State of Climate Adaptation
City of Cranbrook

March 2020
(Revised June 2020)

COLUMBIA BASIN RDI RURAL DEVELOPMENT INSTITUTE Selkirk College

MOUNTAINS OF OPPORTUNITY CRANBROOK

FCM FEDERATION OF CANADIAN MUNICIPALITIES FÉDÉRATION CANADIENNE DES MUNICIPALITÉS

Canada

CONTENTS

ACKNOWLEDGEMENTS

The preparation of this report was carried out with assistance from the Government of Canada and the Federation of Canadian Municipalities, with additional funding from Columbia Basin Trust and participating local governments. The project was led by the Columbia Basin Rural Development Institute with contributions from external experts and local governments.

We acknowledge the following individuals for their contributions to this report:

Columbia Basin Rural Development Institute

- Jayme Jones
- Ingrid Liepa
- Kim Green
- Lauren Rethoret
- Jay Maloney
- Jamiee Remond
- Nerissa Abbott
- Raymond Neto

Climatic Resources Consulting

- Mel Reasoner
- Charles Cuell

City of Cranbrook

- Mike Matejka
- Scott Driver
- Jason Perrault
- Chris Zettel
- Crystal Krefting

And many thanks to the others who helped us secure the needed data to prepare this report, including BC Hydro, Interior Health Authority, and the Province's Southeast Fire Centre.

ACRONYMS

GDD	Growing Degree Days
EMBC	Emergency Management British Columbia
EOC	Emergency Operations Centre
GCM	Global Climate Model
ICI	Industrial, Commercial and Institutional
LiDAR	Light Detection and Ranging
NDMP	Natural Disaster Mitigation Program
NTU	Nephelometric Turbidity Units
$PM_{2.5}$	Fine Particulate Matter
RCP	Representative Concentration Pathways
RDEK	Regional District of East Kootenay
RDI	Columbia Basin Rural Development Institute
SoCARB	State of Climate Adaptation and Resilience in the Basin
SWE	Snow Water Equivalent
WUI	Wildland Urban Interface

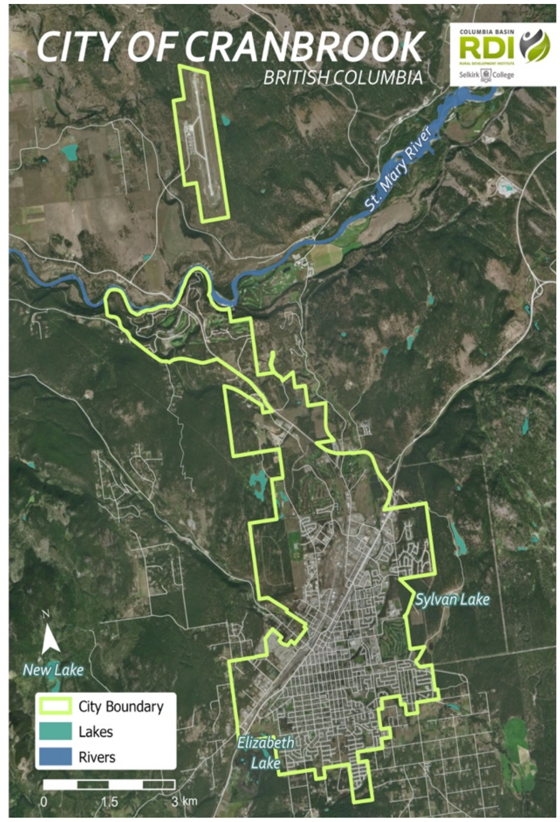
DISCLAIMER

The data for State of Climate Adaptation indicators has been collected and analyzed by a team of qualified researchers. A variety of municipal, regional and provincial data sets informed the indicator findings. In some cases, community-specific data is not available. State of Climate Adaptation indicator reporting should not be considered to be a complete analysis, and we make no warranty as to the quality, accuracy or completeness of the data. The Columbia Basin Rural Development Institute and Selkirk College will not be liable for any direct or indirect loss resulting from the use of or reliance on this data.

The preparation of this report was carried out with assistance from the Government of Canada and the Federation of Canadian Municipalities. Notwithstanding this support, the views expressed are the personal views of the authors and the Federation of Canadian Municipalities and the Government of Canada accept no responsibility for them.

INTRODUCTION

Purpose



Welcome to the City of Cranbrook's 2020 baseline report for the State of Climate Adaptation and Resilience in the Basin (SoCARB) indicator suite. SoCARB indicators were designed to provide data and insights relating to climate change, including local environmental impacts and community impacts (e.g., economic impacts), as well as information to help build adaptive capacity and track local actions. Originally developed in 2015, the SoCARB indicator suite measures community progress on climate adaptation across five climate impact pathways: extreme weather and emergency preparedness, water supply, flooding, agriculture, and wildfire

Climate-related impacts like flooding, drought and high temperatures can be critical events for communities and are examples of events that are projected to occur with greater frequency and/or intensity as the climate gets warmer. Flooding poses a risk to water infrastructure and public safety, and contributes to turbidity in surface sources. Drought has implications for water supply, local food production and increasing wildfire risk. Higher temperatures can impact vulnerable populations, including the elderly, socially isolated, chronically ill and infants.

The information presented in this report is intended to highlight trends and impacts related to the local climate and surrounding environment, and to inform local planning and decision-making. This includes changes in indicators outside of Cranbrook's jurisdiction such as glacier extent and wildfire starts, recognizing that a better understanding of trends associated with these indicators can help the community prepare for current and future changes. For other indicators, like per capita water consumption, local governments are better positioned to identify and track where their actions can increase community climate resilience.

The full SoCARB suite includes 58 climate adaptation indicators. This report, however, excludes indicators that the City of Cranbrook has not identified as a priority or where sufficient data was not available. In addition, the evolution of adaptation practice since the indicator suite was originally developed, and learnings from pilot implementation in 2016-2017 with four Columbia Basin communities, resulted in minor updates to the suite in spring 2019.

Report Highlights

- Cranbrook's climate is changing, with data showing trends toward higher average annual and seasonal temperatures. This upward trend is expected to continue with an increased overall rate of warming. There is also a trend toward more extreme heat days and more growing degree days. Total annual precipitation increased in the 20th century, and it will continue to climb through this century, with less rain falling in summer and more rain falling in the other seasons. Future projections indicate more heavy precipitation days and higher 1-day maximum rainfall events.
- Climate change is becoming evident through changes in environmental conditions. For example, glaciers in the Columbia Basin are becoming smaller, the frequency and volume of heavy snowfalls in the Cranbrook area have been declining, and the amount of heat energy available for crop growth is on the rise. Several environmental impact indicators lack sufficient data to infer trends, suggesting important focal points for efforts to enhance climate adaptation monitoring, planning, and action.
- The City of Cranbrook is taking important steps to adapt to changes that have already happened and to prepare for future changes. These actions are primarily related to water supply, flood mitigation and wildfire risk reduction on City lands. Opportunities exist to further Cranbrook's readiness to adapt, which include exploring additional opportunities to reduce water consumption, completing fuel treatments in high priority wildland-urban interface areas, and promoting community-based efforts to adapt through programs aimed at enhancing personal emergency preparedness, Fire Smart education, and local food production.
- While some datasets are not lengthy or complete enough to evaluate trends in Cranbrook's adaptation, the analyses conducted for this project provide a valuable baseline assessment against which future progress can be compared.

Methods

The State of Climate Adaptation and Resilience in the Basin indicator suite was released in 2015 by a team of climate change professionals. The full suite separates indicators into two instruments:

1) A set of five thematic pathways (wildfire, water supply, agriculture, flooding, and extreme weather) that, through 50+ indicators, measure climate change, climate change impacts, and climate change adaptation; and
2) a Community Resilience Index that uses an additional 20 indicators to provide insights on socio-economic conditions in the community that contribute to its capacity to adapt.

The Water Supply pathway (Figure 1) illustrates how SoCARB conceptualizes the relationships between categories of indicators. Climate changes have direct and indirect impacts on communities. Indirect impacts are experienced through both environmental and community impacts. Impacts can be addressed through adaptation actions and capacity building, and the results of such efforts improve adaptation outcomes.

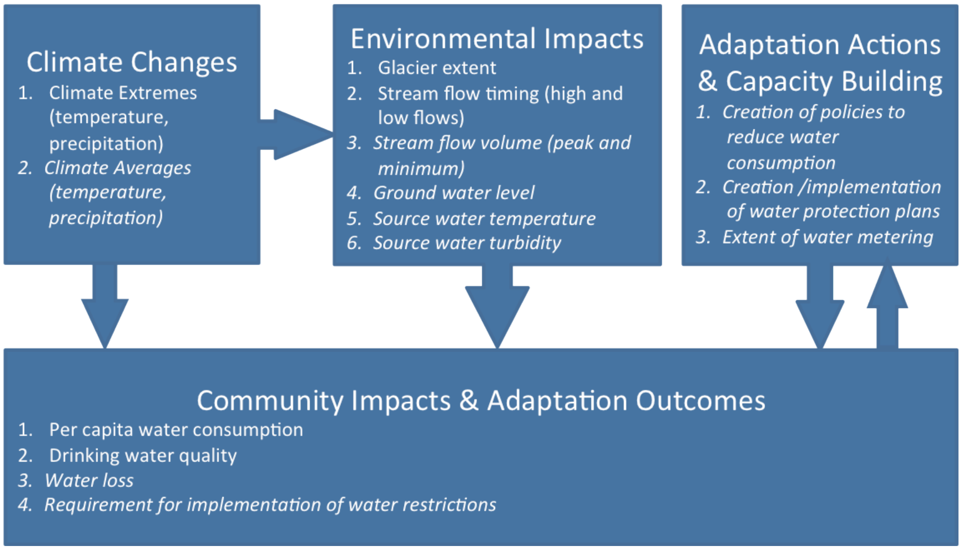


Figure 1: Water Supply pathway from the SoCARB indicator suite

For this report, City of Cranbrook personnel identified 49 indicators reflecting local priorities. Community Resilience Index indicators were not assessed as part of this report; however, many of these indicators can be found in the RDI's annual State of the Basin reports and Community Profiles. This report includes an introductory Climate section, which presents climate change indicators common to all five pathways, followed by pathway-specific sections following the same structure as Figure 1.

This report provides a summary of analysis for each indicator relevant to Cranbrook. Full datasets are available from the RDI on request. Additional details on climate indicators are included in Appendix A.

Notes to the Reader

The indicators and their related data sets range from simple to complex. Additional detail on any of the datasets or analytical methods is available from the RDI. Understanding the data and its limitations is important for many reasons. The points below should be considered while reviewing the report.

- **Climate trends are complex**. It is difficult to look at climate trends over the short or medium term because there are other factors beyond climate change that can influence trends. Climate science experts were consulted when analysing and interpreting data for this report.
- **Use of proxy data**. For some indicators, there is no local data source. Where feasible and appropriate, proxy (or stand-in) data sources were used. Cranbrook is one of five

Columbia Basin communities with a long-term climate record dating back to 1901. More details are provided in the body of the report.

- **Confounding factors**. An indicator can be influenced by several factors, making it difficult to distinguish the cause of a change. For example, trends in water consumption may be influenced by water conservation initiatives, but other factors (e.g., demographic changes) may also be at work.
- **No obvious trend**. Some data may show no obvious trend. However, this data still has value as i) a trend may eventually emerge, and ii) the information can still help inform decision making.
- **Trend that is not statistically significant**: Due to high variability and/or short time periods, some data trends fall below 95 per cent confidence levels (i.e. not statistically significant). This does not nullify the presence of a trend; it highlights that there is less than 95 per cent confidence that the trend captures the true mean.

About the Climate Data

Climate data for Cranbrook was provided by Climatic Resources Consulting, Inc. and come from two main sources. Historical climate data was sourced from Environment Canada's Adjusted and Homogenized Canadian Climate Data (AHCCD), which provides long-term (since the early 1900s) observed data. Climate projections for the 2050s are averages of modeled data for the 2041-2070 period. Two scenarios are presented: low carbon and high carbon. The low carbon scenario (RCP4.5) is considered to be optimistic and, although insufficient to maintain global temperatures to below 2°C warming above pre-industrial temperatures, would require significant international cooperation that exceeds current commitments of signatories to the Paris climate agreement.[1] The high carbon scenario (RCP8.5) is also referred to as 'business as usual'. Global emissions are still moving along a trajectory that could lead to 3 to 5°C of global warming by the end of the century.[2] Consequently, it is important to also consider the high global emissions scenario (RCP8.5) in planning for climate change. Climate trends, i.e. rates of change, are expressed in units per century, meaning the change per 100 years.

Technical Information on Climate Models

Climate projections are based on output from an ensemble of 12 statistically downscaled Global Climate Model (GCM) projections[3] from the Coupled Model Intercomparison Project Phase 5 (CMIP5),[4] and downscaled using Bias Correction/Constructed Analogues with Quantile mapping recording[5] to a resolution of 10 km by 10 km. In this report, all climate projections for the 2050s indicate the mean for the 2041-2070 period.

Representative Concentration Pathways (RCPs) are numbered (e.g. RCP8.5 or RCP4.5) according to the radiative forcing in W/m^2 that will result from additional greenhouse gas emissions by the end of the century. Modellers use RCPs to generate scenarios of future climate.

CLIMATE

Four climate change indicators are common to most pathways: climate averages and extremes for both temperature and precipitation. They are presented first since changes in temperature and precipitation are key drivers of both environmental and community impacts. These four indicators encompass both historical trends and future projections for the City of Cranbrook. Additional climate information can be found in Appendix A.

The Overall Picture

Both annual and seasonal average temperatures are rising in the Cranbrook area and are projected to continue rising through the 2050s and beyond. Annual average temperature has been rising by 1.7°C per century. By the 2050s, this rate is projected at 3.6°C per century under a low global emissions scenario and 7.5°C per century in a high carbon emissions scenario. Hot days have increased in frequency over the last century and this trend is projected to continue.

Total annual precipitation has also increased over the last century and is projected to continue increasing over the coming decades, with more precipitation in winter and spring, and less precipitation in summer. Trends in precipitation extremes, while not statistically significant, indicate more days with precipitation over the 95th percentile threshold of 5.7 mm.

Average annual and seasonal temperatures are getting warmer

Analysis of climate data for Cranbrook shows increasing temperatures since the early 1900s. There has been a statistically significant warming trend in average annual temperature of +1.7 °C per century (Table 1). The 1961-1990 baseline temperature is 5.8 °C (Figure 2). Average seasonal temperatures have also increased in Cranbrook. Winter temperatures have increased at the highest rate, with trends calculated at +2.6°C per century (Table 1).

Projections for the 2050s indicate that summers will be warming faster than other seasons in both low and high carbon scenarios. Average annual temperature is projected to increase by 2.6 °C to 3.2 °C from the 1961-1990 baseline to 8.4 °C and 9.0 °C under low and high carbon scenarios, respectively.

Table 1: Annual and seasonal average temperature trends (rate of change) for Cranbrook in degrees Celsius per century. Results that are not statistically significant (<95% confidence level)) are in italics.

	Annual	Winter	Spring	Summer	Fall
Historic (1901-2018)	+1.7°C per century	2.6	1.1	1.8	1.1
2050s (low carbon)	3.6	*1.5*	3.2	4.0	3.0
2050s (high carbon)	7.5	8.5	4.8	10.1	7.0

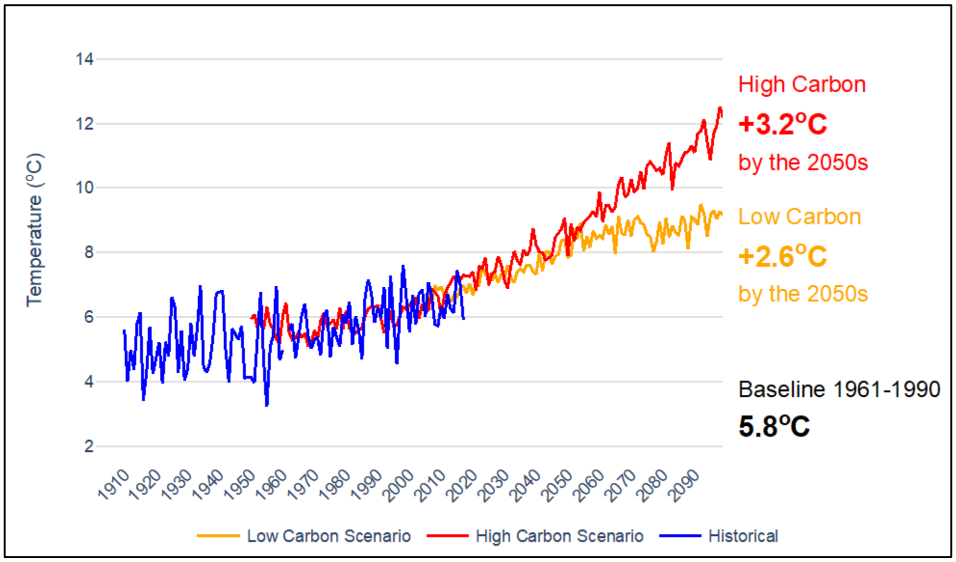


Figure 2: Historical and projected average annual temperature for Cranbrook

Total annual precipitation is increasing

Average annual precipitation trends (Table 2) are not as clear cut as those for average temperature because precipitation has significant natural variability. Cranbrook's precipitation data indicate a baseline annual total of 395.9 mm for the 1961-1990 period (Figure 3). The dataset shows an increasing trend in historical average annual precipitation of 104 mm per century. Seasonally, Cranbrook's data show an increasing trend in spring and summer precipitation since 1909.

Table 2: Annual and seasonal total precipitation trends (rate of change) for Cranbrook, in millimetres per century. Results that are not statistically significant (< 95% confidence level) are in italics.

	Annual	Winter	Spring	Summer	Fall
Historical (1909-2018)	+104 *mm/century*	*-4*	53	38	*16*
2050s (Low carbon scenario)	*82*	*41*	*31*	*16*	*6*
2050s (High carbon scenario)	256	*69*	97	*-13*	*20*

Precipitation projections show increases of approximately 4% to 5% in average annual precipitation by the 2050s, with significantly more precipitation falling in spring and less precipitation falling in summer. Projected trends for the 2050s show precipitation increasing in all cases except summer in a high carbon scenario, however, these trends fall below the 95 per cent confidence level, as noted in italics in Table 2.

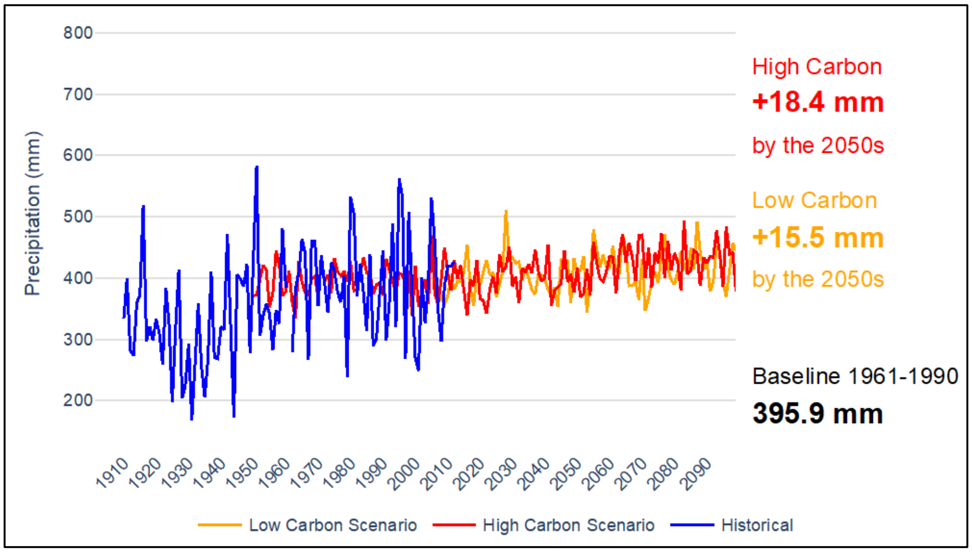


Figure 3: Historical and projected average annual precipitation for Cranbrook

More hot days

This extreme temperature indicator measures the number of days annually when the temperature exceeds the 90th percentile for the baseline period (1961-1990). For Cranbrook, this translates into a baseline of 36 days above 26.7°C, and a statistically significant rate of increase in hot days of 13.5 days per century. Hot days (i.e. those above 26.7°C) are projected to increase by an additional 26 to 35 days by the 2050s, under low and high carbon scenarios, respectively. The rate of increase of hot days could go as high as 96 days per century by the 2050s under a high carbon scenario.

More days with heavy rainfall

This extreme precipitation indicator measures the annual sum of daily precipitation exceeding the 95th percentile of precipitation on wet days for the baseline period (1961-1990) and can be described as the amount of rain that falls during very heavy rainfall days. For Cranbrook's baseline period, the 95th percentile threshold for precipitation is 5.7 mm, with an average total of 76.2 mm falling annually on days when precipitation exceeds 5.7 mm. Cranbrook has experienced a -29.5 mm per century trend in the annual sum of precipitation over the 95th percentile since 1909; however, it has also experienced a 4.1 day per century increase in days with precipitation over the 95th percentile threshold of 5.7 mm. A 97.4 mm per century upward trend is projected for the 2050s in a high carbon scenario, which would add an additional 19 mm to the 1961-1990 baseline in the 2050s. This translates into more rain falling during heavy rainfall events.

EXTREME WEATHER AND EMERGENCY PREPAREDNESS

Extreme weather events, such as extreme precipitation, windstorms and heat waves, can have significant impacts on communities. This was underscored by an independent review of BC's historic flood and fire events of 2017 commissioned by the BC government. This review noted, "A range of data from reputable sources points to growing challenges with respect to heat, drought, lightning and intense rains intersecting with snowmelt, underlining the imperative for government to respond in new, different or better ways."[6] Future climate projections suggest an increase in some extreme weather events, such as warm days, extreme warm days, and extreme wet days. Communities can prepare for the immediate short-term demands of extreme weather events with adaptations such as emergency preparedness plans, backup power sources, business continuity plans, and home emergency preparedness kits.

The Overall Picture

Cranbrook is experiencing a higher number of extreme heat days and fewer extreme snowfalls than in the past. Other indicators of extreme weather in the area, however, are either lacking long-term datasets or not yet showing the trends that have been identified at larger geographic scales. The City of Cranbrook is in the midst of finalizing a comprehensive upgrade of its climate monitoring network, which will include four meteorological stations and four creek flow monitoring stations, all with real time network communications. The meteorological stations will be located near the Gold Creek drinking water diversion intake, Phillips Reservoir, Public Works Yard, and Spray Irrigation Site. The range in location and elevation of these sites is intended to gather more site-specific trends as well as track smaller and isolated storm and weather events that may not be experienced in the broader area. Alarms and warnings will be transmitted in real time to City staff for high creek flow or intense rain fall events, as well as high risk water quality and quantity events. Warnings can also be issued for longer term increasing risks of high heat and low rainfall, or high snowpack and forecast melts, to inform fire and flood risk respectively.

The City of Cranbrook's Emergency Preparedness Plan can help mitigate the impacts of extreme weather events on residents and businesses and will benefit from reviewing and updating the hazard risk assessment component on a more regular cycle. Adoption of a municipal business continuity plan could help minimize disruption to City operations and services in the event of an extreme weather emergency, which can in turn facilitate recovery by local residents and businesses. The number of Cranbrook residents with emergency preparedness kits is low, suggesting the benefits of supporting information and awareness of personal emergency preparedness.

Climate Changes

As discussed in the Climate section, Cranbrook's weather station has recorded increases in annual and seasonal average temperatures and increased annual precipitation over the last century. The frequency of hot days has increased and will continue to increase, and trends are less clear for the amount of rain falling on heavy rainfall days. Additional climate indicators related to the Extreme Weather pathway are discussed below.

More extreme heat days

Temperature data for Cranbrook shows a clear upward trend in the average annual frequency of days over 30°C, which have been increasing at a rate of 9 days per century since 1901. During the 1961-1990 baseline period (Figure 4), Cranbrook experienced an average of 13.6 days per year with maximum temperatures above 30°C. By the 2050s, this is projected to increase by 21.9 days in a low carbon scenario and 30.7 days in a high carbon scenario, resulting in 35-44 days per year above 30°C. Heatwaves and heat extremes have negative health impacts on vulnerable populations including the elderly, socially isolated, chronically ill, and infants.

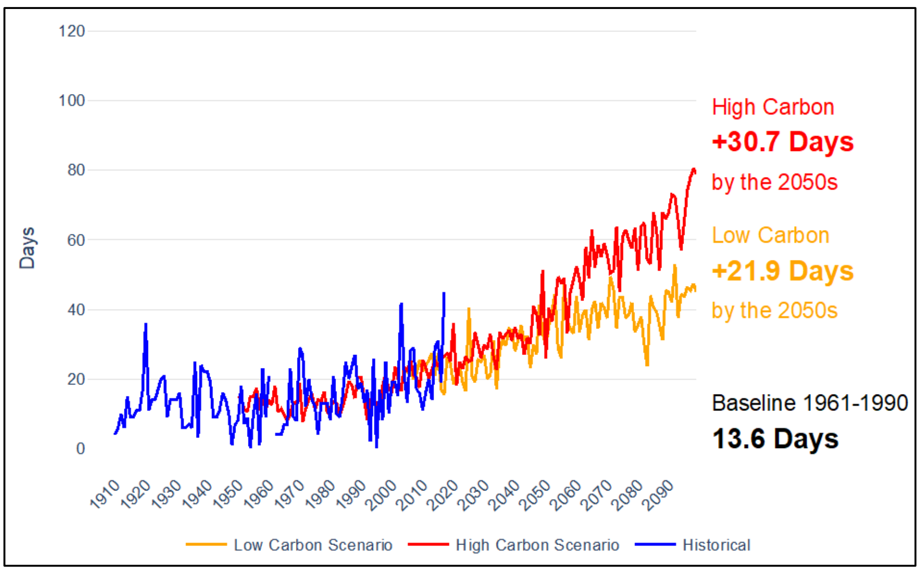


Figure 4: Extreme heat days (above 30ºC) in Cranbrook

Fewer heavy snowfall events

Snowfall records for Cranbrook show a decline in annual heavy snowfall days from 1939 through to 2018. Heavy snowfall days are defined as those receiving 15 cm or more over 24 hours. Since 1939, Cranbrook has experienced between 0 to 7 such events each year, averaging 1.2 events per year, with an overall downward trend in the occurrence of heavy snowfall events (Figure 5). The annual maximum 1-day snowfall is decreasing by 12 cm per century[7].

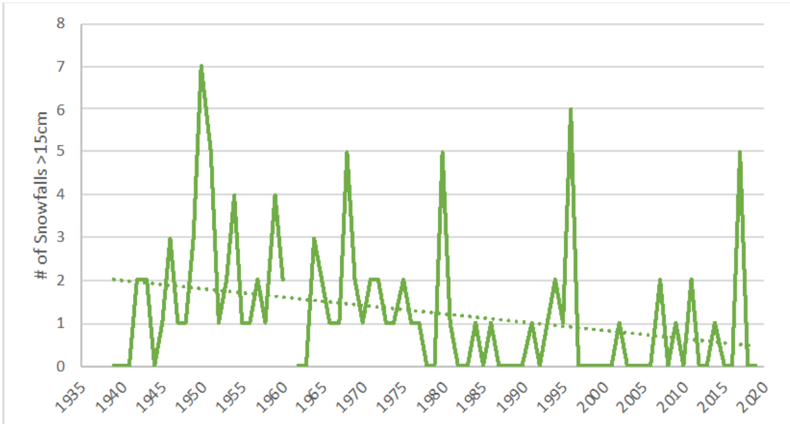


Figure 5: Frequency of heavy snowfalls in Cranbrook (1939-2018)

Insufficient wind data to infer trends

Wind storms can damage infrastructure, bring down trees and power lines, and cause power outages. A strong wind event is defined as a day with sustained winds greater than 70 km/h and/or gusts to 90 km/h or more. Cranbrook's Environment Canada weather station has a relatively complete record of daily maximum wind gusts dating back to 1969. While there is no statistically significant trend in the data, there have been six days with gusts over 90 km/h since 2007, with four of those occurring in 2016 and 2019. No data was collected in 2018. Prior to 2007, there was only one event with gusts recorded over 90 km/h, occurring in 1980[8].

Maximum 1-day rainfall projected to increase

Heavy rainfall is a major cause of flooding of creeks and rivers and can cause stormwater management issues, erosion and debris slides. A warming climate generally increases the risk of extreme rainfall events because a warmer atmosphere can carry more water vapour, which can fuel more intense precipitation events. Historical data for Cranbrook indicates 19.9 mm as the 1961-1990 baseline for average annual maximum 1-day rainfall. The highest recorded 1-day rainfall for Cranbrook was 89.4 mm in 1935. Future projections show an increase of 17.5% and 19% in average annual maximum 1-day rainfall by the 2050s under low and high carbon scenarios, respectively.

Adaptation Actions and Capacity Building

Emergency Preparedness Plan

The Regional District of East Kootenay (RDEK) provides emergency services region-wide, working in partnership with its municipalities. The City of Cranbrook has an administrative agreement with RDEK and is part of RDEK's Central Sub-Region Emergency Program. In the event of an emergency within municipal boundaries, Cranbrook leads the response and emergency operations centre (EOC) with support from the RDEK. Cranbrook is in the process of reviewing its municipal emergency plan in relation to the RDEK's emergency preparedness plan to ensure that all its key risks and hazards are addressed and updated in all aspects. Key areas for review and updates are community evacuation plans, hazard risk assessment, hazard-specific plans, fan-out call lists, and emergency procedures.

Cranbrook has a Fire Services Protection Agreement with the RDEK to provide fire protection for homes in Electoral Area C within 13 km of the City's boundaries. It has a similar agreement with ?aq'am.

Table 3: Emergency preparedness plan components for City of Cranbrook

	Included in Emergency Preparedness Plan?			
Component	Yes	In Progress	No	N/A
Hazard risk assessment[1]	☐	☑	☐	☐
Emergency procedures	☑	☐	☐	☐
Municipal business continuity plan	☐	☐	☑	☐
Community evacuation plan	☑	☐	☐	☐
Public communication plan	☑	☐	☐	☐
Designated emergency operations centre[2]	☑	☐	☐	☐
Emergency program coordinator	☑	☐	☐	☐
Designated emergency response team	☑	☐	☐	☐
Identified emergency roles and responsibilities	☑	☐	☐	☐
Action list for each type of hazard	☐	☐	☑	☐
Designated emergency/reception shelter[3]	☑	☐	☐	☐
Plan for shelter stocking	☐	☐	☑	☐
Training and emergency exercise plan for response personnel	☑	☐	☐	☐
Contact list for all response personnel	☑	☐	☐	☐
Fan-out call list	☐	☑	☐	☐
Mutual aid agreements with any agencies helping in response (e.g. neighbouring municipalities, school board, local service groups)[4]	☑	☐	☐	☐

1: This is being reviewed and updated in 2019-2020.

2: Cranbrook utilizes the Central Subregion EOC.

3: Several evacuation centres have been identified in the community. A centre will be designated based on its geographic location and the location of the emergency.

4. Mutual aid agreements are typically created between communities and with regional districts to facilitate response to emergencies. The City of Cranbrook has a mutual aid agreement in place with the RDEK.

Essential backup power in place

The City of Cranbrook has backup power sources in place for its Fire Hall, City Hall, Emergency Operations Centre, Public Works Yard, and Evacuation Centre. A mobile generator is also available to provide backup power as needed. The City's drinking water system is supported by a generator at the water treatment plant and battery power at the pressure reducing stations. In the event of a power outage, the gravity-fed water system can continue to supply water for core domestic and fire prevention needs.

Few Cranbrook residents have 72-hour emergency kits

Having an emergency preparedness kit can help alleviate some of the difficulties caused by an extreme weather event. A voluntary survey of Cranbrook residents completed in the summer of 2019 found that only 27% (66 of 247 respondents) reported having 72-hour emergency preparedness kits in their homes. Of those, 67% (18 respondents) reported having them consolidated in an easy to access location. Over 90% of residents with kits reported having adequate food for three days, candles, flashlights, and first aid kits, but fewer residents reported having an adequate emergency drinking water supply, copies of relevant identification papers, and battery-powered windup radios (Table 4). Many residents could better prepare for extreme weather events by compiling complete kits and storing them in a single accessible location.

Table 4: Percentage of Cranbrook residents who reported having important items in their kits.

Item	%Yes
Drinking-water (2 - 4 litres of water per person and pets per day)	75.4
Food that will not spoil (minimum 3-day supply)	91.8
Manual can-opener	91.9
Flashlight and batteries	91.9
Candles and matches/lighter	90.3
Battery-powered or wind-up radio	51.6
Cash in smaller bills and change	63.3
First aid kit	95.0
Special items such as prescription medications, infant formula or equipment for people with disabilities	62.3
Extra keys that you might need (e.g. for your car, house, safe deposit box)	59.0
A copy of your emergency plan including contact numbers (e.g. for out-of-town family)	36.7
Copies of relevant identification papers (e.g. licenses, birth certificates, care cards)	53.3
Insurance policy information	61.0
Mobile phone charger	77.0

Community Impacts and Adaptation Outcomes

Freezing rain is responsible for the longest weather-related highway closure

Cranbrook is accessed by highways 3, 93 and 93A and is the largest community in the Kootenays. Closures between Cranbrook and the Elk Valley, Columbia Valley, and Creston Valley can significantly impact the movement of people and goods. From 2007 to 2017, there were 25 weather-related highway closures in the Cranbrook region, lasting for a cumulative total of 71.5 hours (Figure 6). The most extreme year was 2017, which saw six closures. Closures averaged just over four per year during the period of record. Downed power lines are the most common cause of closures near Cranbrook, and mudslides and freezing rain were responsible for the longest single closures of 10.5 and 15 hours respectively[9]. The short length of this record precludes assessment of trends at this time.

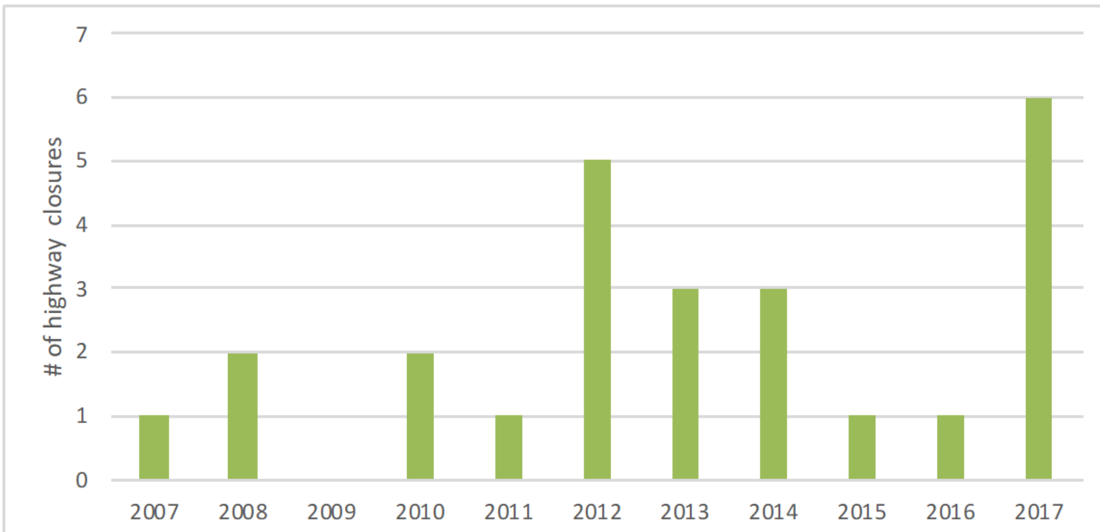


Figure 6: Number of highway closures in the Cranbrook area (2007-2017)

Power outages mostly due to fallen trees and branches

Longer-duration power outages caused by extreme weather events can have significant impacts on local economies, health, and quality of life. BC Hydro data for Cranbrook identifies outages caused by adverse weather, including floods, mud/snow slides, lightning, snow, and damage to trees between 2015 and 2018. The average number of power outages during this time period was 49, with an average duration of 4.5 hours. Total annual outages ranged from a low of 35 in 2016 to a high of 59 in 2017, with an average of 49 outages per year totalling 167 hours. Most of the outages –74.5% – were caused by fallen trees or branches[10].

Provincial emergency assistance issued once in 2014

Monitoring emergency assistance funding issued by the province can provide some measure of the economic impact of a disaster and associated recovery over time. The City of Cranbrook experienced flooding in 2014 that resulted in provincial emergency assistance of $139,225.

WATER SUPPLY

Projected changes to the climate could influence both the supply of and demand for freshwater for human use. Shifts in temperature and precipitation could change the amount of water stored in the snowpack and the timing of surface water availability in the spring, as well as reservoir temperatures in the summer. The water supply pathway focuses on the quality and quantity of water available for consumptive use and adaptation actions that help to conserve and protect the water supply. The City of Cranbrook diverts water from Joseph Creek and Gold Creek into Phillips Reservoir as its primary water source, and supplements higher summer demand with water from three deep groundwater supply wells that were rehabilitated and upgraded about five years ago. As of 2019, the City of Cranbrook's water utility had 8653 connections. Of these, there are 8059 unmetered residential connections, 160 metered industrial, commercial, institutional (ICI) connections for high volume users, and 434 unmetered ICI connections for lower volume users.[11] Peak water demand typically occurs in the months of July and August and is approximately three times winter demand.

The Overall Picture

The trend toward wetter springs and drier summers in Cranbrook is likely to have negative implications for water supply from Joseph and Gold Creeks. These low elevation watersheds are likely to experience reduced snowpacks and earlier snowmelt resulting in reduced and longer periods of summer low flows. Reduced surface flows could also impact the volume of water available for recharging the groundwater aquifer that Cranbrook relies on for its water supply, especially in late summer and early fall. The long-term discharge data available for nearby Moyie River above Noke Creek reveals a decrease in the volume of summer low flows over the 52-year record. The City's water system demonstrates some of the challenges common to utilities in many Canadian communities, including limited resources for system monitoring and improvements. The City of Cranbrook is actively addressing many of its water supply needs, risks and challenges by completing a Master Drinking Water Quality and Supply Strategy in 2019-2020, which includes installation of four stream flow monitoring sites to provide real-time data on water quality and quantity. The flow monitoring stations at Gold Creek, Joseph Creek, Hospital Creek and Jim Smith Creek will gather flow data as well as water quality parameters such as temperature, pH, conductivity, and turbidity. This information will be used primarily to inform water operations for real time water quality and flow, as well as long-term trends for supply and quality sustainability. Additionally, this data will be used to inform ecological impacts of flow quantity and quality on local fish, wildlife and vegetation. The City has a number of untapped opportunities for water conservation as detailed below (Table 5).

Climate Changes

As discussed in the Climate section, average annual and seasonal temperatures are increasing, and are projected to continue increasing over the coming decades. Total annual precipitation has also increased over the last 100 years. Future projections indicate an increase in total annual precipitation by the 2050s under both low and high carbon scenarios, with less rain falling in the summer, and more rain in winter and spring.

Environmental Impacts

Glacier extent is decreasing

Glacier extent in the Canadian Columbia Basin declined by 15 per cent from 1985 to 2005 and glaciers are projected to mostly disappear by 2100.[12] Glaciers in the Basin lost an average of 80 cm of ice thickness per year from 2014-2018, a rate four times greater than the period 2000-2009.[13] A decline in glacier extent and glacial meltwater has implications for reduced summer stream flow and higher summer water temperatures in water bodies that receive glacial flow. Cranbrook does not rely on glacier-fed streams for its water supply and will not be directly affected by the loss of glaciers.

No trend in stream flow timing

Stream flow timing is sensitive to climate change, especially in snowmelt-dominated river systems such as those in the Canadian Columbia Basin. Studies generally discuss a trend toward earlier peak flows, which results in a longer period of low flows. Low summer stream flows mean less water is available for human use at the time of year when it is typically in highest demand. Low flows also result in higher water temperatures, which presents challenges for both ecosystems and water quality. While a trend toward earlier peak flows is present in the western Rockies of the U.S., the same changes have not yet been detected widely by streamflow monitoring in the Canadian Columbia Basin.

Moyie River above Noke Creek is the longest active hydrometric station near Cranbrook with similar physiographic characteristics as Joseph and Gold Creeks. No statistically significant trend in streamflow timing can be observed from this record. Since 1964, the average date of annual maximum discharge has been May 25, and September 12 has been the average date of late summer minimum discharge.[14] Since streamflow is highly complex and can vary significantly with the size, slope, and aspect of the watershed in question, the Moyie River dataset has limited comparative value for smaller Joseph and Gold Creeks.

Stream flow volume in late summer may be decreasing

Maximum daily discharge can be an indicator of flood risk, whereas minimum daily discharge can be an indicator of water supply constraints. The record for Moyie River shows decreasing late summer minimum flow volumes (Figure 7), but the trend is not statistically significant. The largest maximum discharge for the Moyie River occurred in November 1999 in response to a fall rain-on-snow event. The 1999 extreme flow event highlights the influence of rain-on-snow in these relatively low elevation watersheds which have the majority of their catchment below 2000m elevation. Projected climate change indicates more fall and winter rainfall that could lead to more frequent rain-on-snow driven flood events.

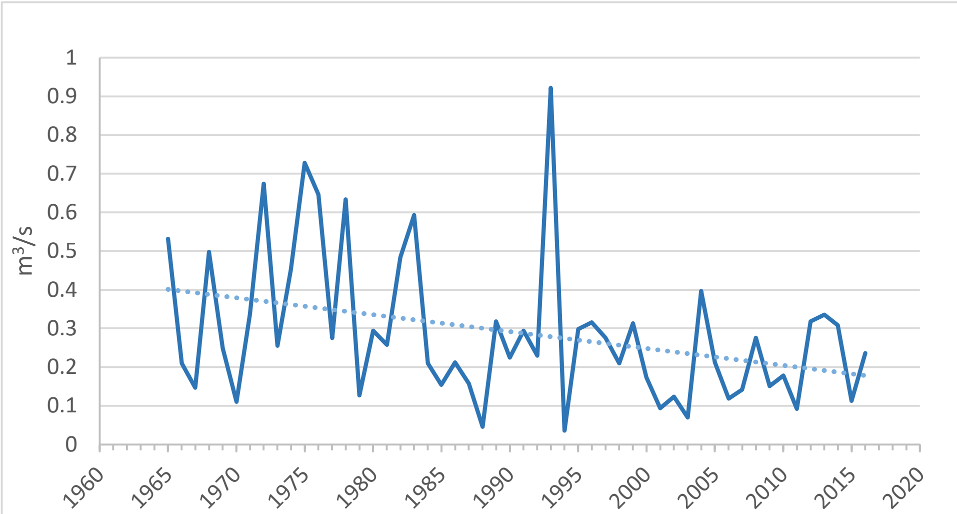


Figure 7: Late summer minimum daily discharge for Moyie River above Noke Creek. Note trend is not statistically significant.

Groundwater levels are lowest in late winter

The City of Cranbrook relies on Joseph and Gold Creek for its main water supply and supplements from three groundwater wells to meet higher summer water demand. The City monitors groundwater levels in all three wells. In addition, the Province of BC currently operates two groundwater observation wells in Cranbrook. Groundwater data shows groundwater levels are variable, and typically have an annual peak that corresponds with spring freshet and lowest levels occurring in late winter. Well logs for the two Provincial observation wells in Cranbrook indicate that the Quaternary sediments in the Rocky Mountain trench contain numerous aquifers and aquitards that likely limit the connectivity of surface water and groundwater. A third Provincial observation well situated in the valley of Gold Creek shows much clearer seasonal variability in water levels.

Source water temperature peaks between late July and early September

Temperature can be an important determinant of water quality. Health Canada's Guidelines for Canadian Drinking Water set 15ºC as an aesthetic objective for drinking water sources because higher temperatures indirectly affect health and aesthetics through impacts on disinfection, corrosion control and formation of biofilms in the distribution system. The Phillips Reservoir is used to store Cranbrook's source water. From September 2014 to November 2019, reservoir temperatures ranged from 0.56ºC to 18.3ºC. Reservoir water temperatures typically rise above 15ºC beginning in late July-early August and remain high until early to mid-September.

Source water turbidity increases during spring freshet

Higher turbidity can result in boil water notices or water quality advisories. Turbidity becomes a concern when it rises above 1 NTU. A turbidity reading between 1 and 5 NTU is considered fair quality, while a reading greater than 5 NTU indicates poor drinking water.[15] In 2018, Cranbrook's monthly averages for surface water in the Phillips reservoir ranged from 0.45 NTU in October to 0.80 NTU in May, averaging 0.67 NTU over the course of the year. Turbidity data from September 2014 to November 2019 shows an average of 0.73 NTU, with turbidity above 1 NTU most likely to occur during the spring freshet in late April and May.

Adaptation Actions and Capacity Building

Policies to reduce water consumption

The City of Cranbrook has implemented a range of water conservation measures, including water conservation targets, public education on water conservation, volumetric billing for a portion of industrial, commercial and institutional users (ICI), water operator training and moderate implementation of targeted leak repair. Table 5 provides insights on opportunities to strengthen policies and practices to reduce water consumption. Since 2010, per capita water consumption has ranged from approximately 609 to 652 litres per day and does not show any clear trend. Total annual municipal water use between 2014 and 2018 ranged from 4317 ML to 5308 ML and also does not show a trend.

Table 5: Implementation of policies to reduce water consumption in the City of Cranbrook

	Level of Implementation			
Policy/Practice	Full	Moderate	Minimal	None
Universal water metering	☐	☐	☑	☐
Public education and outreach on water conservation	☑	☐	☐	☐
Public education and outreach on water consumption trends	☐	☐	☑	☐
Water meter data analysis	☐	☐	☐	☑
Consumer billing by amount of water used (volumetric)[1]	☐	☑	☐	☐
Implementation of water utility rates sufficient to cover capital and operating costs of water system	☐	☑	☐	☐
Water conservation outcome requirements for developers	☐	☐	☐	☑
Water conservation targets	☐	☐	☑	☐
Stage 1 through 4 watering restriction bylaw[2]	☐	☐	☐	☑
Enforcement of watering restriction bylaw	☐	☐	☐	☑
Drought management plan	☐	☐	☑	☐
Actions to address water system leaks:				
Targeted leak repair	☑	☐	☐	☐
Water operator training	☑	☐	☐	☐
Replacement of aging mains	☑	☐	☐	☐
Addressing private service line leakage	☑	☐	☐	☐
Pressure management solutions	☑	☐	☐	☐

1. *ICI customers only.*
2. *Cranbrook has an Outdoor Water Management Policy and Procedure that sets out two phases of graduated outdoor water restrictions. It does include the full continuum of restrictions that would be found in a four-stage bylaw.*

Source water protection plan is in process

The City of Cranbrook recognizes the importance of including climate change considerations in long-term planning for its water supply, treatment, and distribution system. It is currently developing a comprehensive Drinking Water Quality and Supply Strategy that will address climate change projections related to source water protection, water supply planning, treatment, and water system asset management. The strategy will be completed in 2020.

Water loss detection practices on-going

The City of Cranbrook was a participant in the Columbia Basin Water Smart program from 2009 to 2015. The Water Smart program supported Basin communities to develop capacity for water loss detection. The City uses district meters, supplemented by night flow analysis and water loss audits as its main strategies for leak detection (Table 6). Estimated annual water loss between 2014 and 2018 ranged from 14 to 23%.

Table 6: Implementation of water loss detection practices in Cranbrook

	Level of Implementation			
	Full	Moderate	Minimal	None
District water meters	☑	☐	☐	☐
Residential water meters	☐	☐	☐	☑
Night flow analysis	☐	☑	☐	☐
Water loss audits	☐	☑	☐	☐
Acoustic leak detection	☐	☐	☑	☐
Leak noise correlation testing	☐	☐	☑	☐

Community Impacts and Adaptation Outcomes

Per capita water consumption above provincial average

This indicator measures water use attributable to user demand and system water loss. Due to its location and amenities, Cranbrook receives substantial daily and short-stay visitor traffic via highways #3, #93 and #93A. Peak day consumption, which normally occurs in July or August, is approximately triple the average daily consumption in winter months.[16] Total municipal water use per capita ranged from 609 to 652 litres per day between 2010 and 2018, whereas the provincial average is 494 litres per day.[17] Cranbrook water use shows a strong correlation with ambient air temperature, with per capita water use increasing by 39 litres per person per day with each 1ºC increase in air temperature over 15ºC.[18]

Drinking water quality is consistent

Water utilities are required to notify residents of high turbidity and/or the presence of pathogens in drinking water. The frequency of notices could increase with climate change due to potential changes in surface water quality associated with rising temperatures or more rapid runoff. Cranbrook relies primarily on surface water for its water supply, with peak demand supplemented by groundwater. Since 1992, Cranbrook's water supply had one blanket Water Quality Advisory issued by the Interior Health Authority in 2011 due to high turbidity, and two Boil Water Notices in 2016 and 2018 for a small and limited portion of the City's water system.

Watering restrictions

Watering restriction bylaws provide a tool for utilities to reduce their vulnerability to water supply challenges. By tracking the need to implement these restrictions, water operators can better understand how climate change is affecting supply and demand. The City of Cranbrook's *Outdoor Water Management Policy 60-20* designates watering times based on the physical address of water users and contains two stages of water restrictions that can be applied when warranted by weather and climate conditions or other system disruptions that make it necessary to conserve water for more essential uses. These restrictions are not enforced and lack the tighter restrictions typically found in four-stage watering restriction bylaws.

Water loss

On the basis of available data from 2014 to 2018, the City of Cranbrook's estimated annual water system leakage ranged from 14 to 23 per cent. Leak detection and repairs are on-going. The Columbia Basin Water Smart Summary Report states that leakage within most systems in the Columbia Basin is 30 to 40% and that this is typical of aging systems in developed nations, and particularly small rural systems.

FLOODING

Projected climate changes, including more intense rainstorms and warmer wetter winters, indicate a greater likelihood of flooding. Flooding affects communities through damage to homes and infrastructure and reduced water quality. Based on Cranbrook's 2018 NDMP Flood Risk Assessment[19], the more frequent, smaller storm events which cause frequent flooding within the City of Cranbrook appear to have the most impact. Larger storms seem to have only slightly higher consequence, therefore the events that overwhelm City infrastructure frequently are considered most impactful. This report deemed that the risk of fatalities or injuries and impacts to transportation would be at the lowest risk rating possible. While frequent and localized flooding can occur, the impact is relatively minimal due to the lower flow volumes, depths and velocities experienced in the smaller creeks and waterways within the City, and could be appropriately addressed by flood prevention and mitigation actions.[20] As Cranbrook uses groundwater to supplement its drinking water supply, consideration must be given to the protection of the aquifer from surface and soil-based contaminants mobilized by flooding events. Cranbrook is in the process of installing climate and stream monitoring stations to more closely monitor local micro-climate and weather impacts on streams. This is a key step in building its capacity for real-time flood response reporting.

The Overall Picture

Cranbrook has already experienced winter rain-on-snow and spring flood events in recent years. The trend toward higher winter and spring precipitation may drive more rapid snowmelt, increasing the likelihood of flooding in the low elevation watersheds of Joseph Creek and Hospital Creek. Trends in spring snowpack are too weak to determine if this factor may partially mitigate flood risk. Cranbrook has been active in both flood prevention and mitigation, having recently completed several projects, and more are in planning stages. Floodplain maps are in the process of being updated, and with the recent addition of streamflow monitoring and climate stations on local creeks, Cranbrook will have a more accurate understanding of current and future flood risk to inform and guide adaptation efforts.

Climate Changes

As discussed in the Climate and Extreme Weather sections, the analysis of historical precipitation data shows increases in annual and spring precipitation. Projections for the 2050s show increases in annual, winter and spring precipitation, as well as more extreme precipitation.

Freeze-thaw cycles have increased but are projected to decrease

The frequency of freeze-thaw cycles is an important parameter for engineering design in cold regions. It has been calculated as the number of days with temperature fluctuations between -2ºC and +2ºC. The historical data for Cranbrook covers 1901 to 2018 and indicates an upward trend in annual freeze-thaw cycles of 5.1 days per century, and in winter freeze-thaw cycles of 14.7 days per century. Future trends through the 2050s, however, are projected to change direction, with the number of annual days with freeze-thaw cycles dropping from 90.5 in the 1961-1990 baseline period to 64.4 by the 2050s in a high carbon scenario and 70.1 in a low carbon scenario.

Environmental Impacts

Streamflow is sensitive to rainfall

Discharge gauging undertaken by the City of Cranbrook on Joseph Creek and Gold Creek indicates that streamflow rises rapidly in early April in response to warming temperatures. Discharge can remain elevated for several weeks during the spring freshet and often there are several peak flow events during this period in response to fluctuating daily temperatures. While the freshet peaks are driven primarily by warming temperatures, numerous smaller peak events from late spring to fall highlight the rapid response of stream flow to rainfall events in these streams. This suggests that increased frequency and/or volume of rainfall during the spring freshet could contribute to an increased frequency of flooding in Joseph and Gold Creeks.

No trends are apparent in the timing or magnitude of the annual maximum flows in the Moyie River, which is used as a proxy for Joseph and Gold Creeks. An analysis of flood frequency on Moyie River shows that the largest floods (i.e. >10yr return period) have become more common for the post-1990 28-year subset of peak flows compared to the pre-1990 subset of peak flows although this is within the 95% confidence limits around the pre-1990 frequency curve (Figure 8). A longer period of discharge gauging is needed to determine if this trend in changes in the frequency of flooding is related to long-term changes in climate.

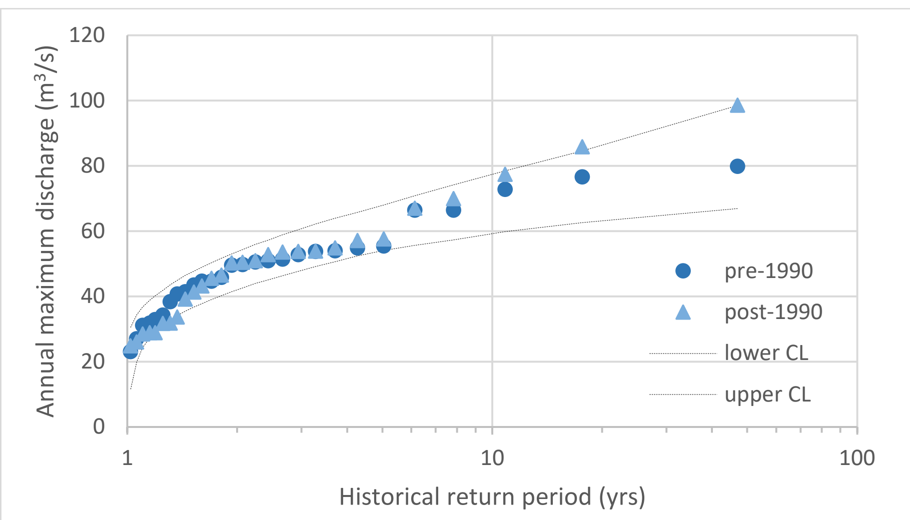


Figure 8: Historical flood return frequency for the Moyie River

Projected climate trends to warmer, wetter winter and spring weather could contribute to an increase in the occurrence of rain-on-snow flooding in the low elevation watersheds of the Southern Purcell Mountains. Although the largest flood on record for Moyie River (November 1999) was caused by a fall rain-on-snow event, a more detailed analysis is needed to determine if rainfall has contributed more substantially to the elevation of the post-1990 frequency distribution.

April 1st snowpack may be declining

Snowpack data provides an indication of the amount of snow available to contribute to water supplies and flooding. Cranbrook relies mostly on small snow-and-rain-dominated surface water sources for its water supply that are sensitive to snowpack variability. Rates of change in April 1st snow water equivalent (SWE) at the nearest snow stations – BC Environment's Moyie Mountain station (elevation 1930 m) and Kimberley Mid and Upper stations[21] (elevations 2140 and 1630 m) – do not show any statistically significant trends in April 1st snowpack since 1969 (Figure 9), however, there is some indication of a small downward trend. The record shows significant variability in SWE at the higher elevation locations, from a low of 170 mm in 1977 to a high of 747 mm in 1974 at Moyie Mountain, averaging 425 mm.

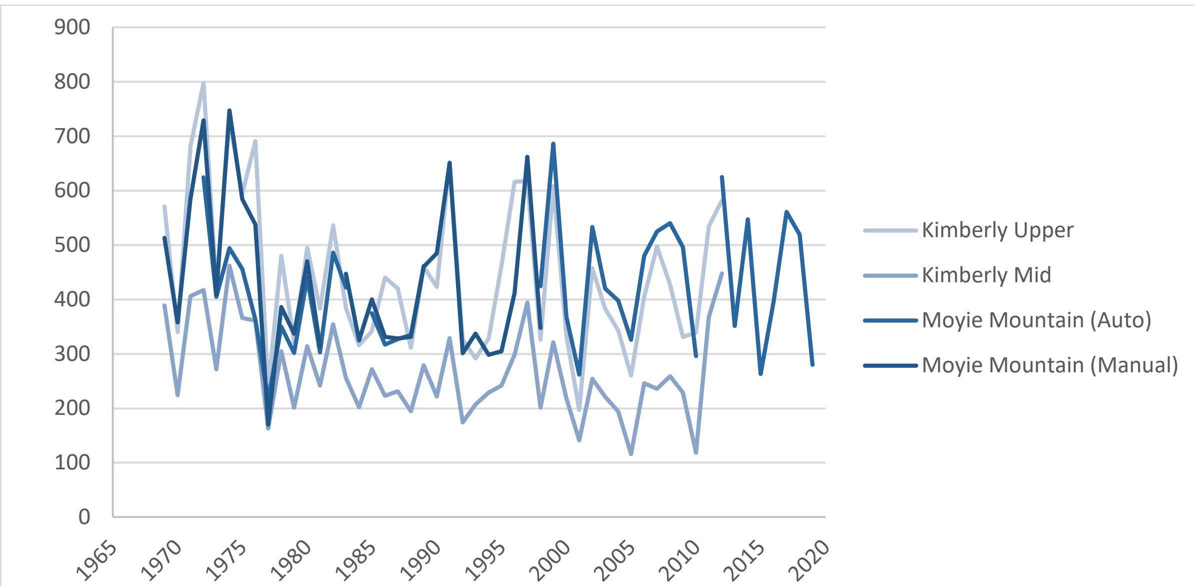


Figure 9: April 1st snowpack at Moyie Mountain and Kimberley stations

Adaptation Actions and Capacity Building

As discussed in the Extreme Weather section, the City of Cranbrook has an Emergency Preparedness Plan in place with several components being reviewed and updated. The City is currently undertaking a major project to update its floodplain mapping using new flood models.

Floodplain mapping

In summer 2019, the City of Cranbrook received funding from the federal National Disaster Mitigation Program (NDMP) to update existing floodplain maps from the 1980s. By collecting and applying LiDAR data, the project will generate a detailed flood model for Cranbrook and pinpoint locations in the community where water will collect under different flood conditions (up to a 1-in-200-year flood), modelling both water depth and velocity of flow. The new floodplain mapping will position Cranbrook to more effectively prioritize projects that mitigate flood risk and protect critical infrastructure.

Flood protection expenditures

Information on spending related to flood protection infrastructure provides some measure of a local government's efforts to improve their resilience to climate change. Cranbrook's flood risk is more appropriately managed by flood prevention and mitigation efforts than flood protection infrastructure. For over five years, the City has budgeted $250k-$300k annually for creek and drainage repairs to improve and maintain creek channel conditions and alleviate localized flooding. In addition, the City recently completed two major flood mitigation and stormwater capacity upgrades in locations that experienced routine flooding, infrastructure and property damage, spending $1.3M on Cobham Ave upgrades in 2018 and $0.7M on Kootenay St upgrades in 2019. A further $0.75M flood mitigation project is scheduled for 2020 that will involve creek channel capacity and armouring upgrades.

Community Impacts and Adaptation Outcomes

Provincial emergency assistance for flooding

Monitoring emergency assistance funding issued by the province can provide some measure of the economic impact of a disaster and associated recovery over time. The City of Cranbrook experienced flooding in 2014 that resulted in provincial emergency assistance of $139,225.

Dwellings in the floodplain

According to Cranbrook's current floodplain mapping, there are 1245 parcels in the floodplain area. The majority of these parcels are developed residential and commercial properties, along with some institutional properties and recreational lands (parks). Updated floodplain mapping will provide a more accurate assessment of current and future flood risk to existing properties and will inform future development policies and practices to mitigate or reduce local flood risk.

Flood-related highway closures

Since the provincial government began recording highway event data in 2006, there have been 25 events affecting highways in and out of Cranbrook. Five were caused by mudslides. Total highway closure time for these five events was 29 hours[22].

AGRICULTURE

Climate has a significant, but complex, impact on food growing activities, with some projected climate changes expected to increase productivity and others reducing it. Climate change also has the potential to negatively affect food production in other parts of the world, which means that locally produced food and local food self-sufficiency could become important climate adaptations in the coming years. The Agriculture Pathway tracks the climate-related viability of local food production, the impact of climate change on agricultural activity, and the degree to which farmers and backyard growers are prepared to deal with climate change.

The Overall Picture

A trend toward higher temperatures is influencing the growing climate in the region, with the Cranbrook area experiencing warmer seasonal temperatures and more growing degree days than in the past. Notably, however, higher temperatures have not been accompanied by a significant change in the length of the growing season. Continued monitoring of drought levels will help planners understand how a trend toward lower summer precipitation levels is affecting agricultural viability, water demand, and local food production. While the number of Cranbrook residents engaged in backyard gardening shows local enthusiasm for food self-sufficiency, backyard garden produce is typically less than ten per cent of annual household consumption. Cranbrook leases out 650 ha of land that is part of its spray irrigation lands to five local ranchers who use it to graze cattle and grow forage crops. These lands produce an average of 3,600 tonnes of hay per year, 1,500 head of market cattle producing as much as 750,000 pounds of beef, and help support 82 local businesses (2010 data). The hay, pasture and beef have a value of more than $1.5 million annually. On-site soil and climate monitoring is generating data beneficial to producers in the wider region.

Climate Changes

As discussed in the Climate and Extreme Weather sections, average annual and seasonal temperatures are increasing, as is annual and spring precipitation. While Cranbrook has not yet seen a significant upward trend in extreme precipitation, projections show it increasing, along with more precipitation in winter and spring. Summer precipitation is projected to decrease, and both the frequency of extreme heat day is also on the rise.

Environmental Impacts

Drought record too short to infer a trend

The BC drought index is comprised of four core indicators: Basin snow indices; seasonal volume runoff forecast; 30-day percent of average precipitation; and 7-day average streamflow. This data set is too short to infer any kind of trend; however, it will eventually contribute to creating a baseline against which future conditions can be assessed. Cranbrook is situated in the East

Kootenay region. From 2015 to 2018, this region experienced an average of 96 “dry days” based on an average sampling season of 150 days, with a low of 70 dry days in 2016 and a high of 133 dry days in 2018[23].

Length of the growing season projected to increase

A longer growing season[24] allows for a greater diversity of crops (especially crops requiring longer days to maturity), greater flexibility in early planting avoiding late summer drought, and more time for plant growth. Some communities in the Columbia Basin are already experiencing a longer growing season.[25] Historical data for Cranbrook (1901-2018) shows a small increasing trend in growing season length of +9 days per century, but it is not statistically significant. During the 1961 to 1990 period, Cranbrook’s growing season length averaged 193 days, and it is projected to increase to between 221 to 227 days by the 2050s. By the 2050s, the trend in growing season length is projected to jump to +36 and +50 days per century under low and high carbon scenarios, respectively.

Growing degree days are increasing

Growing degree days[26] describe the amount of heat energy available for plant growth and provide better insight on how plants are affected by temperatures than straight temperature data. Growing degree days in Cranbrook (1901-2018) are currently increasing at a rate of 244 growing degree days per century. By the 2050s, growing degree days are projected to increase by 568.5 and 731.2 for the low and high carbon scenarios, respectively, from a 1961-1990 baseline of 1638.4 growing degree days (Figure 10).

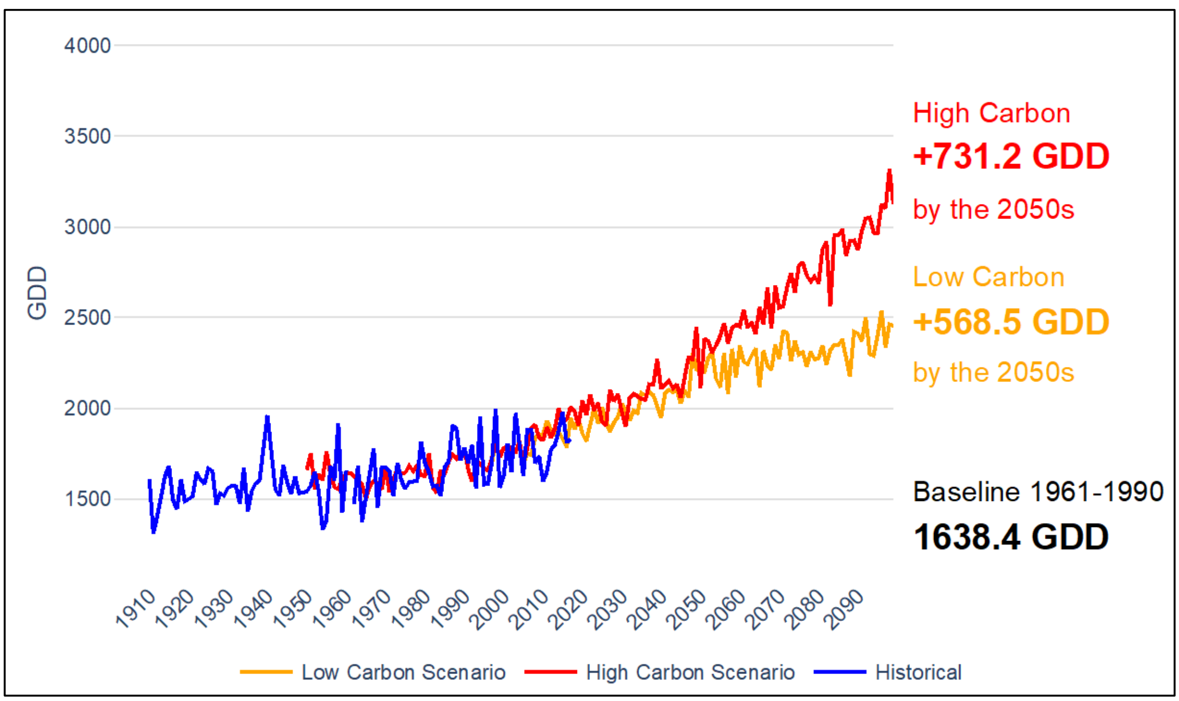


Figure 10: Growing degree days in Cranbrook

Consecutive dry days

The average annual maximum number of consecutive dry days for Cranbrook has been declining since 1909 at a rate of -10 days per century. During the 1961 to 1990 period, Cranbrook's annual maximum number of consecutive dry days was 22 days. In contrast to the declining trend in historic data, the annual maximum number of consecutive dry days is projected to increase by 0.6 to 2.7 days by the 2050s under low and high carbon scenarios, respectively.

Adaptation Actions and Capacity Building

Many residents grow some of their own food

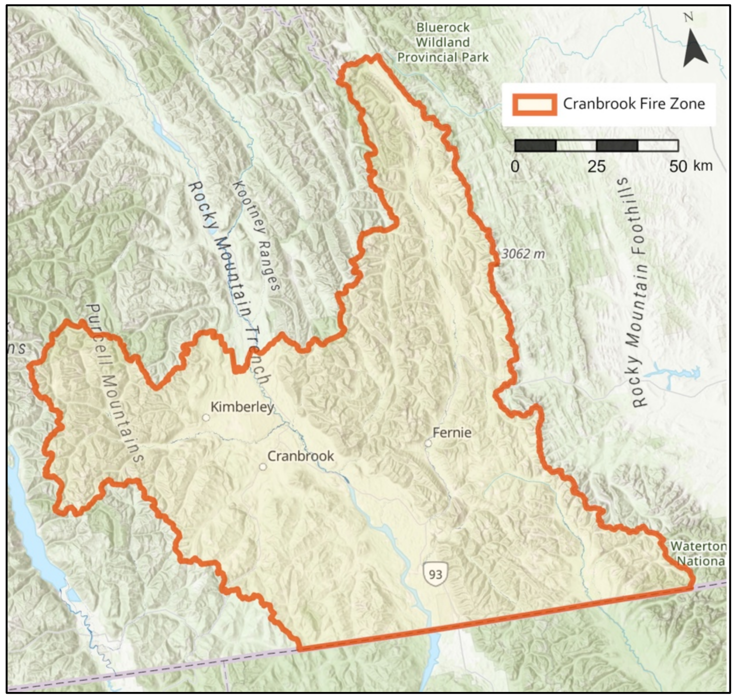
Backyard gardening of edible crops is an indicator of local self-sufficiency and food security. A voluntary survey of Cranbrook residents conducted in the summer of 2019 found that 68% (175 of 258 respondents) grow some of their own food, primarily in home garden plots ranging from less than 5 square feet to over 300 square feet (Table 7). The majority of gardeners (71%) reported growing between 1-10% of their total food intake. Most home gardeners reported growing vegetables, and many also reported having fruit trees, berry patches, and herbs. Some of the most popular items are cucumber, zucchini, beans, beets, strawberries, onions, herbs, lettuce, and tomatoes. Composting was quite common among residents with 74% indicating they compost food scraps and garden waste and 72% indicating they use that compost in their food gardens.

Table 7: Area under cultivation (excluding fruit trees and berry patches) by growers in Cranbrook.

Area	% of respondents	# of respondents
Less than 5 square feet	12.1	20
5-15 square feet	12.1	20
15-30 square feet	6.7	11
30-50 square feet	9.1	15
50-100 square feet	17.0	28
100-200 square feet	19.0	31
200-300 square feet	7.3	12
More than 300 square feet	17.0	28

WILDFIRE

Wildfire can cause serious damage to community infrastructure, water supplies, and human health. It can also result in the evacuation and relocation of people and animals. It is projected that climate change will increase the length of the wildfire season and the annual area burned by wildfire due to warmer, drier summers. The Wildfire Pathway tracks fire risks and impacts on communities as well as adaptation actions being undertaken by communities. Cranbrook is situated in the Cranbrook Fire Zone, which falls within the boundaries of BC's Southeast Fire Centre.



The Overall Picture

Wildfires are becoming more frequent at regional and national scales and studies generally suggest that this trend, along with a trend to more area burned, will continue. Local-scale data relating to wildfire frequency and size does not show reliable trends but provides a baseline for future assessments. The active wildfire seasons experienced in 2017 and 2018 highlight the social and economic impacts of fire due to fire bans, evacuation notices and alerts, and road closures. Fuel treatment of Cranbrook's wildland urban interface (WUI) has been an issue due to Crown tenure; however, the City is actively taking steps to prepare for increased fire risk by completing fuel treatments on its own municipal lands, engaging in partnerships for fuel treatments on Crown lands in the WUI, and by undertaking public education on FireSmart principles and the need for extensive WUI fuel treatment at the landscape level.

Climate Changes

High fire danger has averaged 52 days per year

The BC Wildfire Service establishes wildfire danger ratings using the Canadian Forest Fire Danger Rating System. The number of days in the high and extreme danger classes provides an indication of how weather and water availability are influencing fire risk. From 2001 to 2019, the Cranbrook fire weather station recorded an average of 52.2 days per year at a danger rating of high or above. The highest number of days at a high danger rating or above occurred in 2017 with 109 days (Figure 11). No significant trends can be observed in the data at this time. This may be due in part to the relatively short periods of record and large annual variability in fire danger.[27]

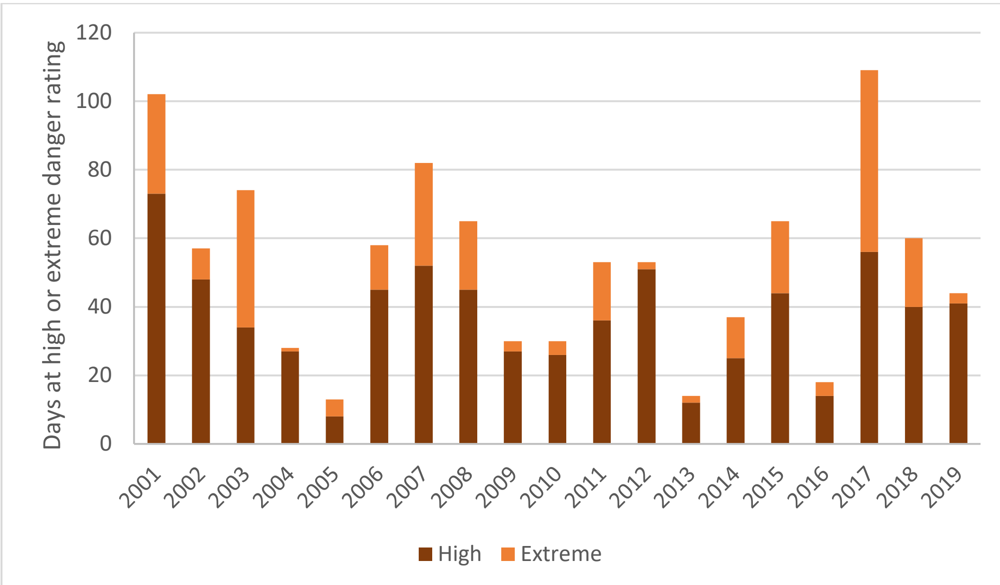


Figure 11: Annual number of days with high or extreme fire danger rating at the Cranbrook fire weather station

Environmental Impacts

Air quality lacked daily monitoring until 2018

The air quality indicator reports daily concentrations of fine particulate matter ($PM_{2.5}$) in the air, which can be strongly influenced by wildfire events. High $PM_{2.5}$ concentrations can have significant impacts on human health.[28] There is currently not enough data available from Cranbrook's air quality monitoring station to provide an analysis of $PM_{2.5}$. The nearest stations are in Golden and Castlegar, which are too distant to provide insight on Cranbrook's air quality. A new 24-hour $PM_{2.5}$ monitoring station was installed in Cranbrook in late summer 2018. This will provide useful data moving forward, as prior monitoring was limited to one sample every six days, which can only provide limited insight on climate-induced trends.[29]

In 2017, the BC Ministry of Environment implemented a Smoky Skies Advisory service to advise communities when they may be affected by wildfire smoke. This predictive smoke modeling initiative does not serve as a substitute for a local $PM_{2.5}$ monitoring station but does provide communities with a smoke forecast. In 2017 and 2018 the East Kootenay-South region was under a Smoky Skies Advisory for 41 and 49 days respectively.[30]

No trend in area burned, but extremes are increasing

This indicator provides a direct measure of how much fire is occurring on a specific landscape. Since the onset of provincial wildfire suppression efforts in the mid-1900s, no statistically significant trend can be observed in the annual area burned in the Cranbrook Fire Zone, or the Southeast Fire Centre region. The annual area burned is highly variable and appears to follow a pattern of severe fires seasons occurring roughly every 10 to 15 years.[31] The area burned during severe fire seasons shows an apparent increase at the regional scale, but this is not detected by statistical trend analysis (Figure 12).

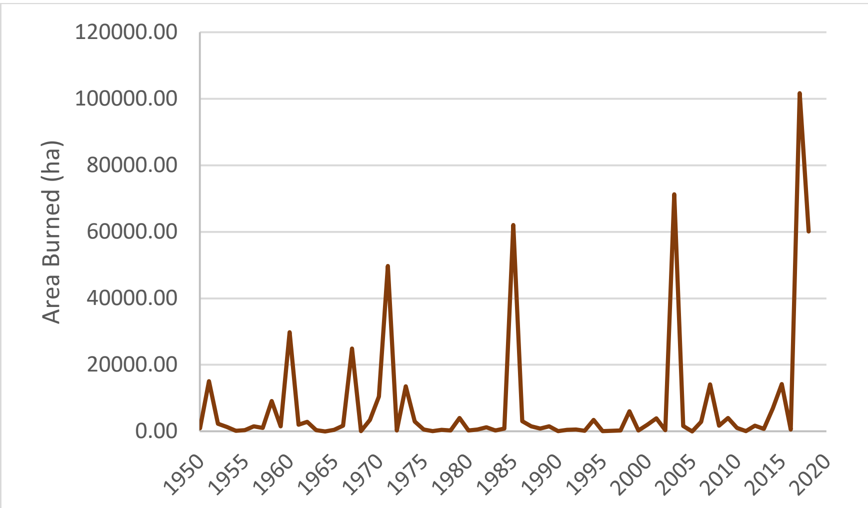


Figure 12: Annual area burned in the Southeast Fire Region

The Cranbrook Fire Zone experienced its most severe wildfire seasons in 1960, 2003, 2017 and 2018. The worst fire season since 1950 in terms of area burned occurred in 2017, with over 40,000 hectares of forest burned in the Cranbrook Fire Zone.[32] This is roughly twice the area burned in 2003, which is the second-worst year on record.

A significant upward trend is present in the number of fires in the Southeast Fire Centre region that grew larger than 1 ha in size (Figure 13). This aligns with recent reports that BC's fire seasons are becoming more extreme as a result of climate change.[33]

Changes in the size of wildfire may reflect changes in forest management practices as well as changing climate conditions. The value of fire as a natural disturbance regime has been more recognized in recent years, and in some cases, forest managers may be allowing wildfires to grow larger now than any time since the 1950s.[34] Improved data quality and fire mapping in later years may also be influencing this trend.

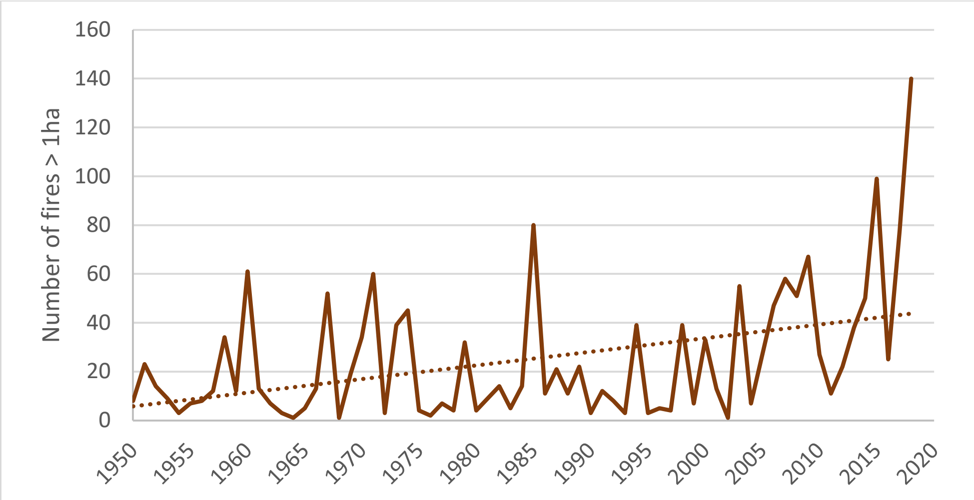


Figure 13: Fires > 1 ha in the Southeast Fire Centre region, 1950-2018

Fewer human-caused fires

This indicator tracks the total number of human-caused and lightning-caused wildfire starts per year. Since the mid-1900s, there is no statistically significant trend in the total number of wildfires starts annually in any part of the Southeast Fire Centre region. All fire zones in the Southeast Fire Centre show significant decreases in human-caused fires since 1950. There are no trends in lightning-caused fire starts over the 68-year recording period within the Cranbrook Fire Zone. This is typical of most of the areas analyzed in the Southeast Fire Centre.[35]

Two factors may be affecting the identification of trends in the analysis. One is the small geographic scale of the datasets, which may not represent changes in weather patterns that take place over a large geographic area. The second is an issue with data reporting standards, which changed in the late 1990s to exclude suspected fires and smoke traces. This may overinflate estimates of fire starts in earlier years.[36]

The ratio of fires caused by humans vs. lightning can be influenced by both climate and human activities. Historically, about two-thirds of wildfires are lightning-caused. This is true for most areas in the Southeast Fire Centre. The Cranbrook Fire Zone is an exception to this as over half of historic wildfire starts have been human-caused. This is also true for Cranbrook's municipal interface area (all areas within two kilometres of Cranbrook's municipal boundaries). However, this pattern is typical around municipalities, as most human-caused fires tend to occur near populations centres. Both the Southeast Fire Centre and the Cranbrook Fire Zone have seen significant declines in human-caused fires over time and records from recent years show lightning as the dominant cause of wildfires. On average, there are 9 wildfire starts per year within two kilometres of Cranbrook, but this is also decreasing.

Adaptation Actions and Capacity Building

Limited interface fire fuel treatments

Fire risk reduction in the WUI (Figure 14) involves assessing and treating high-risk areas to reduce wildfire risk. The City of Cranbrook has a Forest Estate Plan that serves as a community wildfire protection plan (CWWP), and the Regional District of East Kootenay has a CWWP for Area C that addresses lands surrounding Cranbrook. Both documents include mapping and assessment of WUI areas and identification of priority areas for treatment. A significant portion of Cranbrook's WUI lands are Crown lands, and the City has taken the view that the Province is responsible for managing wildfire risk on these lands. The City has successfully treated approximately 10% of its high-risk areas. BC Timber Sales will be logging 105 ha of Crown land east of Cranbrook in winter 2020 to reduce the amount of forest fuel and help lower wildfire risk. RDEK also recently obtained funding to conduct landscape-level interface work that includes the Cranbrook interface area.

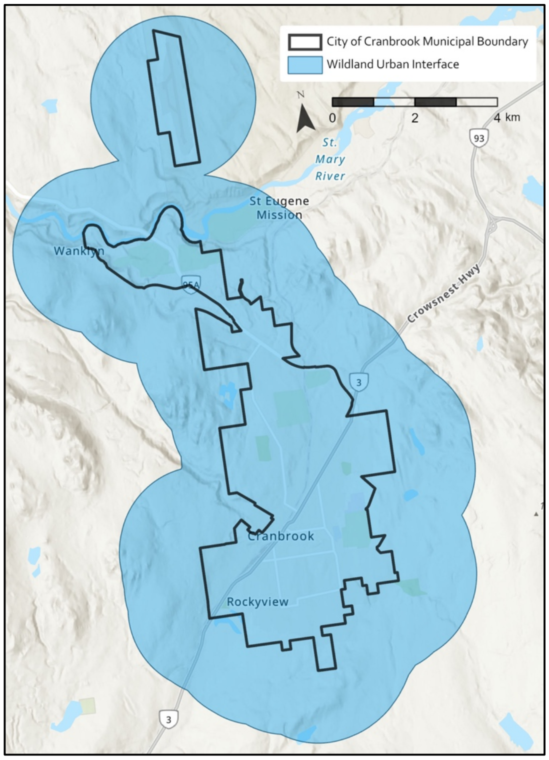


Figure 14: Cranbrook wildland urban interface fire map showing 2 km buffer

Fire Smart principles

This indicator reports on the number of neighbourhoods recognized through Fire Smart Canada's Community Recognition Program, providing a measure of citizen involvement in reducing the risk of wildfire to their homes. For communities that do not currently administer a Fire Smart program, this indicator considers policies and initiatives that contribute to a community being Fire Smart in practice. While Cranbrook does not have any Fire Smart-recognized neighbourhoods, the City of Cranbrook's Official Community Plan has designated Wildfire Hazard Development Permit Areas. To date, the City has typically conducted Fire Smart information campaigns in spring and fall, including media releases, with information for residents on its website, and has observed low uptake. The City's current focus is engaging community support to complete high priority wildland urban interface fuel treatments at the landscape level. It has applied for funding to conduct in-depth community Fire Smart education and awareness including community meetings and homeowner visits in the most directly affected areas. It is working closely with RDEK on these actions.

Community Impacts and Adaptation Outcomes

Frequency of interface fires averages less than one per year
This indicator measures the annual number of wildfires that come within two kilometres of address points. Since 1950, Cranbrook has experienced 7 interface fires that grew to greater than 1 hectare in size.[37] These fires were generally small with only one exceeding 50 ha in 1963. Fire prevention education remains important as most human-caused fires occur near communities.

One fire-related highway closure in 2017
There are three records of fire-related highway closure affecting Cranbrook in the last 13 years. The longest occurred in October 2017 near Sparwood and closed Highway 3 for 16 hours. Other closures occurred in 2008 and 2014 near Fort Steele and Kimberley, respectively, and lasted for less than 8 hours. The analysis is limited as DriveBC records begin in 2006.[38]

Annual days under campfire ban is highly variable
This indicator tracks the number of days annually for which the BC Wildfire Service has issued a campfire ban for the Southeast Fire Centre. It provides a measure of the social cost of the increasing wildfire risk that is projected to accompany climate change. Since 2000, there have been eight years with campfire bans in the Cranbrook Fire Zone. The longest fire ban was in 2017 at 77 days.[39] Long term tracking of this indicator is necessary to establish a trend.

Annual cost of fire suppression
The average annual cost of fire suppression in the Cranbrook Fire Zone from 1970-2019 was $1.91million, peaking at $21.07 million in 2003 and falling as low as $2,190 in 1976[40]. Costs of fire suppression will vary from year to year and are influenced significantly by prevailing weather conditions. The dataset shows an upward trend over the period of record (Figure 15); however, given that reported values are not corrected for inflation, the true direction and magnitude of this trend cannot be assessed.

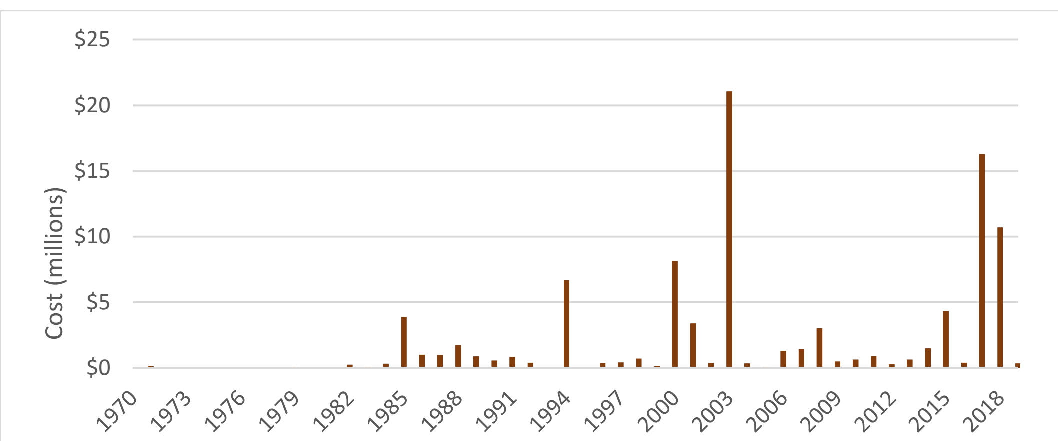


Figure 15: Annual cost of fire suppression in the Cranbrook Fire Zone. Data values from the 1970s are generally too small to show on the scale needed to show data from recent years.

NEXT STEPS

Action Areas

Assessment results indicate that Cranbrook has initiated important steps to improve its adaptive capacity. Seven areas for further consideration are evident in the data:

- **Wildfire risk reduction**. The City has identified several potential measures to reduce interface fire risk and address priority fuel treatment areas. A reluctance to assume responsibility for the management of wildfire risk on crown land has been a barrier to fuel treatments until recently, and this is now shifting as the Province becomes more engaged. Public engagement and education around wildfire risk by the City will increase support for landscape-level fuel treatment and help Cranbrook residents advance their own contributions to risk reduction in the wildland-urban interface. The City will also benefit from undertaking the province's new Community Wildfire Resiliency Planning process.
- **Water conservation.** Both Joseph and Gold creeks are sensitive to precipitation levels. Late summer low flows are already showing evidence of a declining trend. Cranbrook still has a relatively wide range of untapped opportunities and options to increase water conservation and reduce overall water consumption.
- **Emergency preparedness plan.** The plan will benefit from a review and update on risks and hazards associated with climate change and extreme weather, and the creation of hazard-specific plans. Disaster recovery and resilience will be enhanced through the adoption of a municipal business continuity plan.
- **Personal and household emergency preparedness**. Encouraging emergency preparedness among residents would help foster resilience to the types of extreme weather events that are expected to increase with climate change. Local governments have an important role to play in personal emergency preparedness as they are often the 'front line' for residents when disaster strikes. Preparedness begins with a 72-hour emergency kit, but can also include household level actions to reduce the risks of extreme weather and a changing climate.
- **Urban trees.** The combination of historical and projected climate changes will increasingly cause stress to urban trees and forests as the local bioclimatic regime changes. Trees under stress are more susceptible to damage by high winds, freezing rain, heavy snowfalls, drought, floods, disease, and insects. Fallen trees and branches are already the leading cause of power outages. Urban tree care practices, and procedures for identifying and addressing "danger trees" may warrant review and new approaches.
- **Vulnerable populations**. The elderly, chronically ill and the very young are more vulnerable to poor air quality events and extreme heat events. Publicly accessible buildings or refuges are a relatively new idea in most jurisdictions and rural communities may have few locations if any that would be suitable to act as a clean air shelter. While

this is not a lead responsibility for local governments, they can play a supportive role in establishing these facilities.

- **Official Community Plan**. As Cranbrook approaches the update and renewal of its Official Community Plan (OCP), this provides a timely opportunity to identify and incorporate climate-resilient policies that reflect and address the risks and challenges associated with a changing climate.

Future Assessments

Though some SoCARB indicators will be monitored on an annual basis, it is recommended that the next full assessment be conducted in five years (2025). Various SoCARB indicators are also tracked as part of the State of the Basin initiative, which means substantial data may be available through the RDI.

REFERENCES

[1] United Nations Framework Convention on Climate Change. (2019). *The Paris Agreement*. Retrieved from https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

[2] Knutti, R., Rogelj, J., Sedláček, J. et al. (2016). A scientific critique of the two-degree climate change target. *Nature Geoscience, 9*, 13–18. doi:10.1038/ngeo2595

[3] Pacific Climate Impacts Consortium. (n.d.). *Statistically downscaled GCM scenarios - BCCAQv2*. Retrieved from https://data.pacificclimate.org/portal/downscaled_gcms/map/

[4] Taylor, K.E., Stouffer, R.J., and Meehl, G.A. (2012). An overview of CMIP5 and the experiment design. *Bulletin of the American Meteorological Society, 93*, 485–498. doi:10.1175/BAMS-D-11-00094.1

[5] Werner, A.T. and Cannon, A. J. (2016) Hydrologic extremes – an intercomparison of multiple gridded statistical downscaling methods. *Hydrololgy and Earth System Sciences, 20*, 1483-1508. doi:10.5194/hess-20-1483-2016

[6] Government of British Columbia. (2018). *Addressing the new normal: 21st century disaster management in British Columbia*. Retrieved from https://www2.gov.bc.ca/assets/gov/public-safety-and-emergency-services/emergency-preparedness-response-recovery/embc/bc-flood-and-wildfire-review-addressing-the-new-normal-21st-century-disaster-management-in-bc-web.pdf

[7] Environment and Climate Change Canada. (2019). *Historical daily data.* Retrieved from https://climate-change.canada.ca/climate-data/#/daily-climate-data

[8] Ibid.

[9] BC Ministry of Transportation and Infrastructure. (2019). *Drive BC historical highway closure* [custom data request].

[10] BC Hydro. (2019). *Historical power outage data* [custom data request].

[11] City of Cranbrook. *Waterworks Bylaw No. 2785, 1986*. Consolidated, 2016.

[12] Columbia Basin Trust. *Glaciers in the Canadian Columbia Basin: A Summary*. September 2019. Retrieved from https://ourtrust.org/wp-content/uploads/downloads/Glacier_PlainLanguageSummary_smallerfile.pdf

[13] Ibid.

[14] Environment and Climate Change Canada. (2019). Historical Hydrometric Data. Available at: https://wateroffice.ec.gc.ca/index_e.html

[15] Interior Health Authority. (n.d.). *Turbidity education and notifications campaign*. Retrieved from: https://www.interiorhealth.ca/YourEnvironment/DrinkingWater/Documents/turbidity.pdf

[16] Columbia Basin Trust (April 2016). *City of Cranbrook Water Smart Action Plan*.

[17] UBC School of Community and Regional Planning (2016). *BC Municipal Water Survey 2016*. Retrieved from http://waterplanninglab.sites.olt.ubc.ca/files/2016/03/BC-Municipal-Water-Survey-2016.pdf

[18] Columbia Basin Trust (April 2016). *City of Cranbrook Water Smart Action Plan*.

[19] McElhanney Consulting Services Ltd. *City of Cranbrook Flood Risk Assessment*. (2019).

[20] City of Cranbrook. (27 January 2020). *Flood risk*. [Personal communications].

[21] Data record for Kimberley Upper and Mid ends in 2012.

[22] BC Ministry of Transportation and Infrastructure. (2019). *Drive BC historical highway closure* [custom data request].

[23] BC Drought Information Portal. (2019). *Historical drought information.* Retrieved from https://governmentofbc.maps.arcgis.com/apps/MapSeries/index.html?appid=838d533d8062411c820eef50b08f7ebc

[24] For the purposes of this report, growing season is defined as the number of days annually between the first and last five consecutive days with a mean temperature of 5ºC.

[25] See: http://datacat.cbrdi.ca/sites/default/files/attachments/Trends_Analysis_Growing_Season_Fall_2014.pdf

[26] For the purposes of this report, growing degree days was calculated by multiplying the number of days that the mean daily temperature exceeds 5 C (average base temperature at which plant growth starts) by the number of degrees above that threshold. Studies often use different definitions of growing degree days; therefore, caution should be exercised when comparing these results to other research.

[27] BC Wildfire Service. (2019). Daily fire weather danger ratings [custom data request]

[28] BC Center for Disease Control. (2019). Wildfire Smoke and Your Health. Available at: http://www.bccdc.ca/resource-gallery/Documents/Guidelines%20and%20Forms/Guidelines%20and%20Manuals/Health-Environment/BCCDC_WildFire_FactSheet_CompositionOfSmoke.pdf

[29] BC Ministry of Environment. (2019). *BC Air Data Archive*. Available at: https://envistaweb.env.gov.bc.ca/

[30] BC Ministry of Environment. (2019). *Smokey Sky Advisories* [custom data request].

[31] BC Data Catalogue. (2019). *Fire Perimeters – Historical.* Available at: https://catalogue.data.gov.bc.ca/dataset/fire-perimeters-historical

[32] Ibid.

[33] Environment and Climate Change Canada. (2019). Canada's scientists conclude that human-induced climate change had a strong impact on forest fires in British Columbia. Available at: https://www.canada.ca/en/environment-climate-change/news/2019/01/canadas-scientists-conclude-that-human-induced-climate-change-had-a-strong-impact-on-forest-fires-in-british-columbia.html

[34] BC Wildfire Service. (July 19, 2019). *Fire behavior in the Southeast Fire Centre* [personal communication].

[35] BC Data Catalogue. (2019). Fire Incident Locations – Historical. Available at: https://catalogue.data.gov.bc.ca/dataset/fire-incident-locations-historical

[36] Ibid.

[37] Ibid.

[38] BC Ministry of Transportation and Infrastructure. (2019). Drive BC Highway Closure Events [custom data request.]

[39] BC Wildfire Service. (2019). Historical Campfire Prohibitions – Southeast Fire Centre [custom data request].

[40] BC Wildfire Service. (2019). *Annual cost of fire suppression – Southeast Fire Centre.* [custom data request].