State of Climate Adaptation

KIMBERLEY 2017

KIMBERLEY
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CONTENTS

INTRODUCTION

Purpose

Welcome to Kimberley's 2017 baseline report for the State of Climate Adaptation and Resilience in the Basin (SoCARB) indicator suite. The SoCARB indicator suite measures community progress on climate adaptation across five climate impact pathways: extreme weather and emergency preparedness, wildfire, water supply, flooding and agriculture. 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.

This report summarizes the results of an analysis of SoCARB indicators for Kimberley, and has been prepared as part of a two-year Columbia Basin Rural Development Institute (RDI) pilot project to test and refine the SoCARB indicator suite in communities across the Columbia Basin-Boundary region.

Climate-related events like flooding, drought and higher temperatures can be critical events for communities. Flooding poses a risk to water infrastructure 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, changes and impacts to the local climate and surrounding environment, and to inform local planning and decision-making. This includes changes in indicators outside of the City'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 72-hour emergency preparedness and per capita water consumption, for example, communities will be better positioned to identify and track where local actions could increase community climate resilience.

Not all 58 SoCARB indicators are reported here. Indicators that Kimberley has not identified as a priority, as well as all indicators from SoCARB's Community Resilience Index (see page 2), have been excluded. Some indicators may be updated annually as part of the city's annual reporting, while others may be updated over a longer time scale as time and resources allow.

Report Highlights

- Kimberley's climate is changing, with data showing trends toward higher average temperatures, higher annual precipitation, more hot days and more precipitation coming as heavy rainfall.
- Shifts in these basic climate metrics are becoming evident through changes in environmental conditions. For example, the spring snowpack is 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.
- Kimberley has taken important steps to adapt to changes that have already happened, and to prepare for future changes. These actions are primarily related to extreme weather (with the

preparation of an emergency preparedness plan and installation of backup power sources) and community water supply (with extensive water conservation efforts including water loss mitigation). Opportunities exist to further Kimberley's readiness to adapt, which includes actions requiring involvement from residents such as promoting maintenance of 72-hour emergency preparedness kits in Kimberley households, and implementing Fire Smart measures in Kimberley neighbourhoods.

- While some datasets are not lengthy or complete enough to evaluate trends that would indicate the effectiveness of Kimberley's adaptation efforts, 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 developed in 2015 by a team of climate change professionals. The full suite groups indicators into two instruments:

1) A set of five thematic pathways (wildfire, water supply, agriculture, flooding, and extreme weather) that, through 58 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 environmental impacts. Impacts can be addressed through adaptation actions and capacity building, and the results of such efforts improve adaptation outcomes.

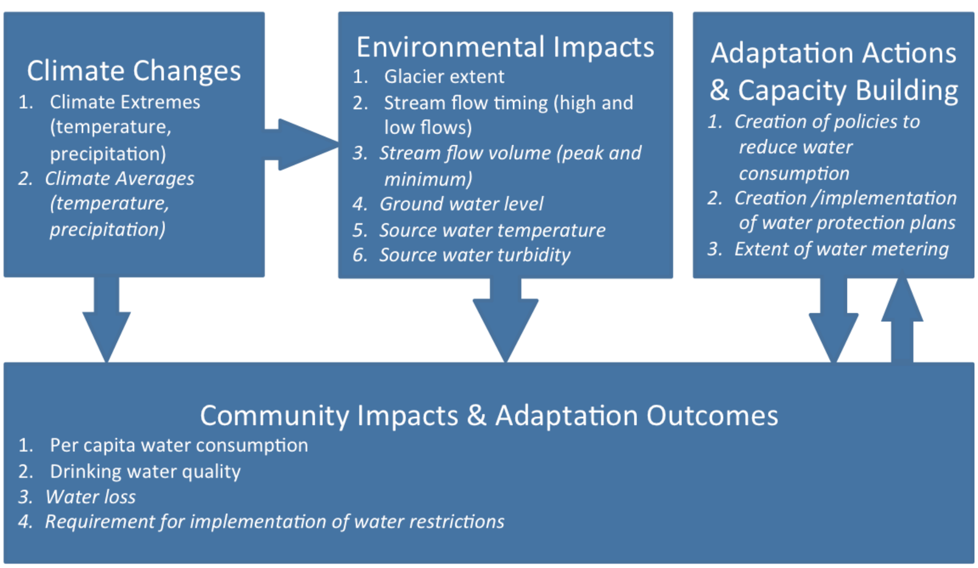

Figure 1: Water Supply pathway from the SoCARB indicator suite

For this report, City staff and consultants identified 42 indicators that reflect local priorities. Community Resilience Index indicators were not assessed as part of this report; however, most are addressed in the

RDI's annual State of the Basin reports. This report includes an introductory Climate section, which presents climate change indicators common to all five pathways, followed by pathway-specific sections structured according to figure 1.

The City of Kimberley has received detailed information as to the data source, analysis method, and reporting for every indicator in this report so that each indicator can be updated and tracked over time.

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 (cbrdi@selkirk.ca). Understanding the data and its limitations is important for many reasons. The points below are general notes to keep in mind 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. Basin climate 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. For example, the closest weather station to Kimberley is in Cranbrook. While overall climate trends are similar for both communities, Kimberley's mean temperatures are lower than Cranbrook (colder) and its mean precipitation levels are higher than Cranbrook (wetter). For this reason, climate data have been modeled for Kimberley. 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., anomalous weather) should also be considered.
- **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.

CLIMATE

Four climate change indicators are common to all five 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 indicators all use two datasets—both of which are discussed for comparative purposes. Adjusted and Homogenized Canadian Climate Data (AHCCD) from Environment Canada provides long-term (since 1901) observed data for Cranbrook. North American Regional Reanalysis data (NARR) from the US National Oceanic and Atmospheric Administration provides shorter-term (since 1979) modeled data for Kimberley[i]. To provide regional context, results of a composite analysis of average temperature and precipitation from AHCCD data available for three stations in the Southeast Canadian Columbia Basin are also discussed[ii].

The Overall Picture

Both average annual and extreme temperatures are rising in the area around Kimberley, with winter warming at a faster rate than other seasons. This could have negative implications for snow-related tourism, local ecosystems and infrastructure. Annual precipitation is also increasing, but the trend is not consistent across seasons. The trend toward higher average precipitation in the spring and summer could have positive implications for water supply and local food production though a simultaneous increase in extreme precipitation events could have the opposite effect due to the impact that flooding and debris slides may have on infrastructure, and the potential for crop damage to impact local food production.

Average annual and seasonal temperatures are increasing

Various analyses of climate data for the Kimberley area consistently show increasing temperatures over time (Table 1, Figure 2).

	Annual	Winter	Spring	Summer	Fall
Kimberley (since 1979)	*1.8*	not available			
Cranbrook (since 1901)	1.8	2.5	1.6	1.8	1.1
Southeast Columbia Basin (since 1915)	1.7	2.7	1.3	1.3	1.4

Table 1: Annual and seasonal average temperature trends for Kimberley, Cranbrook and the Southeast Basin, in degrees Celsius per century. Results that are not statistically significant (reliable) are in italics.

Annually, Kimberley temperatures have averaged 6.2°C since 1979 and ranged from 4.0 degrees in 1996 to 7.8 degrees in 2015. Trends for Cranbrook and the Southeast Columbia Basin are statistically

[i] For the purposes of this report, to more accurately reflect local conditions, NARR data have been adjusted using known trends calculated from the AHCCD dataset. Data and analyses were provided by Charles Cuell and Climate Resilience Consulting. It is important to note that modeled trends based on the NARR analysis encompass only 37 years of data. Relatively speaking, this is a short record for climate trends. Short climate records are vulnerable to inordinate influence by natural fluctuations (“oscillations”) in the climate cycle. For this reason, trends based on NARR data should be viewed and used with consideration of these limitations.

[ii] This analysis was provided by Mel Reasoner and Columbia Basin Trust

significant and show that annual average temperatures have increased at a rate of 1.8 and 1.7 degrees per century (respectively) since the early 1900s.

Winter, spring, summer and autumn average temperatures have also all increased in both Cranbrook and the Southeast Basin over the period of record. Winter temperatures have increased at the highest rate, with increases of 2.5 and 2.7 degrees per century calculated for Cranbrook and the Southeast Basin respectively.

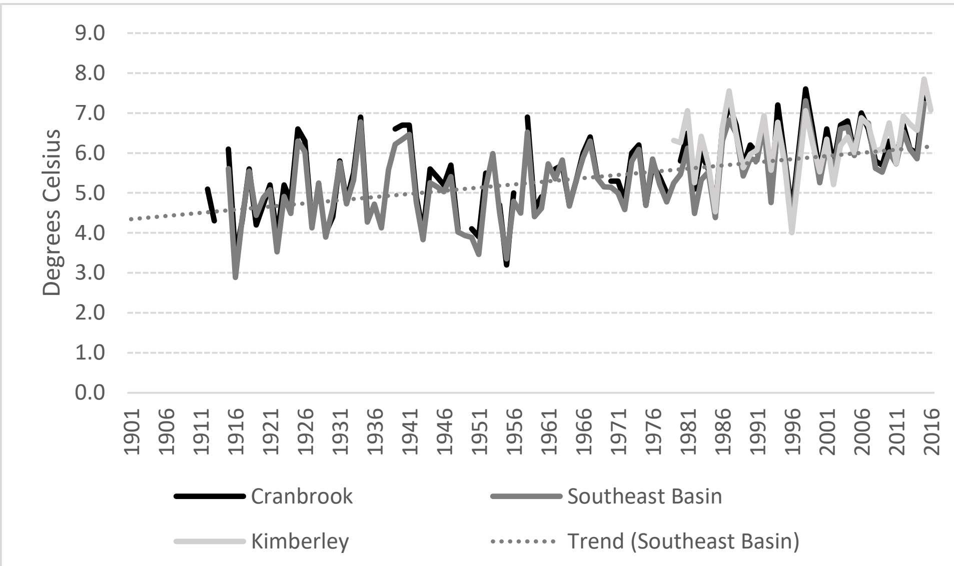

Figure 2: Average annual temperature for Kimberley, Cranbrook, and the Southeast Columbia Basin

Annual precipitation is increasing

Annual precipitation records from the various datasets analysed also generally show increasing trends (Figure 3, Table 2).

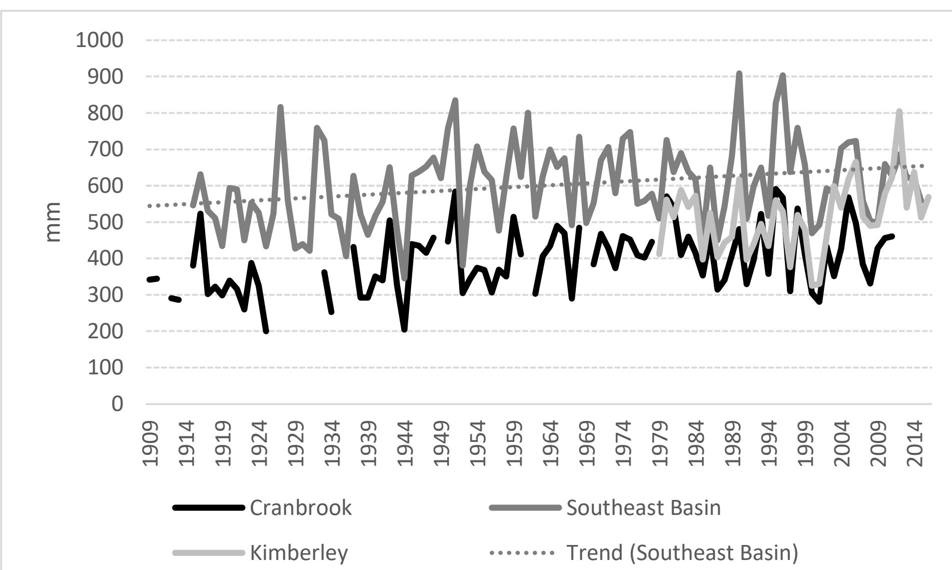

Figure 3: Total annual precipitation for Kimberley, Cranbrook and the Southeast Basin

Total annual precipitation in Cranbrook ranged from 169 to 568 mm per year from 1909 to 2012, while modeled data for Kimberley shows higher annual precipitation, ranging between 325 and 805 mm per year from 1979 to 2015, and averaging 515 mm. Annual precipitation in the Southeast Basin has increased at the rate of 119 mm per century since 1915. Cranbrook and Kimberley are also showing statistically significant increasing trends in annual precipitation of 130 and 301 mm per century respectively.

Seasonally, spring and summer total precipitation records show increasing trends in Cranbrook and the Southeast Basin. Winter precipitation may be declining, but trends are not statistically significant. Seasonal values were not calculated from the Kimberley data.

	Annual	Winter	Spring	Summer	Fall
Kimberley (since 1979)	301	not available			
Cranbrook (since 1909)	130	*-14*	60	43	*21*
Southeast Columbia Basin (since 1915)	119	*-40*	69	46	49

Table 2: Annual and seasonal total precipitation trends for Kimberley, Cranbrook and the Southeast Basin, in millimetres per century. Results that are not statistically significant (reliable) are in italics.

More hot days

The extreme temperature indicator measures the percentage of days where the temperature exceeds the 90th percentile for the baseline period (1961-1990). For Cranbrook since 1909, this percentage has ranged between a low of 2.7% (10 days) in 1948 and a high of 21.1% (77 days) in 1987. For Kimberley, it has ranged between a low of 3.5% (13 days) in 2000 and a high of 22.8% (83 days) in 1987, averaging 11.1% (41 days) since 1979 (Figure 4). The Cranbrook data shows a statistically significant rate of increase of about 0.05% per year (approximately 16 days per century). The Kimberley data does not show a statistically significant trend.

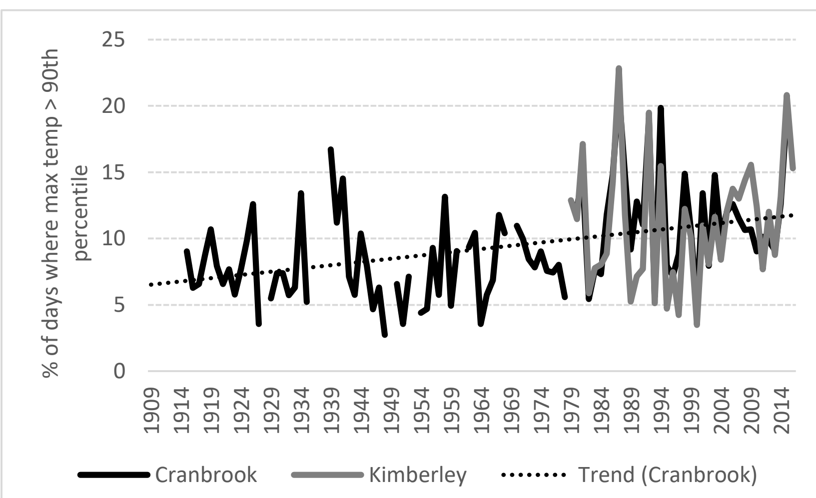

Figure 4: Hot days in Cranbrook and Kimberley

More precipitation during heavy rainfalls

The extreme precipitation indicator measures the annual sum of daily precipitation exceeding the 95th percentile for the baseline period (1961-1990), and can also be described as the amount of rain that falls during very heavy rainfall days annually. The trend in extreme precipitation for Kimberley shows an increase of 2.9 mm per year (285 mm per century) since 1979 (Figure 5), which means an average of 107 mm more rain is now falling during heavy rainfalls as compared to 1979. Cranbrook's long-term record since 1909 does not show a statistically significant trend

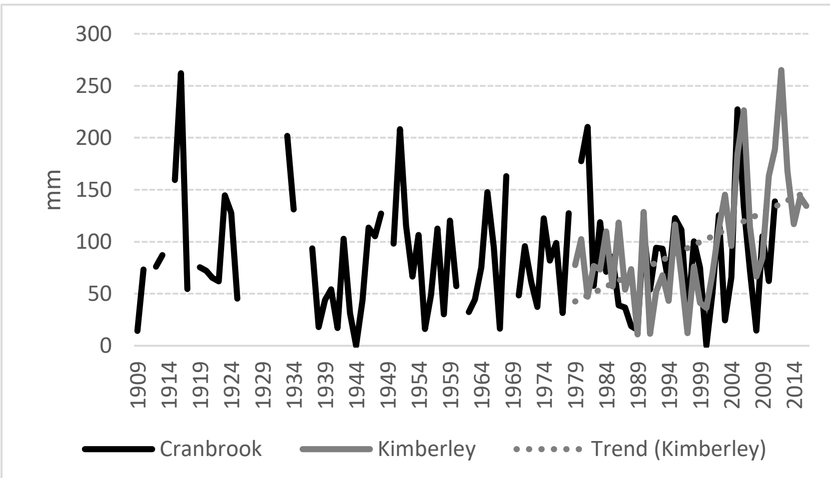

Figure 5: Amount of rain falling during heavy rainfall in Cranbrook and Kimberley

EXTREME WEATHER AND EMERGENCY PREPAREDNESS

Extreme weather events, such as extreme snowfall, windstorms and heat, can have significant impacts on communities, both positive and negative. Future projections suggest an increase in some extreme weather events, such as warm days, extreme warm days, and extreme wet days. Communities can prepare for extreme weather events with adaptations such as emergency preparedness plans, backup power sources and home emergency preparedness kits. Results for nine Extreme Weather pathway indicators are reported below.

The Overall Picture

Extreme weather patterns are changing in Kimberley, with hot days, heavy rain days, extreme heat days, and maximum 1-day rainfall all on the rise in either Cranbrook or Kimberley, and fewer extreme snowfall events occurring. Continued monitoring of highway closures and Provincial Emergency Program payments will aid in understanding how these changes are affecting the municipality and residents. The City is taking action to prepare for emergency events, and there is an important opportunity for residents to enhance their level of preparedness for extreme weather events.

Climate Changes

As discussed in the Climate section, Cranbrook has seen a long-term increase in hot days, and Kimberley has seen a short-term increase in heavy rain days. Additional climate indicators related to the Extreme Weather pathway are discussed below.

More extreme heat days

Temperature data for Cranbrook over the last hundred years shows a clear upward trend in frequency of days over 30°C. The number of days has roughly doubled during this time, increasing at a rate of 9 days per century (Figure 6). Modeled data show that the number of extreme heat days in Kimberley is generally much lower than in Cranbrook, averaging 3 days per year. Kimberley data do not show a statistically significant trend. Heat waves and heat extremes have negative health impacts on vulnerable populations including the elderly, socially isolated, chronically ill, and infants.

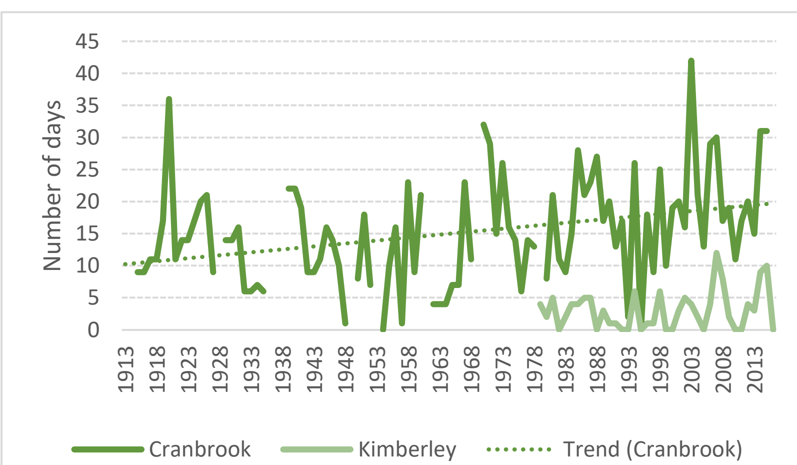

Figure 6: Extreme heat days (above 30°C) in Cranbrook and Kimberley

Fewer extreme snowfall events

Long-term snowfall data is not available for Kimberley. However, Cranbrook data shows a steady decline in extreme snowfall days since 1909 through to 2009, which is defined as receiving 15 cm or more over 24 hours (Figure 7). Cranbrook's annual maximum 1-day snowfall is decreasing by 11 cm per century. A short data record for Marysville shows that Kimberley's location and higher elevation results in more extreme snowfall days than Cranbrook, totalling 28 days over the period 1985-2007 (as compared to 9 in Cranbrook).

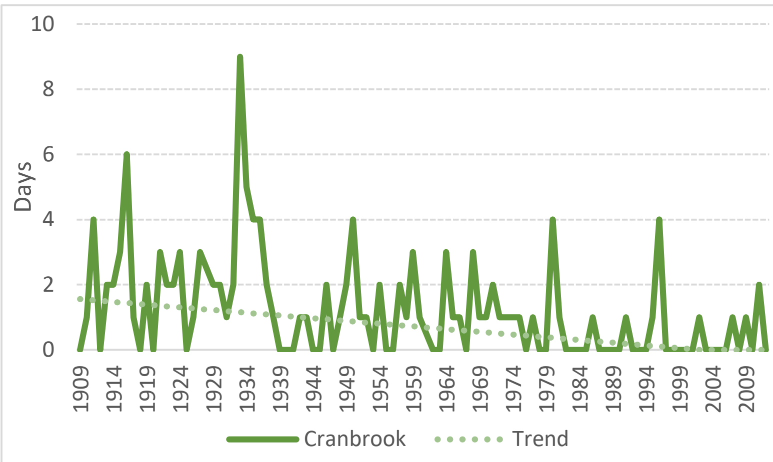

Figure 7: Extreme snowfall days in Cranbrook

Monitoring strong wind events

Wind storms can damage infrastructure, bring down power lines and cause power outages. Between 1985 and 2016 there were 4 strong wind events recorded at the Cranbrook weather station. All four events occurred since 2007. A strong wind event is defined as a day with winds of 70 km/h or more of sustained wind and/or gusts to 90 km/h or more. Wind data is not available for Kimberley.

Increasing maximum 1-day rainfall in Kimberley

Modeled data for Kimberley shows a statistically significant rate of increase in maximum 1-day rainfall of 0.2 mm per year (21 mm per century). Annual maximum 1-day rainfall since 1979 has ranged from 10.9 mm to 34.1 mm, averaging 19.4 mm. Cranbrook's weather data shows no statistically significant trend for 1909-2015. Heavy rainfall is a major cause of flooding of creeks and rivers, and can cause stormwater management issues. A warming climate increases the risk of extreme rainfall events.

Adaption Actions and Capacity Building

Emergency Preparedness Plan in place

Kimberley has an updated emergency plan that is reviewed on a regular basis, with several new components now in development (Table 3).

Table 3: Emergency Preparedness Plan components in Kimberley

	Yes	In Progress
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[1]	☐	☑
Plan for shelter stocking	☐	☐
Training and emergency exercise plan for response personnel	☐	☑
Contact list for all response personnel[2]	☑	☑
Fan-out call list[3]	☑	☐
MOUs with any agencies helping in response (e.g. neighbouring municipalities, school board, local service groups)[4]	☐	☑

1: Location will depend on where the incident happens.
2: Needs to be updated annually.
3: Air horn and pagers for the Fire Department.
4: Mutual aid agreement in place with Cranbrook.

Emergency backup power is in place

Kimberley has backup power sources for its drinking water system and sanitary sewer system. It has not identified a need for backup power at City Hall, the public works yard, an emergency operations centre (EOC) or an evacuation centre. While the location for an evacuation centre and EOC will depend on the location and type of emergency event, Cranbrook is the preferred location.

Few residents have complete emergency preparedness kits

A voluntary resident survey conducted by the City of Kimberley in March 2017 in conjunction with its Emergency Preparedness Week shows considerable opportunity for improvement in emergency preparedness among residents. Of 92 respondents, 64% did not have a 72-hour emergency kit. Of those who had a kit, only three of 16 standard emergency kit items were identified by all respondents: flashlight and batteries, candles and matches/lighter, and a first aid kit (Table 4).

Table 4: % of respondents with emergency kits indicating the presence of important items in their kit

Item	% Yes
Flashlight and batteries	100%
Candles and matches/lighter	100%
First aid kit	100%
Drinking water (2 - 4 litres of water per person and pets per day)	94%
Food that will not spoil (min. 3-day supply)	93%
Manual can-opener	77%
Seasonal clothing and blankets	79%
Extra keys for your car, house, safe deposit box	68%

Battery-powered or wind-up radio	61%
Cash in smaller bills and change	58%
Copies of identification papers (licenses, birth certificates, care cards)	55%
Special items such as prescription medications, infant formula or equipment for people with disabilities	48%
Insurance policy information	45%
A copy of your emergency plan including contact numbers (e.g. for out-of-town family)	47%
Solar charger or power inverter	37%
Diesel- or gas-powered generator	20%

Community Impacts and Adaptation Outcomes

Three weather-related highway closures in past decade

Since 2006, Kimberley has had three weather-related highway closures ranging in duration from 4 to 15 hours. Two closures were due to mudslides in 2012 and 2014, and one closure due to black ice in 2015. A longer-term dataset is needed to evaluate trends.

Provincial emergency assistance paid to local government

From 2006-2016, the City received $201,698 in provincial emergency assistance for a total of three flooding events (2006, 2012, 2013) and one landslide (2011). A longer-term dataset is needed to evaluate trends.

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 could change the amount of water stored in the snowpack and the timing of surface water availability in the spring. 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. Mark Creek is Kimberley's main water source and has the capacity to supply the entire community, and Matthew Creek provides a supplementary water source, primarily for Marysville residents.

The Overall Picture

While the trend toward a wetter spring and summer in Kimberley may have positive implications for water supply, the warming trend may have the opposite effect. Regional research suggests changes to the climate could alter the timing of flow in local streams and, notably, reduce the volume of water available for human use, especially in late summer and early fall; however, gaps in monitoring data for Kimberley's source watersheds preclude an assessment of local trends. Kimberley has expended considerable effort to implement policies and actions to reduce water consumption and water loss. Continued commitment to these practices will help position Kimberley to adapt to changes in its water supply.

Climate Changes

As discussed in the Climate and Extreme weather sections, average annual and seasonal temperatures are increasing, annual precipitation is increasing, Cranbrook is experiencing more hot days, and Kimberley is experiencing more extreme precipitation.

Environmental Impacts

Glacier extent is decreasing

Glacier extent in the Canadian Columbia Basin declined by 20 per cent from 1985 to 2005, and has declined further since then. Data up to 2013 will be released later in 2017. A decline in glacier extent and glacial meltwater has implications for reduced summer stream flow and higher summer water temperatures in the St. Mary River. While Kimberley's drinking water supply comes from non-glacial sources, the St. Mary River forms part of Kimberley's southern boundary and is a popular destination for river and water-based recreation.

Stream flow timing data precludes trend analysis

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; however, while present in the western Rockies of the U.S., this trend has not yet been detected by streamflow monitoring in the Canadian Columbia Basin.

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. Stream flow records for Mark and Matthew Creeks are too short and incomplete to determine trends—the Matthew Creek record ends in 2007 and the continuous Mark Creek record ends in 2012. The City implemented seasonal monitoring on Mark Creek following removal of the continuous monitoring station; however, a change in instrumentation prohibits comparisons between current and historic data. Peak stream flow for Mark and Matthew Creeks between 1989-2012 occurred during a six-week period between May 7 and June 18. During the same period, the timing of half total-flow for Mark and Matthew Creeks occurred between May 21 and June 16.

Stream flow volume data precludes trend analysis

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 both Mark and Matthew Creeks is too short to suggest any statistically significant trends. Annual maximum daily discharge for Mark Creek ranged from 5 to 22 m^3/s between 1989-2012. Matthew Creek ranged from 11-50 m^3/s between 1989-2007. Over the same time periods, annual minimum daily discharge for Mark Creek ranged from 0.1 m^3/s to 0.35 m^3/s and Matthew Creek ranged from 0.12 m^3/s to 0.32 m^3/s.

Source water temperature data collection initiated in 2012

Temperature can be an important determinant of water quality. Data collection for source water temperature for Mark and Matthew Creeks began in 2012 for the months of May to September. Collection of this data creates a baseline against which future measurements of source water temperature can be compared.

Source water turbidity data collection initiated in 2014

Higher turbidity associated with snowmelt and high stream volumes during spring freshet may result in boil water notices or water quality advisories. Kimberley began data collection for this indicator in 2014, which will be useful for setting a baseline against which future measurements of source water turbidity can be compared.

Adaptation Actions and Capacity Building

Policies to reduce water consumption reflect Kimberley's unique circumstances

As shown in the table and associated notes below, Kimberley has integrated a broad range of water conservation measures into its policies (Table 5). As part of the Basin-wide Water Smart program from 2009-2015, Kimberley actively implemented a variety of measures to improve leak detection, reduce water loss associated with aging infrastructure, and encourage water conservation by individual users.

Table 5: Implementation of policies to reduce water consumption in Kimberley

	Level of Implementation				No policy
	Full	**Moderate**	**Minimal**	**None**	
Universal water metering[1]	☐	☐	☐	☑	☑
Public education and outreach on water conservation	☑	☐	☐	☐	☐
Public education and outreach on water consumption trends[2]	☐	☑	☐	☐	☐
Water meter data analysis	☑	☐	☐	☐	☐
Consumer billing by amount of water used (volumetric)	☐	☐	☐	☑	☑
Implementation of water utility rates sufficient to cover capital and operating costs of water system	☑	☐	☐	☐	☐
Water conservation outcome requirements for developers[3]	☐	☐	☐	☐	☑
Water conservation targets[4]	☑	☐	☐	☐	☐
Stage 1 through 4 watering restriction bylaw	☑	☐	☐	☐	☐
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	☑	☐	☐	☐	☐
Other policy: Night flow analysis	☑	☐	☐	☐	☐
Other policy: 24 hr leak detection, 48 hr response	☑	☐	☐	☐	☐

1: Kimberley has assessed universal metering and determined that it is not, at this time, a cost-effective measure. Accordingly, consumer billing based on volume of water use is not under consideration for residential customers.
2: This occurs twice a year.
3. In development (early stages).
4. Updated annually.

Water protection plan will be completed in 2017

Kimberley has one municipal water utility and three water sources: Mark and Matthew Creek, with St. Mary River as a backup/emergency source. Potential climate impacts and adaptive measures have been identified, and an Integrated Watershed Management Plan is due to be released later in 2017.

Water loss detection practices in place

Kimberley is well positioned on water loss detection practices, and has implemented the full suite of water loss detection practices except residential water meters (Table 6). Residential water meters are not being considered because of high turbidity and sedimentation issues associated with spring runoff, and pressure issues in the water system when water volumes are low.

Table 6: Implementation of water loss detection practices in Kimberley

	Full implementation	Moderate implementation	Minimal implementation	No implementation
District water meters	☑	☐	☐	☐
Residential water meters	☐	☐	☐	☑
Night flow analysis	☑	☐	☐	☐
Water loss audits	☑	☐	☐	☐
Acoustic leak detection	☑	☐	☐	☐
Leak noise correlation testing	☑	☐	☐	☐
Reprioritize main replacement annually	☑	☐	☐	☐

Community Impacts and Adaptation Outcomes

Per capita water consumption higher than Basin average

This indicator measures water use attributable to user demand and system water loss. Kimberley's monthly volume of water supplied tends to follow a predictable pattern from year to year, with peak annual supply occurring in summer months (0.95m m^3 - 1.2m m^3) and lowest annual supply occurring during winter months (0.64m m^3 to 0.78m m^3), a seasonal difference of 30 to 50 per cent depending on the year. The Water Smart program reported a 6% decrease in gross community water demand at the end of the program, using 2011 as the baseline year; however, per capita water use continues to be higher than the Basin average (Figure 8). Continued implementation of best practices in water loss management and public education regarding peak demand reduction are the two primary opportunities to reduce water consumption in Kimberley.

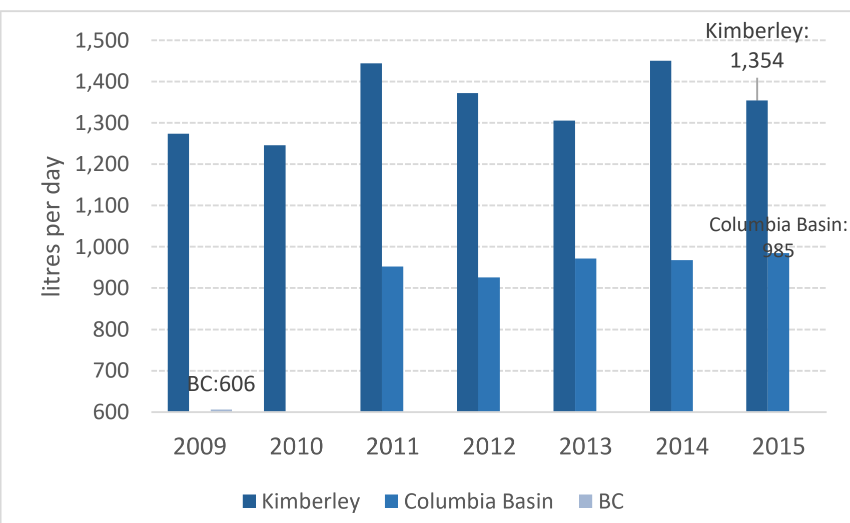

Figure 8: Per capital water consumption in Kimberley, the Columbia Basin, and BC. Note that 2009 and 2010 figures for Kimberley are linked to source meters that were determined to be under-reporting actual water use.

Drinking water quality decreases during spring freshet

The Interior Health Authority requires communities to notify residents of high turbidity and/or the presence of pathogens in drinking water. The frequency of notices could increase with climate change; however, there is currently no such trend in Kimberley. Days under an active Boil Water Notice or Water Quality Advisory since 2006 have ranged from 0 in 2009 and 2010 to 165 in 2014. Water quality events in Kimberley are typically caused by high turbidity in the water system. High turbidity is usually triggered by rapid snowmelt or heavy rainfall.

Implementation of watering restrictions began in 2016

Kimberley implemented Water Shortage Response Bylaw No. 2527 in late 2015 after an unusually hot, dry summer. In 2016, the community experienced 121 days with Stage 1 watering restrictions. The new bylaw means that Kimberley is better equipped to address water shortages using a staged approach. It will be several years before any short-term trends in watering restrictions become evident.

Tackling water loss

Kimberley's 2014 Water Loss Management Plan estimated water loss in the water system at approximately 1600 mL, or about 50% of total water supplied. Kimberley has invested in infrastructure upgrades that will allow for ongoing improvements to water loss detection and repair, so this figure is likely to improve in the future. Reducing water loss will have positive economic and environmental outcomes for the City, residents and local ecosystems.

FLOODING

Projected climate changes, including more intense rainstorms and warmer, wetter winters, indicate a potential for higher flood risk. Flooding affects communities through damage to homes and infrastructure, and negative impacts on water quality. Certain areas in Kimberley are prone to flooding. In some cases, flooding occurs gradually, allowing impacts to be somewhat mitigated with proper planning. In other cases, such as those resulting from severe storms, flooding occurs rapidly, requiring the rapid implementation of emergency measures by the community.

The Overall Picture

A trend toward heavier rainfall events may indicate a higher risk of rapid flooding. Conversely, a shift to lower spring snow packs may have positive implications for flood risk. Kimberley's Emergency Preparedness Plan is an essential tool for minimizing the potential impacts of flooding on residents and the built environment.

Climate Changes

As discussed in the Climate and Extreme Weather sections, the amount of rain falling during heavy rain days and maximum 1-day rainfall are both increasing in Kimberley. One additional climate change indicator in the Flooding Pathway is covered below.

Freeze-thaw cycle not showing a trend

The frequency of freeze/thaw cycles is an important parameter for engineering design in cold regions. The modeled NARR data for Kimberley covers 1979 to 2016 and shows no statistically significant trend. Annual number of days identified as experiencing a freeze/thaw cycle ranged from a minimum of 107 days in 1987 and 1993 to a maximum of 158 days in 1999.

Environmental Impacts

As discussed in the Water Supply section, available streamflow data are inadequate to determine local trends. One additional environmental impact indicator from the Flooding Pathway is covered below.

April 1st snow pack is declining

Snowpack depth provides an indication of the amount of snow available to contribute to water supplies and flooding. The rate of change in April 1st snowpack at the Sullivan Mine from 1946 to present shows a statistically significant decline of 72 cm per century (Figure 9). April 1st snow-water equivalent (SWE) shows a distinctive pattern shift around the mid-1970s when the percent of normal snow-water equivalent starts to drop below 100% with greater frequency.

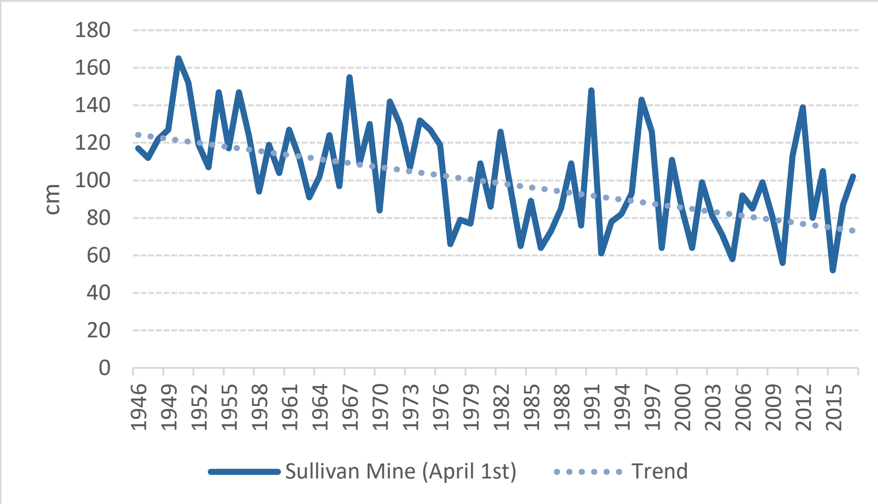

Figure 9: April 1st snowpack at Sullivan Mine

Adaptation Actions and Capacity Building

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

Community Impacts and Adaptation Outcomes

Financial assistance paid to local governments for flooding events

Provincial emergency assistance paid to local government provides an indication of the economic cost of extreme weather events. Since 2006 Kimberley has received $201,698.04 for flood-related response and recovery for four different events (Table 7).

Table 7: Provincial Emergency Program payments to Kimberley

Task #	Claim Type	Year	Event	Eligible Costs	PEP Funding
070385	Response	2006	Morrison Sub Flood	$4,110.92	$4,110.92
120873	Recovery	2011	Mark Creek Landslide	$9,985.88	$7,988.70
130508	Recovery	2012	Morrison Sub Flood	$18,475.29	$13,980.23
130508	Response	2012	Morrison Sub Flood	$112,795.83	$112,795.83
141280	Recovery	2013	Morrison Sub Flood	$54,537.93	$42,830.33
141280	Response	2013	Morrison Sub Flood	$12,736.87	$12,736.87
141280	Response	2013	Morrison Sub Flood	$7,255.16	$7,255.16
Total				**$219,897.88**	**$201,698.04**

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 Cranbrook experiencing 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 higher precipitation levels is affecting agricultural viability and local food production.

Climate Changes

As discussed in the Climate section, average annual and seasonal temperatures are increasing, as is annual and spring/summer precipitation. The number of hot days is also on the rise in Cranbrook and Kimberley is experiencing a higher amount of precipitation falling as heavy rainfall.

Environmental Impacts

Drought Index tracking begins in 2012

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 data set is too short to infer any kind of trend, these initial years will contribute to creating a baseline against which future conditions can be assessed.

Length of the growing season remains unchanged

A longer growing season 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. Data for Cranbrook (1909-2015) does not indicate any discernible trend in growing season length, with the longest and shortest growing seasons at 252 and 139 days, respectively. Modeled NARR data for Kimberley from 1979 to 2016 also lack a statistically significant trend. Kimberley's growing season averages 200 days, peaking at 251 in 2010, dropping to 146 days in 1982.

Growing degree days are increasing

Growing degree days[iii] describe the amount of heat that is available for plant growth, providing better insight on how plants are affected by temperatures than straight temperature data. Growing degree days for Cranbrook (1909-2015) have been increasing by about 2.4 days per year or 238 days per century. While Kimberley's modeled NARR data (1979-2016) doesn't show a statistically significant trend, it shows that Kimberley experiences slightly fewer growing degree days than Cranbrook (an average of 1609 as compared to Cranbrook's 1645).

Less variability in consecutive dry days

There is no statistically significant trend in consecutive dry days in either Cranbrook (since 1909) or Kimberley (since 1979). However, the Cranbrook data shows notably lower variance in the second half of the precipitation record than in the first. This may relate to the long-term increasing trend in annual precipitation.

[iii] 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.

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. Kimberley is situated in the Cranbrook Fire Zone, which falls within the boundaries of BC's Southeast Fire Centre.

The Overall Picture

At the regional scale, wildfires are becoming more frequent and studies generally suggest that this trend, along with a trend to more area burned, will continue. Local-scale data relating to wildfire danger, frequency and size does not show reliable trends but provides a baseline for future assessments. Ongoing monitoring of fire incidents will help Kimberley understand the level of risk that wildfire poses to the community. In addition, continued monitoring of the environmental and economic impacts of fire will help Kimberley evaluate the effectiveness of its mitigation and adaptation actions, including ongoing interface fire risk reduction and implementation of development instruments designed to address fire risk.

Climate Changes

Number of days in high and extreme danger class peaks in August

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 class tells us the number of days where there is high or extreme danger of a fire starting easily and spreading rapidly. For 2001 to 2016, overall fire risk in the Cranbrook Fire Zone was highest in July, August and September (Figure 10), peaking in August with an average of 20 days in the month rated as 'high' or 'extreme.' Extreme fire danger days have occurred as early as May and into September, and high fire danger days have occurred as early as April and as late as November. The short record for this data precludes evaluation of temporal trends.

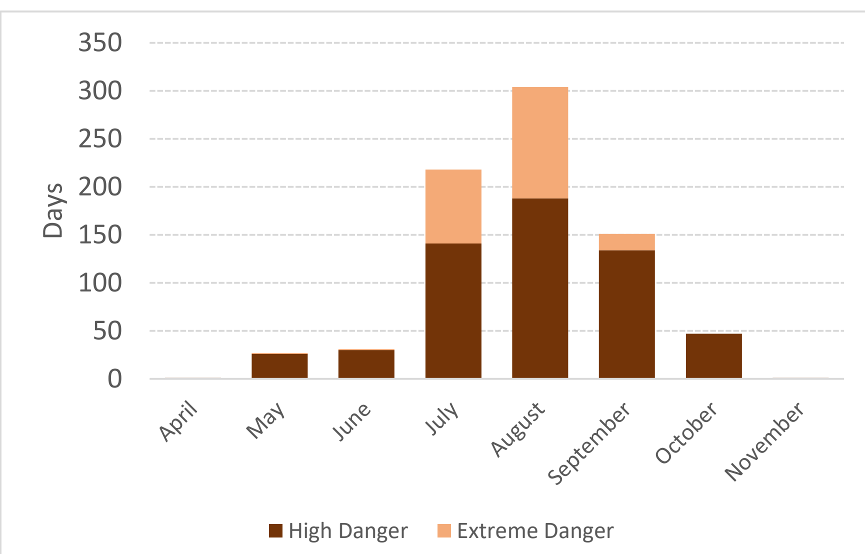

Figure 10: Total days in high or extreme fire danger in the Cranbrook Fire Zone, 2001-2016

Environmental Impacts

Air quality data provides limited insights on wildfire impacts

The air quality indicator reports concentrations of fine particulate matter ($PM_{2.5}$) in the air and is strongly influenced by wildfire. High $PM_{2.5}$ concentrations can have significant impacts on human health. Cranbrook installed an air quality monitoring station in 2008 that samples $PM_{2.5}$ concentrations every sixth day. Since then nine days were recorded with $PM_{2.5}$ concentrations over 12 ug/m^3 (micrometers per cubic meter), a threshold identified by the U.S. Environmental Protection Agency as causing respiratory symptoms in sensitive individuals. The highest level recorded was 49.7 ug/m^3 in August 2015, reflecting a particularly active wildfire season in the larger Pacific Northwest region. Due to the infrequency of sampling, it is not possible to evaluate trends in this data.

Increasing number of wildfires at regional scale

This indicator tracks the total number of human-caused and lightning-caused wildfire starts per year. Though national-scale data points to increasing frequency of wildfires, there is no statistically significant trend in the number of wildfires started annually in the area immediately surrounding Kimberley. However, the small geographic scale of this dataset may be preventing effective evaluation of trends. Across the whole Southeast Fire Centre region, since the onset of provincial wildfire suppression efforts in the mid-20th century, there is a statistically significant upward trend in the number of fires that have been tracked by the BC Wildfire Service, indicating that they grew to over 1 ha in size (Figure 11).

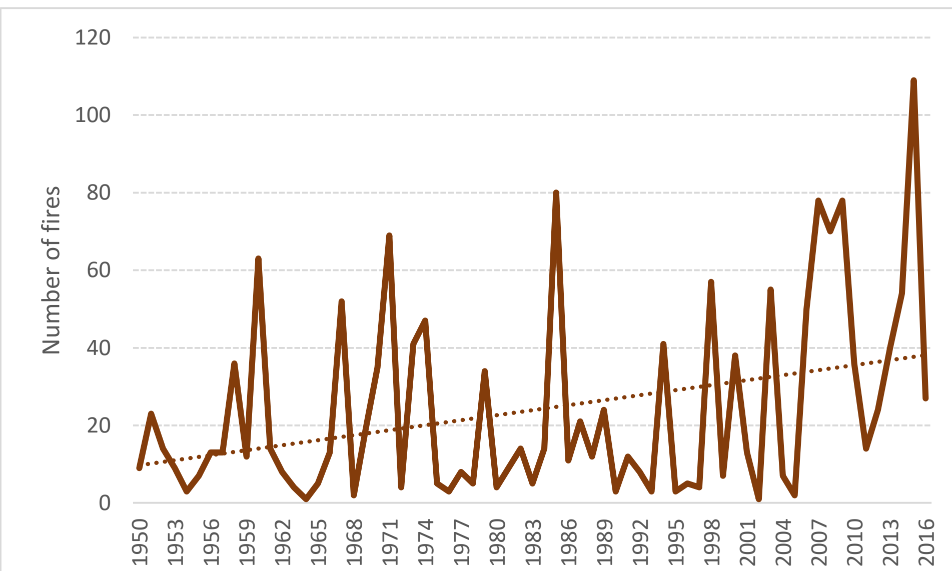

Figure 11: Fires > 1 ha in the Southeast Fire Centre region, 1950-2016

The ratio of starts caused by humans and lightning can be impacted by both climate and public awareness. While 75% of wildfires in the Southeast Fire Centre are caused by lightning strikes, over half of wildfires in the immediate area surrounding Kimberley are human-caused. On average, there are 3 fires per year in this area. Wildfires in the Cranbrook Fire Zone show an even split between human-caused and lightning-caused. This indicator shows that education on wildfire awareness and risk reduction may be useful to reduce the incidence of human-caused fires.

No trend in area burned annually

This indicator provides a direct measure of how much fire is occurring in a specific landscape. Since 1985, the Cranbrook Fire Zone experienced significant wildfire years in 1985 and 2003, and a total of 41,524 hectares burned between 1985-2016. It ranks third in annual area burned among the Fire Zones in the Southeast Fire Region, after the Invermere Fire Zone at 71,086 ha and the Kootenay Lake Fire Zone at 45,149 ha. Since 1985, three fires between 5 and 11 ha have occurred in Kimberley’s immediate surrounding area, and small wildfires (0.1 to 1.5 ha) have occurred in all but four years.

Adaptation Actions and Capacity Building

City engaging in interface fire risk reduction

Interface fire risk reduction involves assessing and treating high risk areas to reduce wildfire risk. The City of Kimberley has a Community Wildfire Protection Plan and is actively engaging in interface fuel treatment efforts each year as funding and weather conditions allow. Details on the extent and nature of these treatments were not available at the time of writing.

No Fire Smart-recognized neighbourhoods

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. While Kimberley does not have any Fire Smart recognized neighbourhoods, it has incorporated Fire Smart principles into its land use planning and development controls using Development Permit Areas (DPAs). A DPA with high wildfire risk requires a proponent to conduct a wildfire risk assessment, and the terms of development will be subject to a special covenant registered on the land title. This process is intended to influence the location and design of development, and ensure measures to reduce wildfire risk to newly-constructed homes and property.

Community Impacts and Adaptation Outcomes

Frequency of interface fires averages 1-2 per year

This indicator measures the annual number of wildfires within 2 km of a community. Since 1985, Kimberley has experienced 51 wildfires within its interface area, ranging in size from under 0.1 ha to 156 ha in 1985. On average, Kimberley can expect one to two interface wildfire events per year, with more events in hotter, drier fire seasons and fewer events in colder, wetter fire seasons. These fires are more likely to be caused by people as opposed to lightning. Increased fire prevention education may therefore be beneficial.

Cost of fire suppression averaging $2.87m per year

The average annual cost of fire suppression in the Cranbrook Fire Zone from 1994-2016 was $2.87 million, peaking at just over $21 million in 2003 and falling as low as $42,000 in 1995. Costs of fire suppression will vary from year to year, and will be significantly influenced by prevailing weather conditions. There is no discernible trend over this period.

NEXT STEPS

Action Areas

Assessment results indicate that Kimberley has a high level of awareness regarding the importance of climate adaptation and has taken significant steps to improve its adaptive capacity. Three areas for further consideration are evident in the data:

- **Water Monitoring**. The recent addition of water quality and water loss monitoring programs show that Kimberley recognizes the importance of reliable information related to its water supply. Stream flow is extremely complex and site-specific, and regional data has only limited value. Therefore, the loss of continuous stream flow monitoring in 2012 has important consequences for the community's ability to know and adapt to changes in water supply. While Kimberley has implemented seasonal water quantity monitoring on Mark Creek, the same on Matthew Creek would track water availability for the southern portion of the community, and continuous monitoring on both water sources would permit assessments of change in annual hydrographs.
- **Personal Emergency Preparedness**. Encouraging emergency preparedness among residents would help foster resilience to the type of extreme weather that is expected to increase with climate change. Over two-thirds of Kimberley's survey respondents did not have an emergency kit. This is higher than the Canadian average. Municipalities have an important role to play in personal emergency preparedness as they are often the 'front line' for residents when disaster strikes.
- **Wildfire Risk Reduction.** Kimberley's use of Development Permit Areas to encourage adaptation of the built environment to wildfire will encourage gradual implementation of Fire Smart principles in designated areas. However, Development Permits are required only when developing properties (e.g., subdividing lands, constructing or altering buildings). Achieving Fire Smart certification (or equivalent) in established neighbourhoods would support resilience of the wildland urban interface. In addition, continued progress on interface fire risk reduction is essential. New funding opportunities and unconventional partnerships with industrial operations could help accelerate this work. Finally, public engagement and education around wildfire risk may help reduce the high number of human-caused fires in the area.

Future Assessments

While some indicators are already reported annually by the City, it is recommended that the next full report be conducted in five years (2022). An update cycle is included with the documentation provided for specific indicators. Many indicators are tracked as part of the State of the Basin initiative, which means substantial data will be available through the RDI.

The SoCARB Pilot Project

This pilot project has produced a toolkit for Kimberley to enable future assessments and reporting on the SoCARB indicators. In addition, the results from this pilot will help shape the next stage of the project by informing revisions to the indicator suite and articulating strategies to promote uptake by other communities in the Columbia Basin.