State of Climate Adaptation

City of Nelson

July 2020

COLUMBIA BASIN RDI RURAL DEVELOPMENT INSTITUTE Selkirk College

City of NELSON

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Columbia Basin Rural Development Institute

- Jayme Jones
- Ingrid Liepa
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ACROYNMS

AHCCD	Adjusted and Homogenized Canadian Climate Data
ALR	Agricultural Land Reserve
BWN	Boil Water Notice
CL	Confidence Level
CMIP5	Coupled Model Intercomparison Project Phase 5
GDD	Growing Degree Days
GIS	Geographic Information Systems
DPA	Development Permit Area
EMBC	Emergency Management British Columbia
EOC	Emergency Operations Centre
GCM	Global Climate Model
IHA	Interior Health Authority
NTU	Nephelometric Turbidity Units
OCP	Official Community Plan
$PM_{2.5}$	Fine Particulate Matter
RCP	Representative Concentration Pathways
RDCK	Regional District of Central Kootenay
RDI	Columbia Basin Rural Development Institute
SoCARB	State of Climate Adaptation and Resilience in the Basin
SWE	Snow Water Equivalent
UBCM	Union of British Columbia Municipalities
WQA	Water Quality Advisory
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 Nelson 2020 baseline report for the State of Climate Adaptation and Resilience in the Basin (SoCARB) indicator suite. SoCARB indicators were designed by a team of climate change professionals 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.

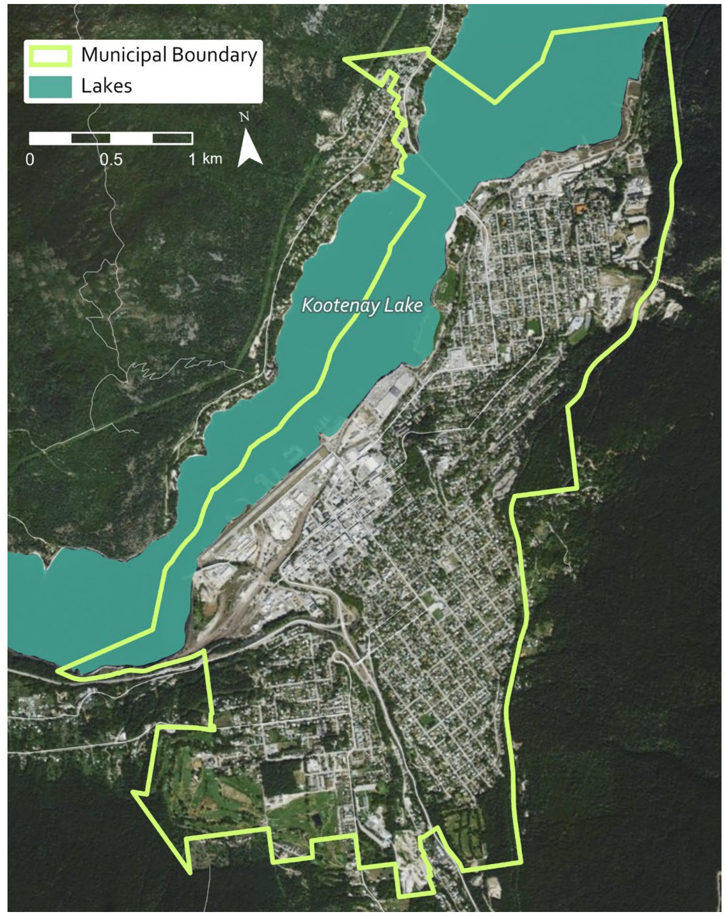

Figure 1: *City of Nelson*

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 to be used as a reference document for the City of Nelson, intended to highlight trends and impacts related to the local climate and surrounding environment, and to inform local planning and decision-making. While focused on Nelson, this report includes changes in indicators outside of the City of Nelson jurisdiction, such as wildfire starts, recognizing that a better understanding of trends associated with these indicators can help the community prepare for current and future changes. The data for some indicators, such as per capita water consumption and FireSmart uptake, come directly from City of Nelson staff, as they are best positioned to identify and track potential opportunities for increasing community climate resilience in their own community.

The full SoCARB indicator suite includes 58 climate adaptation indicators. This report, however, excludes indicators that the City of Nelson has not identified as a priority or where sufficient data was not available, as well as all indicators from SoCARB's Community Resilience Index. In addition, the evolution of adaptation practice since 2015 and learnings from pilot implementation in 2016-2017 with four communities within the Columbia Basin resulted in minor updates to the suite in spring 2019.

Report Highlights

- The climate in the Nelson area is changing, with data showing trends toward higher average annual and seasonal temperatures. This upward trend is expected to continue with an increasing overall rate of warming and shifts in precipitation, resulting in warmer, wetter winters and hotter, drier summers. There is also a trend toward more extreme heat days, a longer growing season and more growing degree days. Historical trends for precipitation do not present a clear signal/trend, and future projections indicate increases in both annual precipitation and heavy precipitation.
- Climate change is becoming evident through some noticeable changes in Nelson's environmental conditions. For example, air quality issues resulting from wildfire are increasing, and the amount of heat energy available for crop growth is on the rise. Several environmental impact indicators lack sufficient data to infer trends and could be focal points for efforts to enhance climate adaptation monitoring, planning and action.
- The City of Nelson is actively taking steps to adapt to changes that have already happened and to prepare for future changes, including the current development of a comprehensive climate change action plan focused on mitigation and adaptation priorities. Other actions include having an emergency preparedness plan with key elements in place or in progress, having a Water Master Plan that considers climate change, showing success in reducing per capita water consumption, and having a strong commitment to adoption of FireSmart principles in policy and planning. Opportunities exist to further Nelson's readiness to adapt, which include additional actions on water conservation, especially around water loss, and promoting community-based efforts to adapt (e.g., through programs aimed at enhancing personal and household emergency preparedness).
- While some datasets are not lengthy or complete enough to evaluate trends in the City of Nelson'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 (SoCARB) 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 2) 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.

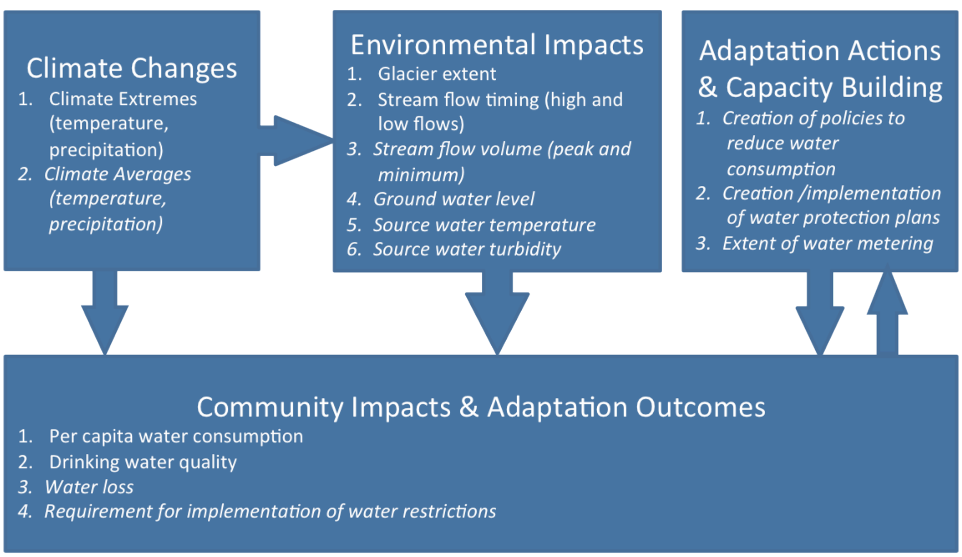

Figure 2: *Water supply pathway from the SoCARB indicator suite*

For this report, City of Nelson personnel identified 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 Columbia Basin Rural Development Institute's (RDI) State of the Basin reports and Community Profiles. The Community Resilience Index presents an opportunity for further applied research to inform local climate adaptation and resilience efforts.

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 2 .

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. Related to this, 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.
- **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., anomalous weather) must also be considered.
- **No obvious trend**. Some data may show no obvious trend. However, this data still has value as a trend may eventually emerge, and the information can still help inform decision making.
- **Trend that is not statistically significant**. Due to high variability in the data 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 average.

About the Climate Data

Climate data for the City of Nelson was provided by Climatic Resources Consulting, Inc. and comes from two main modeling sources. Technical information is presented below. Climate projections for the 2050s in this report include two scenarios: low carbon and high carbon, delineated according to Representative Concentration Pathways (RCP's), which are greenhouse gas concentration trajectories used worldwide for consistent and comparable climate modeling. Climate projections for the 2050s indicate the average for the 2041-2070 period. 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 in the Columbia Basin and Boundary regions. Climate trends, i.e. rates of change, are expressed in units per century, meaning the change per 100 years.

Technical Information

Historical climate data was prepared using climate reanalysis ERA5.[3,4] Climate reanalyses combine past observations with models to generate consistent time series of multiple climate variables.[5] They provide a comprehensive description of the observed climate as it has evolved during recent decades, on 3D grids at sub-daily intervals. The estimates are produced for all locations on earth, and they span a long time period that can extend back several decades or more. Adjusted and Homogenized Canadian Climate Data (AHCCD) from Environment Canada provides long-term (since the early 1900s) observed data. Climate projections are based on output from an ensemble of 12 statistically downscaled Global Climate Model (GCM) projections[6] from the Coupled Model Intercomparison Project Phase 5 (CMIP5),[7] and downscaled using Bias Correction/Constructed Analogues with Quantile mapping recording[8] to a resolution of 10 km by 10 km.

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 Nelson.

The Overall Picture

Both annual and seasonal average temperatures are rising in the Nelson area and are projected to continue rising through the 2050s. Annual average temperature has been rising 2.4°C per century. By the 2050s, this is projected to go to 3.6°C per century under a low global emissions scenario and 7.1°C per century in a business as usual scenario. Total annual precipitation has decreased over the last century, but this trend is not consistent across seasons. Total annual precipitation is projected to increase over the coming decades, with less precipitation during the summer under a high carbon scenario. Temperature extremes have increased over the last century and are projected to continue increasing.

Average annual and seasonal temperatures

Analysis of modelled historical climate data for Nelson shows increasing temperatures since the1950s. There has been a statistically significant warming trend of +2.4°C per century in average annual temperature (Table 1). The 1961-1990 baseline for annual average temperature is 8.3°C.

Average seasonal temperatures have also increased in Nelson. 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 (up to 10.7°C per century in a high carbon scenario). Average annual temperature is projected to increase 2.6°C to 3.3°C by the 2050s relative to the 20th century baseline (Figure 3). This would result in average annual temperatures of 10.9 °C and 11.6 °C, respectively, under low and high carbon scenarios.

Table 1: *Annual and seasonal average temperature trends for Nelson in degrees Celsius per century.*

	Annual	Winter	Spring	Summer	Fall
Historic (1901-2018)	+2.4°C per century	2.6	2.0	1.9	1.6
2050s (low carbon)	3.6	1.6	3.1	3.7	2.9
2050s (high carbon)	7.1	7.6	5.0	10.7	6.7

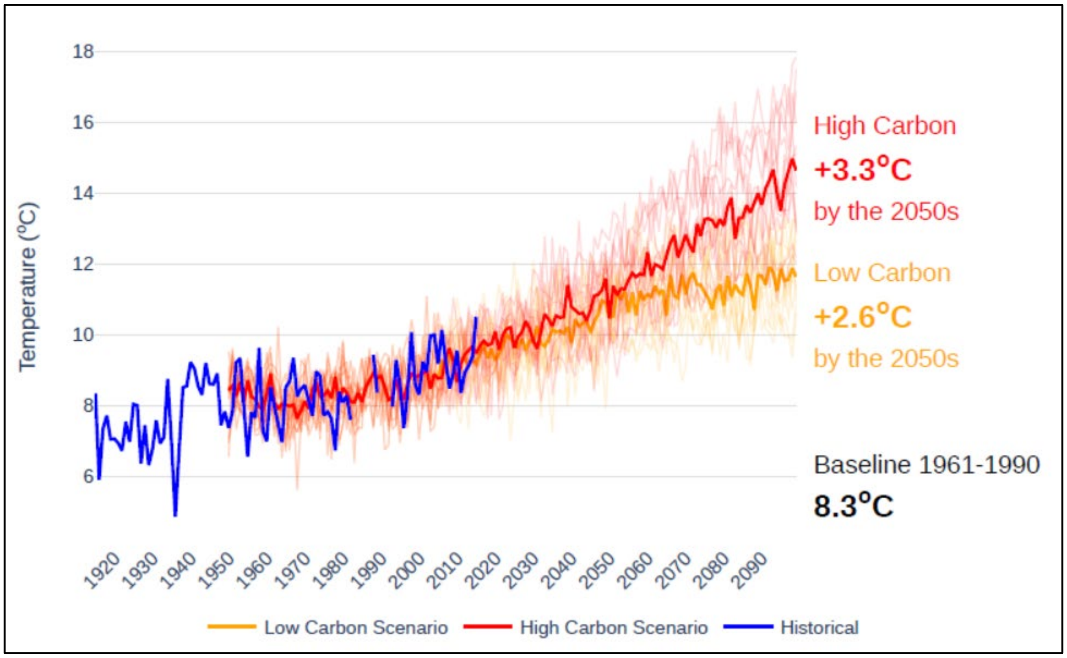

Figure 3: *Historic and projected average annual temperature for Nelson*

Precipitation trends

Average annual precipitation trends are not as clear cut as those for average temperature (Table 2, Figure 4). The dataset shows a decreasing trend in historic average annual precipitation of -232 mm per century at a 94% confidence level. Nelson's baseline annual precipitation for the 1961-1990 period is 640.8 mm. Seasonally, Nelson's historical data show that winter and fall precipitation has been decreasing, whereas precipitation has been increasing in spring and summer.

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

	Annual	Winter	Spring	Summer	Fall
Historic (1901-2018)	*-232 mm/century*	-253	*55*	69	-109
2050s (Low carbon)	*66*	*28*	*39*	*5*	*30*
2050s (High carbon)	190	*46*	67	*-91*	*78*

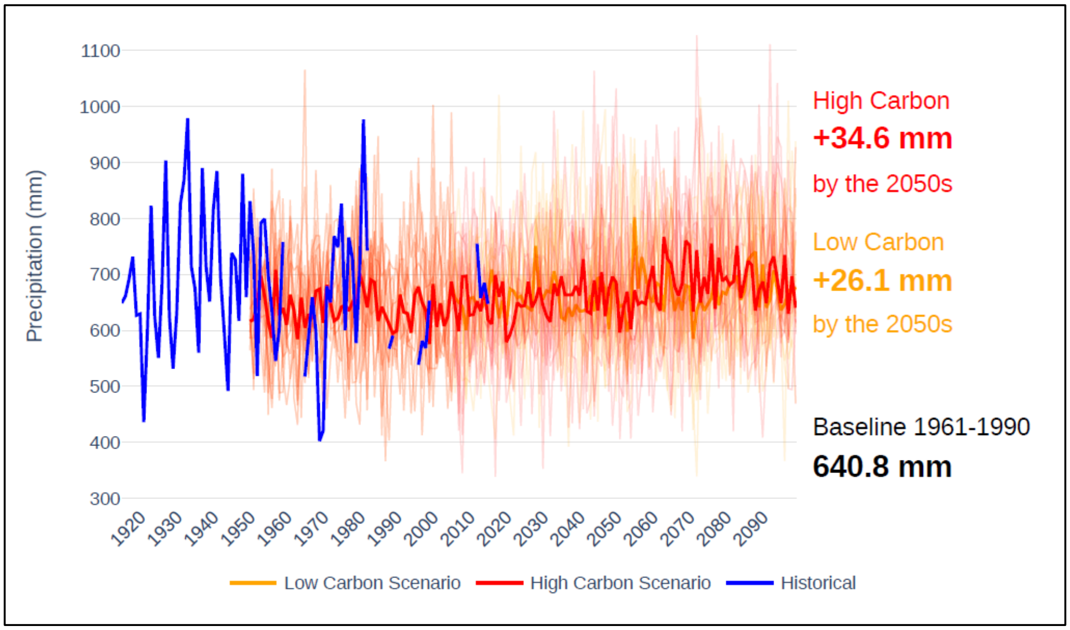

Figure 4: *Total annual precipitation for Nelson*

Precipitation projections indicate increases of approximately 4% to 5% in average annual precipitation by the 2050s, with significantly more precipitation falling in spring and fall (94% confidence level), and less precipitation falling in summer in a high carbon scenario. Precipitation has considerably more variability than temperature, thus confidence levels for some projections fall below 95 per cent, identified by italics in Table 2.

Frequency of hot days

This extreme temperature indicator measures the number of days when the temperature exceeds the 90th percentile for the baseline period (1961-1990). For Nelson, this translates into a baseline of 36 days above 27.7°C. Hot days (i.e. above 27.7°C) are projected to increase from 26.5 to 34.5 days per year by the 2050s under low and high carbon scenarios, respectively, and the warming trend could go as high as 100 days per century by the 2050s in a high carbon scenario.

Amount of precipitation falling during heavy rainfalls / More days with heavy rainfall

The extreme precipitation indicator measures the annual sum of precipitation exceeding the 95th percentile for the baseline period (1961-1990) and can be described as the amount of rain that falls during very heavy rainfall days. For Nelson, the threshold for very heavy rainfall is 7.8 mm (95th percentile). During the baseline period, Nelson received a total of 101.2 mm annually based on the sum of days when precipitation exceeded this threshold. Since 1950, this annual total has been declining by 12 mm per century. Projections for the 2050s indicate an increase of 33 mm in annual 95th percentile precipitation, falling primarily in spring and fall seasons.

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 snow melt, underlining the imperative for government to respond in new, different or better ways." [9] The review produced over 100 recommendations to improve emergency preparedness and disaster response in British Columbia. Future projections suggest an increase in some extreme weather events, such as extreme heat 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, and home emergency preparedness kits.

The Overall Picture

The City of Nelson is experiencing a higher number of extreme heat days than in the past. Other indicators of extreme weather in the area are either lacking long-term datasets or not yet showing the trends that have been identified at larger scales. The City of Nelson's Emergency Preparedness Plan will help mitigate the impacts of extreme weather events on residents and businesses. The number of residents with emergency preparedness kits is low, suggesting a need for further supporting information and awareness of personal emergency preparedness opportunities.

Climate Changes

As discussed in the Climate section, Nelson's annual and seasonal average temperatures have increased over the last century. The frequency of hot days has increased and will continue to increase, and a similar but less pronounced trend is occurring in respect of the amount of rain falling on heavy rainfall days. Additional climate indicators related to the Extreme Weather pathway are discussed below.

Extreme heat days

Temperature data for Nelson shows a clear upward trend in frequency of days over 30ºC, increasing at a rate of 12.9 days per century. During the 1961-1990 baseline period, Nelson experienced an average of 19.4 days per year above 30ºC (Figure 5). By the 2050s, this is projected to increase by 24 days in a low carbon scenario and 33 days in a high carbon scenario. This translates to approximately 43 to 52 days per year above 30ºC, more than double what was experienced during the baseline period. Heat waves and heat extremes have negative health impacts on vulnerable populations including the elderly, socially isolated, chronically ill, and infants.

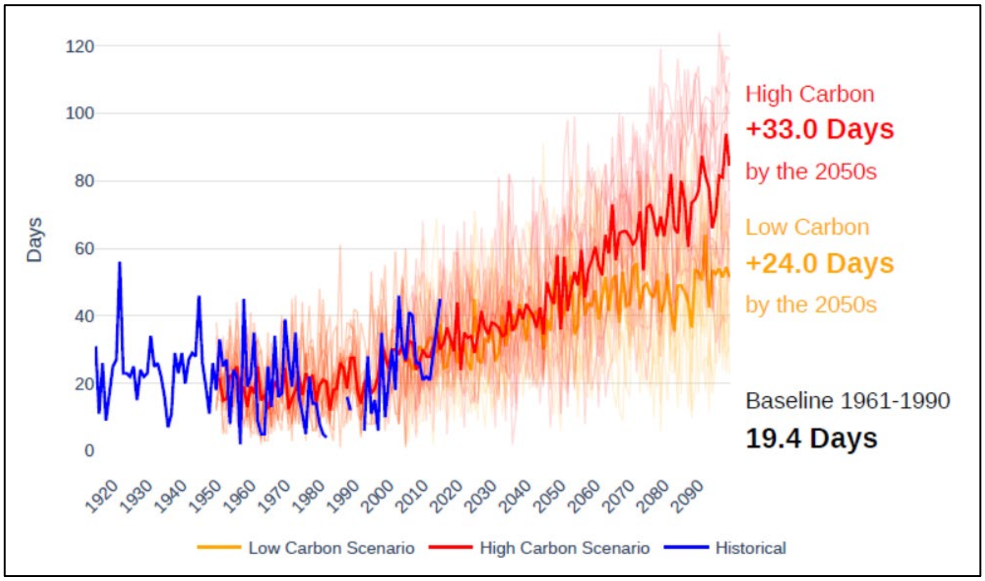

Figure 5: *Extreme heat days (above 30ºC) in Nelson*

Fewer heavy snowfalls

Heavy snowfall days are defined as those receiving 15 cm or more over 24 hours. These events can pose challenges to the regular operations of businesses and local governments and may affect the movement of people throughout the region. Snowfall records from Environment and Climate Change Canada's weather station in Nelson show an average of 2.7 heavy snowfall days per year from 1904 through to 2019. Although the trend is not statistically significant, a downward trend is visible in the number of heavy snowfall days (Figure 6). It is important to note variations in data quality from discontinuous station records. Three stations have existed in Nelson since 1904 - all with different locations and elevations. This makes the data variable and difficult to compare.[10]

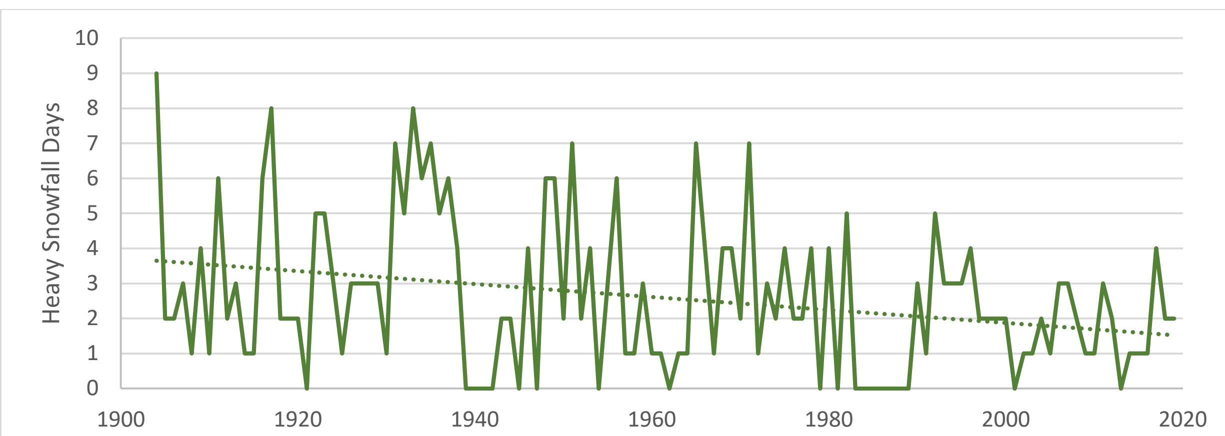

Figure 6: *Number of heavy snowfall days (>15 cm over 24hours) in Nelson, trend is not statistically significant*

The same data was used to assess annual maximum one-day snowfall; there is no significant trend for this indicator either. The average maximum one-day snowfall in Nelson between 1988 and 2019 was 23 cm.[11]

Poor data for strong wind events

Windstorms can damage infrastructure, bring down power lines and cause power outages. A strong wind event is defined as a day with sustained winds of 70 km/h or more and/or gusts to 90 km/h or more. Wind data is not well recorded in the Columbia Basin and the only consistent data available near Nelson comes from BC Wildfire Service weather stations. These stations provide an hourly reading of sustained wind speed over a ten-minute period, which means 83% of wind behaviour is unrecorded. [12] Analysis of the Smallwood station near Nelson, which has data from July 1991 to the present, revealed no records over the 70 km/h threshold.[13] Records of maximum daily wind gusts are also available from the Environmental and Climate Change Canada weather station in Nelson, but this dataset has large gaps that make the identification of extreme wind events unreliable.

Maximum 1-day rainfall

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. Historic data for Nelson indicates 18.5 mm as the 1961-1990 baseline for maximum 1-day rainfall. There is no clear trend up or down since the 1950s. It should be noted that this indicator does not capture the intense micro-burst precipitation events (i.e. high volume/short duration) that have caused overland flooding in Nelson in the past decade. Future projections show an increase in maximum 1-day rainfall by the 2050s under low and high carbon scenarios, of approximately 17% and 19%, respectively.

Adaptation Actions and Capacity Building

Emergency Preparedness Plan

Up until 2018, emergency planning for the City of Nelson was done through the Regional District of Central Kootenay (RDCK). In 2018, the City of Nelson *Emergency Management Program Bylaw No. 3431* was passed, moving emergency planning responsibility from the RDCK to the City of Nelson.[14] The full transition of emergency planning responsibilities from RDCK to City of Nelson will take three years and will take place through phased implementation. As a result, many emergency preparedness plan components were still in progress when this report was prepared. As an example, emergency procedures are in place from the RDCK emergency planning, while the City of Nelson is building plans for each hazard with the goal for this to be done within three years. The first version of a comprehensive Hazard Risk and Vulnerability Assessment was completed in 2019.[15]

Table 3: Emergency preparedness plan components for the City of Nelson

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

Essential backup power in place

The City of Nelson has backup power in place for its Emergency Operations Centre (EOC), City Hall, and fire halls. All sanitary sewer lift stations, except Lakeside Park and Tyler Park stations have backup power. Nelson's drinking water system is gravity-fed, so only the treatment plant needs and has backup power. The water system has a supervisory control and data acquisition (SCADA) system that sends alarms to operators who are available 24/7. There are several reception centres and group lodging facilities that would be activated during an emergency. It is unknown if these facilities have backup power.[16]

Few residents have emergency preparedness kits

Having an emergency preparedness kit can help alleviate some of the difficulties caused by an extreme weather event or wildfire. Out of the 132 Nelson residents who completed a voluntary survey in the summer of 2019, only 32% of respondents reported having 72-hour emergency preparedness kits in their homes. Of those, 67% reported having them in an easy-to-access location. Table 4 shows the percentage of respondents having important items in their kit. Many residents could better prepare for extreme weather events by compiling complete kits and storing them in a single accessible location. In the case of an evacuation, 66% of respondents said they would stay with out-of-town friends or relatives or at a summer home, while 18% said they would go camping and 16% said they had no place to go.

Table 4*: Percentage of respondents from the City of Nelson with emergency kits indicating the presence of important items in their kit*

Item	Yes
Drinking water (2-3 litres of water per person and pets per day, for 3 days)	81%
Foods that will not spoil (minimum 3-day supply)	90%
Manual can opener	81%
Flashlight and batteries	93%
Candles and matches/lighter	95%
Battery-powered or wind-up radio	58%
Cash in smaller bills and change	44%
First aid kit	98%
Special items such as prescription medications, infant formula or equipment for people with disabilities	49%
Extra keys that you might need (e.g. for your car, house, safe deposit box)	60%
A copy of your emergency plan including contact numbers (e.g. for out-of-town family)	34%
Copies of relevant identification papers (e.g. licenses, birth certificates, care cards)	59%
Insurance policy information	59%
Mobile phone charger	76%

Community Impacts and Adaptation Outcomes

No trend in weather-related highway closures

Between 2006 and 2017, there have been six weather-related highway closures near Nelson. This number comes from Drive BC records that report closures on major highways only. For Nelson, this is Highway 6 to Salmo and Highway 3A from Castlegar to the Kootenay Bay Ferry at Balfour.[17] Half of weather-related highway closures on these roads are due to downed power lines. A washout near the Kootenay Bay Ferry caused the longest closure of 20 hours in 2012.

Nelson is also impacted by closures on Highway 3 over Kootenay Pass and the Blueberry-Paulson Pass. Avalanche control is the main cause of closures on these passes, though other weather-related events have closed these highways in the past. Between 2006 and 2017, Kootenay Pass has had five weather-related closures, the longest being a mudslide that closed the road for 13 hours. The Paulson Pass has only two recorded closures from rock slides in 2008 and 2009 that stopped traffic for less than 2 hours.[18] Avalanche-related activities have accounted for an average annual closure time of 93 hours over 37.6 closures at Kootenay Pass (2003-2019) and 4.7 hours over 1.5 closures at the Paulson Pass (1989-2019). No trends are evident in the number or duration of avalanche-related closures at this time.[19]

Power Outages

Longer-duration power outages caused by extreme weather events can have significant impacts on local economies, health and quality of life. Nelson Hydro provides power for the City of Nelson.

Power outage data for the Nelson Hydro area is available for 2012 to 2019 for the service sub-regions of North Shore, South Shore and City. An analysis of outages caused by fire, lightning, snow, trees, and wind in these sub-regions resulted in an average of 91 outages per year. Of these outages, most are due to trees. Trees are included in list, as it is assumed most trees fall due to extreme weather, such as high winds or high snow load. The average outage length is five hours, while the median outage length is two hours. The longest outage for the City of Nelson was three days in October 2017.[20] Media reports from this time indicated a major wind event knocked down trees causing power outages for most Nelson Hydro customers.[21]

Provincial emergency assistance

Monitoring emergency assistance funding issued by the province can provide some measure of the economic impact of disaster and associated recovery over time. There has been no provincial emergency assistance for any extreme weather events paid to Nelson in the last five years.[22]

WATER SUPPLY

Projected changes to the climate could influence both the supply of and demand for fresh water for human use. Shifts in temperature and precipitation together with decreased forest cover due to pests and wildfire could change the amount of water stored as snowpack and the timing of surface water availability. 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 Nelson's primary water source is Five Mile Creek, which is transported through a 7.5 km pipeline to the Mountain Station Reservoir. Secondary seasonal sources include Anderson Creek and Selous Creek.[23]

The Overall Picture

Nelson appears to be in a relatively strong position with respect to water supply. Stream flow volumes for its two main water sources, Anderson and Five Mile Creeks, appear stable, but it should be noted that the timing of flows have changed. Anderson Creek maximum daily flows are occurring earlier in the year and this shift to earlier snowmelt runoff is also seen in the timing of half-flow volumes. The timing of runoff on Five Mile Creek does not show a consistent trend and there is increased variability in the date of return to summer low flows. Ongoing monitoring of Anderson Creek and re-establishment of flow monitoring in Five Mile Creek is recommended and would add valuable information to Nelson's understanding of its water security. The City of Nelson Water Master Plan considers the impacts of climate change.

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 been decreasing 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 summer under a high carbon scenario.

Environmental Impacts

Stream flow volume

The stream flow volume indicator measures trends in annual maximum and minimum daily discharge. Nelson's main water sources, Anderson Creek and Five Mile Creek, have discharge records of 56 and 33 years respectively.[24] Continuous gauging on Five Mile Creek, the larger of the two watersheds (47.7 km^2), began in 1983 and was discontinued in 2015. Continuous gauging on Anderson Creek (9 km^2) began in 1966 and is ongoing. Five Mile Creek is characterized as a moderate-sized alpine watershed with headwaters above 2000 metres elevation. In contrast, Anderson Creek is a small, low elevation watershed with headwaters below 2000 metres elevation.

No statistically significant trends exist for annual peak or summer low flow volumes for Anderson or Five Mile Creeks (Figure 7, Figure 8) although a visual inspection of the time series of maximum annual peak flows for Anderson Creek suggests a trend to higher peak flows since 1995 (Figure 7).

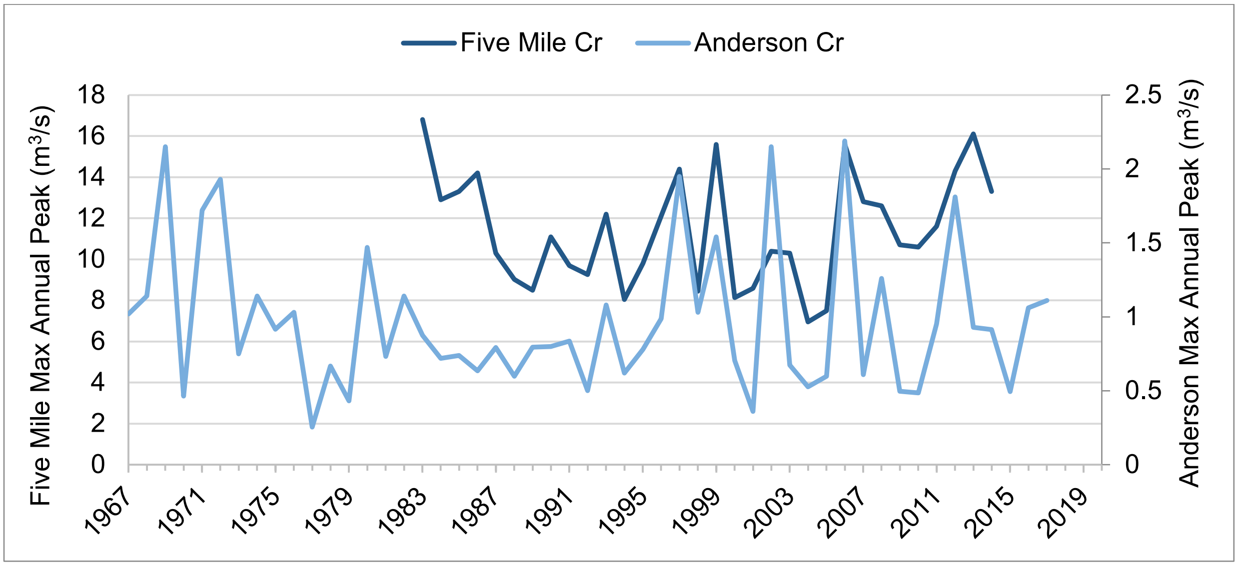

Figure 7: *Maximum daily discharge for Anderson Creek and Five Mile Creek for the period of continuous gauging*

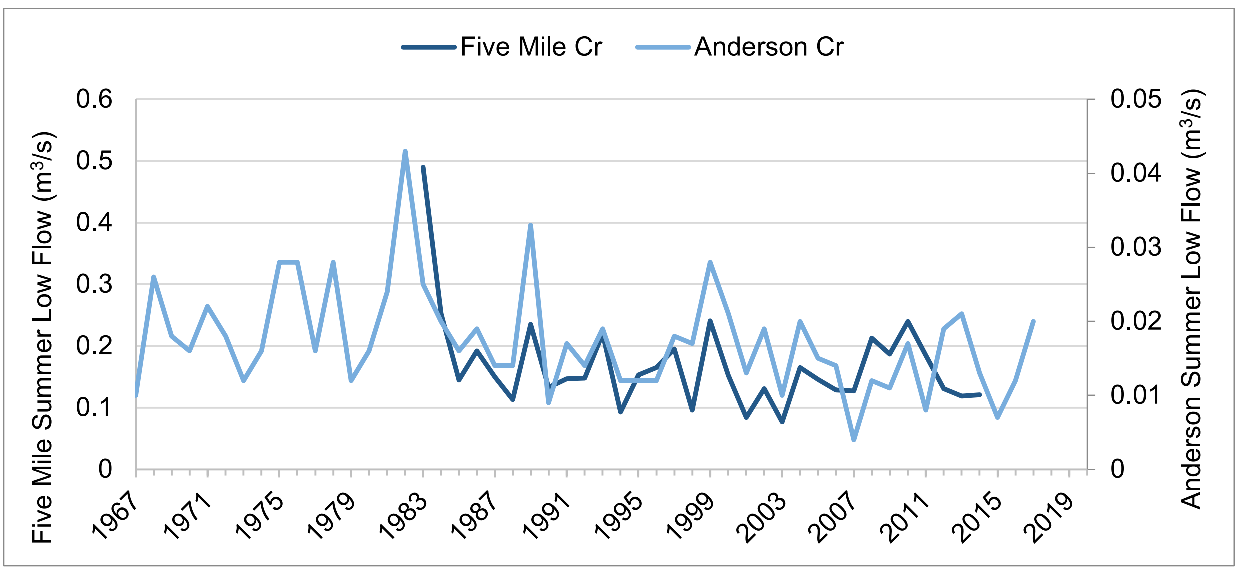

Figure 8: *Minimum daily discharge for Anderson Creek and Five Mile Creek for the period of continuous gauging*

Stream flow timing

Using Environment Canada data,[25] changes in the timing of peak flows are apparent for Anderson Creek (Figure 9). Excluding the outlier of 2015, the timing of annual peak flows after 1990 is, on average, 6.3 days earlier than the timing of peak flows preceding 1990. With the 2015 outlier included, the timing of peak flows has shifted over eight days earlier in Anderson Creek. Although this trend is visually apparent, it is not statistically significant. A weak positive trend in the timing of the date of maximum peak flow is present for Five Mile Creek but is not statistically significant.

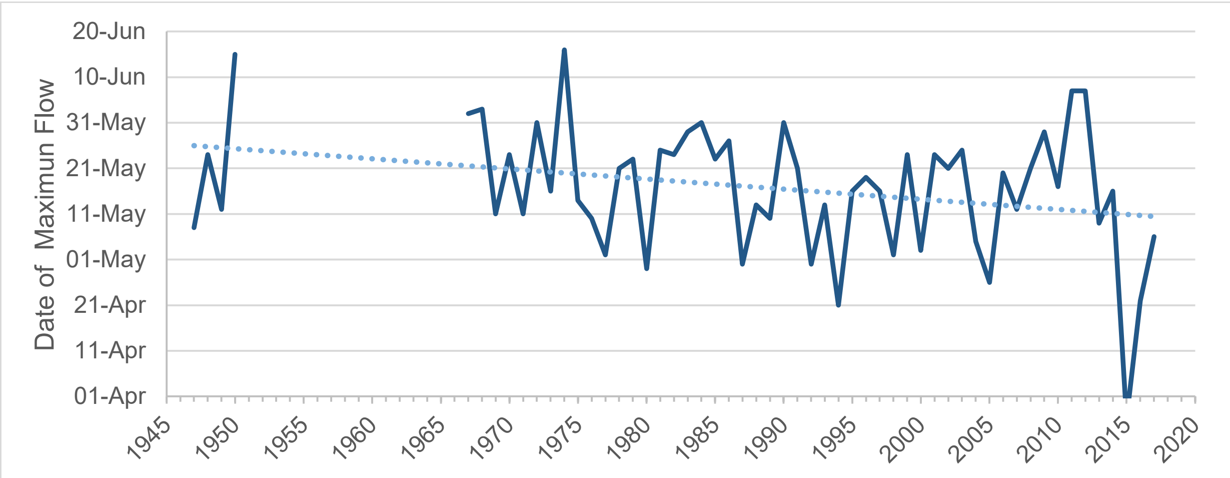

Figure 9*: Maximum daily discharge date and trend line for Anderson Creek, trend not statistically significant*

No trends are evident in the timing of summer low flows for either Anderson Creek or Five Mile Creek; however, a visual inspection of the Five Mile Creek data (Figure 10) shows a change in variability in the timing of summer low flows after 2000. In the period between 2000 and 2015 the variability in the timing of summer low flow, as measured by the standard deviation of the sample, increased by 29% compared to the pre-2000 period. A more detailed investigation is needed to determine if the increased variability of summer low flows in Five Mile Creek is due to alterations in land cover or climate or a combination of both.

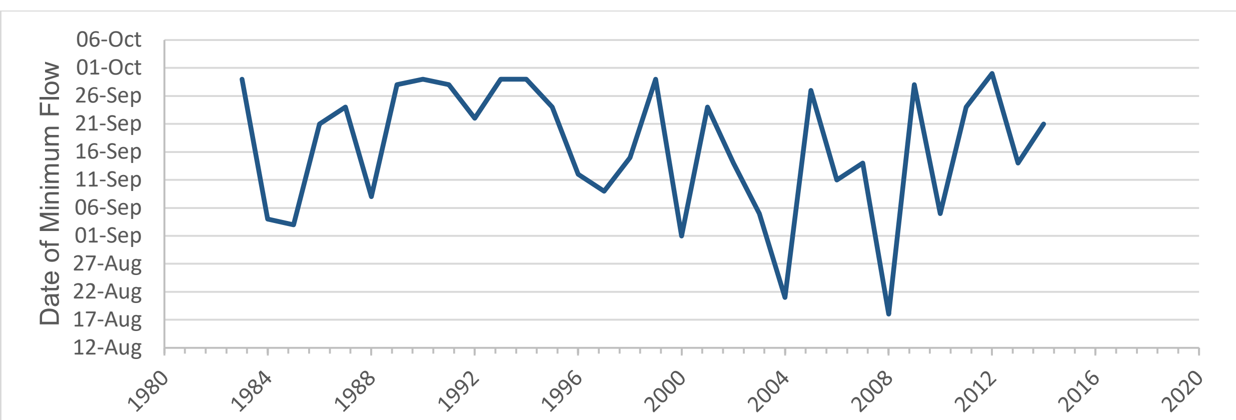

Figure 10: *Minimum daily discharge date for Five Mile Creek.*

The half-annual flow variable provides a metric to investigate changes in the annual distribution of flow volume. Trends observed in half-annual-flow timing for Anderson Creek are consistent with those observed for maximum daily flow timing. In Anderson Creek, the date of half-annual-flow volume has advanced so that it is occurring, on average, four days earlier now than when continuous gauging began in 1967 (Figure 11). This trend is not considered statistically significant at the 95% confidence level. There is no obvious trend in the timing of half-annual-flow in Five Mile Creek.

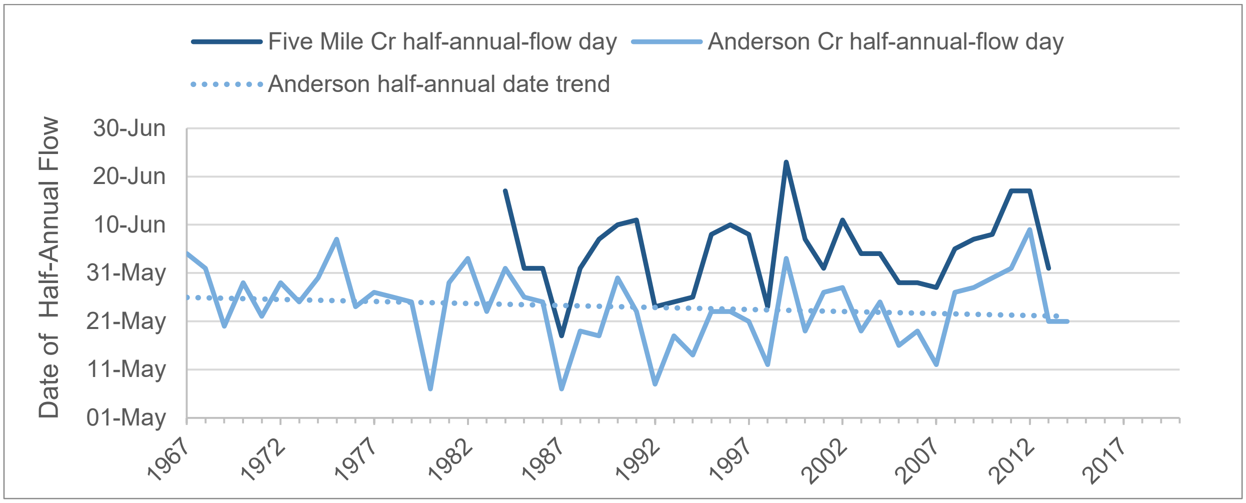

Figure 11: *Date of half-annual flow for Anderson Creek and Five Mile Creek, with trend line for Anderson Creek, trend not statistically significant*

Source water temperature

Temperature can be an important determinant of water quality. Water temperature should be below 15ºC - an aesthetic drinking water objective set by Health Canada.[26] Daily temperature data for the Mountain Station reservoir was provided for the years 2013 and 2014.[27] This data provides a look of the temperature variation in the reservoir over the course of each year. In 2013, 23 days exceeded 15ºC, while 30 days exceeded 15ºC in 2014. Not surprisingly, these days occurred during July and August.

Source water turbidity

Higher turbidity can result in boil water notices or water quality advisories. Turbidity becomes a concern when it rises above one (1) Nephelometric Turbidity Units (NTU). A turbidity reading between one to five NTU is considered fair quality, while a reading greater than five NTU indicates poor drinking water.[28] For the Mountain Station reservoir providing drinking water to the City of Nelson, the 2018 data shows that the turbidity typically varies between 0.08 NTU and 0.86 NTU throughout the year (Figure 12).[29]

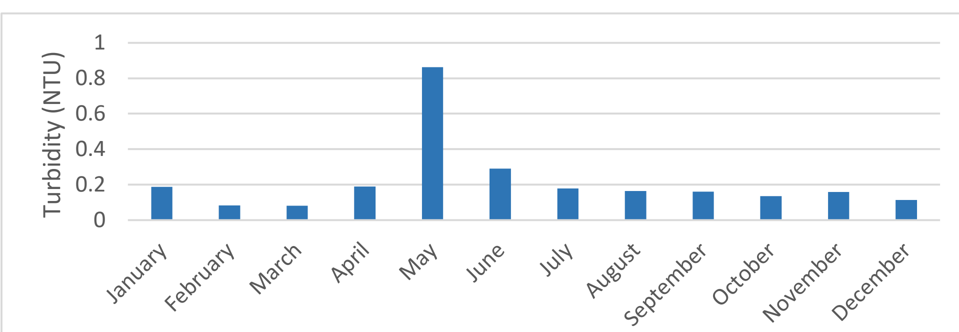

Figure 12: *Turbidity for the City of Nelson throughout the year in 2018*

Adaptation Actions and Capacity Building

Policies to reduce water consumption

The City of Nelson has implemented many water conservation initiatives, ranging from legislative to educational (Table 5: *Implementation of policies to reduce water consumption for all the City of Nelson.* The *Waterworks Regulations and Rates Bylaw No. 3293*, for example, addresses water meters and water restriction stages and enforcement.[30] Nelson currently has district water meters on their four water zones. Water meters are only mandatory on institutional, commercial and industrial properties. However, some other properties have water meters, such as the Rosemont Trailer Park. Public education on water conservation has been delivered by summer students in five of the last six years, including one year-long student placement. This outreach was targeted to high water users.

Table 5: *Implementation of policies to reduce water consumption for all the City of Nelson.*

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

i. Bylaw 3293 states that only institutional, commercial, or industrial connections must install a water meter.
ii. Incorporated into City newsletters and talked about during public outreach
iii. Some businesses and the Rosemont Trailer park are billed metered rates
iv. Bylaw 3092 Schedule H
v. In 2009, the Nelson Water Smart Action Plan had a 20% water conservation target. By 2015, a 5% reduction was achieved.

vi. Some monitoring and education done through summer students; no bylaw enforcement with fines
vii. On a case by case basis
viii. There is an aggressive capital replacement program of approximately 2% annually
ix. On a case by case basis
x. Pressure reducing valves are installed as per the Water Master Plan and best practice

Source water protection plan and climate change

The City of Nelson has a Water Master Plan last updated in 2017. This update considers the impact of climate change, such as reduced watershed yield and reduced water quality. The updated plan also suggests other options for sourcing drinking water.[31]

Water loss detection practices

The City of Nelson participated in the Columbia Basin Water Smart program, which helped identify opportunities to address water loss. The Rosemont Trailer Park is a leaky private system that the City has focused on through extensive outreach, education, and assistance measures to help address the leaks. Night flow analysis has been done for some areas, with more planned as resources and schedule allow. Both acoustic leak detection and leak noise correlation testing are done on an as-needed basis, with leak noise correlation testing focused on the Rosemont Trailer Park.

Table 6: *Implementation of water loss detection practices for the City of Nelson*

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

Community Impacts and Adaptation Outcomes

Per capita water consumption

This indicator measures water use attributable to user demand and system water loss. The available data shows that the per capita water consumption for Nelson residents is going down. In 2009, per capita water consumption was 595 litres per day. In 2015, it was 519 litres per day. In 2018, it was 482 litres per day. [32, 33] This is just below the provincial average of 494 litres per day.[34] The City of Nelson Water Master Plan update indicates that summer per capita water consumption decreased 30% between 2007 and 2016.[35]

Drinking water quality

Drinking water quality can be adversely affected by source water quality issues caused by higher air temperatures, more extreme precipitation patterns, and more rapid snowmelts that may accompany climate change.[36] From 2005 to mid-July 2019, the City of Nelson's water system has experienced 12 Water Quality Advisories (WQA) and four Boil Water Notices (BWN). Advisories for the City of Nelson water system were generally short duration, with only one incident lasting longer than 25 days. This WQA occurred in 2007 and lasted 65 days. There are no trends in the annual number or duration of advisories. The highest occurrence of water quality issues (two WQA and two BWN) occurred in May 2017.[37] Unfortunately, the cause of water advisories is not specified in the dataset provided by Interior Health Authority, making it difficult to link water quality issues to weather-related events.

Watering restrictions

Watering restriction bylaws provide a tool for utilities to reduce vulnerability to water supply challenges, and by tracking the need to implement these restrictions, water operators can better understand how climate change is affecting supply and demand. The *City of Nelson Waterworks Regulatory Bylaw No. 3293* was passed in 2015, introducing year-round water restrictions that can be upgraded to stages 1 through 3 restrictions as necessary. Under normal conditions water use is regulated to watering every second day during specific daily time windows. At stage 1, watering is limited to two days a week (Figure 13). [38] The number of days each year within each restriction stage are not tracked.[39]

City of NELSON

Mandatory Water Conservation Measures

Activity	Normal Regulations	1	2	3
Watering lawns using a sprinkler or irrigation system	4am - 9am & 7pm-10pm Even # address: Even # days of the month Odd # address: Odd # days of the month	4am - 9am & 7pm-10pm Even # address: ONLY ON Wednesday and Saturday Odd # address: ONLY ON Thursday and Sunday	4am-9am & 7pm-10pm Even # address: ONLY ON Wednesday Odd # address: ONLY ON Thursday	✗
Watering trees, shrubs, or vegetable & flower gardens using a sprinkler or irrigation system	✓	4am-9am & 7pm -10pm ANY DAY	4am-9am & 7pm -10pm ANY DAY	4am-9am & 7pm -10pm ANY DAY
Watering trees, shrubs, or vegetable & flower gardens using a hand-held container, a hose with a shut-off nozzle, or a drip-irrigation system	✓	✓	✓	4am-9am & 7pm -10pm ANY DAY
Washing sidewalks, driveways, parking lots, exterior building surfaces, and exterior windows *	✓ with a handheld shut-off nozzle	✓ with a handheld shut-off nozzle	✗	✗
Washing personal Vehicles **	✓ with a handheld shut-off nozzle	✓ with a handheld shut-off nozzle	✓ with a handheld shut-off nozzle	✗
Filling of fountains, pools, hot tubs, or garden ponds	✓	✓	✓	✗
Watering new sod or grass outside of the permitted restrictions ***	PERMIT REQUIRED	PERMIT REQUIRED	✗	✗

Figure 13: *City of Nelson water restrictions stages from normal through stage 3*

Water loss

The City of Nelson's 2016 Water Smart Action Plan estimates that its water system experiences approximately 18% water loss due to leakage.[40] A previous 2005 Water Conservation and Drought Management Study estimated 22% "unaccounted for use", which includes water loss due to leaks.[41] The City of Nelson replaces water infrastructure on an on-going basis, focusing on galvanized steel pipe and cast iron mains due to a history of breaks and water loss.[42] The Columbia Basin Water Smart Summary Report states that leakage within most systems in the Columbia Basin is 30-40%, and that this is typical of aging systems in developed nations, and particularly small rural systems.[43]

FLOODING

Projected climate changes, including more intense rainstorms and warmer, wetter winters, indicate a potential for increased flooding in snowmelt watersheds. Similarly, alterations to forest cover through wildfire, disease and logging can also increase flooding. Increases in the frequency and magnitude of floods affects communities through damage to homes and infrastructure, and negative impacts on water quality. In Nelson, several streams, including Anderson Creek, flow through the community. These channelized and culverted streams represent the greatest risk to community infrastructure given changes in the flood regime. Recognizing how flooding is changing allows communities to improve infrastructure and establish flood mitigation measures. The flooding pathway indicators include half total flow and annual peak flow timing, as well as changes in annual peak flow volume and depth of April 1st snowpack. In addition, changes in the frequency of peak flows are investigated where stream flow records are of sufficient length. Although it is recognized that flooding risk can also occur from Kootenay Lake, lake flooding is not examined in this report.

The Overall Picture

Both high elevation and lower elevation streams supplying Nelson's drinking water show increases in the frequency of flooding for larger-than-average floods. A more detailed investigation is needed to determine the cause in the altered flood regime. Although the West Kootenay is not yet witnessing trends toward more extreme precipitation that some studies have predicted for our region, a trend toward higher average spring temperatures and higher spring precipitation may drive more rapid snow melt, increasing the likelihood of flooding, particularly for lower elevation watersheds. However, this potential for increased flooding may be partially mitigated by a declining trend in spring snowpack at lower elevations. Nelson has detailed flood inundation and hazard mapping that will help inform risks due to climate change.

***Figure 14**: Flooding in Downtown Nelson in June 2006*

Climate Changes

As discussed in the Climate and Extreme Weather sections, trends toward more extreme rainfall have not been confirmed through an analysis of historic climate data for stations in and around Nelson. However, an analysis of average precipitation data shows rising annual and spring precipitation.

Freeze-thaw cycles

The frequency of freeze-thaw cycles is an important parameter for engineering design in cold regions. Freeze-thaw cycles are calculated by the number of days with temperature fluctuations between -2ºC and +2ºC. The historical data for Nelson indicates a downward trend in freeze-thaw cycles in winter, spring, and fall, decreasing at a rate of 17 days per century, with most of the decline occurring in the spring season. The historical trends are projected to continue downward across all seasons through the rest of the century, dropping from 30.3 days per year in the 1961-1990 reference period to 16.2 days per year by the 2050s in a low carbon scenario and 12.2 days per year in a high carbon scenario.

Environmental Impacts

April 1st snowpack

Springtime high elevation snowpack provides some indication of how much meltwater will be available to feed creeks in the early summer months. The April 1st snowpack data for Nelson is available for both low and high elevation sites. [44]

The low elevation Nelson site is a manual snow survey site dating back to the late 1930's located near Cottonwood Lake at an elevation of 930 meters. The high elevation site is an automatic snow pillow site located at an elevation of 2100 metres in Redfish Creek that started recording in 2002. The data at the low elevation site reveals a downward trend in April 1st snow water equivalent (SWE), which is determined to be statistically significant at the 95% confidence level (Figure 15). The Redfish snow pillow site reveals an increasing trend in April 1st SWE (Figure 16). A longer record of high elevation April 1st SWE is needed to confirm the significance of the increasing trend suggested in the 18-year record for Redfish given the 20- to 30-year cyclic influence of the Pacific Decadal Oscillation. Regardless of statistical significance, both trends are consistent with climate model projections for the Nelson region, which forecast increases in winter and spring precipitation and spring temperatures that would result in greater snow accumulation above 2000 meters and relatively lower accumulation at low elevations.

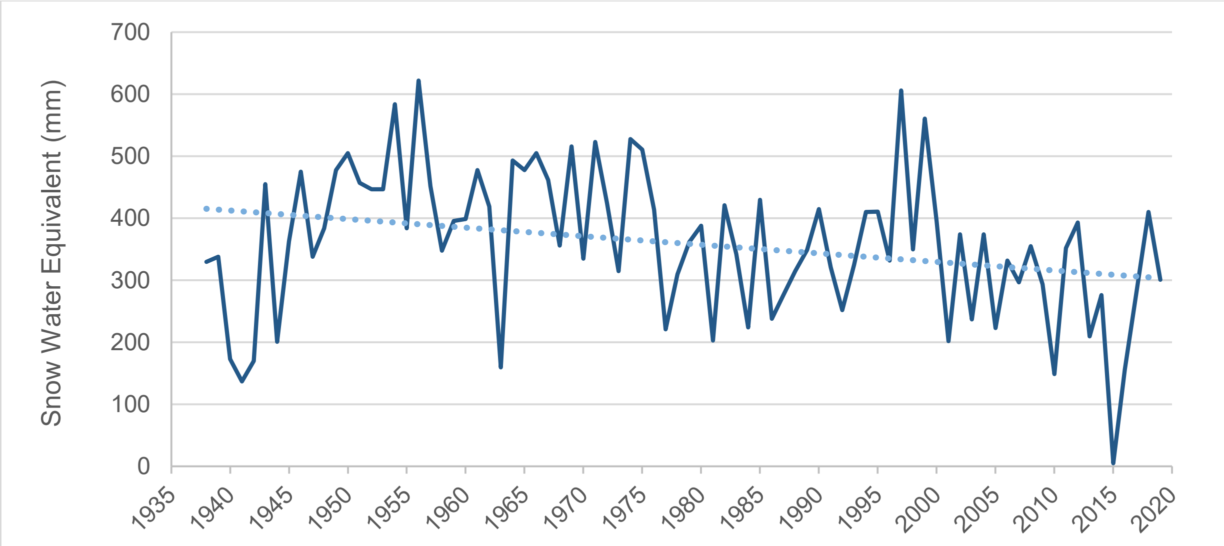

***Figure 15**: April 1st snow water equivalent (SWE) and trend line at the Nelson manual snow survey site at 930 meters elevation*

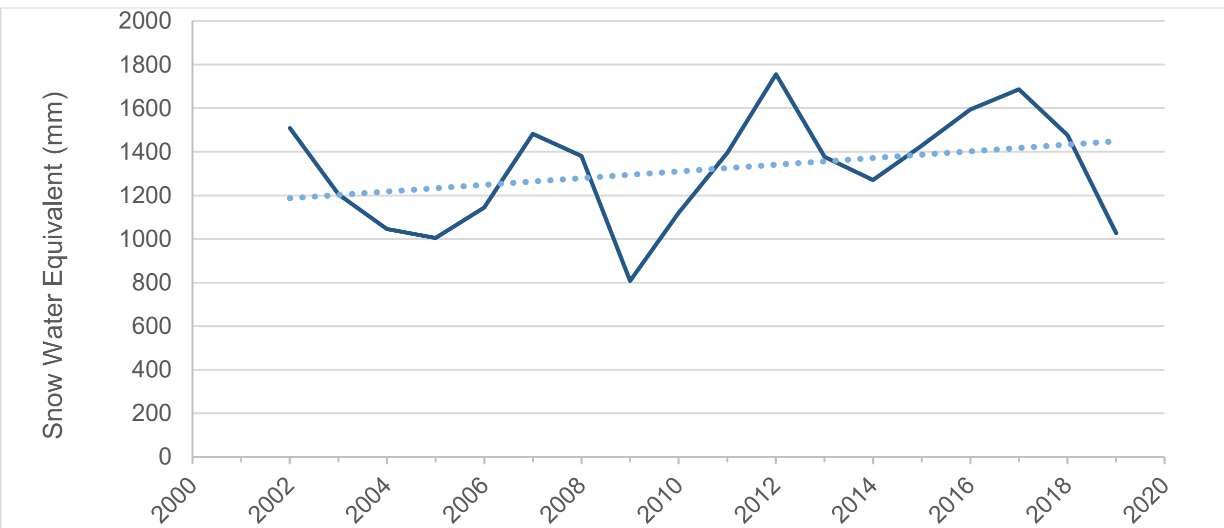

***Figure 16:** April 1st snow water equivalent (SWE) and tend line at the Redfish automatic snow pillow site at 2100 meters elevation*

No trend in stream flow timing and volume

As discussed in the Water Supply section, trends are not present for the half annual flow or peak flow timing for Five Mile Creek. Peak flow volume for Five Mile Creek also does not show a significant trend, although the shorter record length is a limitation in the detection of trends. In Anderson Creek the annual peak flow and the half-annual flow volume have shifted forwards in time by over six days and four days, respectively, on average, compared to when gauging began. No trends in peak flow volume are detected and a visual inspection of the time series of annual maximum peak flows for Anderson Creek suggests more large flows have occurred since about 1995.

Flood frequency increasing

Changes in flood frequency for Five Mile Creek and Anderson Creek is investigated. A relatively lengthy record of stream flow gauging on Anderson Creek and a moderate record on Five Mile Creek allows for an investigation of changes in the frequency of flooding on these streams. Changes in flood frequency is investigated by dividing the record of annual maximum peak flows into two subsets of data and applying a frequency analysis to both subsets. The historical return period of a flood reflects the annual probability of occurrence of a flood of a given magnitude for the period of record (i.e. annual probability is reciprocal of the return period).

The flood frequency analysis for Anderson Creek reveals an upward shift of the 1990 to 2017 subset of maximum peak flows relative to the 1947 to 1990 for return periods ranging from 5- to 20-years (i.e. maximum daily flows ranging from 1.1 to 2.2 m^3/s, Figure 17). The upward shift for a given return period flood translates to an increase in the probability of occurrence for a given magnitude. A flood with a magnitude of just under 1.5m^3/s that originally had a return period of about eight years is now occurring with a frequency of just under six years (shown by red arrow in Figure 17), a 33% increase in frequency. The upwards shift of the 1990 to 2017 frequency distribution in Anderson Creek is not statistically significant at the 95% confidence level.

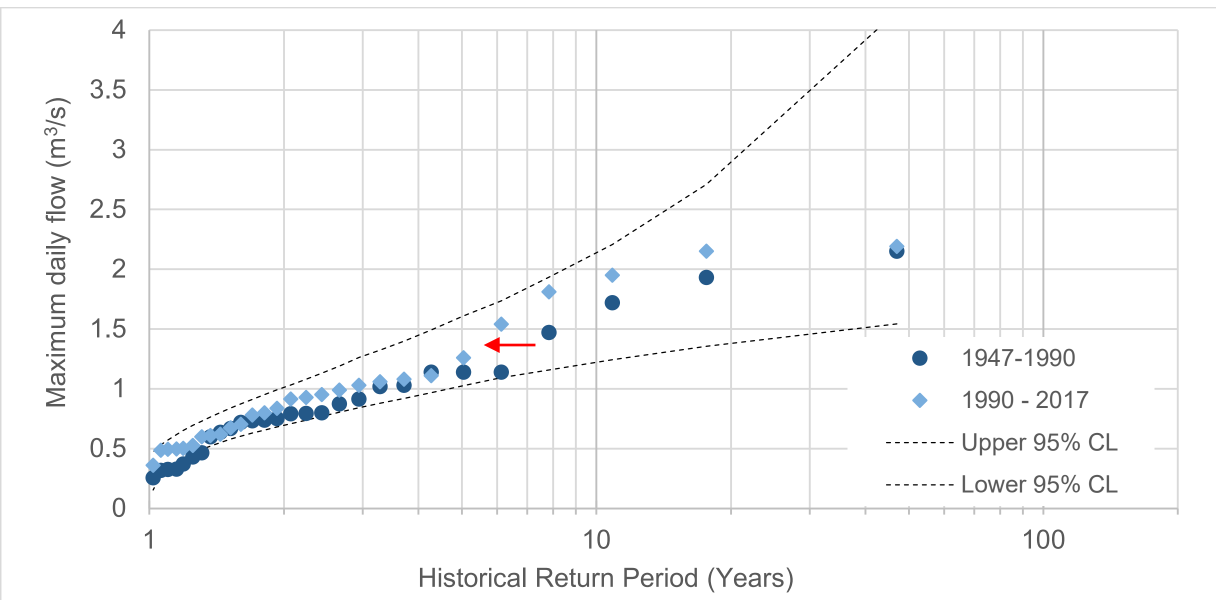

Figure 17: *Flood frequency analysis for subsets of the annual maximum daily flow record on Anderson Creek. The upwards shift falls within the 95% confidence level (CL) around the 1947–1990 subset indicating it is not statistically significant. Red arrow reveals a 33% change in return period (frequency) for a 1.5 m^3/s flood.*

Five Mile Creek frequency analysis also reveals an increase in frequency for floods ranging in magnitude from 13m^3/s to 16m^3/s (Figure 18). As with Anderson Creek, the upwards shift in the frequency distribution of floods is not considered statistically significant at the 95% confidence level.

A more detailed level of investigation and longer record length is needed to determine the cause of the upward shift of the frequency distribution of floods on Anderson and Five Mile Creeks. It is possible that it reflects the cumulative effects of decadal climate cycles and altered forest cover associated with wildfire and disease.

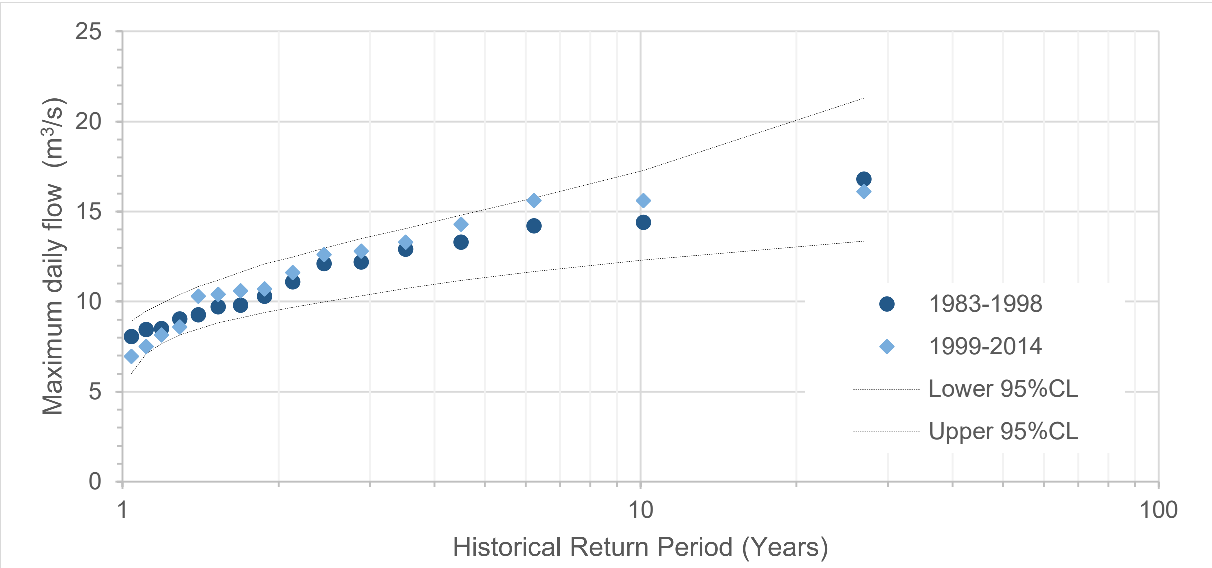

Figure 18: *Flood frequency analysis for 16-year subsets of the annual maximum daily flow record on Five Mile Creek. The upward shift of the 1999-2014 subset lies within the confidence bands around the 1983-1998 subset indicating that this increase is not statistically significant at the 95% confidence level (CL).*

Adaptation Actions and Capacity Building

As discussed in the Extreme Weather section, the City of Nelson has an Emergency Preparedness Plan in place with several established components and others in development.

Floodplain mapping

Flood inundation and hazard mapping was completed in 2019 for the entire City of Nelson. This includes stormwater modeling for storm events.[45]

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. This data was not made available for this report.

Community Impacts and Adaptation Outcomes

Provincial emergency assistance

As with the Extreme Weather pathway, monitoring emergency assistance funding issued by the province can provide some measure of the economic impact of disaster and associated recovery over time. There has been no provincial emergency assistance for any flooding events in Nelson within the last five years.[46]

Dwellings in the floodplain

Understanding how many dwellings are within the floodplain will permit a more accurate assessment of flood risk and help planners understand whether new development policies are needed to support community resilience to flooding. According to a 2018 report, the City of Nelson has 44 dwellings within the floodplain.[47]

Flood-related highway closures

There are no records of flood-related highway closures in the Nelson area since the launch of Drive BC monitoring program in 2006. Closures related to mudslides are reported in the Extreme Weather Pathway.[48]

No evacuation notices

There have been no recent evacuation notices for flooding within the City of Nelson.

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 coming years. The Agriculture Pathway tracks the climate-related viability of 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 Nelson experiencing more growing degree days than in the past and a small increase in the length of the growing season. Continued monitoring of drought levels will help planners understand how a trend toward higher precipitation levels is affecting agricultural viability and local food production. While the number of Nelson residents engaged in backyard gardening shows local enthusiasm for food self-sufficiency, the proportion of homegrown food consumed is low.

Climate Changes

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

Environmental Impacts

Drought Index

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. While this Drought Index data is too short to infer any trends, initial years will contribute to creating a baseline against which future conditions can be assessed. The City of Nelson is contained in the 'West Kootenay Basin' of the index. Since 2015, there has been an annual average of 59 'dry' and 31 'very dry' days in the West Kootenay Basin. The number of days under drought conditions varies from year to year. For example, 2018 was a particularly dry year with 98 days drier than normal conditions (70 dry and 25 very dry), while 2016 was a wetter year with only 70 dry days and no very dry days. [49]

Length of the growing season

A longer growing season[i] allows for 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 experiencing a longer growing season. Historic climate data for Nelson (1950-2018) shows growing season length increasing by 40 days per century. By the 2050s, this trend is projected to jump to 41 and 62 days per century under low and high carbon scenarios, respectively. During the 1961 to 1990 baseline period, Nelson's growing season length averaged 220 days, and is projected to increase to between 245 and 233 days by the 2050s.

Growing degree days

Growing degree days[ii] 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 for Nelson (1950-2018) have been increasing by 418 growing degree days per century. By the 2050s, growing degree days are projected to increase by 631.1 and 819.5 for the low and high carbon scenarios, respectively, from a 1961-1990 baseline of 1963.6 growing degree days (Figure 19).

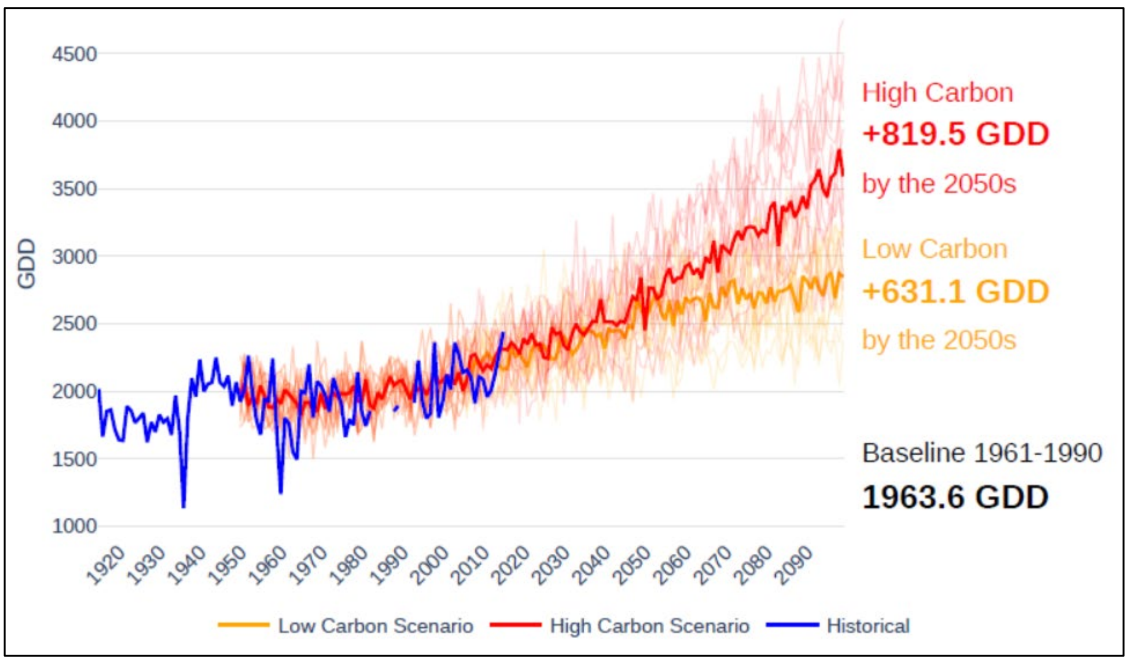

***Figure 19**: Growing degree days in the City of Nelson*

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[i] 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 5°C.

[ii] For the purposes of this report, growing degree days is 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.

Consecutive dry days

The annual maximum number of consecutive dry days for Nelson has declined since the 1950s at a rate of -10.7 days per century. During the 1961 to 1990 period, Nelson's annual maximum number of consecutive dry days was 17.6 days. This is projected to increase by 1.7 to 2.6 days by the 2050s under low and high carbon scenarios, respectively. In a high carbon scenario, the maximum dry spell is projected to be increasing at a rate of 13 days per century by the 2050s.

Adaptation Actions and Capacity Building

Many residents grow some of their own food

Backyard gardening of edible crops is an indicator local self-sufficiency and food security. A voluntary survey of Nelson residents conducted in the summer of 2019 and completed by 132 people found that 83% of respondents grow some of their own food, mostly in home gardens (97%), in plots ranging from less than 5 square feet to over 700 square feet (see Table 7 for more detail). No residents reported growing food in community gardens. The majority of respondents (71%) reported growing between 1-10% of their total food intake. Most home gardeners reported growing vegetables. Over half reported growing fruit or herbs, with raspberries being the most common berry. Only 6% of gardeners reported having nut trees. The most popular items grown were tomatoes, lettuce, potatoes, kale, beans, and berries. Composting is very common with respondents, with 86% indicating they compost garden and yard waste and 83% indicating they use that compost in their food gardens.

Table 7: *Area under cultivation (excluding orchards and berry patches) by growers in the City of Nelson*

Area	% of respondents	# of respondents
Less than 5 square feet	9.8	10
5-15 square feet	14.7	15
15-30 square feet	14.7	10
30-50 square feet	9.8	10
50-100 square feet	19.6	20
100-200 square feet	11.8	12
200-300 square feet	12.8	13
More than 300 square feet	9.8	10

WILDFIRE

Wildfire can cause serious damage to community infrastructure, water supplies and human health. It is projected that climate change may 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. The City of Nelson is situated in the Kootenay Lake Fire Zone (Figure 20), which falls within the boundaries of BC's Southeast Fire Centre.

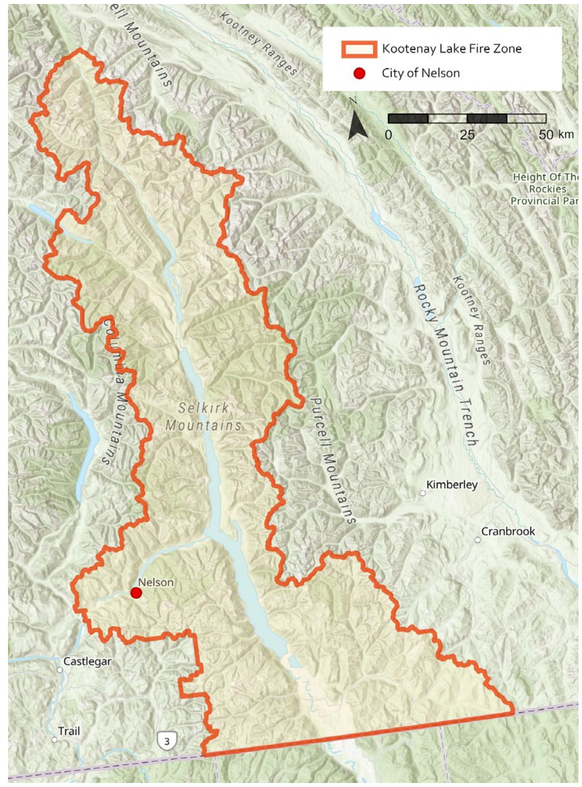

Figure 20*: Kootenay Lake Fire Zone and the City of Nelson*

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. 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, air quality advisories, and road closures. Since 1950, the City of Nelson has had multiple wildfire starts within two kilometres of the municipal boundary, yet only two fires have grown greater than one hectare. Although human-caused wildfires are decreasing, fire prevention education and fuel management remain important as most human-caused fires occur near communities. To reduce wildfire risk, Nelson has a Community Wildfire Protection Plan and a strong commitment to FireSmart practices, as evidenced by recent updates to its Wildland Interface Development Permit Area.

Climate Changes

High fire danger is increasing

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 1991 to 2019, the Smallwood fire weather stations had an average of 20.2 days per year with a danger rating of high or above. Smallwood is the nearest fire danger forecasting station to Nelson. The greatest number of days above a high danger rating at 68 days occurred in 2017, followed by 57 days in 2003, and 55 days in 2015 (Figure 21).These data show a significant trend of roughly 0.6 more days each year at or above a high danger rating.[50]

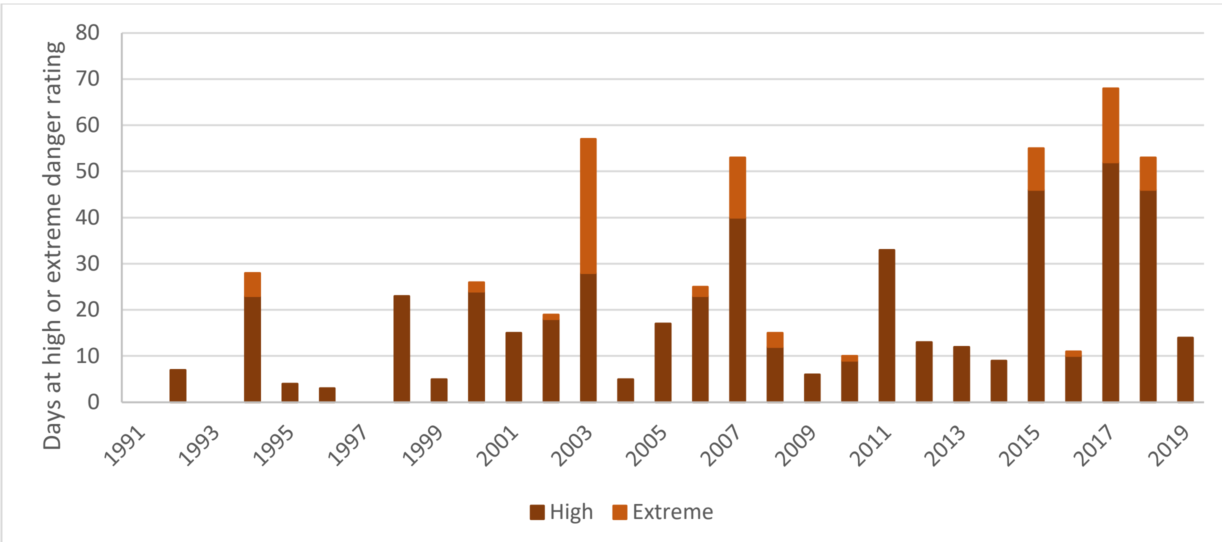

Figure 21: *Days with high or extreme fire danger rating at the Smallwood fire weather station (West of Nelson)*

Environmental Impacts

Air quality declines in active fire years

The air quality indicator measures 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.[51] There is no air quality monitoring station in Nelson; however, the nearest station in Castlegar can provide some insight on air quality in the region. The worst air quality on record occurred in 2018, with 30 days of $PM_{2.5}$ concentrations above the 24-hour $PM_{2.5}$ air quality objective for British Columbia of 25 ug/m^3.[52,53]

A comparison of Castlegar data from 2016 (a year with minimal wildfire activity) to 2018 (a year with exceptionally high wildfire activity) shows how air quality in our mountainous region can be influenced by smoke from wildfires (Figure 22).

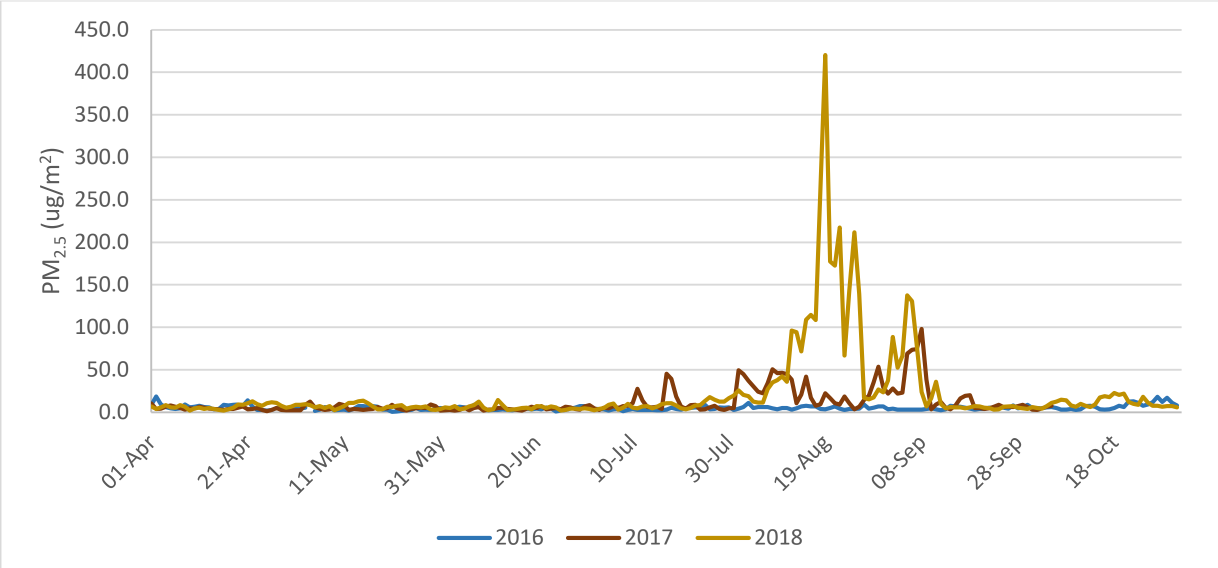

Figure 22: *Daily average $PM_{2.5}$ readings at Castlegar Zinio Park in 2016, 2017 and 2018*

In 2017, the BC Ministry of Environment implemented a Smokey Skies Advisory service to advise communities when they are likely to be affected by wildfire smoke. This smoke modeling initiative does not serve as a substitute for a $PM_{2.5}$ monitoring station but can provide some indication of smoke prevalence. In 2017 and 2018 West Kootenay forecast region was under a Smokey Skies Advisory for 43 and 46 days respectively.[54]

Average of three wildfire starts per year

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 number of wildfires started annually in the Southeast Fire Centre region. All fire zones in the Southeast Fire Centre and the Kootenay Lake Fire Zone 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 Kootenay Lake Fire Zone. This is typical of most of the areas analyzed in the Southeast Fire Centre.[55]

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.[56]

On average, there are three wildfires starts per year within two kilometres of Nelson. The ratio of fires caused by humans vs. lightning can be influenced by both climate and human activities. Within a two kilometres radius of Nelson, the ratio differs from that of the Southeast Fire Centre where, historically, about two thirds are lightning-caused. Near Nelson, records show that more fires have been caused by humans than lightning. This is a typical pattern around municipalities, as most human-caused fires tend to occur near populations centers. However, both the Southeast Fire Centre and the Kootenay Lake Fire Zone have seen significant declines in human-caused fires over time and records from recent years show lighting as the dominant cause of wildfire.

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 1900's, no statistically significant trend can be observed in the annual area burned in the Kootenay Lake 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 20 years.[57] 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 23)

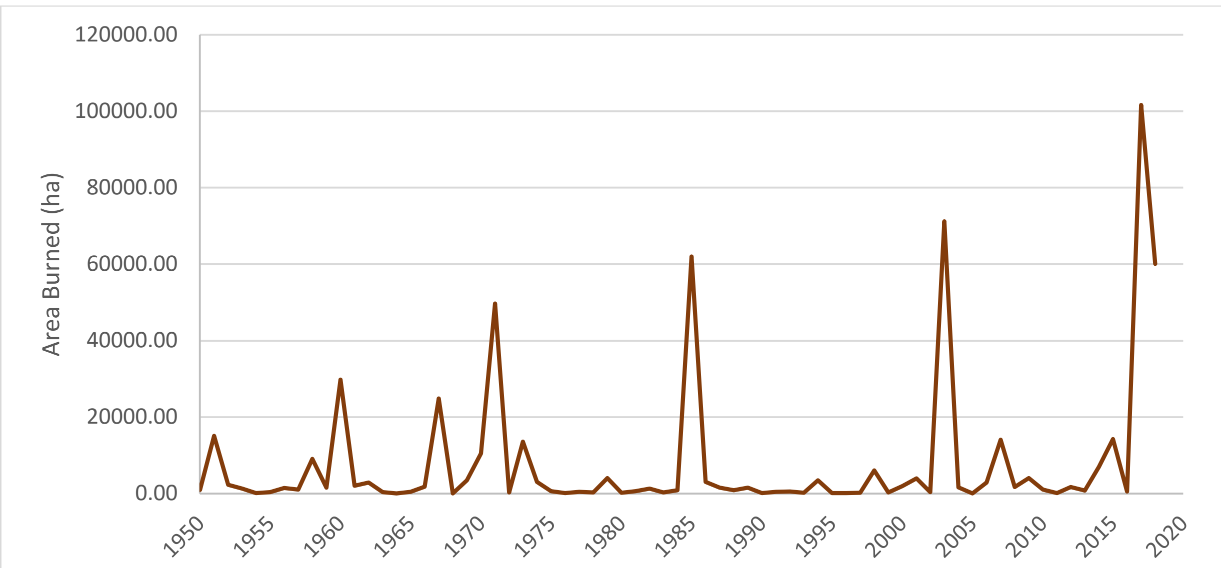

***Figure 23**: Annual area burned in the Southeast Fire Region*

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 in the past.[58] Improved data quality and fire mapping in later years may also be influencing this trend.

The Kootenay Lake Fire Zone, which includes Nelson, experienced severe wildfire seasons in 1967, 1985, 2003, 2017 and 2018. The worst fire season since 1950 in the Kootenay Lake Fire Zone was 2003 in terms of area burned, with over 19,000 hectares of forest burned.[59] Significant fires have occurred in close proximity to Nelson in recent years. Nelson's watershed had fires greater than 500 hectares in both 1985 and 2003.

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 24). This aligns with recent reports that BC's fire seasons are becoming more extreme as a result of climate change.[60]

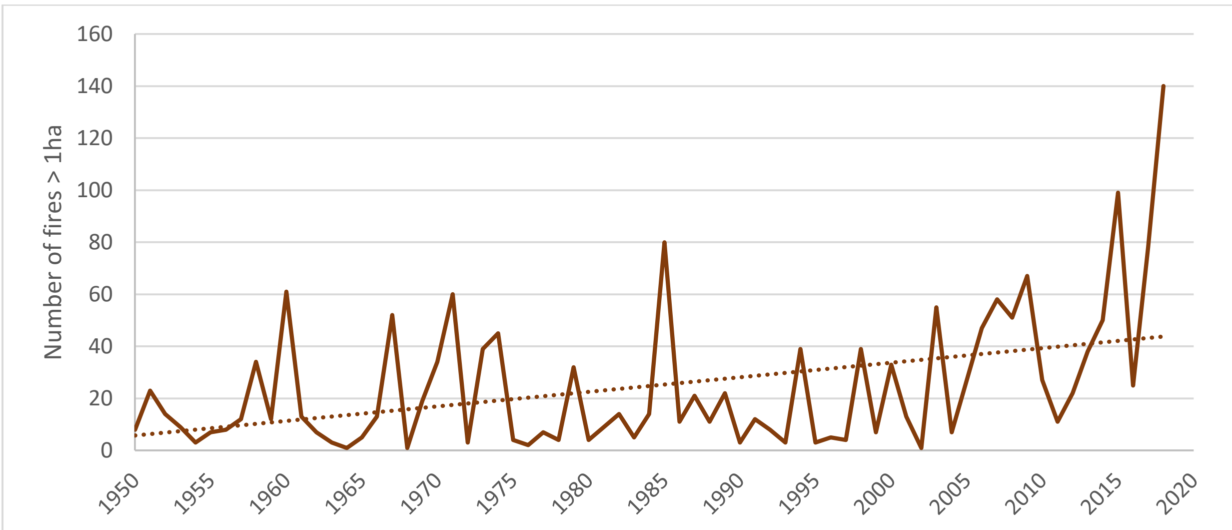

***Figure 24**: Fires >1 ha in the Southeast Fire Centre region, 1950-2018*

Adaptation Actions and Capacity Building

Interface fire fuel treatments

Interface fire risk reduction involves assessing and treating high-risk areas to reduce wildfire risk. The City of Nelson has a Community Wildfire Protection Plan that was last updated in 2015. Within this plan, 100% of the interface area around Nelson has been mapped.[61] City staff estimate that, as of 2019, 5-10% of priority interface area has been treated. A significant challenge is that most of the land immediately adjacent to the City is under private ownership.[62]

FireSmart recognition

This indicator reports on the number of neighbourhoods and households recognized through Fire Smart Canada's Community Recognition Program and Home Partners Program, providing a measure of citizen involvement in reducing the risk of wildfire to their homes. The City of Nelson has a FireSmart program that has been in place since 2010. Since 2015, there has been extensive community awareness programs and over 300 FireSmart home assessments have been completed (average between 60-80 assessments per year). The City has a *Development Permit Area #3 - Natural Environment and Hazardous Lands* (DPA) that includes properties in the City located next to forested lands in the wildland interface zone. This is an updated DPA that reflects the most recent FireSmart guidelines and replaces the previous DPA that was in place since 2008. This DPA contains requirements for FireSmart landscaping and building materials.[63, 64, 65]

Community Impacts and Adaptation Outcomes

Frequency of interface fires

This indicator measures the annual number of wildfires that come within two kilometers of address points (Figure 25). Since 1950, Nelson has experienced only two interface fires greater than 1 hectare in size.[66]

Cost of fire suppression

The average annual cost of fire suppression in the Kootenay Lake Fire Zone from 1970-2019 was $1.95 million, peaking at $22.44 million in 2003 and falling as low as $1317 in 1976. [67] Costs of fire suppression will vary from year to year and are significantly influenced by prevailing weather conditions. The dataset shows an upward trend over the period of record (Figure 26); however, given that reported values are not corrected for inflation, the true direction and magnitude of this trend cannot be assessed.

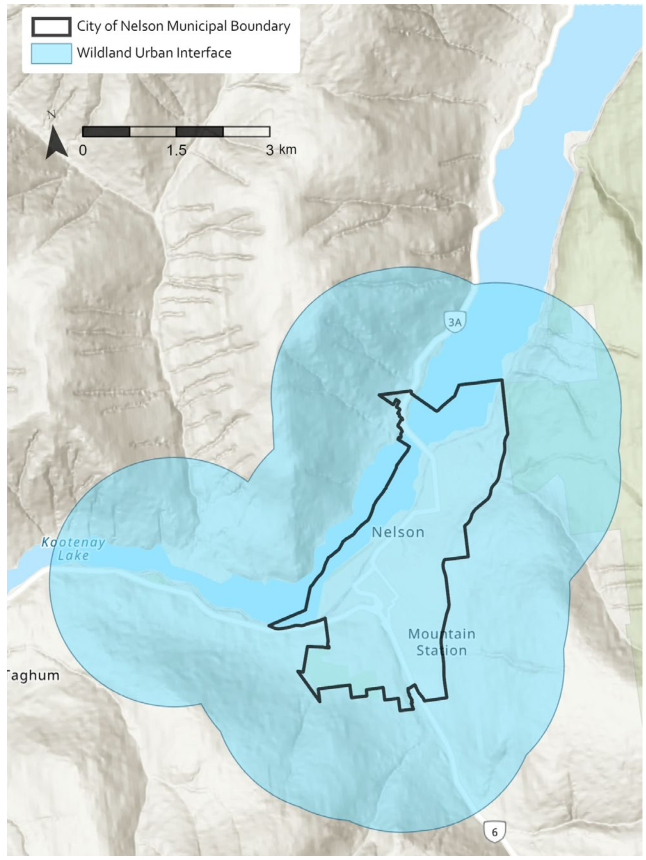

Figure 25: *2 km wildland urban interface zone around the City of Nelson.*

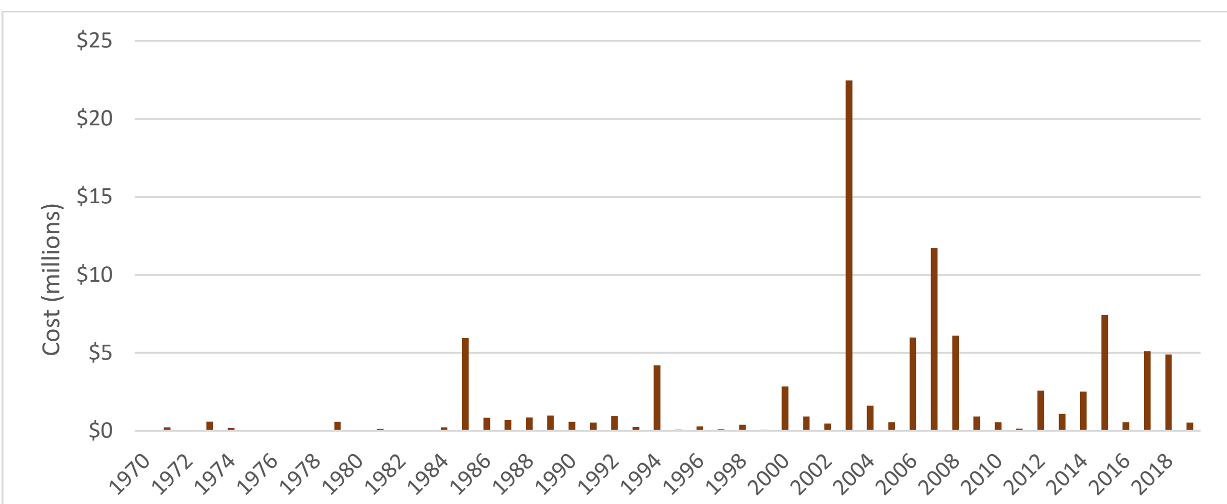

Figure 26: *Annual cost of fire suppression in the Kootenay Lake Fire Zone. (Data values from the 1970s are generally too small to show on the scale needed to show data from recent years.)*

Fire-related highway events

On July 26, 2017, a small wildfire near Tagum caused a closure of Highway 3A in both directions for two hours. This is the only wildfire-caused highway closure near Nelson recorded by Drive BC, which has records beginning in 2006. Highway 3A and Highway 6 are the only roads in in the Nelson area monitored by Drive BC.[68]

Provincial emergency assistance

As with the Extreme Weather and Flooding pathways, there has been no provincial emergency assistance for any wildfire events in Nelson in the last five years.[69]

Annual days under campfire ban

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. The longest fire ban occurred in 2017, lasting 77 days.[70] Long term tracking of this indicator is necessary to establish a trend.

Within the City of Nelson, backyard fires are not allowed at anytime of year, with some exceptions.[71]

No evacuation notices

There have been no recent wildfire evacuation notices for the City of Nelson.

NEXT STEPS

Action Areas

The findings of this report will inform Nelson's upcoming Climate Change Action Plan, which will likely surface additional adaptation priorities and opportunities. Assessment results from this report indicate that the City of Nelson has initiated important steps to improve its adaptive capacity. Some areas for further consideration are evident in the data:

- **Wildfire risk reduction**. Nelson's Community Wildfire Protection Plan identifies recommendations to reduce interface fire risk and establishes priority fuel treatment areas. A very small portion of priority interface land has been treated. By engaging other agencies and private land owners, the City of Nelson may be able to advance creative solutions to this issue, an approach that is supported by the province's new community wildfire resilience framework. The City of Nelson's commitment to FireSmart will help residents advance their own contributions to wildfire risk reduction in the wildland urban interface.
- **Personal and household emergency preparedness**. Continued encouragement of personal and household emergency preparedness among residents would help foster resilience to the types of extreme weather 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.
- **Local food production.** Supporting local food self-sufficiency is an important contributor to the resilience of a community, and the enthusiasm for farming and backyard food growing in Nelson is evident. At the same time, growing agricultural water demand and climate impacts on water supply and demand during the growing season could result in water use conflicts and shortages in the future.
- **Water conservation.** Source water monitoring and protection, water conservation targets, residential water metering, and leak detection and repair represent opportunities to increase the efficient use and resilience of Nelson water supplies.
- **Community trees.** The combination of historical and projected climate changes will increasingly cause stress to community 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. Tree care and procedures for identifying and addressing "danger trees" may warrant new approaches, including education and engagement of residents and property owners.
- **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 heat refuge or clean air shelter. While this is not a lead responsibility for local governments, they can play a supportive role in establishing these facilities.

Future Assessments

It is recommended that the next full SoCARB assessment be conducted in five years (2025). In the interim, the City of Nelson may wish to track certain priority indicators on a more frequent basis to inform City planning and decision making on policy, operations and capital expenditures. A number of SoCARB indicators are tracked as part of the State of the Basin initiative, which means substantial data may be available through the RDI.

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