# Evaluation

# Pincher Creek Climate Impact Assessment Results

A climate impact assessment workshop was held on March 1, 2023 at the MD of Pincher Creek Council Chambers. The goal of the session was to assess the potential consequences of climate impacts affecting the Town and MD of Pincher Creek.

This document contains the following:

1. A summary of the climate impact assessment results from the workshop, including comments discussed at the March 1 workshop regarding the impact matrix
2. Section 2 provides instructions for completion of the climate impact evaluation
3. Section 3 includes the details of the climate risk assessment process, including the Consequence Scale (Table 3) that was used as a guideline at the workshop for determining the severity of potential climate change impacts
4. Appendix A provides a list and details of each climate impact scenario
5. Appendix B includes a summary of climate projections for the Pincher Creek area.
6. Appendix C contains the list of attendees who were at the workshop

## 1. Climate Impact Assessment Results

The final results of the Pincher Creek Climate Impact Assessment are provided in Figure 1. The matrix delineates between impacts that pose a significant threat to the Pincher Creek community, and those that do not. The upper right corner of the matrix (in orange and red) represents larger impacts that would be priorities for action planning. Figure 2 provides a decision framework that will be used to prioritize scenarios for action planning based on where they fall in the matrix – Very high (red) and high (orange) rated impact scenarios should be considered for action planning.

*Figure 1 Climate Impact Matrix for Pincher Creek*

| CONSEQUENCE | | | | | | |
|---|---|---|---|---|---|---|
| | Very high (5) | | | | | |
| | High (4) | | River flood | Wildfire<br>Drought<br>Water shortage | | |
| | Medium (3) | | Overland flood | Dam flood<br>Invasive weed outbreak<br>Vector-borne disease<br>Changing ecosystems | Extreme heat<br>Loss of winter recreation | Smoke |
| | Low (2) | | | Hail | Invasive species outbreak<br>Blizzard | Windstorm<br>Freezing rain<br>River flood (ongoing) |
| | Very low (1) | | | | | |
| | | Rare (<1% AP) (1) | Unlikely (1-2% AP) (2) | Possible (2-10% AP) (3) | Likely (10-50% AP) (4) | Almost certain (>50% AP) (5) |
| | LIKELIHOOD | | | | | |

*Figure 2 Decision Thresholds for Action Planning*

| Label | Decision |
|---|---|
| Very high priority | Adaptation actions should be developed in the near-term to reduce risks. |
| High priority | Adaptation actions should be developed in the near- to medium-term, to reduce risks. |
| Medium Priority | No action required at this time. Actions may be identified, 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. |

The following is a summary of comments discussed at the March 1 workshop. Regarding the risk matrix:

- Maybe some of the orange boxes should be red (very high risk)? For example: drought, wildfire, and water shortage (Likelihood = 3, Consequence = 4)
- Reduced recreation might be rated a bit high, but it is a very important economic driver for the region
- The consequence score for 'Water shortage' was changed from a 3 (Medium) to a 4 (High) at the workshop
- Dam flood may have been over-rated, as consequences don't seem as severe as some of the other risks

# 2. Climate Impact Assessment Method

This section outlines the process that was followed to complete the climate impact assessment for the Pincher Creek area. The Climate Impact Assessment involved four key steps:

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

Each step in the climate impact assessment process is defined in detail below.

## Defining Climate Impact Scenarios

Climate impact scenarios characterize the cause-and-effect relationship, or impact chain, between climate changes, impacts, and the potential consequences of those impacts on Pincher Creek. Impact scenarios also account for local exposure to climate hazards, including consideration of the vulnerability (sensitivity and lack of coping capacity) of local services, infrastructure, populations and the natural environment. Vulnerability to a given climate impact influences the magnitude or severity of impacts and consequences. It is therefore important to characterize key vulnerabilities as part of the climate impact scenarios.

Based on the results of the community survey, and discussions with the Project Team, the following climate impact scenarios were identified and were considered through the climate risk assessment process (Table 1). Each impact scenario is outlined in detail in Appendix A.

*Table 1 Summary List of Climate Impact Scenarios*

| | Climate Impact Scenario |
|---|---|
| 1 | Extreme heat impacts to human health and livestock |
| 2 | Wildfire causes damage to homes and infrastructure |
| 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 | River and creek flooding requires ongoing response |
| 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 |

## Assessing Likelihood

The likelihood of each climate impact was determined using a combination of methods ranging from analysis of historic event occurrences, external research, and professional judgment of the project team. Where possible, climate projections were used to estimate the future likelihood. A likelihood score was established for each scenario using the scale at Table 2. The detailed climate impact scenarios in Appendix A include a Likelihood Score, and description of the strategy used to determine the likelihood of each impact scenario.

*Table 2 Climate Impact Likelihood Sale*

| Score | Descriptor | Likelihood / Probability |
|---|---|---|
| 1 | Rare | Impact scenario is expected to happen less than once every 100 years (Annual chance < 1% in 2050) |
| 2 | Unlikely | Impact scenario is expected to happen about once every 51-100 year (1% ≤ annual chance < 2% in 2050) |
| 3 | Possible | Impact scenario is expected to happen about once every 11-50 years (2% ≤ annual chance < 10% in 2050) |
| 4 | Likely | Impact scenario is expected to happen about once every 3-10 years (10% ≤ annual chance < 50% in 2050) |
| 5 | Almost Certain | Impact scenario is expected to happen once every two years or more frequently (Annual chance ≥ 50% in 2050) |

## Assessing Consequence

The consequence assessment was completed at the March 1 workshop (attendee list available in Appendix C) and involved assigning categorical and numerical (1 to 5) values to the potential consequences of each climate impact scenario. A tailored rating scale for assessing the consequences of climate change impacts on Pincher Creek was developed (Table 3), attempting to achieve consistency with the Region's Hazard Identification and Risk Assessment, and with guidance and best practices for climate change risk assessment[1]. The consequence scale should be viewed as a guideline only, to support the prioritization of climate change impacts facing the Town and MD.

[1] 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 3 Scale for Rating the Consequences of Risks*[2]

| Criteria | Very Low (1) | Low (2) | Moderate (3) | High (4) | Very High (5) |
|---|---|---|---|---|---|
| Health & Well-being | • Negligible impact<br>• 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<br>• Some psychosocial impacts<br>• 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<br>• Widespread psychosocial impacts<br>• Long-term impact on quality of life for most residents and vulnerable populations |
| Business / Financial | • Very minimal impact on local businesses or the economy<br>• 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<br>• Financial loss of between 3% and 5% tax impact | | • Long-term impact on businesses and economic sectors, major economic costs or disruption<br>• 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<br>• possible | | • Could cause severe and irreversible environmental damage.<br>• 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<br>• Long-term interruption of critical municipal services |

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

After the evaluation process is complete and all climate impacts have been finalized, the next step is to determine which climate impact scenarios should be considered for action planning. Table 4 provides a decision framework that can be used to prioritize scenarios based on where they fall in the matrix.

*Table 4 Impact Decision Thresholds 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. |

# Appendix A: Climate Impact Scenario Details

## 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 |

| Likelihood Scores | |
|---|---|
| **Historic** | **Future** |
| 2 [unlikely] | 4 [likely] |

| | |
|---|---|
| **Potential consequences** | • Injuries/fatalities (vulnerable populations disproportionately affected including seniors, obese individuals, and those with chronic conditions)<br>• Minor discomfort<br>• Increased space cooling costs<br>• Reduced participation in outdoor activities<br>• Increased water demand for both irrigation and drinking<br>• 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[3] |
| **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[4]. |

[3] See: Health Canada (2012) Heat Alert and Response Systems to Protect Public Health; or BC Provincial Heat Alert and Response System (BC HARS) (2022)

[4] Data derived from PARC climate projections Report (2023), for the Town of Pincher Creek area

## 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 |

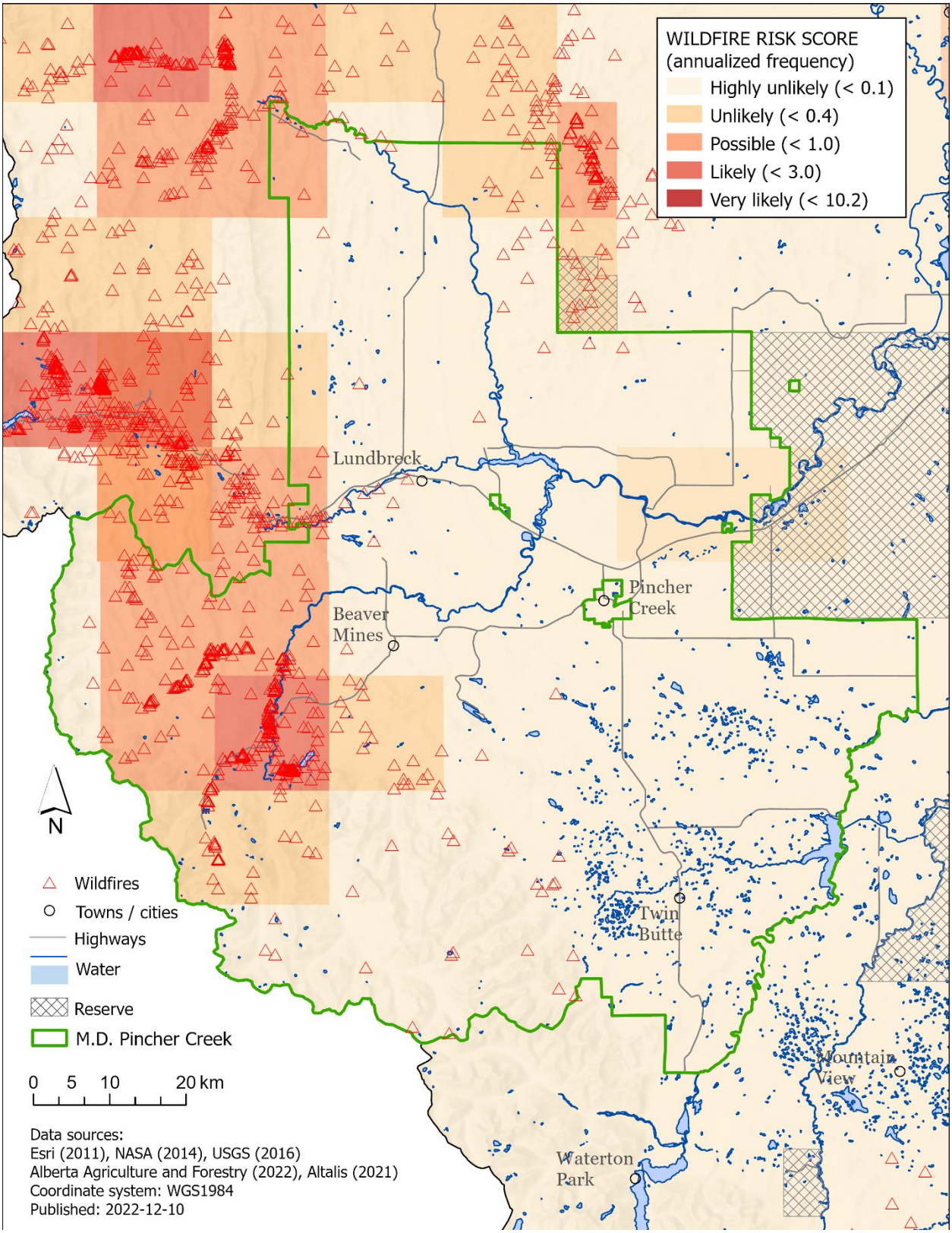
| Likelihood Scores | |
|---|---|
| **Historic** | **Future** |
| 2 [Unlikely] | 3 [Possible] |

| | |
|---|---|
| **Potential consequences** | • Injuries/fatalities<br>• Damage to homes, buildings and infrastructure<br>• Damage to parks and natural assets<br>• Community evacuations and displacement<br>• Forest/backcountry closures, reduced access to recreation<br>• Economic disruption to forestry, agriculture and oil and gas sectors<br>• Temporary disruptions/inconveniences from shifting a wildfire to a manageable location<br>• 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 3)[5]. 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[6] |

5 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

6 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 3: 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, Severe storms, Drier summer conditions |
| **Threshold:** | Visibility due to wildfire smoke falls below average (7km) |

| Likelihood Scores | |
|---|---|
| **Historic** | **Future** |
| 5 [almost certain] | 5 [almost certain] |

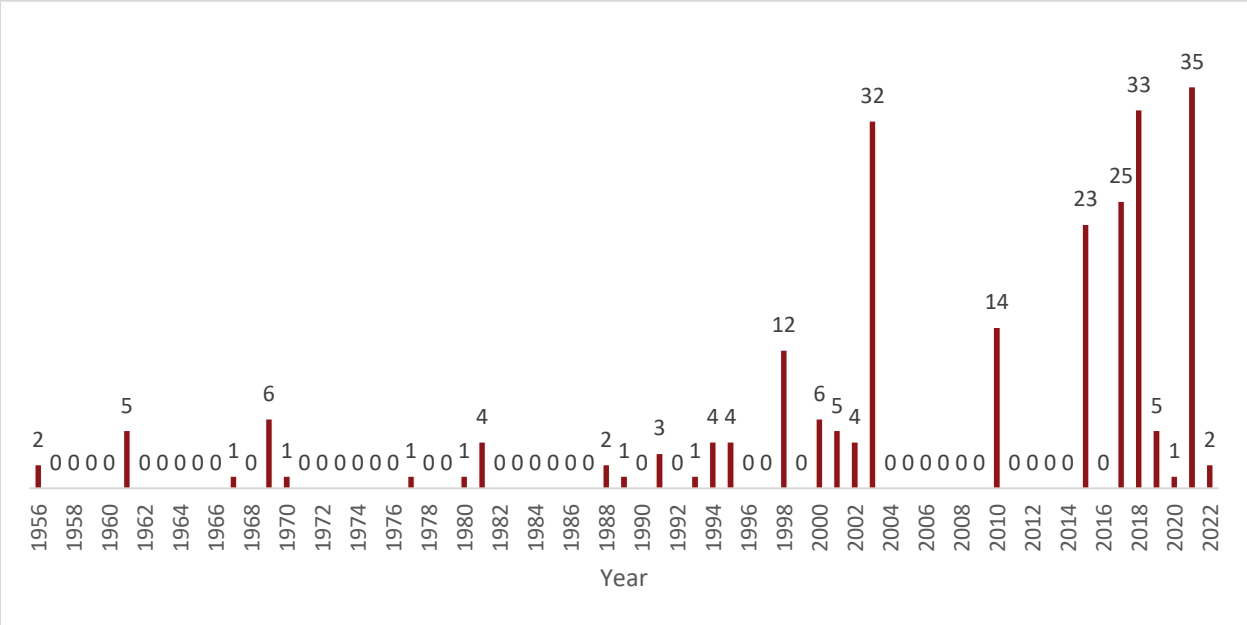
| | |
|---|---|
| **Potential consequences** | • Health and respiratory impacts (e.g., difficulty breathing, liver and kidney failure), particularly on vulnerable populations<br>• Shortened life expectancy particularly among young and old populations<br>• Reduced outdoor recreation activities and quality of life (e.g., hiking, running, etc.)<br>• Impact on local events (delays/cancellations)<br>• Increased costs to install/upgrade filtration systems<br>• Increased demand for emergency services and assistance<br>• Amplified heat impacts from closing windows and doors during smoke |
| **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 4)[7] |
| **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[8] |

[7] 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.

[8] 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 4 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) | |
| **Likelihood Scores** | | |
| **Historic** | | **Future** |
| 3 [possible] | | 3 [possible] |
| **Potential consequences** | • Evacuations / displacement<br>• Health impacts (injuries/fatalities), particularly on vulnerable populations<br>• Power outages<br>• Increased cost/insurance<br>• Increased demand for emergency services and assistance<br>• 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[9] | |
| **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[10] | |
| **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[11]. | |

[9] 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

[10] Data retrieved from Environment and Climate Change Canada (ECCC) (2023).

[11] 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, which disrupts transportation networks |
| **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[12] |

| **Likelihood Scores** | |
|---|---|
| **Historic** | **Future** |
| **5 [almost certain]** | **4* [likely]** |

| | |
|---|---|
| **Potential consequences** | • Health impacts (injuries/fatalities)<br>• Power outages<br>• Impact on local events (delays/cancellations)<br>• Damage and disruption to transportation networks (roads, bridges, etc.)<br>• Increased cost/insurance<br>• Increased demand for emergency services and assistance<br>• Loss of information/technology/communications<br>• Reduced ability for emergency services to provide support/assistance |
| **Consequence score** | **2 (Low)** |
| **Risk Score** | **Medium** |

| **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"[13] |
| **Historic likelihood** | • 64 blizzards were recorded at the Lethbridge weather station between 1953 and 2020, about 1 blizzard per year (Figure 5)[14]. |
| **Future likelihood** | • Climate projections indicate warmer temperatures which will reduce snowfall at lower elevations and may reduce the annual number of blizzard events |

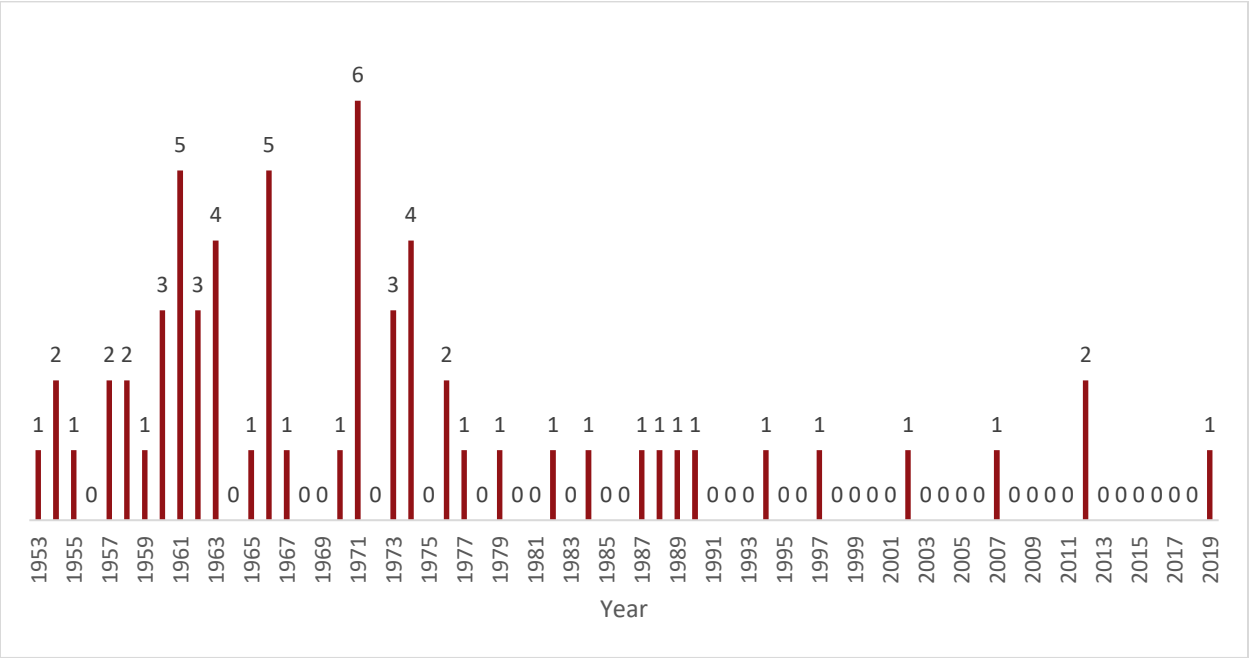
* Likelihood score was changed from 3 to 4 upon discussions with Pincher Creek staff. It was noted that blizzard events should be at least as likely as freezing rain events. Furthermore, blizzard projections are based off Lethbridge data which may not be as accurate.

[12] Based on Environment and Climate Change Canada *Criteria for public weather alerts.*

[13] 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

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

*Figure 5 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 Canada |

| Likelihood Scores | |
|---|---|
| **Historic** | **Future** |
| 5 [almost certain] | 5 [almost certain] |

| | |
|---|---|
| **Potential consequences** | • Health impacts (injuries/fatalities)<br>• Power outages<br>• Impact on local events (delays/cancellations)<br>• Damage to parks and natural assets<br>• Increased cost/insurance<br>• Reduced economic activity and deterrence of new residents moving to Pincher Creek<br>• Increased demand for emergency services and assistance<br>• Loss of information/technology/communications |
| **Consequence score** | 2 (Low) |
| **Risk Score** | Medium |

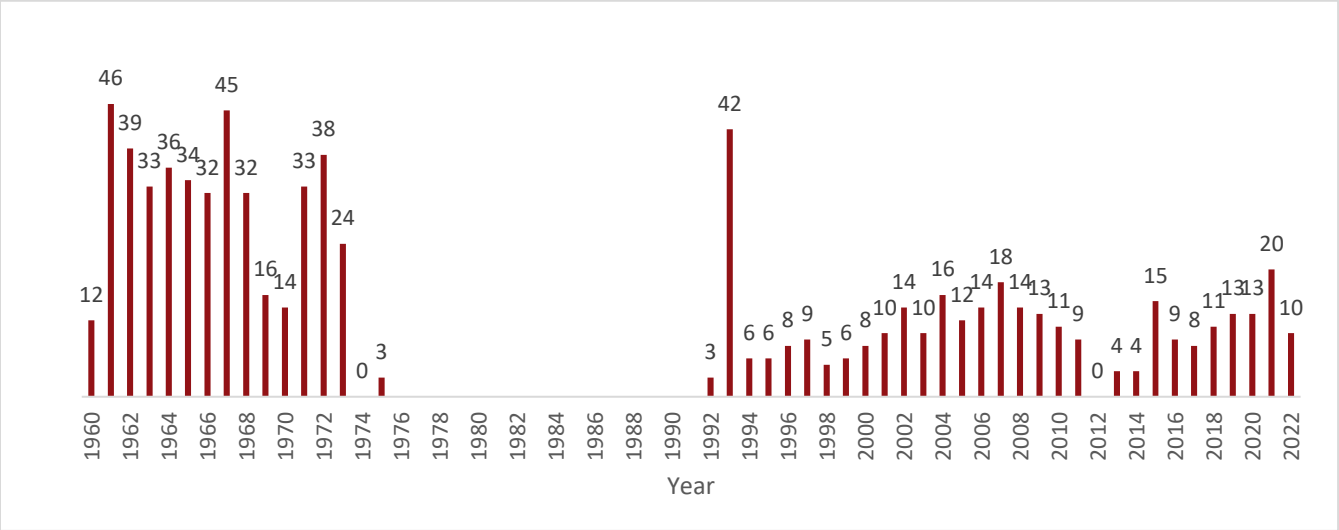
| Notes | |
|---|---|
| **Climate driver(s)** | • Climate projections indicate an increase in summer temperatures and extreme heat, which contribute to stronger thunderstorms that can produce high winds |
| **Threshold** | • The criteria for a wind warning is "80 km/h or more sustained wind; and/or gusts to 100 km/h or more[15]" |
| **Historic likelihood** | • 778 wind gusts to 100km/hour or more were recorded between 1960-2022, an average of about 17 windstorms per year (Figure 6)[16] |
| **Future likelihood** | • 50-60% of extreme wind gust events (i.e., 90km/h wind speeds or greater) are associated with warmer temperatures[17]. With warming temperatures projected across Alberta, an increase in the future likelihood of a windstorm event is anticipated |

[15] 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

[16] Data retrieved from Environment and Climate Change Canada (ECCC) (2023)

[17] 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 6 Historic windstorm frequency (gusts exceeding 100km/h) at Pincher Creek (1960-2022)*[18]




[18] 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 Canada |

| **Likelihood Scores** | |
|---|---|
| **Historic** | **Future** |
| 5 [almost certain] | 5 [almost certain] |

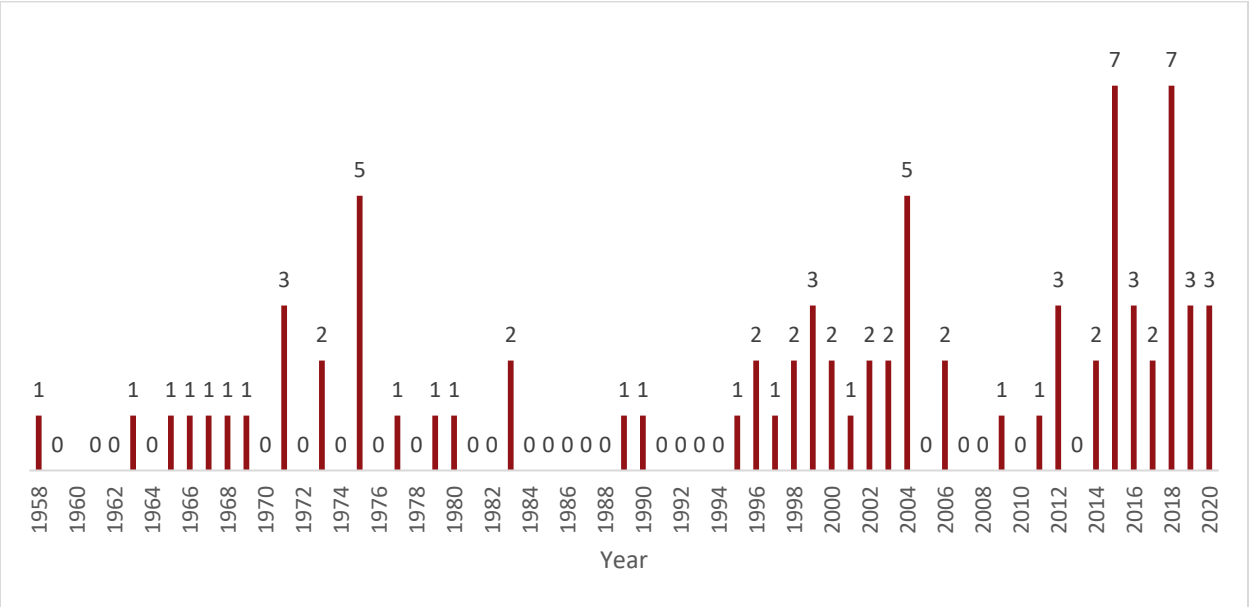
| | |
|---|---|
| **Potential consequences** | • Health impacts (injuries/fatalities) from slips, trips, and falls, particularly on vulnerable populations and livestock<br>• Power outages<br>• Damage and disruption to transportation networks (roads, bridges, etc.)<br>• Damage to parks and natural assets<br>• Increased cost/insurance<br>• Increased demand for emergency services and assistance<br>• Loss of information/technology/communications |
| **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."[19] |
| **Historic likelihood** | • 86 freezing rain events were recorded between 1958-2022, about 1.3 events per year on average (Figure 7)[20] |
| **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 [21] |

[19] 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

[20] 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.

[21] 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 7 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 and increased precipitation |
| **Threshold:** | Pincher Creek flow rate of about 270 cubic metres per second ($m^3/s$), about a 1:200 year event |
| **Likelihood Scores** | |
| **Historic** | **Future** |
| 1 [Rare] | 2 [Unlikely] |
| **Potential consequences** | • Flooding of basements, homes and buildings in low-lying areas<br>• Flooding of parks and natural assets<br>• Evacuations / displacement<br>• Reduced water quality from soil erosion and increased sedimentation<br>• Costs to repair and clean up<br>• 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 $m^3/s$[22]<br>• Flood map showing the 1:100-year period provided at Figure 8 below |
| **Historic likelihood** | • The 1995 flood on Pincher Creek (271 $m^3/s$) was estimated to be about a 200-year event[23] |
| **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 (see Figure 16 in Appendix B)[24] |

[22] Pincher Creek Flood Hazard Study (2020)
[23] Pincher Creek Flood Hazard Study (2020)
[24] Projections obtained from the PARC climate projections Report (2023)

*Figure 8 Flood map showing 100-year return period*

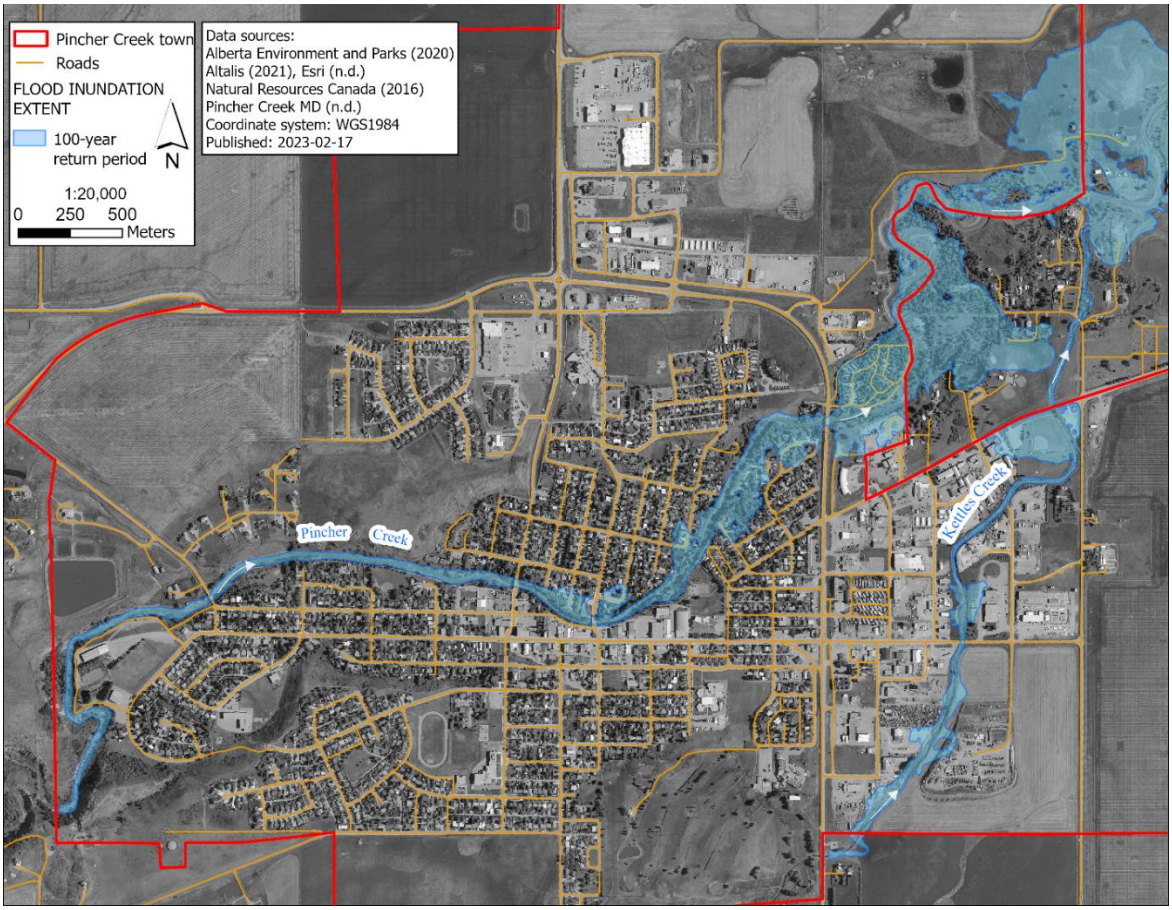



*Figure 9 Photo from 1995 flood*[25]

[25] Source: Pincher Creek Flood Hazard Study (2020)

## 9) River and creek flooding requires ongoing response

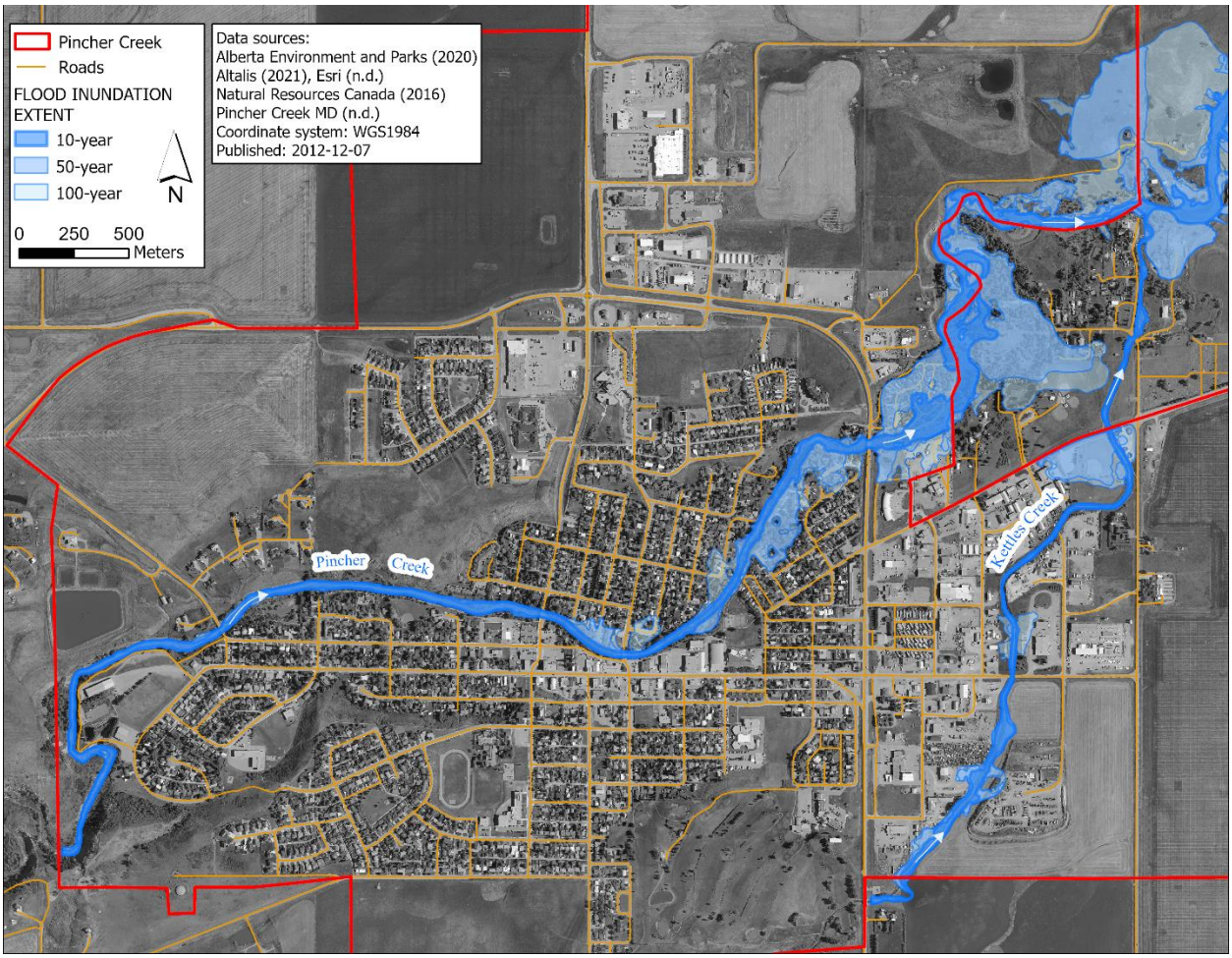
| | |
|---|---|
| **Description** | Heavy rainfall causes flooding of local creeks and rivers |
| **Climate driver(s)** | Severe storms and increased precipitation |
| **Threshold:** | Recurring river and creek flood events with a 1:10-year return period |

| Likelihood Scores | |
|---|---|
| **Historic** | **Future** |
| 4 [Likely] | 5 [Almost certain] |

| | |
|---|---|
| **Potential consequences** | • Inundation of some basements and other assets in low-lying areas<br>• Strain on emergency response personnel and resources<br>• 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 8 below |
| **Historic likelihood** | • Event occurs approximately 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 (see Figure 16 in Appendix B)[26] |

[26] Projections obtained from the PARC climate projections Report (2023)

*Figure 10 Flood map showing 10-year return period*



## 10) Dam flooding (overtopping) occurs across the District

| | |
|---|---|
| Description | Prolonged rainfall causes several small dams to overtop |
| Climate driver(s) | Severe storms and increased precipitation |
| Threshold: | 26 very wet days per year where 10mm of precipitation falls within 24 hours |

| Likelihood Scores | |
|---|---|
| Historic | Future |
| 2 [unlikely] | 3 [possible] |

| | |
|---|---|
| Potential consequences | • Inundation of farms and cropland, disrupting livelihoods and economic activity (especially downstream of dams)<br>• 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[27] |

[27] Data derived from PARC climate projections report (2023)

## 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)** | Heavy rainfall |
| **Threshold:** | A 1:100-year rainfall event occurs within 24-hours |
| **Likelihood Scores** | |
| **Historic** | **Future** |
| 1 [rare] | 2 [Unlikely] |
| **Potential consequences** | • Inundation of homes and buildings (basement flooding especially on the North side of Pincher Creek)<br>• Damage to buildings and infrastructure (slumping on the hills impacts road networks)<br>• Damage to local amenities<br>• Damage to parks and natural assets<br>• 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[28] |
| **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)[29] |

[28] 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

[29] 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 |

| Likelihood Scores | |
|---|---|
| Historic | Future |
| 3 [possible] | 3 [possible] |

| | |
|---|---|
| Potential consequences | • Crop damages and reduced yield from crop harvests, disrupting livelihoods and economic activity (increased food prices, water restrictions, etc.)<br>• Loss of or damage to plants and wildlife, including sweetgrass and willow populations<br>• Reduced water availability on farms and ranches (dugouts, sloughs) leading to operational constraints<br>• Exacerbated effects in downstream areas<br>• 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[30] |
| 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”[31] |

[30] PARC climate projections report 2023)

[31] PARC climate projections report (2023)

## 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 |

| Likelihood Scores | |
|---|---|
| **Historic** | **Future** |
| 2 [unlikely] | 3 [possible] |

| | |
|---|---|
| **Potential consequences** | • Reduced water availability leading to operational constraints and decreased livelihood (e.g., water restrictions)<br>• Impacts to water-based recreational activities (e.g., pools, spray parks, fishing, etc.)<br>• Increased maintenance costs or damage to irrigated parks and fields<br>• Economic impacts especially to businesses (e.g., carwashes) and farmers<br>• Impacts exacerbated downstream |
| **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** | • 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[32] |

* Consequence score changed from 3 to 4 upon discussions with Pincher Creek staff at the workshop

[32] Data derived from PARC climate projections Report (2023)

## 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 |

| Likelihood Scores | |
|---|---|
| **Historic** | **Future** |
| 3 [possible] | 4 [likely] |

| | |
|---|---|
| **Potential consequences** | • Reduced quality of life from loss of winter activities and sports<br>• Reduced tourism visitation and expenditures (Castle Mountain normally gets 100,000 visits per year)<br>• Economic disruption, particularly from the collapse of the winter skiing industry<br>• Increased difficulty to manage indoor recreation facilities offering winter recreation (e.g., maintaining humidity in ice rinks) |
| **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[33] |

[33] Data derived from PARC climate projections Report(2023)

## 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 | |
| **Likelihood Scores** | | |
| **Historic** | | **Future** |
| 2 [unlikely] | | 3 [possible] |
| **Potential consequences** | • Diminished crop health and yield<br>• Increased weed management costs<br>• Loss of food supply for cattle, 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[34] | |
| **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[35] | |

[34] See: Edmonton Metropolitan Region: Managing Invasive Species and Pests in a Changing Climate

[35] Data derived from PARC climate projections document (2023)

## 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 |

| Likelihood Scores | |
|---|---|
| Historic | Future |
| 1 [rare] | 4 [likely] |

| | |
|---|---|
| Potential consequences | • Damage to natural infrastructure (local parks and forests)<br>• Reduced visual quality of the landscape<br>• Increased tree management / maintenance costs<br>• Negative impact to plants and 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[36]. 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 (see Figure 14 in Appendix B)[37]. Fewer cold days may lead to better overwintering survival rates for some invasive species and pest populations and increased likelihood of an outbreak |

[36] See: Edmonton Metropolitan Region: Managing Invasive Species and Pests in a Changing Climate

[37] Data derived from PARC climate projections Report (2023)

## 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)** | Longer summer season, warmer temperatures |
| **Threshold:** | The frost-free season is extended to 231 days |

| Likelihood Scores | |
|---|---|
| **Historic** | **Future** |
| 2 [unlikely] | 3 [possible] |

| | |
|---|---|
| **Potential consequences** | • Risk of mortality, morbidity, especially due new unknown vector-borne diseases that could emerge<br>• 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[38] |
| **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[39] |

[38] 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

[39] Data derived from PARC climate projections report (2023)

## 18) Changing ecosystems negatively affects wildlife and habitat

| | |
|---|---|
| **Description** | Changing ecosystems negatively affects habitat quality and wildlife populations |
| **Climate driver(s)** | Warmer temperatures, changing seasons and ecosystems, |
| **Threshold:** | The frost-free season is extended to 231 days |

| Likelihood Scores | |
|---|---|
| **Historic** | **Future** |
| 2 [unlikely] | 3 [possible] |

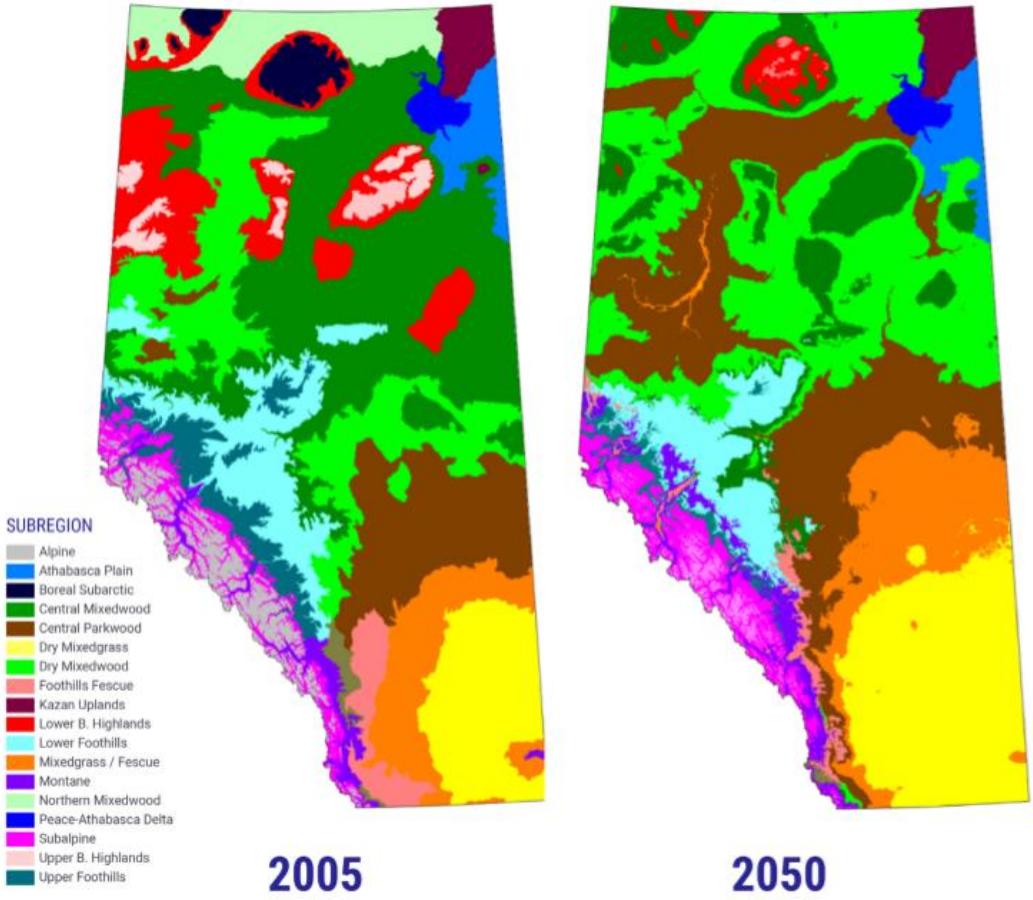
| | |
|---|---|
| **Potential consequences** | • Loss or reduction in habitat for some wildlife species<br>• Changes in wildlife species distribution and composition in the Pincher Creek area<br>• Impacts to recreation use and quality of life (changes to visual quality of the landscape)<br>• Reduced vibrancy due to an increase in rodents and agricultural pests<br>• Increased pest management costs |
| **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[40] |
| **Threshold** | • The frost-free season is the approximate length of the growing season during which there are no freezing temperatures[41]. 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[42] |

[40] Schneider, R.R. 2013. Alberta's Natural Subregions under a changing climate: past, present and future. Alberta Biodiversity Monitoring Institute, Edmonton, AB

[41] Threshold obtained from the definition of a frost-free season from the Prairie Climate Centre (2022)

[42] Data derived from PARC climate projections Report (2023)

*Figure 11 Map showing projected changes to Ecoregions in Alberta (2005 – 2050)*



# Appendix B: Climate Projections for Pincher Creek Area

Climate projections for the Pincher Creek area were based on a 3°C increase global mean temperature relative to the 1976 to 2005 historical baseline period. This projection is considered a "current policies" scenario where greenhouse gas emissions continue relatively unabated until the end of the century[43]. A 3°C increase global mean temperature is expected to occur around the 2060s or 2070s.

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

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

Table 5 provides a summary of projected changes to climate variables for the MD of Pincher Creek area.

*Table 5 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) | 198.1 | 133.7 | -64.4 |
| Length of the frost-free season (days) | 166.9 | 231.3 | +64.4 |
| Average annual precipitation (mm) | 794.6 | 853 | +58.4 (+7%) |
| Average spring precipitation (mm) | 255.9 | 312.1 | 56.2 (+22%) |
| Average summer precipitation (mm) | 176 | 164.8 | -11.2 (+6%) |
| Number of wet days (>10mm rainfall) | 23.9 | 26.4 | +2.5 |
| 12-Month Standardized Precipitation Evapotranspiration Index[44] | 0.7 | 0.6 | -0.1 |

A selection of maps from the Pincher Creek climate projections report are provided below.

[43] Network for Greening the Financial System, 2021. NGFS Climate Scenarios for central banks and supervisors

[44] The 12-Month Standardized Precipitation Evapotranspiration Index (SPEI) is…

*Figure 12 Projected changes in Summer Maximum Temperature*

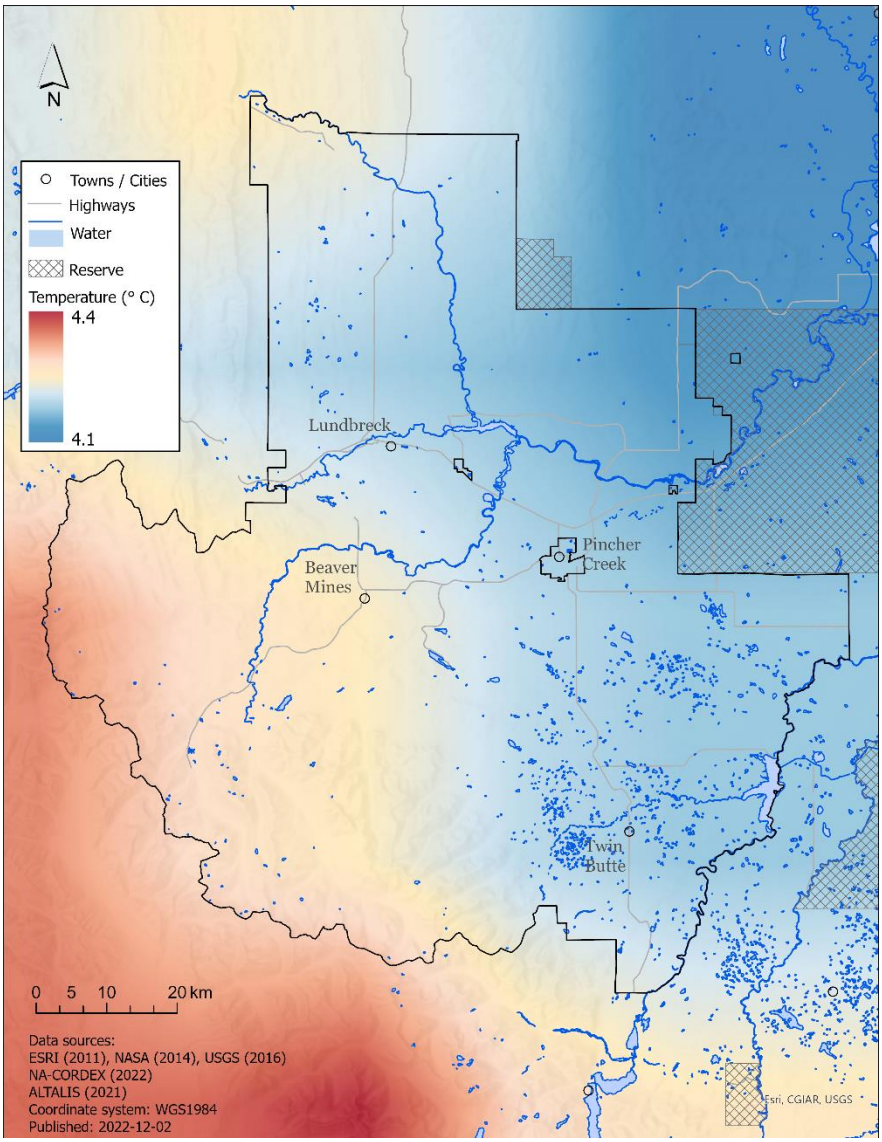


*Figure 13 Projected changes in the Number of Hot Days (> 30 °C)*

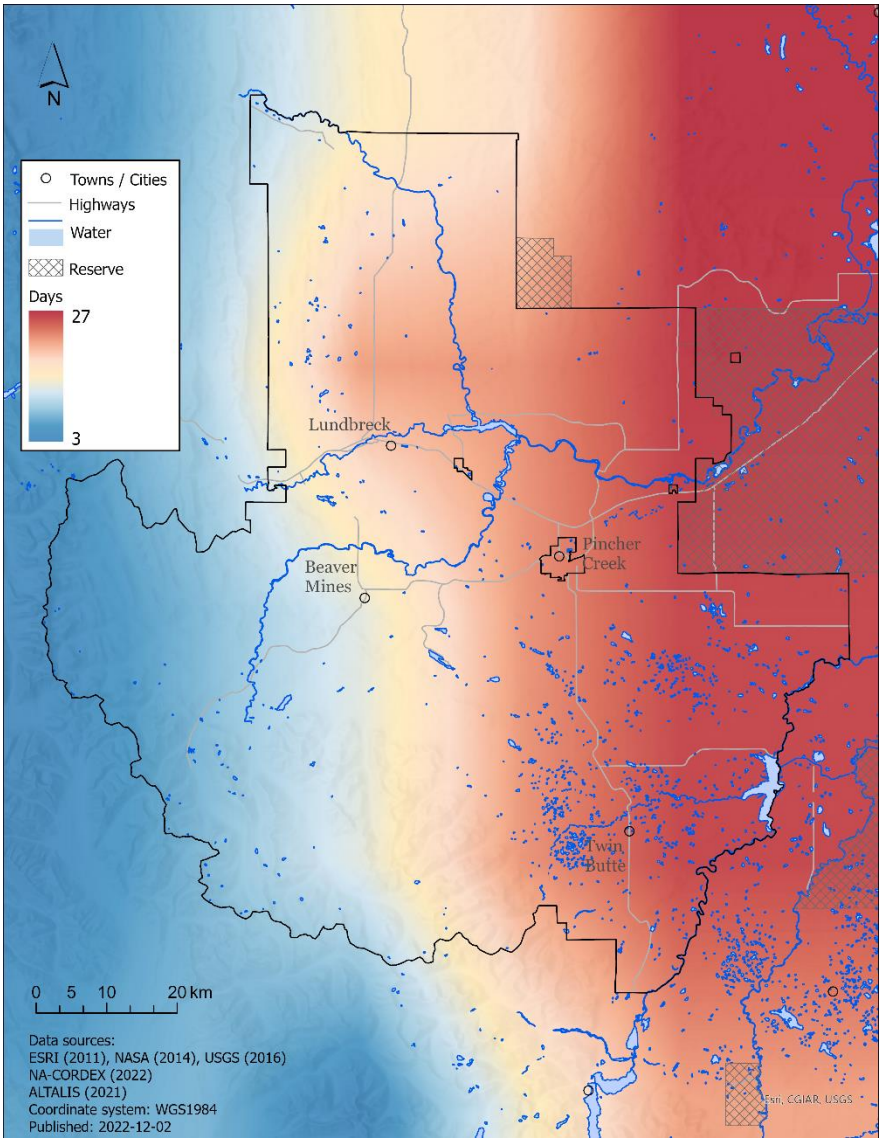


*Figure 14 Projected changes in the Number of Cold Days (< -30 °C)*

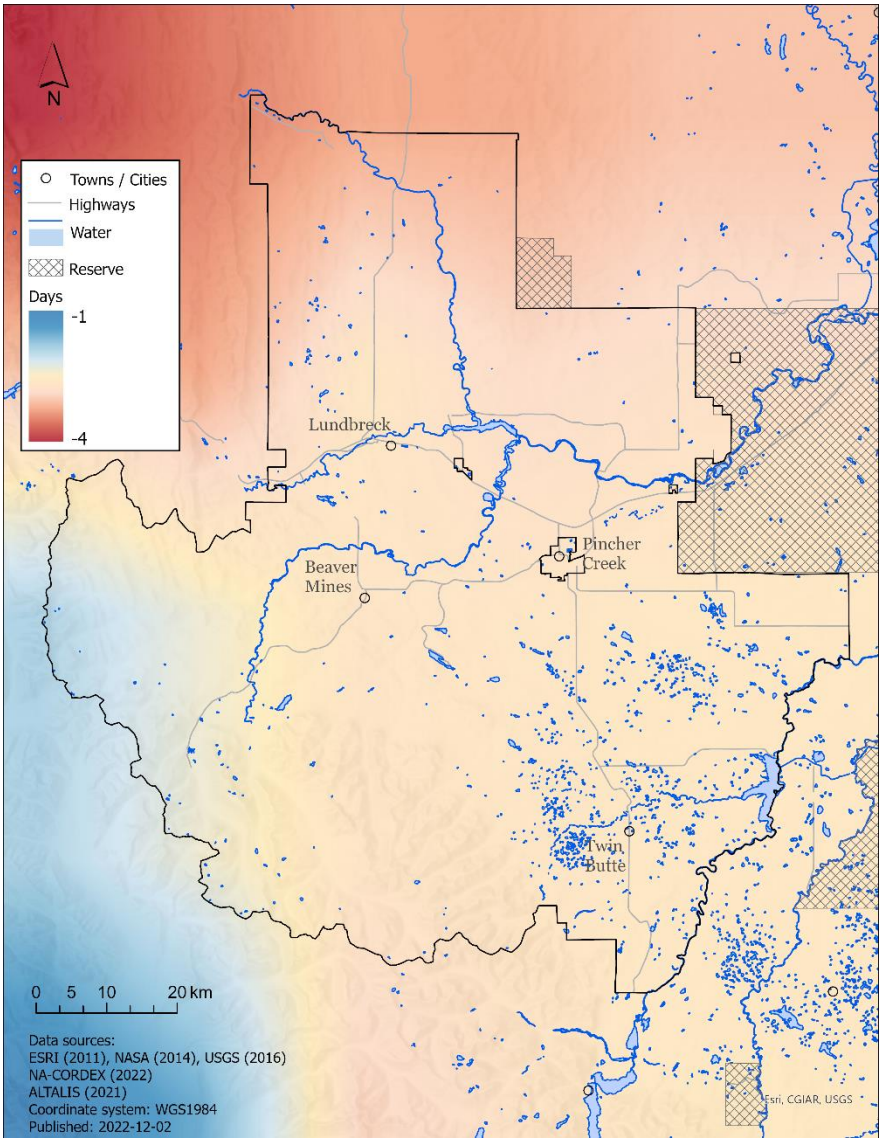


*Figure 15 Projected changes in Summer Precipitation*

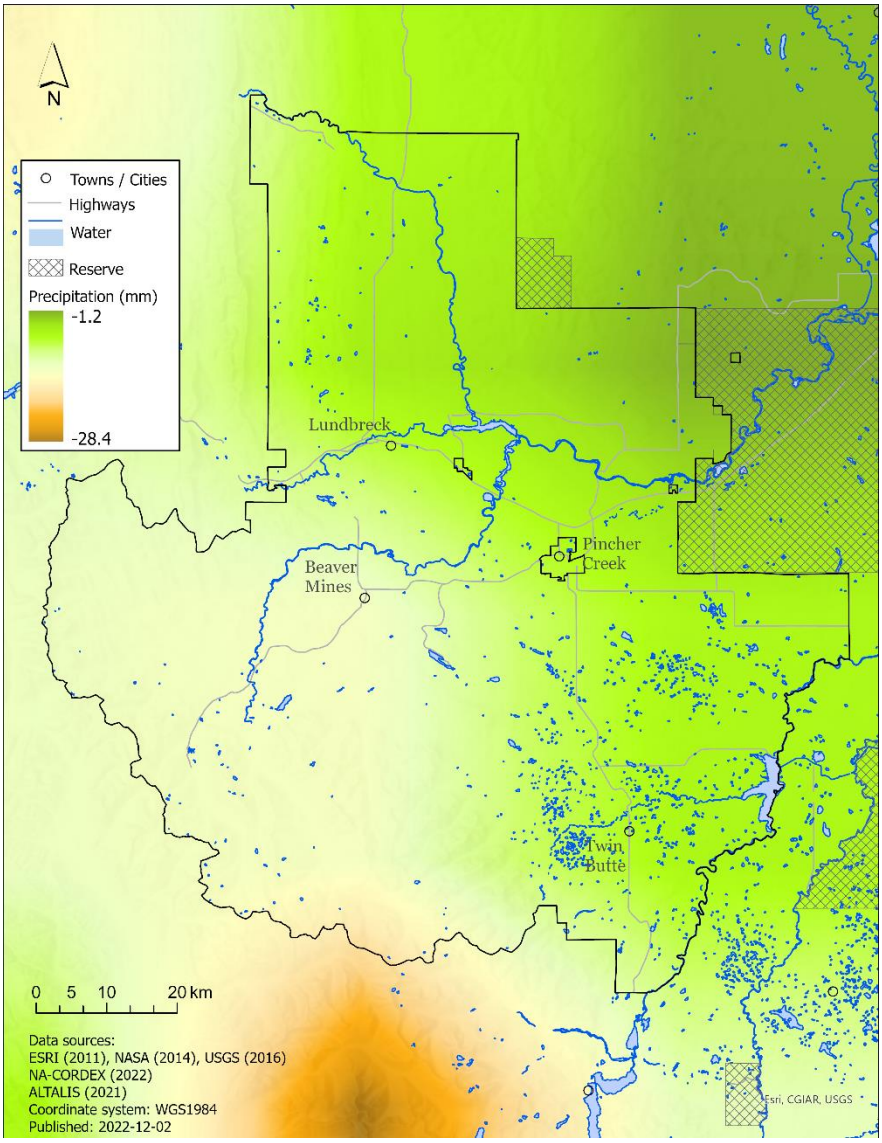
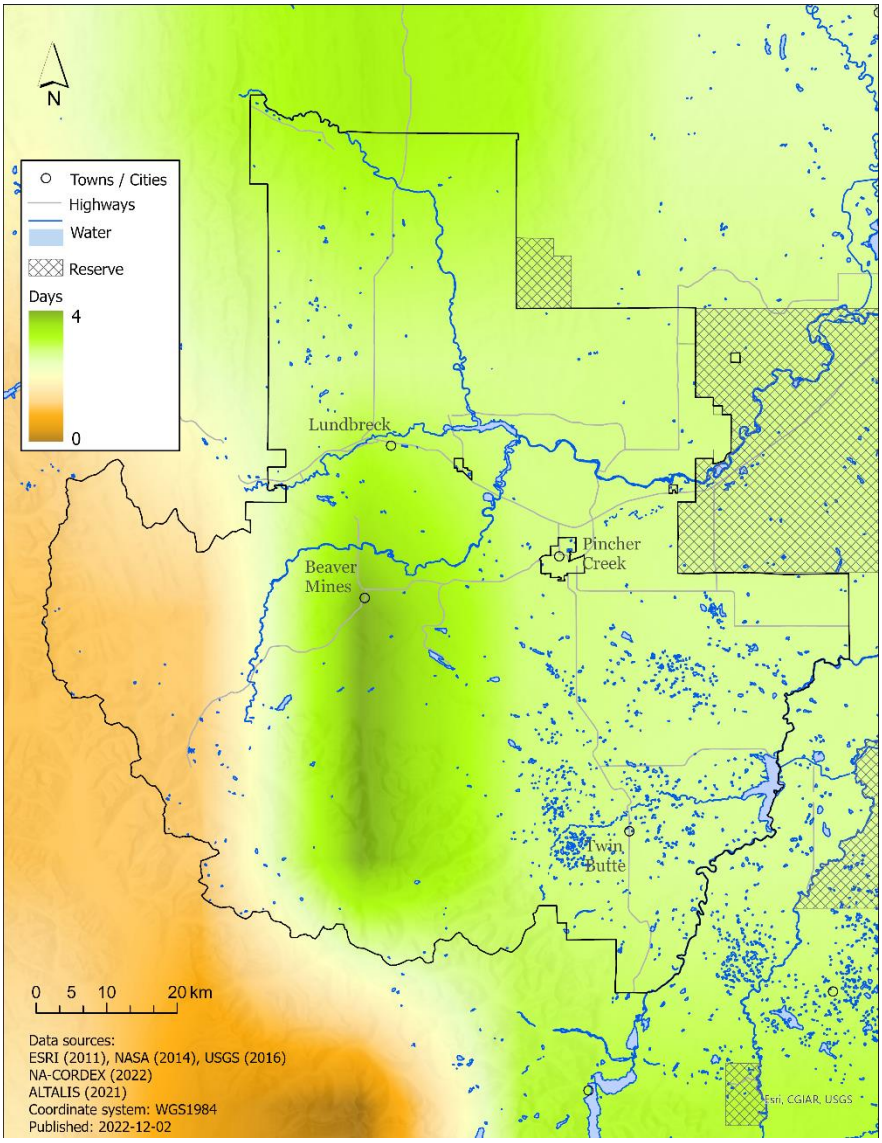


*Figure 16 Projected changes in number of wet days (>10mm rainfall)*




# Appendix C: Workshop Attendee List

| Name | Department |
|---|---|
| Tristan Walker | Municipal Energy Project Lead |
| LaVonne Rideout | Town Director of Community Services |
| Alexa Levair | Town Director of Operations |
| Andrea Hlady | Town Family and Community Support Services |
| Roland Milligan | MD Chief Administrative Officer |
| Laura McKinnon | MD Development Officer |
| David Desabrais | MD Utilities and Infrastructure Manager |
| John Gaydos | MD acting Public Works Supervisor |

| | |
|---|---|
| Pat Neumann | Pincher Creek Fire Chief |
| Brett Wuth | Pincher Creek Director of Regional Emergency Management |
| Michael Swytsun | Alberta Health Services Officer |
| Tawnya Plain Eagle | Piikani Lands Department Project Manager |