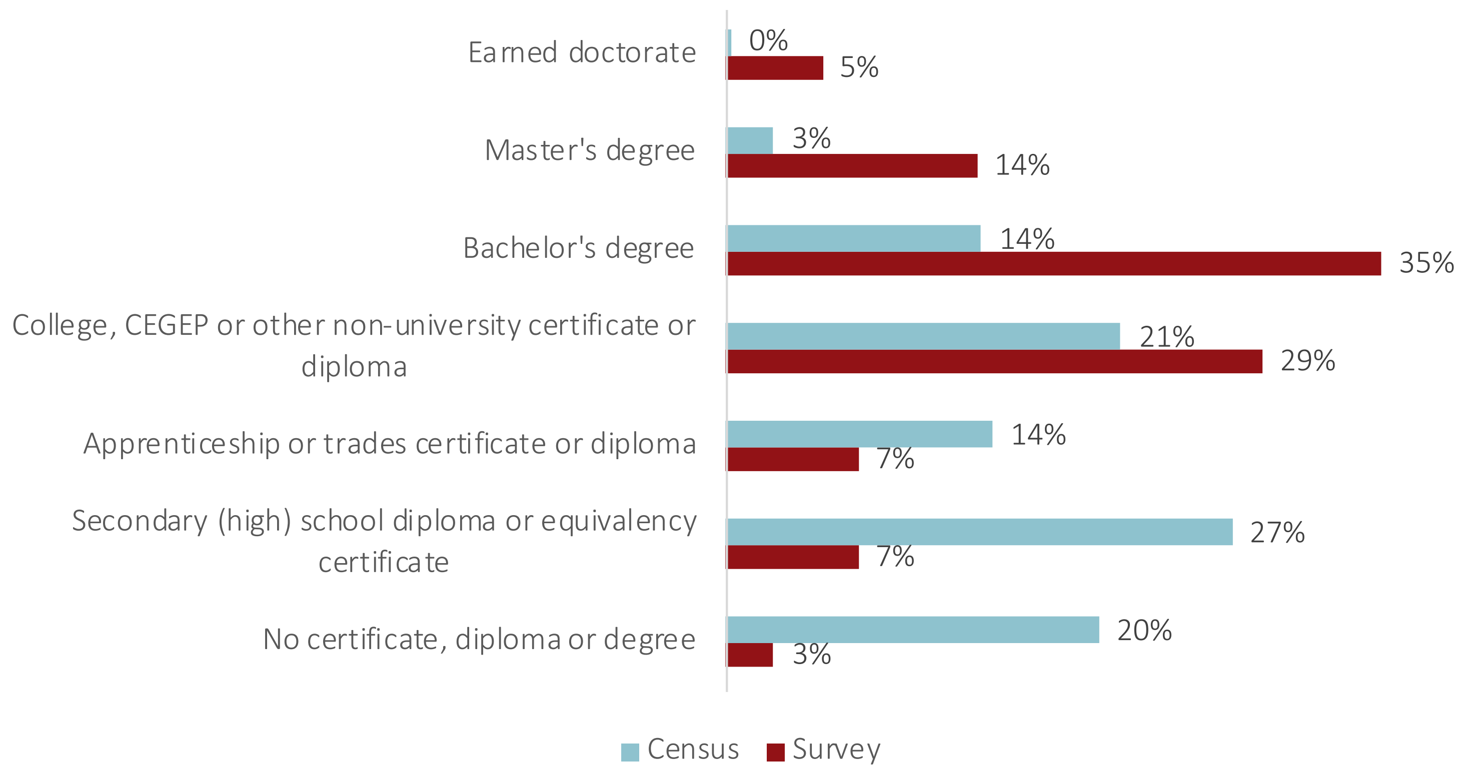


Education

The majority of the surveyed population are shown to have a post-secondary education (90%) as their highest level of educational attainment (Figure 20). This is different from the overall population as only 53% are educated beyond high school.

Figure 20:

Comparison of educational achievement between survey results and the population

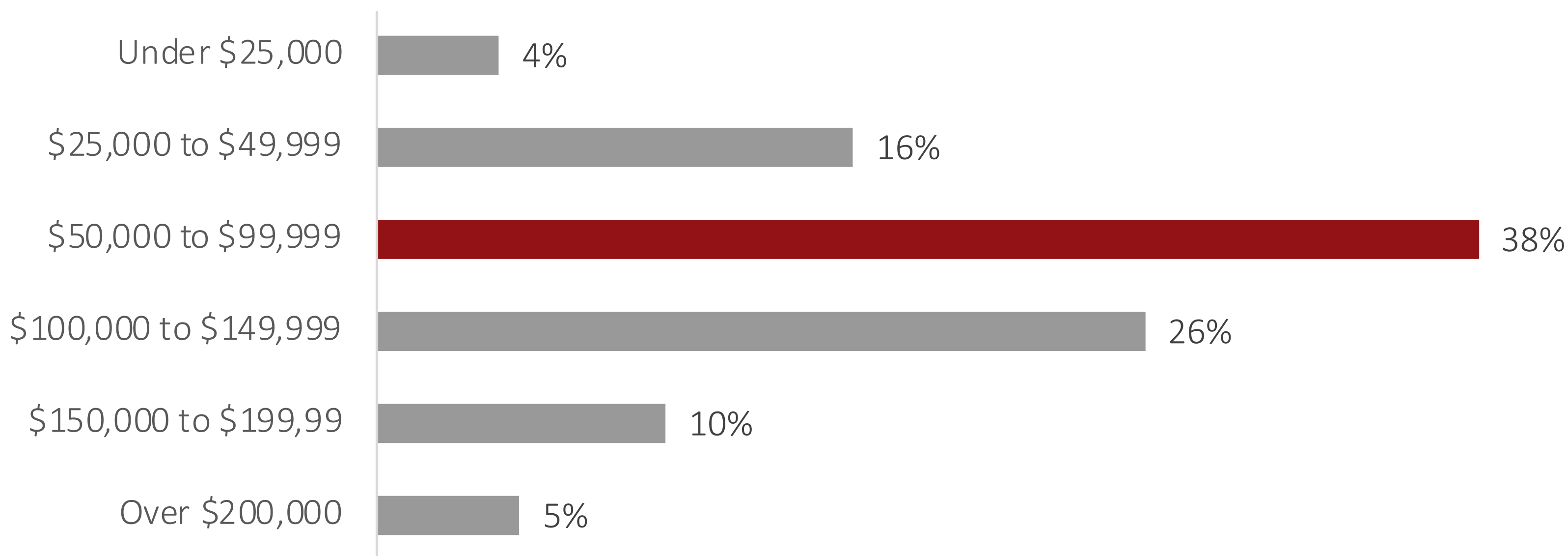


Income

The majority of survey respondents (38%) are shown to have an annual income (before tax) between $50,000 - $99,0000 (Figure 21). The trend follows an even distribution with the largest representation of participants in the median income brackets.

Figure 21:

Income ranges between survey respondents

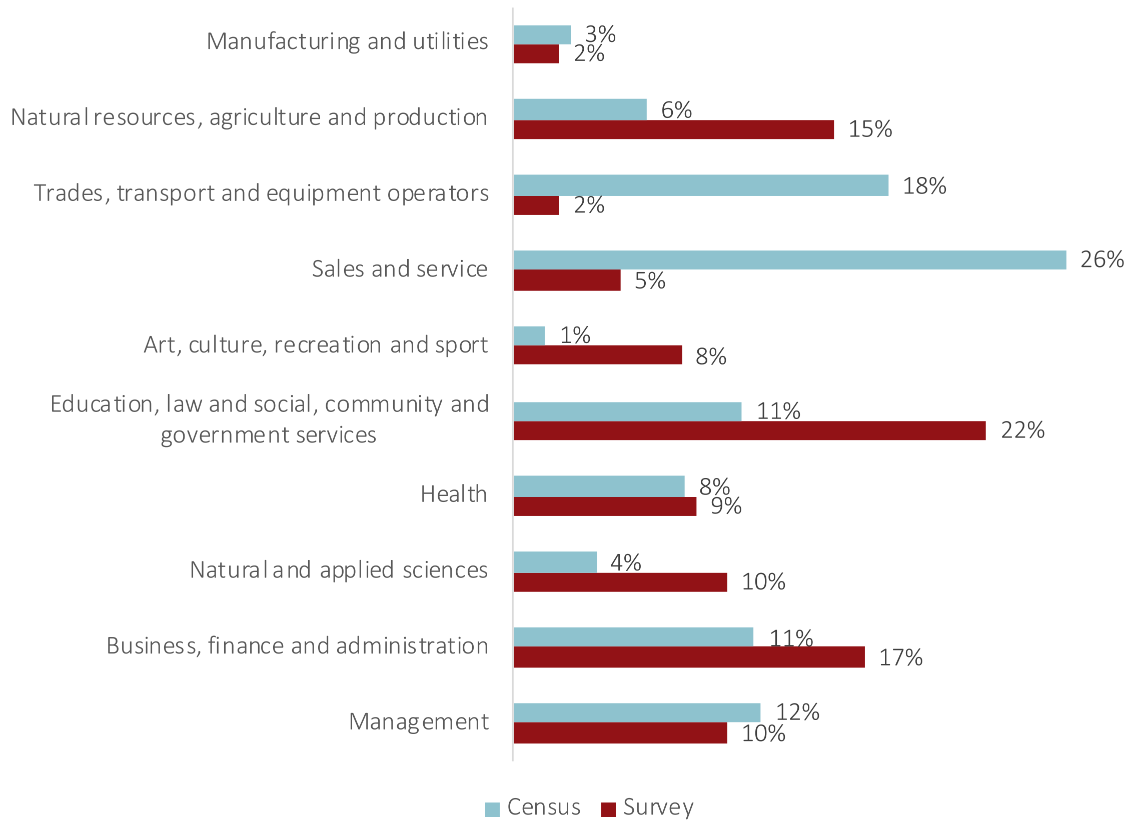


Occupation

The majority of survey respondents (22%) work in the Education, Law, and Social, Community and Government Services sector (Figure 22). This is a contrast to the overall population as 26% of Pincher Creek residents work in Sales and service. Additionally, most survey respondents (63%) do not work in the farming or ranching sector in Pincher Creek.

Figure 22:

Comparison of primary occupation between survey results and the population



Climate Change Impacts

The survey contained five key sections (hotter temperatures, warmer winters, drier summer conditions, severe storms, and changing seasons and ecosystems) which asked participants to identify the degree to which climate changes would impact the community. For each section, respondents were asked to rate the degree to which each impact would affect the community, ranging from ‘no effect’, to ‘minor’, ‘moderate’, or ‘major’ effect.

Importantly, the survey also asked participants about what they thought the most significant climate change-related impacts were, and how the community can increase resilience. Survey results are presented below for each survey section, followed by an overall summary of results.

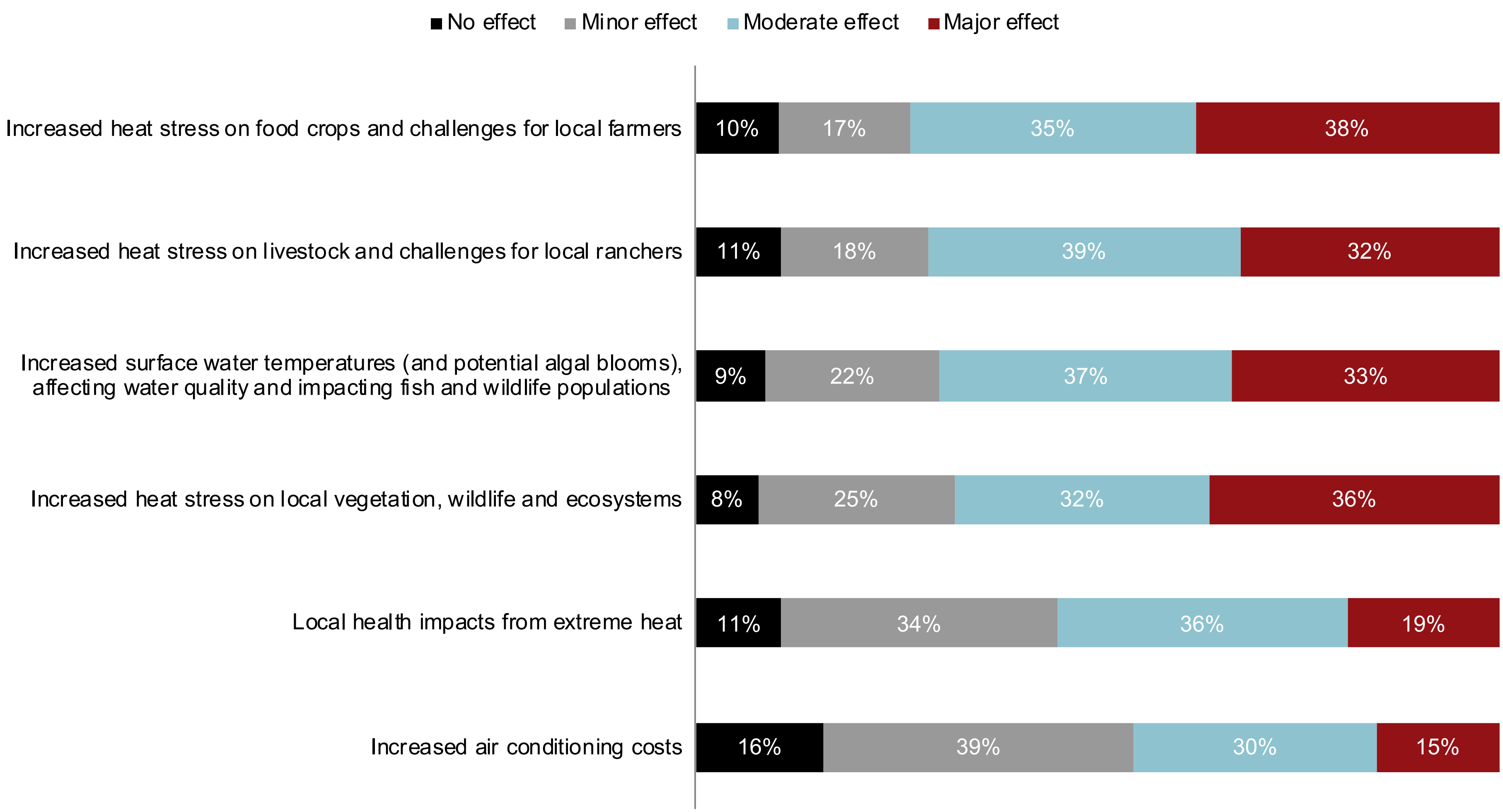
Hotter Temperatures

Figure 23 shows how survey respondents perceived the potential impacts of hotter temperatures in Pincher Creek. Increased heat stress on food crops and challenges for local farmers was the most concerning impact, with 73% of respondents either moderately or majorly concerned. Increased heat stress on livestock, increased surface water temperatures (and algal blooms), and increased heat stress on local vegetation, wildlife, and ecosystems were also relatively concerning impacts as 70% or more respondents indicated them to have a moderate or major effect on the community.

In contrast, increased air conditioning costs and local impacts from extreme heat (only 15% and 19% rated ‘major effect’, respectively) were the least concerning climate impacts, with over 45% of participants rating them to have little to no effect on Pincher Creek.

Figure 23:

Community perceptions of the effects of hotter temperatures on Pincher Creek

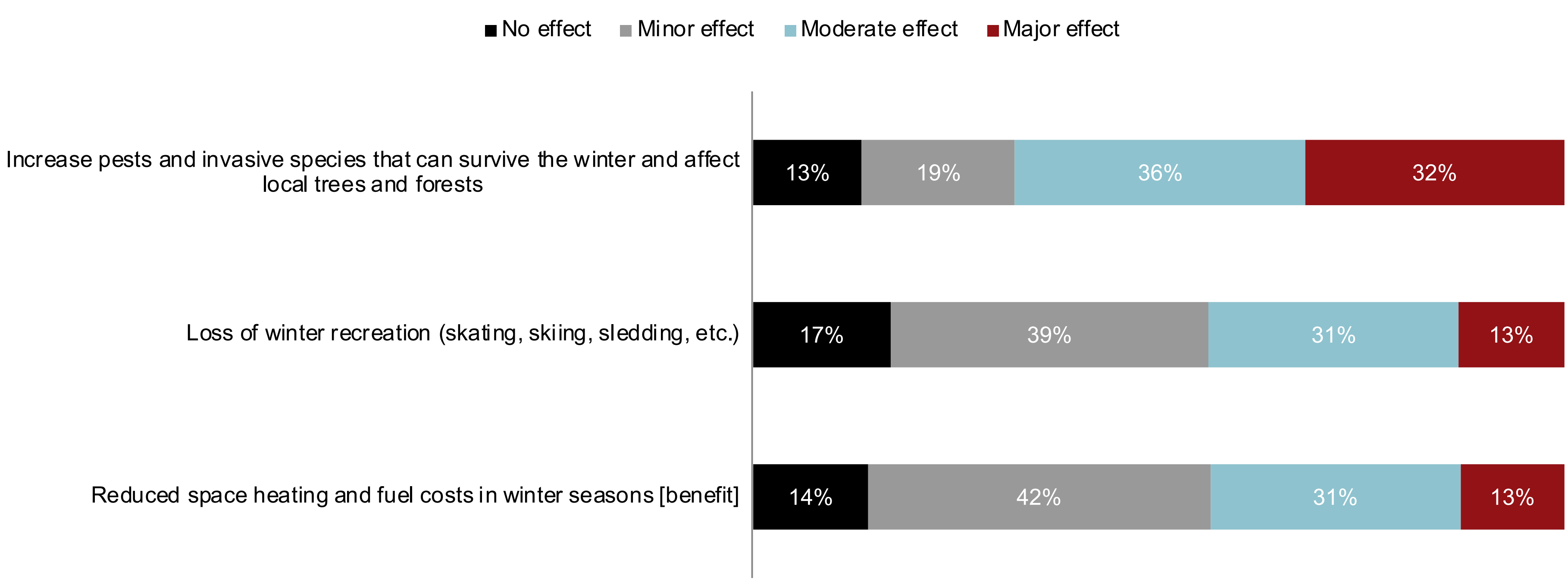


Warmer Winters

Figure 24 shows community perceptions of the potential impacts of extreme weather in Pincher Creek. Increased pests and invasive species that could survive the winter and affect local trees and forests received the greatest concern with almost 70% of respondents rating it to have a moderate or major impact on the community. Loss of winter recreation and reduced space heating costs were rated lower, with only 44% of respondents indicating both impacts to have a moderate or major effect.

Figure 24:

Community perceptions of the effects of warmer winters in Pincher Creek

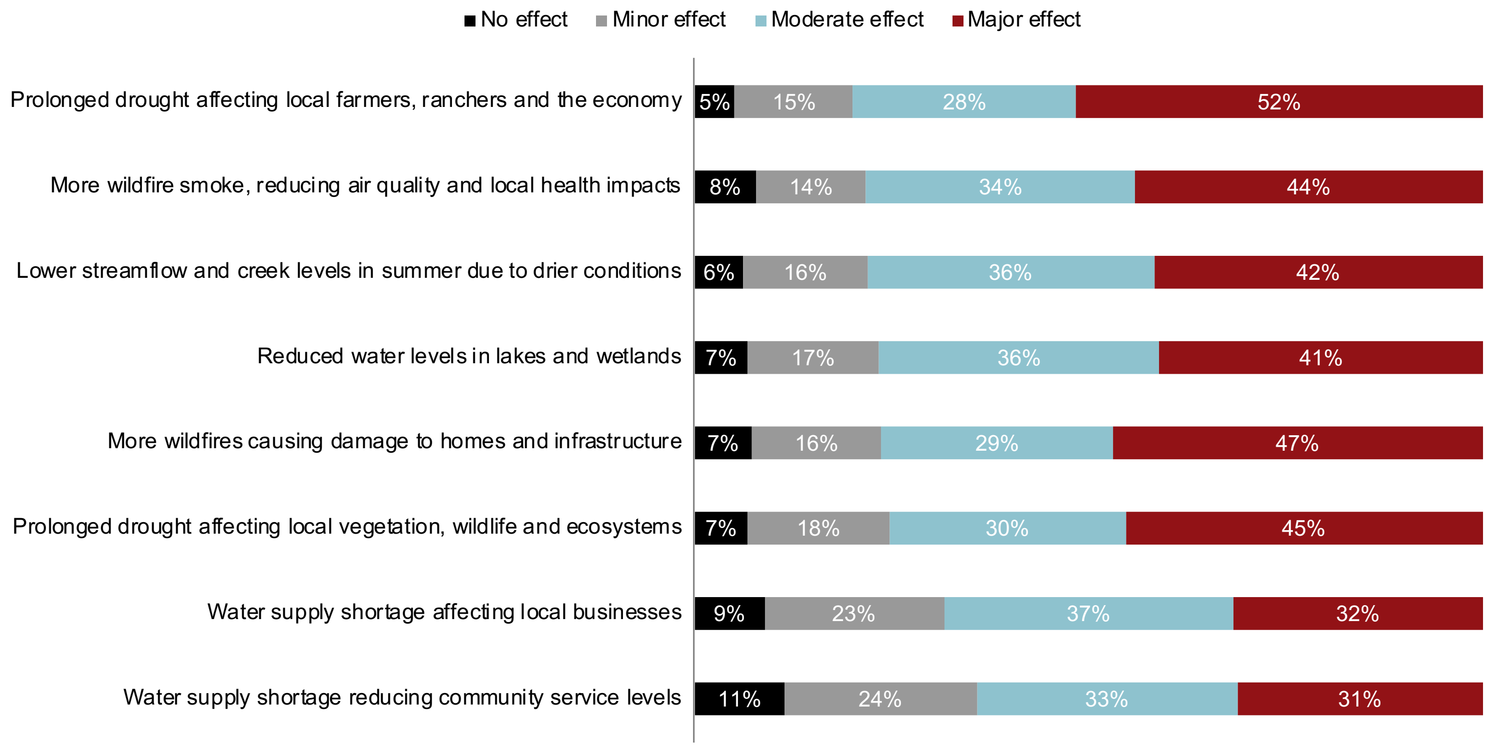


Drier Summer Conditions

Figure 25 shows community perceptions of impacts relating to drier summers on the community. Prolonged drought affecting farmers, ranchers, and the economy received the greatest concern, as more than half of participants rated the impact to have a major effect on Pincher Creek (80% of participants rated moderate or major impact). Wildfire smoke, lower streamflow, reduced water levels, wildfires, and prolonged drought affecting local vegetation, wildlife , and ecosystems were also concerning impacts, as 75% or more participants rated them to have a moderate or major effect on the community. Impacts relating to water shortages received slightly less concern with less than 70% of participants rating them to have a moderate or major effect.

Figure 25:

Community perceptions of the effects of drier summer conditions in Pincher Creek

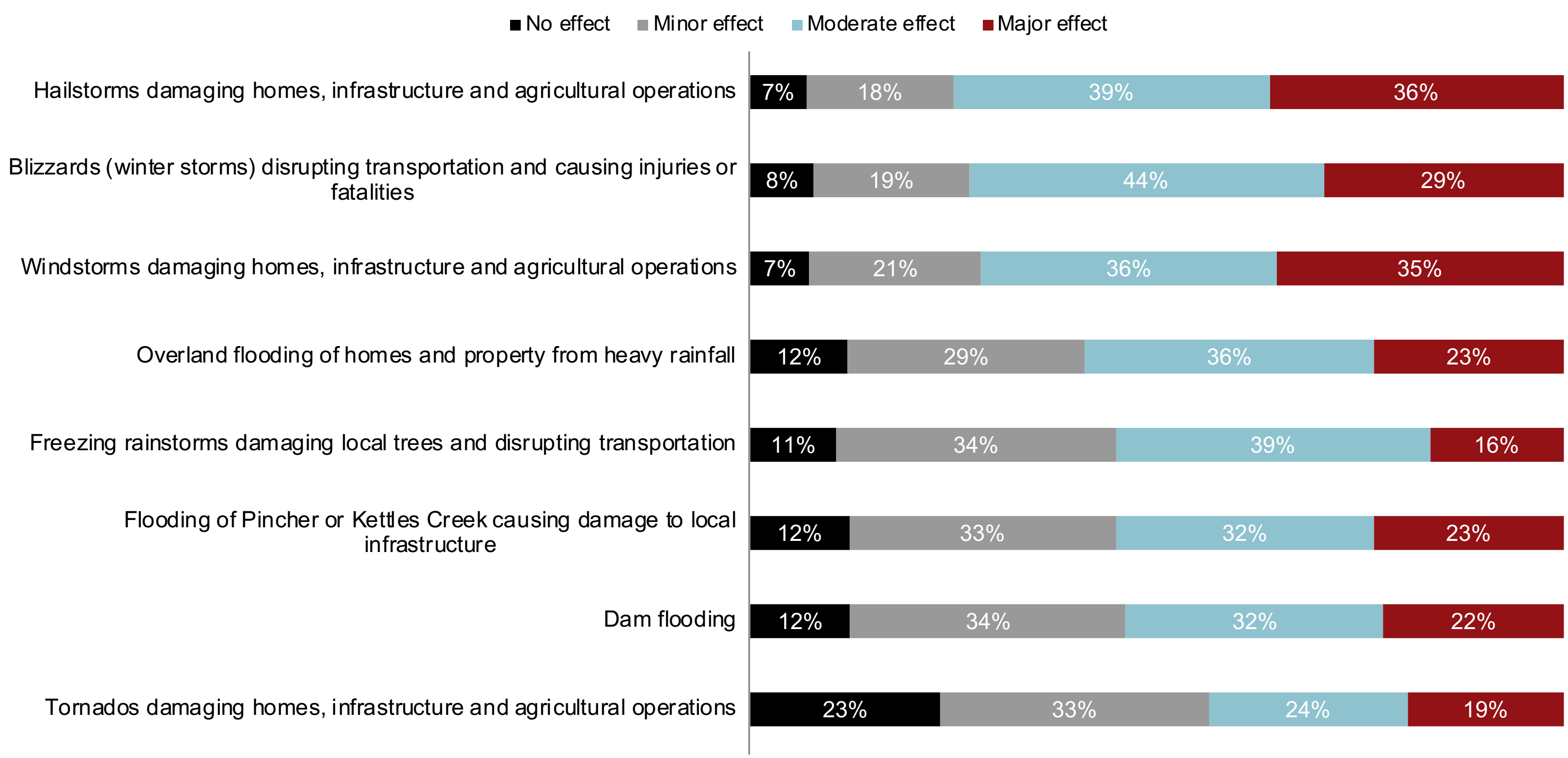


Severe Storms

Figure 26 shows community perceptions of impacts relating to severe storms on Pincher Creek. Hailstorms damaging homes, infrastructure, and agricultural operations received the most concern (75% of participants rated moderate or major effect), with blizzards and windstorms following closely behind (73% and 72% rated moderate or major effect, respectively). Freezing rain and flooding related impacts were slightly less concerning as less than 60% of participants rated these impacts to have a moderate or major effect on the community. The least concerning impact was tornadoes damaging homes, infrastructure, and agricultural operations (56% of participants rated the impact to have little to no effect on the community).

Figure 26:

Community perceptions of the effects of severe storms in Pincher Creek

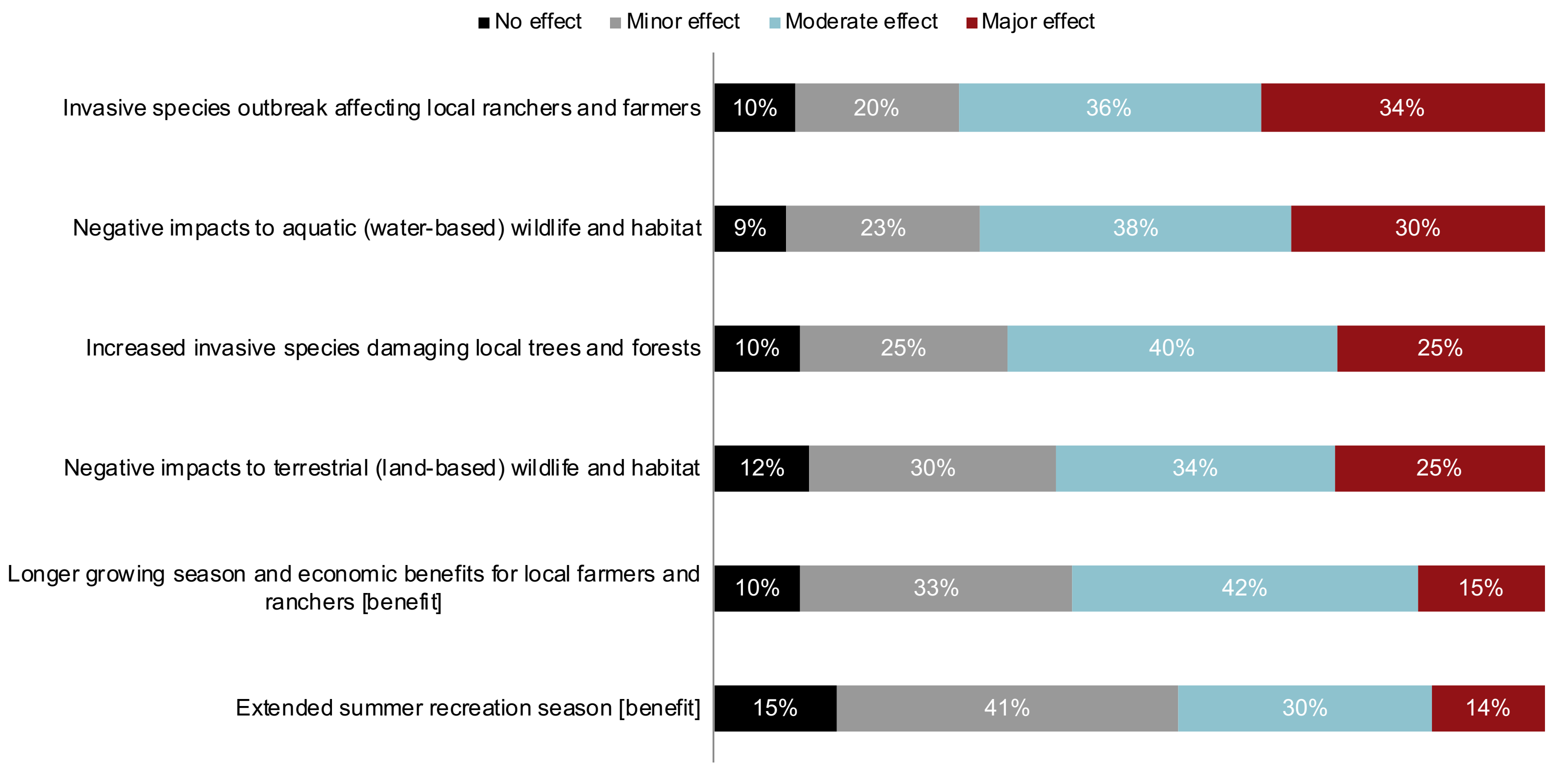


Changing Seasons and Ecosystems

Figure 27 outlines community perceptions of the potential impacts from changing seasons and ecosystems in Pincher Creek. Invasive species outbreak affecting local ranchers and farmers was the most concerning impact with 34% of participants indicating a 'major' effect, and 36% indicating a 'moderate' effect on the community. Negative impacts to aquatic wildlife and habitat, invasive species damaging local trees and forests, negative impacts to terrestrial wildlife, and a longer growing season were also identified as important impacts with more than half of participants identifying them as having either a moderate or major effect. An extended summer recreation season was the least concerning impact to participants, with 56% rating this to have little to no effect on the community.

Figure 27:

Community perceptions of the effects of changing seasons and ecosystems in Pincher Creek

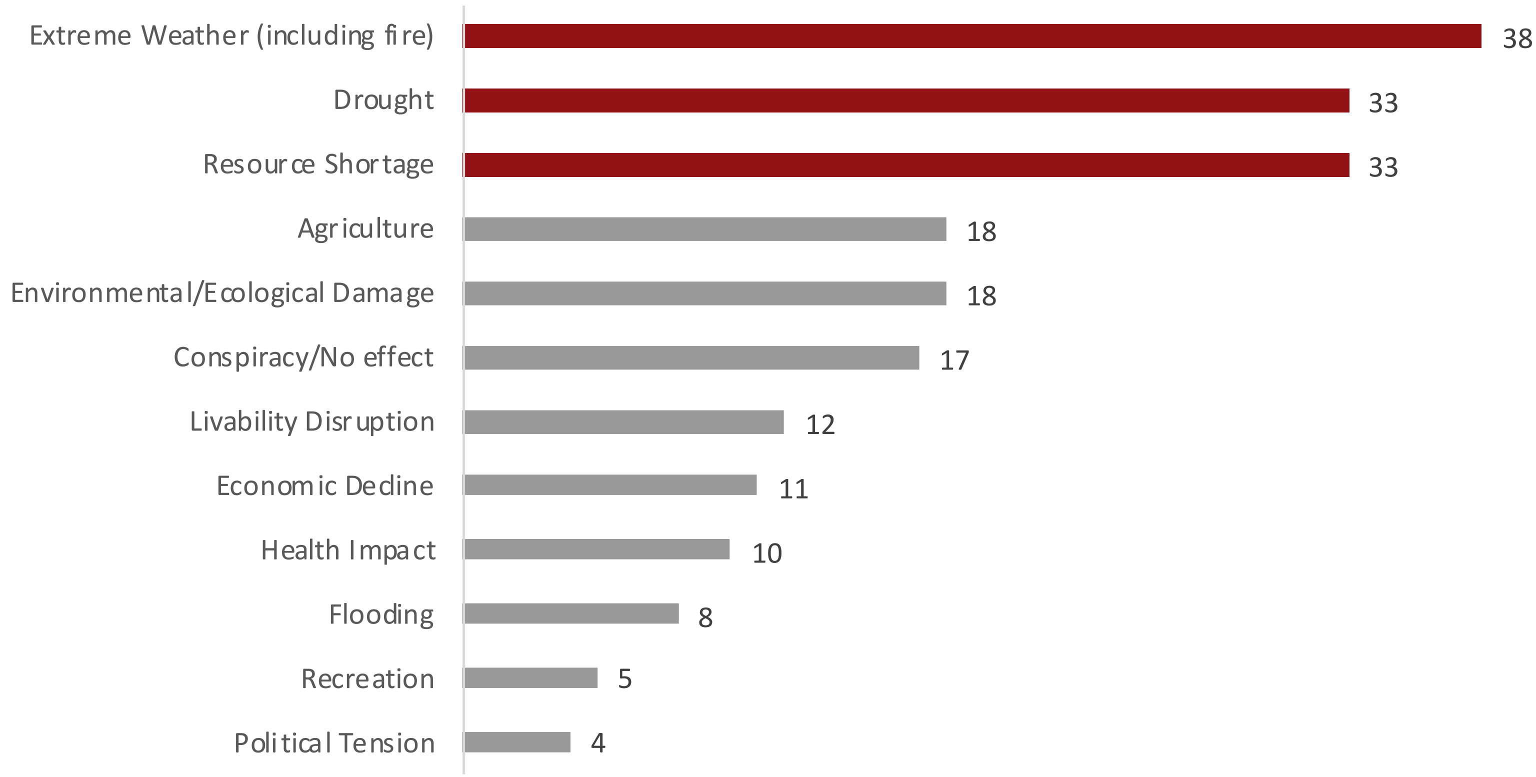


Climate Impact Summary

The survey also asked respondents to identify what they perceived to be the most significant impacts of a changing climate on Pincher Creek. 207 responses were recorded with extreme weather events, resource shortages, and droughts being the most concerning to participants. The complete results are shown in Figure 28 below.

Figure 28:

Open-ended response results for the most significant impacts in Pincher Creek



Climate Change Impacts and Demographics

Age and Climate Impacts

Table 6 compares how different age groups prioritized climate impacts in Pincher Creek. For this analysis, participants were separated into a 'younger population' (under 35 years of age) and an 'older population' (35+). Overall, the younger population were shown to be more concerned about flooding related impacts, including overland flooding from heavy rainfall, creek flooding, and dam flooding. Local health impacts from extreme heat, and freezing rainstorms were also other impacts of concern for this age category. In contrast, older populations were more concerned about reduced water levels, increased heat stress on crops for local farmers and ranchers, and increased air conditioning costs.

Table 6 — Perceptions of climate impacts in Pincher Creek between younger and older populations[57]

Impact	Overall 'Moderate' or 'Major' responses	Younger population ratings	Older population ratings
Prolonged drought affecting local farmers, ranchers and the economy	80%	78%	84%
More wildfire smoke, reducing air quality and local health impacts	78%	80%	81%
Lower streamflow and creek levels in summer	78%	78%	82%
Reduced water levels in lakes and wetlands	77%	70%	83%
More wildfires causing damage to homes and infrastructure	76%	84%	77%
Prolonged drought affecting local vegetation, wildlife and ecosystems	75%	80%	79%
Hailstorms damaging homes and infrastructure	75%	76%	80%
Increased heat stress on food crops and challenges for local farmers	73%	68%	80%
Blizzards disrupting transportation and causing injuries	73%	74%	74%
Windstorms damaging homes and infrastructure	72%	76%	74%

57 Red coloured cells indicate differences of 10% or more between younger and older populations

Table 6 — Perceptions of climate impacts in Pincher Creek between younger and older populations (Continued)

Impact	Overall 'Moderate' or 'Major' responses	Younger population ratings	Older population ratings
Increased heat stress on livestock and challenges for local ranchers	71%	70%	78%
Invasive species outbreak affecting local ranchers and farmers	71%	72%	73%
Increased surface water temperatures (and potential algal blooms)	70%	70%	76%
Water supply shortage affecting local businesses	68%	67%	74%
Negative impacts to aquatic (water-based) wildlife and habitat	68%	68%	69%
Increased heat stress on local vegetation, wildlife and ecosystems	68%	64%	73%
Increase pests and invasive species that can survive the winter and affect local trees and forests	68%	76%	72%
Increased invasive species damaging local trees and forests	65%	68%	66%
Water supply shortage reducing community service levels	64%	65%	67%
Overland flooding of homes and property from heavy rainfall	59%	72%	56%
Negative impacts to terrestrial (land-based) wildlife and habitat	59%	59%	60%
Longer growing season for local farmers and ranchers [benefit]	57%	60%	56%
Local health impacts from extreme heat	55%	68%	56%
Freezing rainstorms damaging local trees and disrupting transportation	55%	64%	53%
Creek Flooding causing damage to local infrastructure	55%	69%	50%
Dam flooding	54%	61%	51%
Increased air conditioning costs	45%	40%	52%
Extended summer recreation season [benefit]	44%	46%	44%
Loss of winter recreation (skating, skiing, sledding, etc.)	44%	46%	45%
Reduced space heating and fuel costs in winter seasons [benefit]	44%	42%	45%
Tornados damaging homes and infrastructure	44%	43%	44%

Primary Place of Residence and Climate Impacts

Table 7 compares how respondents from the town and MD prioritized climate impacts in Pincher Creek. Results indicated that respondents from the Town were relatively more concerned about local health impacts from extreme heat and loss of winter recreation. On the other hand, respondents from the MD indicated that reduced water levels, negative impacts to aquatic wildlife, and increased invasive species damaging local trees and forests to be the most concerning impacts.

Table 7 — Perceptions of climate impacts in Pincher Creek between the town and MD[58]

Impact	Overall 'Moderate' or 'Major' responses	Younger population ratings	Older population ratings
Prolonged drought affecting local farmers, ranchers and the economy	80%	77%	85%
More wildfire smoke, reducing air quality and local health impacts	78%	78%	79%
Lower streamflow and creek levels in summer	78%	78%	80%
Reduced water levels in lakes and wetlands	77%	73%	84%
More wildfires causing damage to homes and infrastructure	76%	77%	80%
Prolonged drought affecting local vegetation, wildlife and ecosystems	75%	77%	77%
Hailstorms damaging homes and infrastructure	75%	77%	83%
Increased heat stress on food crops and challenges for local farmers	73%	73%	82%
Blizzards disrupting transportation and causing injuries	73%	73%	74%
Windstorms damaging homes and infrastructure	72%	70%	74%
Increased heat stress on livestock and challenges for local ranchers	71%	73%	77%
Invasive species outbreak affecting local ranchers and farmers	71%	71%	74%
Increased surface water temperatures (and potential algal blooms)	70%	69%	77%
Water supply shortage affecting local businesses	68%	73%	66%
Negative impacts to aquatic (water-based) wildlife and habitat	68%	63%	75%

58 Red coloured cells indicate differences of 10% or more between Town and MD residents

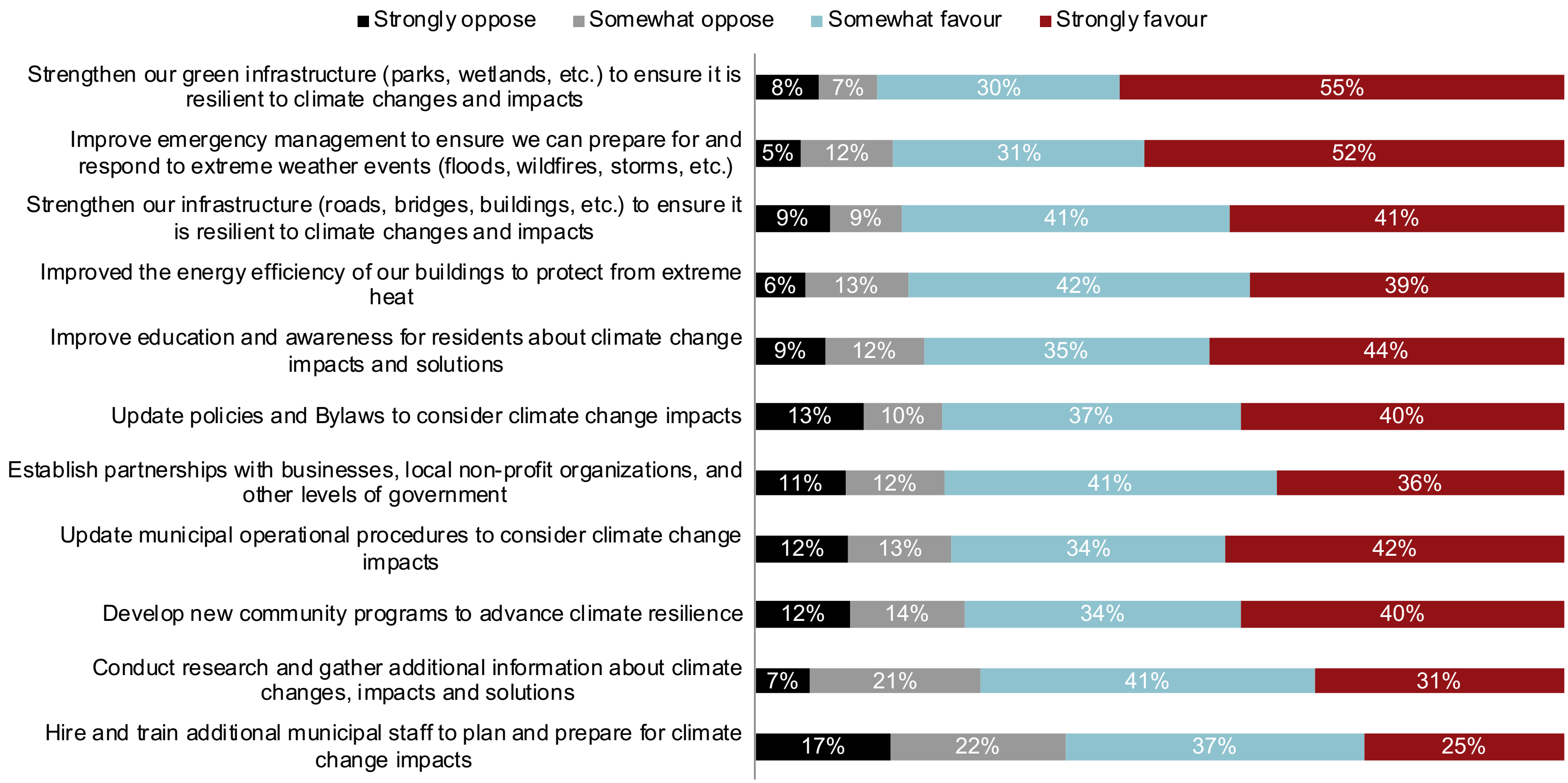
Impact	Overall 'Moderate' or 'Major' responses	Younger population ratings	Older population ratings
Increased heat stress on local vegetation, wildlife and ecosystems	68%	71%	70%
Increase pests and invasive species that can survive the winter and affect local trees and forests	68%	71%	72%
Increased invasive species damaging local trees and forests	65%	60%	70%
Water supply shortage reducing community service levels	64%	67%	61%
Overland flooding of homes and property from heavy rainfall	59%	59%	59%
Negative impacts to terrestrial (land-based) wildlife and habitat	59%	56%	59%
Longer growing season for local farmers and ranchers [benefit]	57%	56%	56%
Local health impacts from extreme heat	55%	64%	45%
Freezing rainstorms damaging local trees and disrupting transportation	55%	59%	52%
Creek Flooding causing damage to local infrastructure	55%	54%	56%
Dam flooding	54%	53%	49%
Increased air conditioning costs	45%	46%	44%
Extended summer recreation season [benefit]	44%	41%	44%
Loss of winter recreation (skating, skiing, sledding, etc.)	44%	48%	43%
Reduced space heating and fuel costs in winter seasons [benefit]	44%	46%	34%
Tornados damaging homes and infrastructure	44%	41%	43%

Climate Resilience Actions

The survey also asked participants to rate their level of support for a variety of local actions that could be implemented to increase community resilience to climate change, and to take advantage of potential climate change benefits (Figure 29). Strengthening green infrastructure (parks, wetlands, etc.) and improving emergency management to respond to extreme weather events were the most popular options, with more than half of participants strongly favoring both actions. Overall, the majority of participants (77% rated 'somewhat favor' or 'strongly favor') showed support to enhance climate resilience in Pincher Creek.

Figure 29:

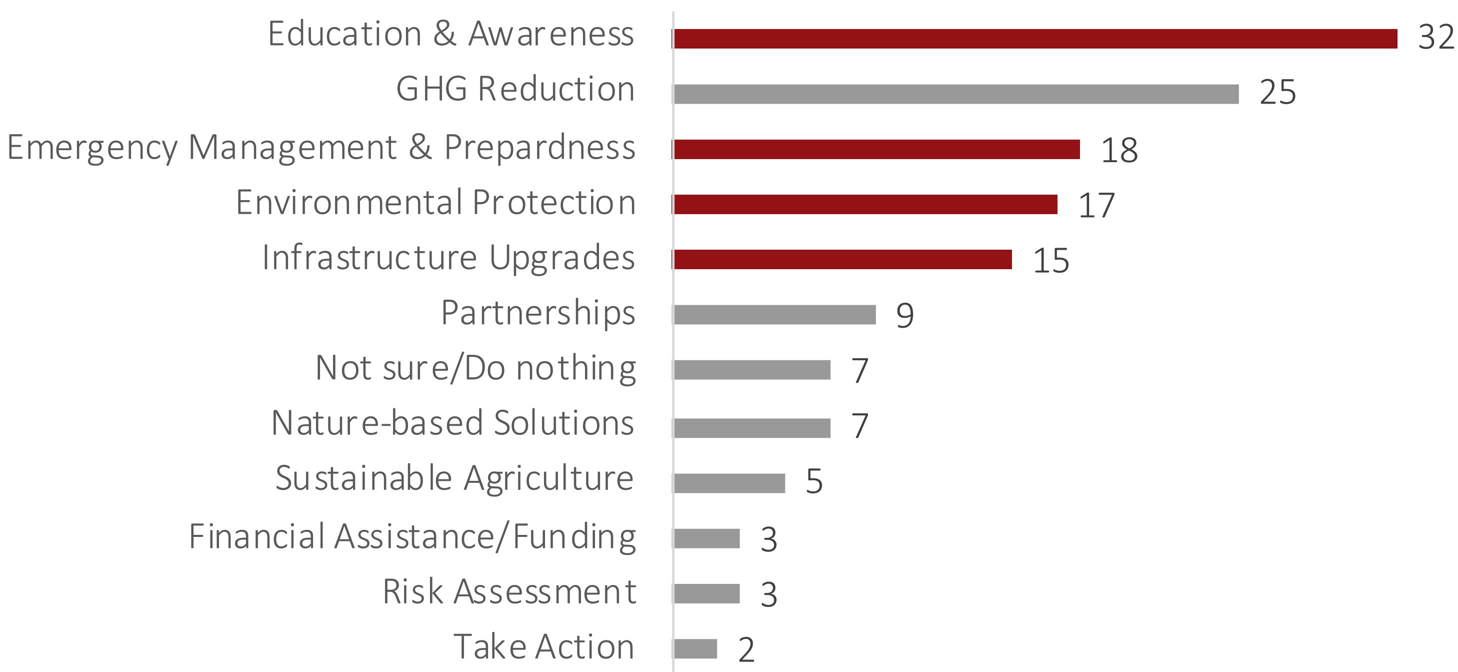
Level of support for climate resilience actions in Pincher Creek



Additionally, the survey also asked participants to write down the most important action they thought Pincher Creek could take to increase resilience across the community. A total of 143 responses were recorded and categorized into a variety of themes as shown in Figure 30 below. Overall, the most popular suggestions included enhancing education and awareness, emergency management and preparedness, environmental protection, and upgrading infrastructure. Actions pertaining to greenhouse gas (GHG) reduction are not included as they are focused on climate change mitigation rather than adaptation.

Figure 30:

Open ended response results for climate resilience actions



Appendix C: Prioritizing Identified Adaptation Actions

Due to human resource and financial constraints, well as competing priorities, it is unlikely that the MD and Town of Pincher Creek will be able to implement all identified adaptation actions. Consequently, it is necessary to evaluate and prioritize identified actions to determine those that are expected to perform best with respect to key decision criteria. A multi-criteria, cost-benefit analysis of each action was performed to enable the rank-ordering of actions both within each theme and across all themes. The decision criteria and calculations are explained below:

- Benefit-cost ratio = weighted average benefits / weighted average costs
- Weighted average benefits = [Effectiveness score x 3 + Co-benefit score x 1 + Equity score x 1 + Flexibility score x 1] / 4
- Weighted average costs = [Total cost score x 2 + Negative side-effects score x 1 + Feasibility score x 1] / 3

The total costs criterion and the effectiveness criterion have been assigned weights of, respectively, 2 and 3.

On the cost side, in addition to total costs (i.e., any required capital expenditures and ongoing annual expenses), the potential for negative side-effects—for example, increasing greenhouse gas emissions—is captured. Feasibility considers whether implementation is possible, given technological, legal and/or economic constraints. Acceptability captures whether the public and elected officials would accept and implement the action.

On the benefit side, the effectiveness of the action in achieving the stated adaptation goals is clearly important. But it is also important to capture equity and whether the action helps under-served and marginalized groups in the region. To help manage uncertainty about future levels of climate change, a higher priority should be given to actions that offer greater flexibility to be modified or scaled-up or down over time in response to new information. Finally, the potential for the action to generate co-benefits for the region in addition to reducing risk is captured.

The performance of each identified adaptation action with respect to each decision criterion was first scored by the consulting team using the 5-point scale shown in Table 8, then verified with the Pincher Creek project team and other stakeholders. The results are summarized in Table 9 through Table 13 below.

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59 The total cost score is calculated as the sum of the identified investment cost and annual operating cost (times 10), normalized to fit the 1-5 scale.

Table 8 — Scoring rubric for evaluating adaptation actions

	Criteria	Very Low (1)	Low (2)	Medium (3)	High (4)	Very High (5)
Costs	**Investment costs**	<$10,000 [~$5,000]	$10,000–$50,000 [~$30,000]	$50,000–$100,000 [~$75,000]	$100,000–$500,000 [~$300,000]	>$500,000 [~$1,000,000]
	Annual operating costs	<$10,000 [~$1,000]	$10,000–$50,000 [~$30,000]	$50,000–$100,000 [~$75,000]	$100,000–$200,000 [~$150,000]	>$200,000 [~$400,000]
	Negative Side-effects	Little to no unintentional negative impacts and consequences		Unintentional negative impacts with moderate consequences		Unintentional negative impacts with significant consequences
	Feasibility	Little to no technological knowledge, staff capacity, or public acceptance barriers prevent the action from being implemented successfully		Moderate technological knowledge, staff capacity, or public acceptance barriers prevent the action from being implemented successfully		Significant technological knowledge, staff capacity, or public acceptance barriers prevent the action from being implemented successfully
Benefits	**Effectiveness**	Minor reduction in priority climate risk		Moderate reduction in priority climate risk		Significant reduction in priority climate risk
	Co-benefits	Little to no cross-over and positive contribution to other City economic, social or environmental objectives, including greenhouse gas reduction		Modest cross-over and positive contribution to other City economic, social or environmental objectives, including greenhouse gas reduction		Significant cross-over and positive contribution to other City economic, social or environmental objectives, including greenhouse gas reduction
	Equity	Action benefits a narrow segment of the population or business community AND does not help disadvantaged and underserved segments of the population. [That is, the action only helps a small group of middle- to upper-income households]		Action benefits a wide segment of the population or business community OR helps disadvantaged and underserved segments of the population. [That is, the action either offers widespread benefits OR alleviates inequalities in the community]		Action benefits a wide segment of the population or business community AND helps disadvantaged and underserved segments of the population. [That is, everyone is made better-off, including underserved groups]
	Flexibility	Action and implementation strategy has little to no ability to be adjusted (brought forward or delayed, or scaled up or down)		Action and implementation strategy can be partially adjusted, but at moderate additional costs		Action and implementation strategy can be fully adjusted at minimal additional costs

Note: Investment and operating costs show the cost range, as well as an estimated average cost [in brackets]

Table 9 — Evaluation of Adaptation Actions: Health and Wellbeing

ID	Action	Weighted average benefits	Weighted average costs	Weighted benefit-cost ratio (BCR)	Rank of BCR across all adaptation actions
HW1	Support community gardening	4.25	1.38	3.09	9
HW2	Install outdoor water features	4.00	1.46	2.75	15
HW3	Upgrade the spray park	4.50	1.85	2.43	18
HW4	Purchase temporary shading structures	4.50	1.89	2.38	19
HW5	Install permanent shade structures	5.00	2.36	2.12	25
HW6	Adjust recreation programming during extreme heat and smoke events	3.75	1.84	2.03	26

Table 10 — Evaluation of Adaptation Actions: Disaster Resilience Theme

ID	Action	Weighted average benefits	Weighted average costs	Weighted benefit-cost ratio (BCR)	Rank of BCR across all adaptation actions
DR1	Update Land Use Bylaws to enhance flood protection	5.50	1.38	3.99	2
DR2	Develop a heat alert response plan	5.50	1.46	3.78	3
DR3	Develop a smoke alert response plan	5.50	1.46	3.78	3
DR4	Develop a homeowner climate change vulnerability assessment toolkit	4.75	1.46	3.26	7
DR5	Develop a Drought Response Plan that considers climate change	4.00	1.38	2.90	12
DR6	Enhance emergency preparedness education and communication	5.25	1.89	2.78	14
DR7	Conduct research to understand future wind patterns	5.50	2.12	2.59	16
DR8	Develop a plan for enhanced fire department response capabilities	5.25	2.04	2.57	17
DR9	Update development legislation with FireSmart revisions	4.50	2.04	2.20	24
DR10	Conduct forest fuel treatments and vegetation management	5.00	3.03	1.65	28
DR11	Retrofit designated emergency reception centres	6.25	3.93	1.59	30

Table 11 — Evaluation of Adaptation Actions: Infrastructure

ID	Action	Weighted average benefits	Weighted average costs	Weighted benefit-cost ratio (BCR)	Rank of BCR across all adaptation actions
IF 1	Develop a climate resilient procurement policy	5.75	1.33	4.31	1
IF 2	Apply research on climate resilient building materials and infrastructure appropriate for the Pincher Creek region	4.00	1.38	2.90	12
IF 3	Upgrade municipal buildings to provide better protection from extreme heat	6.00	4.26	1.41	30
IF 4	Upgrade and enhance flood mitigation infrastructure	6.25	4.93	1.27	33
IF 5	Install a solar covering on the Town water reservoir	4.25	3.73	1.14	34

Table 12 — Evaluation of Adaptation Actions: Parks and Environment

ID	Action	Weighted average benefits	Weighted average costs	Weighted benefit-cost ratio (BCR)	Rank of BCR across all adaptation actions
PE 1	Develop a Natural Asset Inventory and Management Plan	5.50	1.46	3.78	3
PE 2	Develop a water sharing agreement between that Town and MD	4.75	1.33	3.56	6
PE 3	Develop a Source Water Protection Plan	4.75	1.46	3.26	7
PE 4	Develop a Water Conservation, Efficiency and Productivity Plan	4.25	1.46	2.92	11
PE 5	Update the Water Utility Bylaw with an improved water pricing structure	4.75	2.00	2.38	20
PE 6	Enhance support for watershed planning and protection	4.25	1.84	2.31	21
PE 7	Develop a tree planting program	4.00	2.22	1.80	27
PE 8	Enhance irrigation infrastructure	3.75	2.70	1.39	31
PE 9	Enhance environmental monitoring	3.75	4.67	0.80	35

Table 13 — Evaluation of Adaptation Actions: Economy

ID	Action	Weighted average benefits	Weighted average costs	Weighted benefit-cost ratio (BCR)	Rank of BCR across all adaptation actions
EC 1	Provide climate resilience education materials to farmers and ranchers	4.25	1.38	3.09	9
EC 2	Develop a Tourism & Recreation Master Plan	4.75	2.12	2.24	22
EC 3	Improve accessibility to outdoor recreation	5.25	2.36	2.22	23
EC 4	Enhance marketing of the Pincher Creek region	3.00	2.18	1.38	32

All One Sky

FOUNDATION

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

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