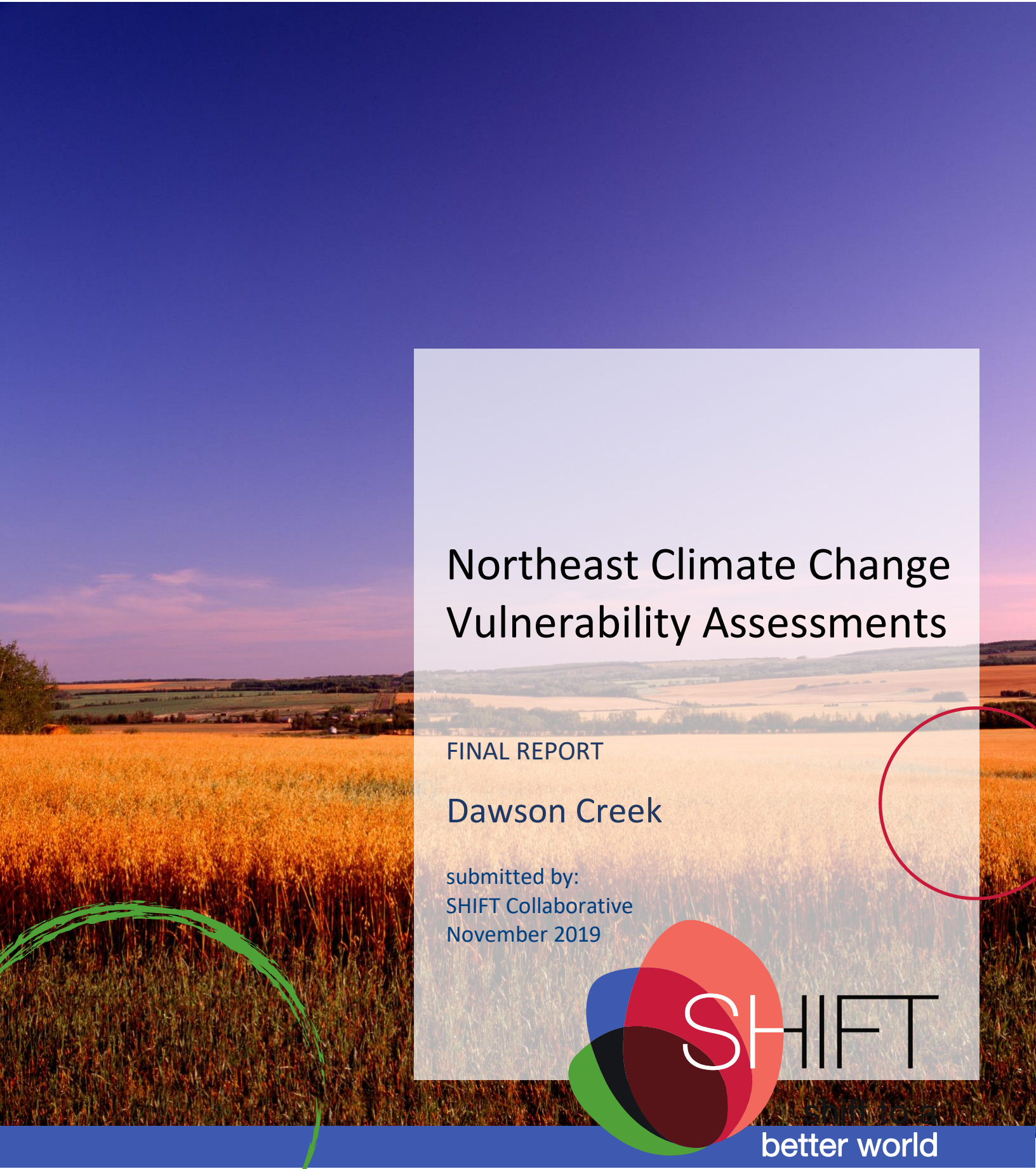


Northeast Climate Change Vulnerability Assessments

FINAL REPORT

Dawson Creek

submitted by:
SHIFT Collaborative
November 2019

SHIFT

shift to a better world

Table of Contents

List of Figures

List of Tables

1. Introduction

The Northeastern region of BC represents 21.8% of the land area of the province (20,494,470 ha), but is the least populated region in BC, with just 1.6% of the population (about 69,068 people). The Northeastern region is expected to undergo significant population and economic growth as a result of rapid expansion in natural gas and oil development. (The population is expected to increase by 30% over the next 25 years, BC Stats, 2014).

There are two broad types of actions relating to climate change: reducing greenhouse gas emissions (climate change mitigation), and preparing for and adjusting to changes in climate that impact human and non-human systems (climate change adaptation). The focus of this effort is climate change adaptation.

Recent Federal research[1] indicates that Canada is warming at twice the global average rate, with severe impacts already being felt and anticipated to increase in severity. Compounding this, northeastern BC has experienced a significantly more rapid rate of warming over the last 100 years (2.2 °C) than has BC overall (1.2°C). Significant changes in climate are projected for the future. The region is expected to see increases in average temperature and precipitation, the frequency and severity of extreme precipitation, drought and flood events, and other associated impacts.

Recent Climate Events in the Northeast Region

- Annual near flood events across region
- 2017 Pouce Coupe Hail Storm
- 2016 Dawson Creek flood
- 2016 Chetwynd Flood
- 2014 Regional Drought

Changes to the climate and extreme weather is challenging industry and communities across the Northeast region of the province. Wildfires, hail storms and floods have already impacted local infrastructure and posed health risks to communities. Ensuring the region is as prepared as possible for future climate events is critical to maintaining a thriving community, robust natural environment, and vibrant economy. “As prepared as possible” means the region understands how the climate is changing and is working together to increase resiliency and improve natural and physical infrastructure. Early efforts will reduce the reliance on emergency management and support the ability to change and thrive over time. Local governments in the region are taking a proactive approach to understand how climate change will pose risks to Northeast communities and are planning together to build resiliency across the region. Designing to current and future climate parameters is anticipated to be more cost-effective than reacting to climate shocks and stresses over time.

1.1 The Northeast Climate Risk Project

This project is being conducted for the Northeast Climate Risk Network (NECRN). The NECRN includes partners from: the City of Fort St. John, City of Dawson Creek, District of Tumbler Ridge,

[1] Government of Canada, Natural Resources Canada https://www.nrcan.gc.ca/environment/impacts-adaptation/21177

District of Chetwynd, Village of Pouce Coupe and Northern Rockies Regional Municipality who have come together to better understand and build capacity to address the impacts of climate change. NECRN is a peer-mentoring network on adaptation to climate change, which also serves as an advisory body for the overall Northeast Climate Risk Project. This project was initiated in 2018 by the Fraser Basin Council, in partnership with the six local municipalities. The Project has three goals:

1. Support the Northeast BC local government partners in preparing for a changing climate and understanding the associated risks and vulnerabilities;
2. Collaboratively address climate risks at a regional and community scale through a peer network; and,
3. Increase staff and stakeholder awareness of climate change impacts through the planning process as a first step to building community, public and private sector awareness of climate change impacts.

The NECRN has been working collaboratively to produce a number of products that will support communities in the region to better prepare for and adapt to a changing climate, namely:

Northeast BC Regional Climate Projections Report
The regional climate projections report[2] provides Northeast BC with regional information on climate projections, precipitation indicators, summer and winter temperature indicators and hydrology for selected river catchments, for the 2050's and 2080's.

Community Scoping Reports
An internal gap analysis was conducted for each of the six municipalities, which identified priority climate change impacts, outlined related work done to date and identified priority gaps and opportunities to address changing climate conditions.

Community Vulnerability Assessments (this document)
This report is the final comprehensive report on the results of the year-long process outlined in Figure 1. Each community prioritized impacts for initial action planning employing a vulnerability and risk assessment.

[2] https://www.fraserbasin.bc.ca/Northeast_BC_Climate_Risk.html

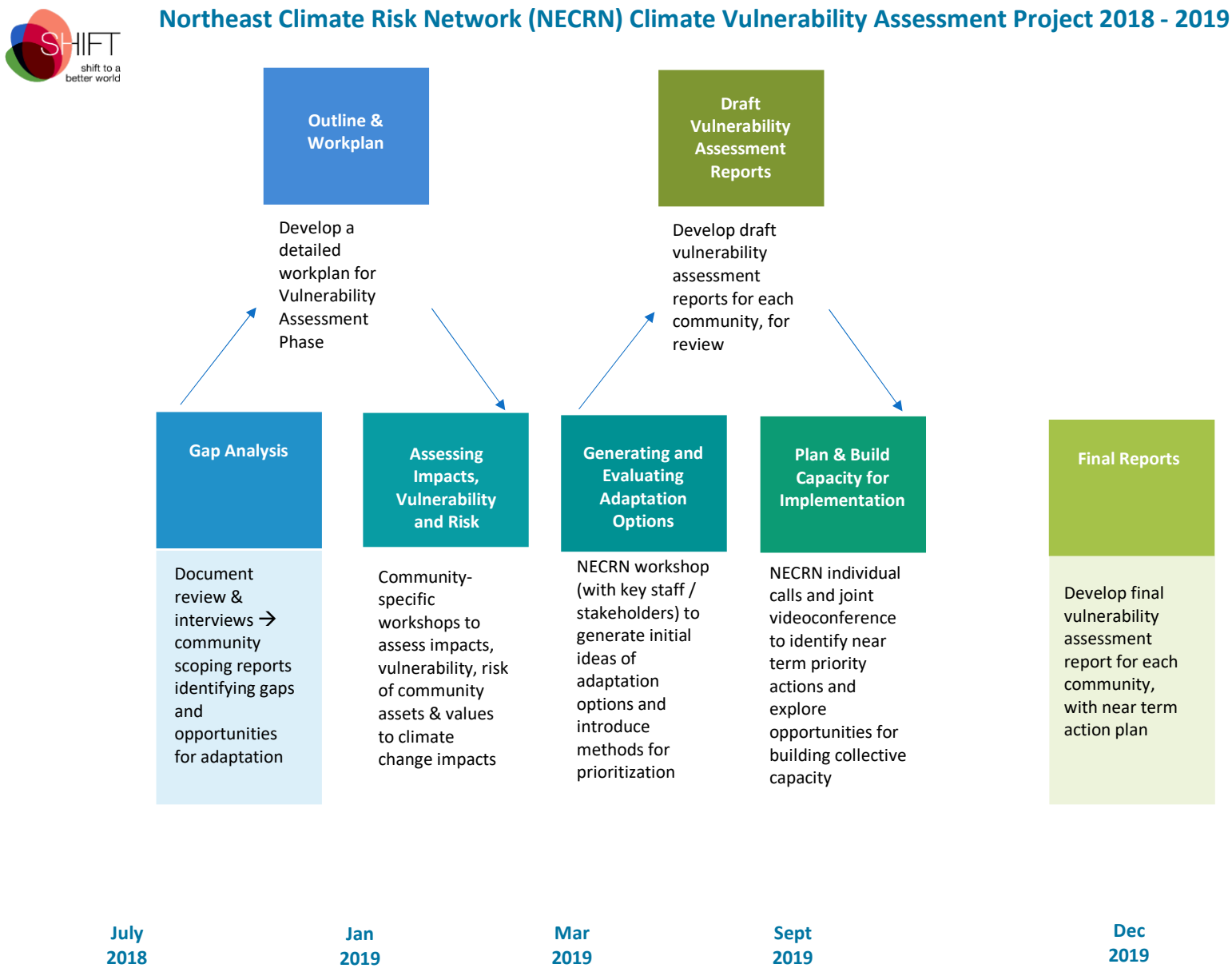


Figure 1. Northeast Climate Vulnerability Assessment Project Overview

1.2 What determines risk and vulnerability to changes in climate?

A key first step on the way to adapting to climate change is to consider what the relative risks and vulnerabilities are likely to be for the various components of the community. To do this, we have taken a commonly used approach to understanding risk and vulnerability, as represented in Figure 2:

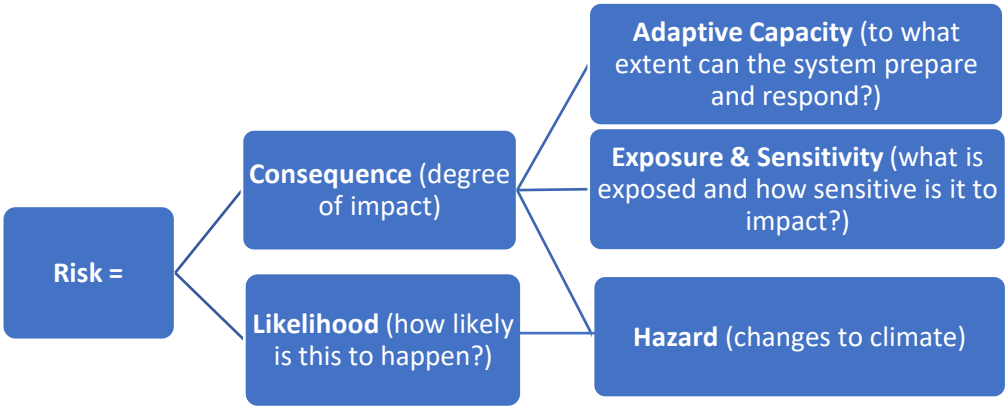


Figure 2. Assessing risk and vulnerability to changing climate conditions

The risks posed by climate change are a combination of the characteristics of the climate-induced ***hazard*** itself (e.g. magnitude of the hazard (such as flooding) and frequency) and how this interacts with human, built and ecological systems. The degree to which these systems are vulnerable, depends in part on whether they are ***exposed*** to the hazard, and how ***sensitive*** they are to its effects. For example, a housing development in a floodplain is exposed to flood risk while a subdivision at higher elevation is not. Similarly, a newer development built with floodproofing features is less sensitive than an older home without any such features.

But vulnerability also depends on the ways in which the affected systems can anticipate, prepare and adapt to better manage the challenge (***adaptive capacity***). For example, communities with a well-developed emergency management system or who have used tools and resources to divert development to areas outside of the floodplain, are more adaptive to an increasing flood hazard.

The degree of impact that occurs as a result (***consequence***), combined with how **likely** the event or impact is to occur, provides an indication of the degree of risk due to these changing conditions.

2. Methodology

Risk management across domains follows the basic steps listed and includes an iterative process of adaptive management and continuous improvement: identification of risk, analyzing risk to understand whether it requires a response, and choosing the best risk management options[3]. Several adaptation or risk-based planning tools are variations on these common steps (see Appendix A). All of these approaches use relatively qualitative assessment techniques for vulnerability and risk, which is the appropriate methodology for higher-level assessments such as this one. This Vulnerability Assessment has a specific purpose of better understanding the range of impacts the community may face and prioritizing across and between them as a basis for deciding on where to focus their limited resources and time. The need for more detailed assessments may be identified as a near-term action step resulting from this prioritization process[4].

In order to consider the range of ways that a changing climate will impact the community and the work of the local government specifically, impacts were organized by municipal service areas, as shown in **Error! Reference source not found.**. These service areas were considered in the gap analysis, pre-workshop survey and throughout the vulnerability and risk assessment.

This Vulnerability Assessment Report is the culmination of three key components:

1. A community-level gap analysis;
2. A qualitative vulnerability and risk assessment process with stakeholders; and
3. An action planning process led by each community's Climate Adaptation Team.

Each of these components is outlined below (and in the associated appendices), followed by a discussion of the limitations of the methodology.

[3] See ISO 31000 Risk Management Framework https://www.iso.org/iso-31000-risk-management.html

[4] For example, an assessment of a sewerage area or a flood risk assessment can rely on damage-curves and specific calculations of consequences to provide quantitative detail where it is needed. Engineers Canada's PIEVC protocol has a specific option to undertake a more detailed engineering study, and is a common approach to climate risk assessment for engineered infrastructure.

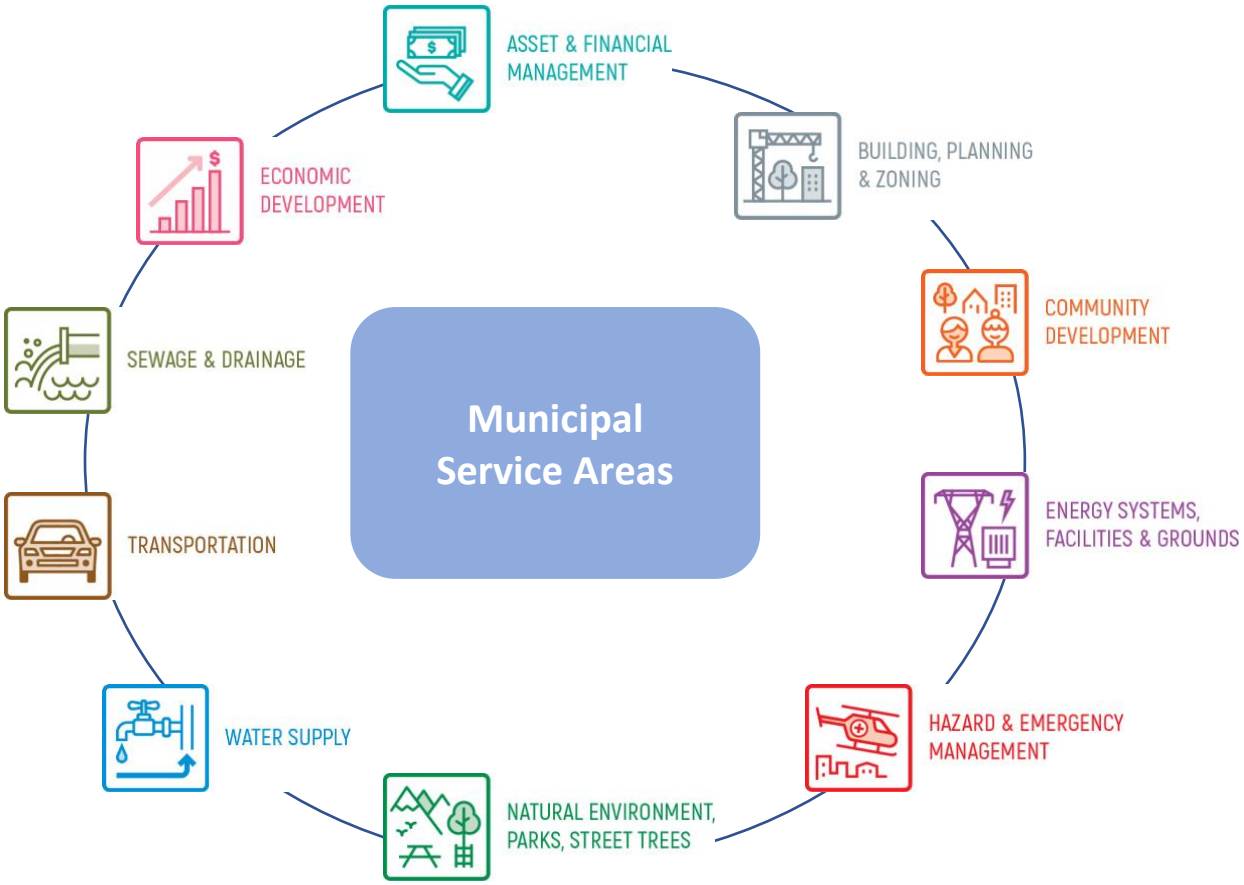


Figure 3. Municipal service areas were used to illustrate the range of areas impacted by climate change.

2.1 Gap Analysis

The gap analysis was conducted to produce the "Community Scoping Report" for Dawson Creek, a stand-alone internal document for use by the local government. The gap analysis consisted of a combination of document review and interviews. Documents were reviewed to identify:

- Key background and contextual information about the community and systems that may be vulnerable to climate change impacts;
- Any policies or actions that directly or indirectly address potential vulnerabilities to climate change;
- Any immediate or planned windows of opportunity for incorporating a climate lens; and
- Any existing information, studies, and reports that contribute to an understanding of climate change projections or vulnerabilities in the community or the northeast region.

Following the initial review of documents, a number of interviews were conducted with local government staff and other agencies, to fill in gaps in information. Information from these two key sources was compiled in the resulting report. Information gaps and opportunities for

applying a climate lens were identified by service area (e.g. sewage and drainage, community development).

2.2 Vulnerability & Risk Assessment Process

This step in the methodology aimed to outline which impacts from a changing climate pose the greatest risk to each community, and thus form the basis for prioritizing near-term actions. To better understand the baseline knowledge and perspectives of participants about the impacts and potential for adaptation to changing climate conditions, a survey was conducted of confirmed participants in advance of the workshop. The compiled results of this survey across all participants in the region, are included in Appendix B.

On February 28th, 2019 a workshop was held in Dawson Creek with City staff and other community and regional stakeholders, to discuss the possible climate impacts for Dawson Creek and begin to prioritize which impacts to focus on in the near term. Eighteen people participated in this workshop, representing the following organizations:

- City of Dawson Creek (12)
- Peace River Regional District
- Peace River Forage Association
- Northern Health
- Northern Environmental Action Team
- BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development
- BC Oil and Gas Commission

The workshop began with a summary of the regional climate projections outlined in the report "Climate Projections for the BC Northeast Region[5]." Impact statements describing the types of impacts expected for the community (based on information from the Gap Analysis), were developed as the basis for discussion and input during the workshop. These impact statements were taken through a three-step process[6], outlined in Figure 4 below:

[5] Produced by Pacific Climate Impacts Consortium and Pinna Sustainability, completed in 2019.

[6] The process used borrows from the ICLEI BARC process and employed the BARC rating scale for vulnerability. The focus for impact statement generation was the climate projections to 2050. When assessing vulnerability and risk, current community characteristics were used to simplify the process.

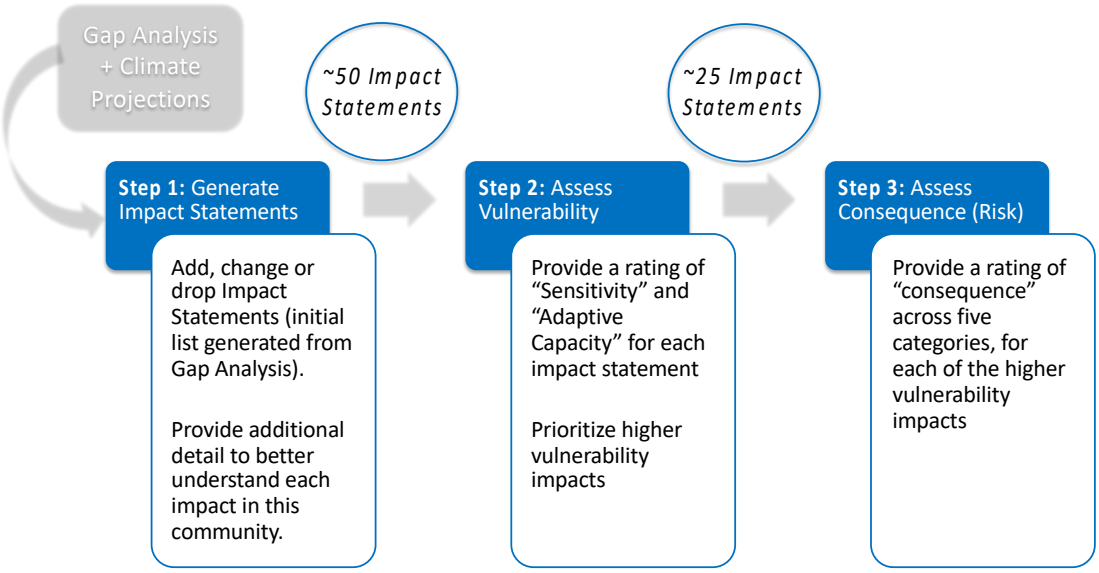


Figure 4. Three step vulnerability and consequence assessment method used in workshop 1

See Appendix C for further detail on the assessment process used to qualitatively assess vulnerability (sensitivity x adaptive capacity) and consequence during Workshop 1.

Three University-based experts with background in the Northeast region and climate change provided likelihood scores for the impact statements. The consequence ratings for the higher vulnerability impacts generated during the workshop were combined with these likelihood ratings to provide an overall risk score. Those impact statements that fall into the medium to high risk category were then cross-referenced with the gap analysis results and reviewed by the community's Climate Adaptation Team in Workshop 2 to arrive at the final list of priority impacts.

2.3 Initial Steps Toward Action Planning

In order to operationalize the findings of this assessment process each community was invited to form a Climate Adaptation Team to attend the second workshop and lead the initial action planning. A description of the purpose, potential membership and functions of these teams is outlined in Appendix F.

The final list of higher risk impacts was used as the basis for action planning. Action planning focuses on exploring options and next steps to reduce these key risks and enhance resilience to these climate impacts. Lower risk impacts were provided to the teams as well, to scan for those that could easily be addressed by low-effort/no-regret actions. The action planning process was introduced in Workshop 2, and then completed by each Climate Adaptation Team working with the support of the project team. Each community's action plan was shared with NECRN

members, who together identified opportunities for regional collaboration and learning. This process is outlined in Figure 5.

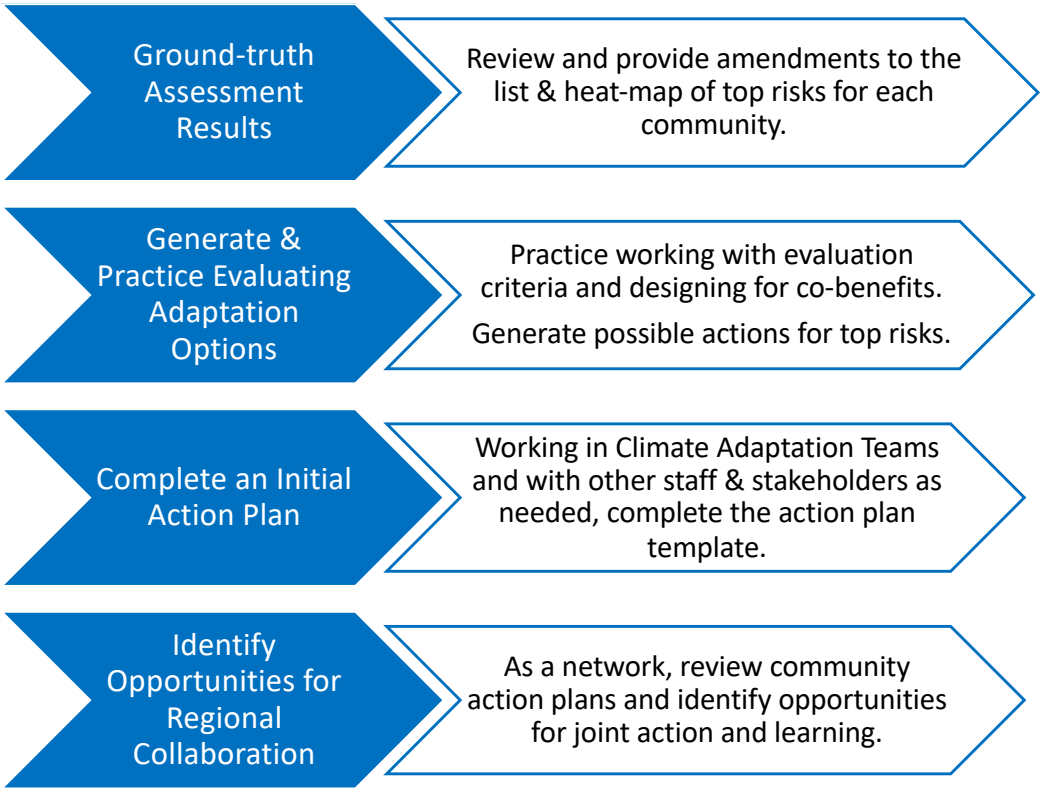


Figure 5. Action planning process

2.4 Limitations of the Methodology

Efforts have been made at each step of the process to "ground-truth" results with those who have local knowledge and/or topic-specific expertise. However, there will be inevitable gaps and omissions due to the breadth of what is being considered. This report is to be considered a working document – as communities take the next steps to address priority impact areas, more information will emerge and be developed that will inform further steps. Adaptation assessment and planning is an inherently iterative process as understanding and conditions (i.e. the climate, political will, priorities, land use patterns, infrastructure needs, innovations, etc.) develop over time.

Due to time and availability, the number of interviews for each community during the Gap Analysis was constrained and this limits the range or depth of perspectives that we were able to gather on specific aspects of system vulnerability. While additional information and perspectives were incorporated through stakeholder feedback on the impact statements in Workshop 1, this was still limited by the knowledge of participants who were able to attend.

Numerous adaptation methodologies (i.e. see Appendix A for examples) rely on stakeholder opinions as a basis for vulnerability and risk assessment. That said, the qualitative approach to

risk and vulnerability assessment has a number of limitations. Ratings for sensitivity, adaptive capacity and consequence were all based on informed judgment of stakeholders who were present for Workshop 1. As such, there are gaps in the expertise and understanding of the relationships between future climate conditions and how these would affect various parts of the system. This was mitigated by having multiple people rate each impact statement and deliberate on the final rating assigned to each, along with two additional steps to double-check the results with participants and a further step of cross-referencing with information compiled during the Gap Analysis. Still, these are subjective ratings and may contain biases, for example:

1) Recently experienced impacts may be rated higher in vulnerability and/or consequence
2) More familiar impacts may be rated differently than less familiar impacts
3) Impacts of general importance to participants may be rated more highly than others (e.g. someone who works on water treatment may rate associated risks more highly than those to emergency volunteer capacity)

It is important to remember that the purpose of this assessment is to provide a basis for prioritizing more important impacts for the purposes of allocating time and resources to addressing these. This is a first step, providing a high-level assessment that supports the community to make more informed choices about how to prepare and adapt to the projected changes in climate conditions.

Likelihood was rated by four academics with firsthand research experience in the Northeast region, in related fields. Their ratings were generally quite similar but not identical for all impacts, and were averaged where they did not converge.

3. How Will Climate Conditions Change in Northeastern BC?

Dawson Creek is considered a lowland community based on elevation. Dawson Creek and the other network communities can expect significant changes to its climate in the coming decades, including:

- **Increased precipitation across all seasons**. The largest increases in precipitation will take place during the spring & autumn months during which, on average, the region can expect 30% more precipitation by the 2050s. This can lead to more frequent ***flooding*** and stress to ecosystems.

- **Summers will be considerably warmer.** In the past, the region experienced an average of 12 days over 25°C annually. We can expect 32 days by the 2050s (49 days by the 2080s). Dawson Creek is expected to experience 40 days above 25°C by the 2050s and 60 days by the 2080s, with 10 days above 30°C by the 2050s and ***21 days over 30°C by late century.*** By the 2080s, summer temperatures are projected to be about as warm as Kelowna's past summers (1980s).

- **Summer is expected to remain the wettest season**, **though by a smaller margin**. Even though precipitation is projected to increase slightly over summer months, on average, normal seasonal variability in precipitation plus hotter temperatures (and thus increased evaporation) could lead to drier, hotter summers, posing ***increased risk of wildfire and associated physical and mental health impacts***.

- Temperatures projected will ***trigger significant heat stress*** across the region. The ability to provide clean drinking water as a shared resource to communities, industry and agriculture may be strained. Higher demand for water during longer, hotter summers as well as during dry spells, could create ***challenges for water supply, water quality, livestock and crop yields***.

- **Winter temperatures are also projected to warm**. By the 2080s, January temperatures are projected to feel like March temperatures of the past, with warmer nights, 28% less frost days and 37% longer growing seasons than the past. More winter precipitation and later onset of freezing temperatures could potentially lead to ***additional annual freeze thaw cycles*** and ***more frequent rain-on-snow events***. Shifting seasonal temperatures could also result in ***premature pollination of crops and increased invasive species and pests***, impacting agriculture and forestry.

- **More extreme storm events in the future**. As the climate warms, more moisture is held in the atmosphere, resulting in more intense precipitation during extreme events. Future storms may also bring stronger winds and hail events. These events will challenge regional infrastructure, and may ***overwhelm sewerage and drainage systems*****.** Other extreme weather events of concern include river floods, high winds, drought, and wildfire.

- **Summer streamflow will decrease in all basins**. Warmer temperatures mean that relatively more precipitation will fall as rain rather than snow, which in general means an increase in winter runoff, reduced snowpack and ***an earlier freshet*** for the Kiskatinaw River. Less water stored over winter and melted earlier in the year also means reduced summer and early fall streamflow for the Kiskatinaw and other area rivers. These changes will be exacerbated by increased evaporation, further contributing to ***increased stress to water resources.***

The projected changes to climate conditions for Dawson Creek and Northeastern BC[7], are summarized in the tables below.

Table 1.Temperature *Expect summers and winters to warm with summer days getting hotter*	
Description of Metric	**Anticipated change for NEBC Lowlands**
Annual average temperature increase	Average Annual temperature will increase +3.7°C by 2050 and +6°C by 2080s
Overall Change: Summers get warmer with hotter "hot days"	
Number of days where maximum temperature is above 25°C	Number of summer days increases by 50% (from 16 up to 24)
Maximum daytime temp of the warmest summer day	Warmest summer day is 3.7°C warmer
Maximum night time temperature in the summer	Hottest summer night is 3.3°C warmer
Hot summer days = days above 30°C in any one year	The number of summer days above 30°C is projected to occur 9 times/year by the 2050s and 20 times/year by 2080s. (previously occurred ~1 time/year)
Maximum daily temp expected to occur on average 1:20 years (5% chance in any year that the temp could reach this magnitude).	Very hot days increase in intensity from 31°C to 38°C by the 2080s
Overall Change: Winters get warmer, especially nights	
Min temp of the coldest night time in winter	Coldest winter nights: 6.5°C warmer
Max temp of the warmest night time in winter	Warmest winter night: 2.4°C warmer
Minimum daytime temperature of the coldest day in winter	Coldest winter day: 6.2°C warmer
Max daytime temperature of the warmest day in winter	Warmest winter day: 1.5°C warmer
Minimum night time temp expected to occur on average 1:20 years (5% chance in any year that the temp could reach this magnitude).	Very cold nights are projected to warm from -44°C to -38°C
Ice Days is an annual count of days when daytime high temp is less than 0°C	17% fewer ice days

Table 2. Heating and Cooling *Greater need for summer cooling while winter heating demand decreases slightly*	
Description of Metric	**Anticipated change for NEBC Lowlands**
Indicator for heating demand. (Total of the number of degrees below 18°C that occur daily, summed over each	18% fewer Heating Degree Days

[7] Data as generated by Pacific Climate Impacts Consortium (www.pacificclimate.org) in the Regional Climate Projections Report. All projections are to the year 2050 unless noted. Change is relative to the baseline period of 1971 – 2000. All projections are averages from Global Climate Models.

day of the year)	
Indicator for cooling demand. (Total of the number of degrees above 18°C that occur daily, summed over each day of the year)	600% more Cooling Degree Days (18 – 94 days lowlands)

Table 3. Growing Season *Longer growing season with a doubling of Growing Degree Days (GDD)*	
Description of Metric	**Anticipated change for NEBC Lowlands**
Growing season length is the length between the first span of six days above 5°C in spring, and the first span of six days below 5°C in the fall.	Growing season length increases from 160 to 189 days in 2050, and 205 days in 2080.
Annual count of days when daily minimum temp is below 0°C	17% fewer frost days
GDD is an indicator for plant growth: Total of the number of degrees above 5°C that occur daily, summed over each day of the year.	Lower elevations can expect 2000 GDD by 2080s (81% increase from the past)

Table 4: Precipitation *Expect more precipitation annually with the largest increases in the spring and autumn. Summer remains the wettest season to the 2050s. Expect an increase in frequency and intensity of rain events.*	
Description of Metric	**Anticipated change for NEBC Lowlands**
Average seasonal changes in precipitation	19% increase in spring precipitation, 15% increase in autumn, 7% in summer and 11% in winter
Overall Change: Intensity (volume/ size of event) of significant rain events will increase	
Wettest day is the largest amount of rain that falls on any single day in the year on average	17% increase (from 28mm) in amount of rain on the wettest day of the year
Largest amount of precipitation that falls over a period of 5 consecutive days in the year.	19% increase in rain amount over 5 consecutive days to 68mm by the 2080s
Overall Change: More frequent intense precipitation events and more rain to fall during these events.	
Annual total precipitation that falls on the wettest days of the year (days where	The amount of precipitation falling on very wet days of the year, increases by 35% by 2050 and

precipitation exceeds the 95th percentile amount recorded during the baseline period).	51% by 2080.
As above but 99th percentile	The amount of precipitation falling on the wettest days of the year, increases by 59% by 2050 and 78% by 2080 (from 35mm).
Max daily precipitation expected to occur on average once in 20 years (5% chance in any given year)	A 1:20 year return precipitation event will increase in intensity by 25% (to 61mm of precipitation) in a day

4. What Impacts Can We Expect From These Changing Conditions?

Workshop 1 participants from each community were invited to complete a survey (see Appendix B) that asked about climate-related hazards of concern for their community (Figure 6). The top concern across all communities was wildfire (78% of respondents ranked this as something they are most concerned about), followed by flooding (56%), other extreme events such as storms, hail, freezing rain (53%) and extreme rainfall events (51%). The climate-related hazard communities were least concerned about was extreme heat (20%).

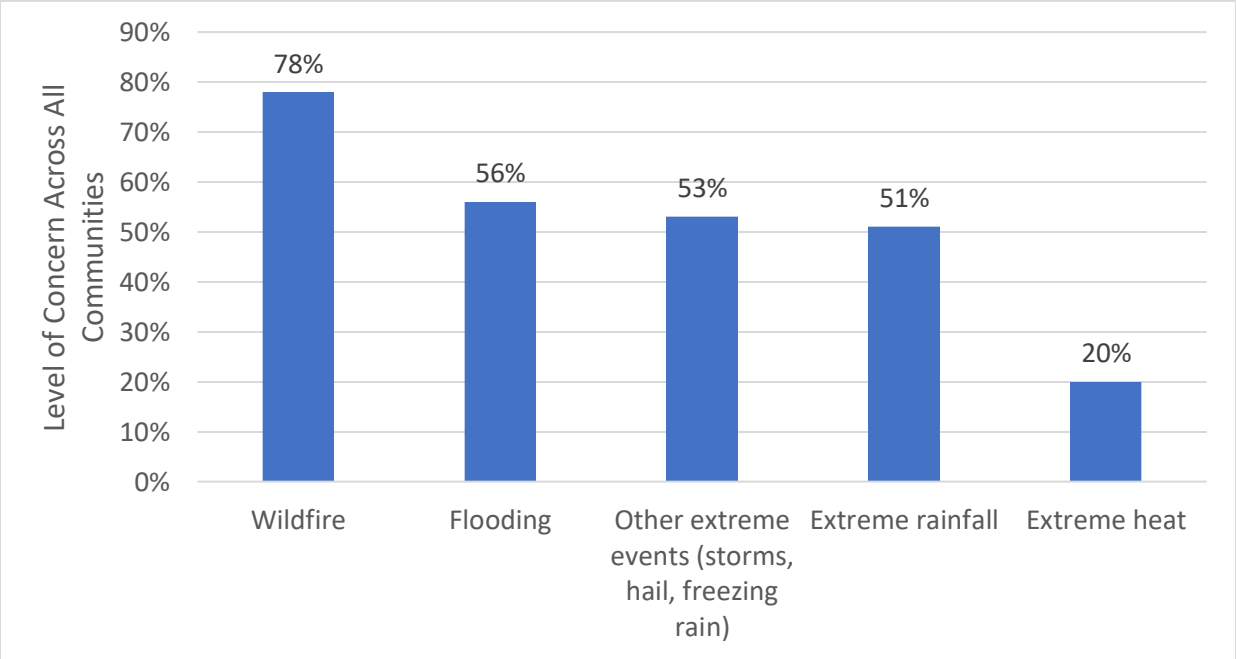


Figure 6. Current levels of concern about climate-related hazards for Northeast communities

In terms of the impact that changing climate conditions could have on municipal service areas, respondents from Dawson Creek were equally concerned about a number of municipal services—67% of respondents were concerned about negative impacts to each of: water supply, storm drainage, transportation and hazard and emergency management.

An important step in this assessment was to translate knowledge about the projected future changes in climate-related hazards into the impacts of concern to municipal service areas. Through the gap analysis and Workshop 1, information was gathered to create impact statements that clearly define the impact a changing climate would have on important aspects of community life. Impact statements combine specific climate hazard features (e.g. increasing potential for rain-on-snow events) with specific impacts to community functioning, assets and/or values (e.g. flooding, street closures and mobility issues). An example of an impact statement is:

"Increasing potential for rain-on-snow events (and freezing rain) increases the risk of street flooding, street closures, mobility issues and potential damage to nearby buildings."

There is a wide range of potential impacts to municipal service areas of the changing climate conditions in the Northeast region – a detailed list is included in Appendix D, which provides additional details relating to each impact statement.

The full list of potential impacts to municipal service areas was prioritized through the vulnerability and risk assessment process, to identify those impacts of greatest concern and where attention should be prioritized in the near term. Those impacts are outlined in Sections 5 and 6 below.

5. What Impacts Are We Most Vulnerable To?

As described above (see Figure 2), vulnerability is a combination of exposure (whether an element is exposed to the climate hazard), sensitivity (how sensitive the element is to its effects) and adaptive capacity (the ways in which the affected systems can anticipate, prepare and adapt to better manage the challenge). Based on the assessment completed in workshop 1, the following impacts (listed in Table 5 below) were identified as those the community is most vulnerable to, given current adaptive capacity.

Table 5. Climate impact statements with highest vulnerability in Dawson Creek

Climate Hazard	Impact Statement
	• Increased river flow and flood events damage buildings, crops, parkland, infrastructure such as bridges, etc. • Increased river flow and flood events cause increased avulsions (changes to the river's path) and bank erosion, impacting aquatic habitat. • More frequent flood events increase costs and require more capacity for flood clean-up and restoration • More frequent flood events contribute to cumulative anxiety, stress and mental health challenges among affected residents and service providers

	• Increased flood events cause strain and stress on municipal wastewater systems, and private layouts and dugouts (also private septic and lagoons)
 WARMER **WINTERS**	• Warmer winter temperatures may enable spruce beetle infestations which decreases local forestry incomes • More rapid snow melt leads to increasing localized flooding from backed up culverts • Increasing freeze/thaw cycles decrease the durability of infrastructure (such as roads and trails) and increase maintenance needs • Increasing potential for rain-on-snow events (and ice storms) increases the risk of street flooding, street closures, mobility issues and potential damage to nearby buildings • Increased presence of ticks • Rain or snow events increase run-off in non-typical times of the year (January). Catalyst for localized flooding
 INCREASED INTENSITY & FREQUENCY OF **PRECIPITATION**	• Situations of increased turbidity due to larger or more frequent precipitation events decrease the number of days that pumping can occur from the river to water supply reservoirs • Heavy rainfall events cause more sewer back-up, which damage buildings and can cause health impacts • Increasing surface run-off during the rainy season and decreasing recharge during the longer dry spells will impact groundwater and base flows • Increasing intensity of rainfall causes more frequent localized flooding and sewer surcharge in parts of the community • Increased surface runoff can lead to increased nutrient concentrations in the water and increased sediment load thereby impacting operation of water supply infrastructure
 INCREASE IN OTHER **EXTREME EVENTS** (i.e. storms, hail, extreme heat, wildfires, landslides)	• Increase in extreme events cause more frequent power outages, in turn affecting household power and power to critical infrastructure • Increasing frequency and intensity of extreme events puts pressure on the physical and emotional capacity of community volunteers including ESS and volunteer fire fighters • Increasing extreme events decreases the durability of infrastructure generally, leading to earlier replacement and increased maintenance needs • More frequent / larger scale emergency and disaster events place increasing demands on municipal resources and capacity for mitigation, planning, preparedness, response and recovery • Increasing number or magnitude of wildfires, impacts the health of the community due to poor air quality days and mental health

	impacts • Major events (landslide, flood, wildfire) lead to impacted transportation within the community or between communities. (i.e. isolation from critical services, jobs, evacuation routes)
	• The combination of hotter and drier conditions increases potential for drought and decreased water supply in late summer – industry is first to be impacted when conservation measures are introduced

In Summary:

Flooding was identified as a major vulnerability for Dawson Creek including overland river flooding and urban flooding. River and creek flooding may cause damage to infrastructure, crops, public and private waste water systems as well as the environment. These impacts all require capacity and resources to clean up and recover and impacted residents and responders are vulnerable to anxiety and other mental health effects.

As the climate changes, increasing rain on snow events and freeze/thaw cycles are anticipated and the municipalities more vulnerable to urban flooding from blocked sewers and culverts etc. Transportation, mobility and exposed infrastructure are all vulnerable to urban flooding.

With warmer winters, an increase in pests is anticipated. Economic vulnerability to agriculture pests and the spruce beetle were identified as well as health vulnerability to ticks.

Water supply vulnerabilities were identified from a range of climate changes. The infrastructure is vulnerable to increasing turbidity and sediment load resulting from heavier rainfall. Drier summers and heavier rains may impact groundwater and flow volume making water management planning more challenging. Industry may be vulnerable to water supply pressures felt late in the summer.

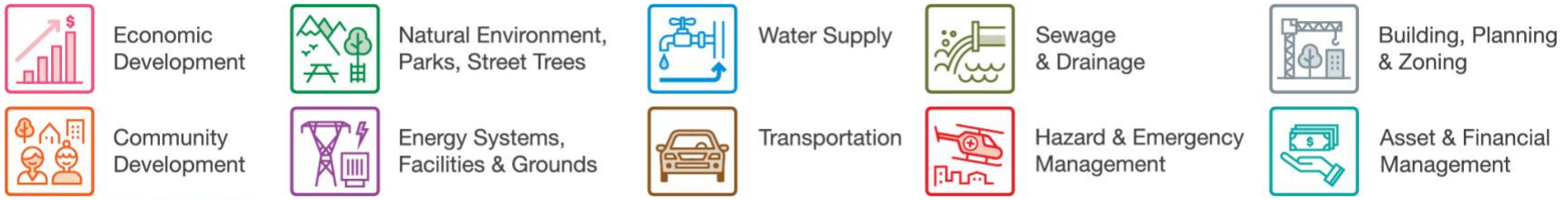
Vulnerabilities to extreme events range from health impacts, to the capacity to respond and recover to lifeline impacts such as power outages and transportation disruptions.

6. Which of These Impacts Pose the Highest Risk?

As Figure 2 depicts, risk is a product of consequence and likelihood. The degree of impact that occurs as a result of the climate hazard (***consequence***), combined with how **likely** this is to happen, provides an indication of the degree of risk due to these changing conditions.

Risk results for Dawson Creek fall into the high to medium-low range. None of the impacts were assessed as low risk. To be rated high or medium-high risk, the impact has a combination of high consequence rating and medium or high likelihood rating, high ratings for both, or a medium consequence rating and high likelihood rating. Table 6, below summarizes the risk assessment results, also indicating which service areas are most affected by each impact statement.

Table 6. Summary of Climate Hazards and Risk Ratings for Dawson Creek



DAWSON CREEK

CLIMATE-RELATED HAZARD	QUALITATIVE RISK	#	IMPACT STATEMENT	SERVICE AREA	CONSEQUENCE	LIKELIHOOD	RISK
INCREASED RIVERINE **FLOOD RISK**	HIGH	1	Increased river flow and flood events damage buildings, crops, parkland, infrastructure such as bridges, etc.		5	3	15
	MEDIUM-HIGH	2	Increased river flow and flood events cause increased avulsions (changes to the river's path) and bank erosion, impacting aquatic habitat **		3.8	3	11.5
	MEDIUM-HIGH	5	More frequent flood events increase costs and require more capacity for flood clean-up and restoration		3.5	3	10.5

CLIMATE-RELATED HAZARD	QUALITATIVE RISK	#	IMPACT STATEMENT	SERVICE AREA	CONSEQUENCE	LIKELIHOOD	RISK
WARMER **WINTERS**	HIGH	20	Increasing potential for rain-on-snow events (and ice storms) increases the risk of street flooding, street closures, mobility issues and potential damage to nearby buildings		4.5	4.3	19.5
	HIGH	19	Increasing freeze/thaw cycles decrease the durability of infrastructure (such as roads and trails) and increase maintenance needs		3.7	4	14.7
	HIGH	17	More rapid spring melt leads to increasing localized flooding from backed up culverts		3.5	4	14
	MEDIUM-HIGH	80	Rain or snow events increase run-off in non-typical times of the year (January). Catalyst for localized flooding		3.2	4	12.7
	MEDIUM-HIGH	15	Warmer winter temperatures may enable spruce beetle infestations which decreases local forestry incomes		2.5	4	10
	MEDIUM	69	Warmer conditions and changing seasonality may lead to an increased presence of ticks		1.7	3	5

CLIMATE-RELATED HAZARD	QUALITATIVE RISK	#	IMPACT STATEMENT	SERVICE AREA	CONSEQUENCE	LIKELIHOOD	RISK
 INCREASED INTENSITY & FREQUENCY OF **PRECIPITATION**	HIGH	34	Increasing intensity of rainfall causes more frequent localized flooding and sewer surcharge in parts of the community		4.3	4.5	19.5
	HIGH	77	Increased flood events cause strain and stress on municipal wastewater systems, and private layouts and dugouts (also private septic and lagoons)		5	3.5	17.5
	MEDIUM-HIGH	37	Increased surface runoff can lead to increased nutrient concentrations in the water and increased sediment load thereby impacting operation of water supply infrastructure		3	4	12
	MEDIUM-HIGH	30	Situations of increased turbidity due to bigger or more frequent precipitation events decrease the number of days that pumping can occur from the river to water supply reservoirs		2.7	4	10.7
	MEDIUM-HIGH	31	Heavy rainfall events cause more sewer back-up, which damage buildings and can cause health impacts		2.7	4	10.7
	MEDIUM-HIGH	33	Increasing surface run-off during the rainy season and decreasing recharge during the longer dry spells will impact groundwater and base flows		2.3	2.5	5.8

CLIMATE-RELATED HAZARD	QUALITATIVE RISK	#	IMPACT STATEMENT	SERVICE AREA	CONSEQUENCE	LIKELIHOOD	RISK
 INCREASE IN OTHER **EXTREME EVENTS**	HIGH	68	Major events (landslide, flood, wildfire) lead to impacted transportation within the community or between communities. (ie. isolation from critical services, jobs, evacuation routes)		3	4.5	13.5
	MEDIUM-HIGH	51	Increasing extreme events decreases the durability of infrastructure generally, leading to earlier replacement and increased maintenance needs		3	4	12
	MEDIUM-HIGH	45	Increase in extreme events cause more frequent power outages, in turn affecting household power and power to critical infrastructure		3.7	3	11.0
	MEDIUM-HIGH	50	Increasing frequency and intensity of extreme events puts pressure on the physical and emotional capacity of community volunteers including ESS and volunteer fire fighters		2.7	4	10.7
	MEDIUM	52	More frequent / larger scale emergency and disaster events locally &/or regionally place increasing demands on municipal resources and capacity for mitigation, planning, preparedness, response and recovery		2.7	3.5	9.3
CLIMATE-RELATED HAZARD	**QUALITATIVE RISK**	**#**	**IMPACT STATEMENT**	**SERVICE AREA**	**CONSEQUENCE**	**LIKELIHOOD**	**RISK**
 HOTTER **SUMMERS**	HIGH	64	The combination of hotter and drier conditions increases potential for drought and decreased water supply in late summer		3.3	4	13.3
	MEDIUM	65	Increasing number or magnitude of wildfires impacts the health of the community due to poor air quality days and mental health impacts		2.5	4	10

** Following assessment the risk rating for impact #2 was lowered qualitatively by staff. The impact was still rated high and carried into action planning.

For Dawson Creek, flood impacts related to the Creek flooding and intense precipitation events featured prominently among the 18 highest risks identified (Table 6) with the impacts of extreme events and drier periods also having important effects.

A range of types of flood impacts made up the majority of the top risks for Dawson Creek, with concern about impacts due to both localized surface flooding (rainfall/rain on snow related) and riverine (rivers overcoming capacity) flood events. Flood impacts will be an important focus for the next steps of this work.

Aside from the impacts of floods, there were a handful of additional key risks. The effects of both flood and other extreme events, and changes to freeze-thaw cycles, were of concern with respect to the durability of infrastructure. Impacts to water supply and quality due to changes in precipitation patterns and dry / drought conditions were important. The impact of extreme events was another key issue, with concern for issues such as disrupted transportation and mobility within and between communities (and isolation from critical services); the stress and capacity drain for staff, volunteers and first responders; and effects of power outages. The impact of spruce beetle infestations on forestry incomes rounded out the top risks.

7. Initial Action Ideas

Community-specific

In September 2019, the project team from Dawson Creek put together initial action ideas for addressing the highest risk impacts. For each higher risk impact the team began developing:

- A list of actions,
- A description of the action,
- The status of the action (underway, act now / by X year, monitor or investigate further),
- The range of funding and HR to carry out the action (low, medium or high),
- Next steps, and
- Notes on how well the action addresses evaluation criteria

To view the initial action ideas for Dawson Creek, please visit Appendix G. Detailed Action Plan.

Region-wide

Adapting effectively and building resilience to a changing climate will require action at both a local and regional level. Actions that lend themselves to regional collaboration were discussed with the Northeast Climate Risk Network throughout the course of this project. Broadly across hazards, the Network provides opportunities to:

- share purchasing power for hard goods or common consultancy needs;
- advocate as a united front with stakeholders and other levels of government;

- avoid costly projects if recommendations or best practices from one municipality can be transferred to another;
- share progress and discuss barriers and solutions and;
- partner as a group on common projects and work with the regional governments and other stakeholders.

Hazard-specific opportunities for regional collaboration are summarized in Table 7 below.

Table 7. Potential opportunities for regional collaboration across the Network

Climate Hazard	Impact Statement
 INCREASED RIVERINE **FLOOD RISK**	• Chetwynd and Dawson Creek have parallel processes currently including identifying and studying the hazard, mapping flood extents, coming up with mitigation options and including findings in the OCP. While at different steps, this provides an opportunity to learn from each process and pass lessons on across BC.
 WARMER **WINTERS**	• The region has to work together and work with the Province on understanding forest management for pest (and wildfire) resilience • Snow and ice clearing policies and road and bridge closure policies came up frequently as requiring updates and clear communication to the public. Sharing policies and best practices makes sense. • Steaming vs. Heat tracing culverts. A study across municipalities and conditions would provide more fruitful conclusions and recommendations. • PRRD Everbridge Emergency Notification System collaboration ○ Freezing rain information and health and social wellness information is shared on this platform already • Could intentionally set up to trial different types of materials to use on various roads during temperature fluctuations. • Invasive species programs provide another opportunity to learn from each other and possibly collectively hire consultants.
 INCREASED INTENSITY & FREQUENCY OF **PRECIPITATION**	• There are several sewage and drainage studies underway in the region. Resultant recommendations could be shared with the network via webinar with consultants on hand. • Understanding how to incorporate new rainfall projections and IDF curves into design could be done by a common consultant or process shared by one municipality to the others. • Several municipalities are further ahead on green infrastructure use (for infiltrating rainfall). Sharing actions and any pamphlets produced for the public is an opportunity for collaboration. • Dawson Creek has significant expertise in watershed and riparian health and may focus more on this area. Best practices could be

	shared through the Network meetings.
 INCREASE IN OTHER **EXTREME EVENTS** (i.e. storms, hail, extreme heat, wildfires, landslides)	• Set up a more formal contact person and liaison between the Network and the Ministry of Transportation and Infrastructure. They have done significant work on climate change guidelines and the Network municipalities identified flooding, landslides and wildfires to have the potential to limit access to their communities. • Several communities will refresh or initiate landslide and steep slope reviews. This provides an opportunity to share consultants or at least process and best practices. Translating findings into land use controls may also be an area to share ideas. • Asset management becomes an important element of ensuring infrastructure is resilient to climate change. Opportunity: collaborating on a project to apply a climate lens to asset management (in one area or across the board).
 HOTTER **SUMMERS**	• Air quality monitoring is already completed by Oil and Gas industry. Collaboration with industry could add air quality data for rural and urban areas. • Municipalities have Community wildfire plans at different stages of development, update and implementation. Opportunity to learn from each other and also possibly share a consultant from out of town for economies of scale. • Fuel removal communication / education campaign could be shared • Network could partner with the regional health authority to have consistent messaging on wildfire smoke, heat and health • Municipalities all work on water conservation techniques for drought. Many deal with agriculture and/or industry water needs as flow volumes change, and as a result, there are lessons to be shared.

Key Competencies for Advancing Adaptation

As part of the Gap Analysis at the beginning of this project, the consultant team provided an initial assessment of Dawson Creek's stage of development around climate change adaptation planning, using the Climate Adaptation Maturity Scale developed by the Federation of Canadian Municipalities. The checklist version used to guide the assessment, is included in Appendix H.

The scale has three competency areas: policy, human resources and governance, and technical and risk management capacity. Each competency area has 5 levels through which a municipality can progress.

The competencies are:

- **Policy:** Putting in place policies and objectives related to the development of an environment and vision that supports local climate adaptation.

- **Human resources and governance:** Ensuring staff and council are equipped with the mandate, understanding, skills and knowledge needed to support local climate adaptation.
- **Technical and risk management capacity:** Preparing the tools needed to deliver adaptation initiatives and manage operations in a way that minimizes climate risk (e.g. software, hardware, maps, models, etc.).

At the beginning of this project, Dawson Creek was considered to be at Level 1 for two out of three competencies (Human Resources and Governance, and Technical and Risk Management Capacity), and working towards Level 2 for Policy.

At the end of the action planning process, the assessment using the Maturity Scale was completed again. Based on this assessment, Dawson Creek is working on level 2 for Human Resources and Governance as they build awareness of the work completed during this project with decision-makers and leaders across the organization. Level 2 for Policy will be completed at the end of this project. On Technical and Risk Management Capacity, completing this project has moved the dial from level 1 to level 3 and for some impacts to level 4 for Dawson Creek. Staff have been committed to assessing risks, forming a team and brainstorming adaptation responses. The organization has already put significant resources into planning for climate-related hazards such as flooding and this project has complemented those efforts.

Next Steps

The **Climate Adaptation Team** is well-positioned – with an overall understanding of the climate projections, potential impacts and priority risks – to continue working across disciplines in the organization and in collaboration with community stakeholders to mitigate risks and build resilience to changes in climatic conditions moving forward. The initial action ideas included above and in Appendix G provide direction and focus in these next phases of the work.

An important aspect of implementation is continual monitoring and review. With climate change, more so than some other things that we plan for, conditions are highly complex and will continue to change and evolve over time. As a result, we need to continue to monitor changes to:

1. Climate projections – particularly any regional and local data;
2. Actual and potential impacts – for example, air quality due to wildfire was not a common concern just a few years ago. New impacts will emerge and existing ones will evolve;
3. Opportunities to mitigate risks and build resilience – windows of opportunity should be constantly in mind to take advantage of sources of funding, partnerships, awareness, and political will, etc.

It is recommended that the Climate Adaptation Team **develop a monitoring and review strategy** to ensure that this function is continually addressed. This may include:

- A review of the climate science every 3-5 years
- A scan of existing and emerging impacts every 1-2 years
- Re-evaluating the top priority impacts and action ideas every 2-3 years

As well, the **NECRN is a valuable resource** for all communities in the region that will require ongoing participation and investment of time and energy by its members to cultivate that value. The Fraser Basin Council will be convening the network in January of 2020, creating an opportunity to identify some initial areas of collaboration and joint projects. Generating some early wins and getting some experience in working together across communities would be a helpful foundation for the work moving forward.

8. Conclusion

The six communities in the Northeast Climate Risk Network have all experienced climate-related shocks (such as a flood or wildfire) or a stress (such as drier conditions, or more rain-on-snow events in the winter) in recent years. These events have impacted city services, community assets and residents. The climate vulnerability assessments have built on the good work started in each community to prepare and respond to a changing climate.

Based on information provided in an initial community-specific Gap Analysis and the climate projections for the region for the time periods of the 2050s and 2080s, staff and stakeholders from the communities and the region identified impacts to a range of service areas. The vulnerability of certain assets or areas was assessed and risk ratings supported prioritization of the impacts to ensure that resources can be directed to where they are most needed.

Throughout the process there were opportunities to learn from and share with others across the network, and to develop capacity within communities to continue with this work. Within each community, cross-disciplinary staff teams considered the top risks for their community as they identified and developed action ideas to mitigate risks, and to prepare and respond to the climate change-related impacts. These teams are well-placed to continue to guide and lead this work forward into implementation and ongoing monitoring and iterations. A range of possible ways to work together, capitalize on resources across communities, and maintain and build capacity as a region were identified.

Together, these assessment results and the initial action ideas developed by the Climate Adaptation Teams reflect the growing capacity of each community and the Northeast Climate Risk network as a whole to form a strong foundation for building resilience across the Northeast Region.

Appendix A. Risk-based Adaptation Planning Tools

Infrastructure or risk-specific assessments, such as an assessment of a sewerage area or a coastal flood risk assessment can rely on damage-curves and specific calculations of consequences to provide quantitative detail where it is needed. **Engineers Canada's PIEVC protocol** has a specific option to undertake a more detailed engineering study—the need for a more detailed assessment like this is something that may be identified through the more qualitative risk assessment. This higher level risk assessment has a specific purpose of better understanding the range of impacts the community may face, and prioritizing across and between them as a basis for deciding on where to focus their limited resources and time.

The **risk-based land use guide for Canada** outlines steps for planning including:

- establish the community needs,
- define hazard potential,
- identify what could be harmed,
- calculate potential losses (consequences),
- recommend safe land-use,
- and monitor decision success.

The **UKCIP tool** **(Adaptation Wizard)** for planning looks at current climate vulnerability and future climate vulnerability (risk included) before brainstorming adaptation options and monitoring and reviewing iteratively.

The **ICLEI BARC tool** follows 5 milestones including:

- initiating (taking a first look at impacts and adaptation actions underway;
- researching climate science and completing vulnerability and risk assessments;
- planning (identifying and evaluating actions);
- implementation and;
- monitoring and review.

The ICLEI BARC tool relies on clear impact statements throughout the vulnerability and risk assessments.

The International Standards Association (ISO) published a standard for climate change adaptation (ISO 14090) in June, 2019. The standard provides a framework to help organizations consider climate change adaptation in policies, strategies and plans. A companion standard (ISO 14091) is under development currently and will specify risk and vulnerability assessment steps.

In July, 2019 the provincial government published the Preliminary Strategic Climate Risk Assessment for British Columbia. The publication includes a strategic climate risk assessment framework for B.C that was developed to be scalable to analyze risks at multiple levels and a variety of climate-related risks. The framework has 4 steps:

- Understand the Context (including scope and objectives and audience);
- Identify risk events (they use a scenario approach to risk events);

- Analyze risks (Likelihood and Consequence); and
- Evaluate risks (rate risks and assess the adequacy of existing risk mitigation).

The new **Temperate tool** for use in the US, identifies hazards for the specific region populated from National Climate Assessments and other research. Hazards are translated into suggested risks for communities focusing on several priority community systems. Adaptive Need is calculated from a ranking of Impact Magnitude and Adaptive Capacity and is used to prioritize the risks. Actions are pre-populated based on prioritized risks.

The **Infrastructure Canada Climate Lens – Climate Change Resilience Assessment** recommends employing the principles of ISO 31000 Risk Management Standard with future climate conditions and impacts. If climate risks to the project in question are identified, an analysis of likelihood, consequence and vulnerability should be summarized and resilience measures taken. Using impact statements is recommended as is assessing risk across a range of domains such as public safety, economy etc. Methodologies listed as consistent with ISO 31000 are Envision, PIEVC and SuRE, not surprisingly all with a focus on Infrastructure.

The most common steps in adaptation methodologies are outlined below in Table 8, with a description of how this project undertook each step. This project will not complete the full cycle of adaptation planning, but will provide each community with an actionable assessment of priority risks and identify key next steps for adaptation and adaptation planning.

Table 8. Steps in Climate Change Adaptation Methodology

	Description / Questions to answer	Methods used
Determine the current and potential hazard	In this step climate-related hazards are identified. • What climate-related issues are we concerned about that could cause us harm? • What events have occurred to date and what were the consequences? • With climate projections in hand, what are the hazards and opportunities in climate conditions that we could face by 2050 and/or 2080?	Regional climate projections report (separate from this project) and Community Scoping Reports.
Impacts: identify what could be harmed and what could benefit from climate-related changes	This step contextualizes the current and anticipated climate-related hazards into how they will impact the community. • Impact Statements (ICLEI BARC methodology and Infrastructure Canada Climate Lens).	Scoping Report, survey and ground-truthing of impact statements in Workshop 1.
Assess Vulnerability	A vulnerability assessment investigates what and who are most vulnerable to the climate-related impacts (and opportunities). • Where is the community the most vulnerable? • What is in the way of/exposed to the hazard? • What is very sensitive to the hazard vs. very resilient (sensitivity)? • Where is there high versus low capacity to adapt to the change or hazard (adaptive capacity)?	Workshop 1: • Review and rate impacts for exposure and sensitivity • Identify impacts where there is low versus high adaptive capacity • Provide an assessment rating for overall vulnerability to key impacts
Assess and Prioritize Risks	The assessment of risk further prioritizes where to focus resources for adaptation by identifying where high likelihood of an impact coincides with high consequences. • For the impacts identified as having high vulnerability, determine the consequences that will result for people and things exposed to the potential impact	Initial assessment in Workshop 1: • Consequence ratings of high vulnerability impacts Likelihood ratings developed by the project team with expert input. • Rank overall community risk from these impacts

	• Assess risk across a range of consequences – i.e. to safety, to the environment, to the economy, etc. Prioritize where the need is greatest for adaptation action (risk management) in the community • Completed in many different ways but generally where a community is the most vulnerable and has the highest risk is targeted first for risk management action.	
Develop and evaluate adaptation options	Once impacts are prioritized, actions and measures can be planned to reduce the risk of the impact and/or reduce the vulnerability of the system. • Generate strategies and actions to reduce risk and vulnerability to priority impacts. Some actions are going to have a greater effect relative to the investment made, be more easily implemented than others or be more flexible to future climate ranges. • Develop evaluation criteria and apply to the actions	Workshop 2 • Brainstorm and discuss actions to reduce risk and vulnerability for prioritized impacts • Practice evaluating the actions • *At this stage this is an introduction to developing and evaluating options – we will not be developing a comprehensive set of actions, but we will consider what options are available and what initial steps can be taken.*
Implement	Detail actions including timeline, funding source if needed, responsibility and accountability.	Each community Climate Adaptation Team will be tasked with developing an initial action plan, with guidance from the project team. Final videoconference: • Communities share their priorities and action plans with other NECRN members • Discuss common interests, synergies and opportunities for collaboration
Monitor and Review	A monitoring and review strategy should be included in planning documents and government process planning.	

Appendix B. Regional Results of Pre-Workshop Survey

Background

In total 55 people completed the survey from across five communities (no one from Pouce Coupe completed the survey), see Figure 7. Given the low responses from several communities, this survey cannot be considered statistically representative sample of those that attended Workshop 1.

Chetwynd	12.7%	7
Tumbler Ridge	5.5%	3
Dawson Creek	16.4%	9
Fort St John	34.5%	19
Northern Rockies Regional Municipality	20.0%	11
Other - Write In	10.9%	6

Figure 7. Survey Respondents from Across Communities

Most respondents were from a local government, followed by the private sector.

Table 9. Respondents by Sector

Local or regional government	54.5%	30
Provincial government	10.9%	6
Health care	1.8%	1
Community organization	7.3%	4
Private sector	18.2%	10
Resource industry (Oil & Gas, Forestry, Agriculture)	7.3%	4
Other - Write In	12.7%	7

Understanding of Climate Change

Overall, 60% of respondents self-reported that they had a 'moderate' level of understanding of climate change. Dawson Creek (22%) and Fort St John (16%) had the most respondents with a 'high' level of understanding of climate change.

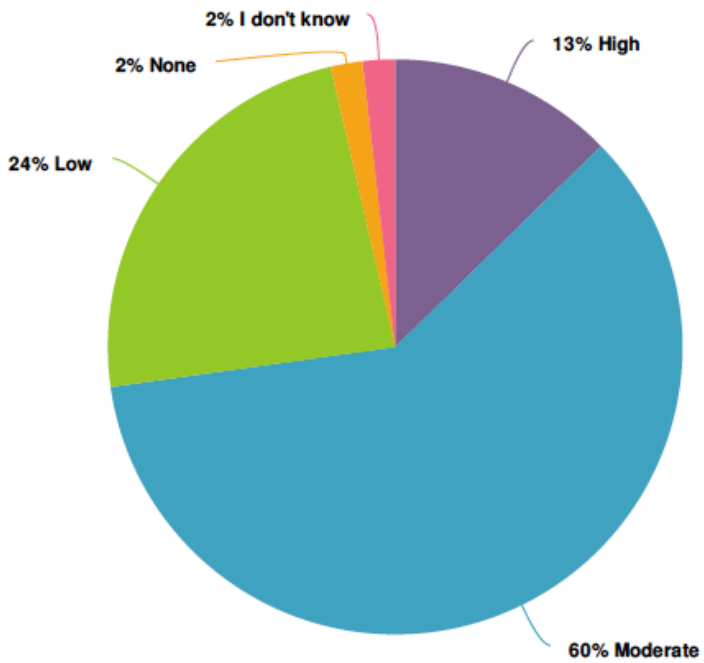


Figure 8. Survey respondents understanding of climate change

Action to Address Climate Change

Overall, 42% of respondents (across all communities) disagreed or strongly disagreed that their community was doing enough to adapt to a changing climate. A significant number of respondents (33%) did not know if their community was doing enough.

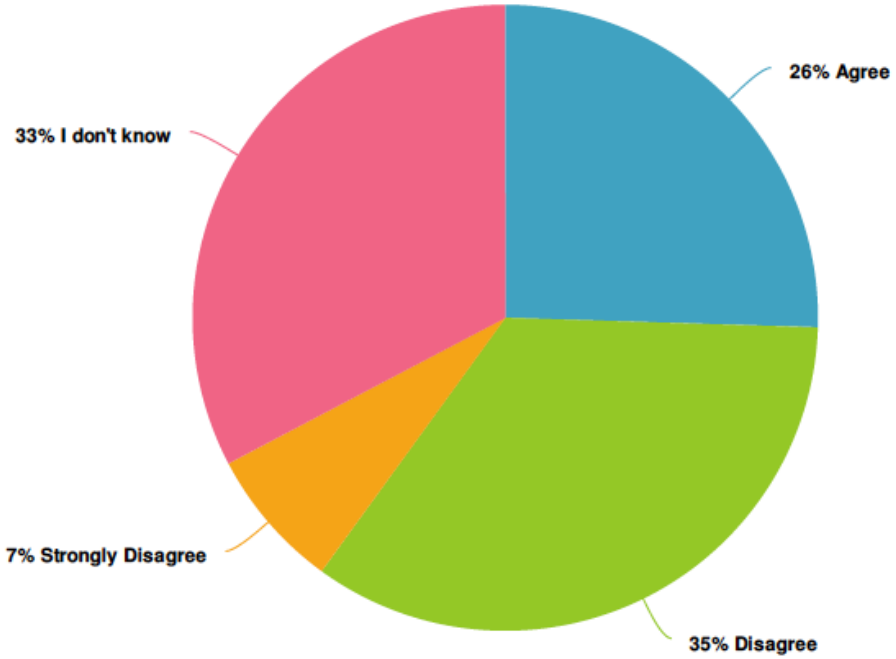


Figure 9. Survey respondents' agreement that their community is doing enough to adapt to climate change.

- In Dawson Creek, 33% agreed that their community was doing enough to adapt to climate change (44% of respondents either disagreed or strongly disagreed).
- In Chetwynd, 14% agreed that their community was doing enough to adapt to climate change (57% disagreed or strongly disagreed)
- In Fort St John, 42% agreed that their community was doing enough to adapt to climate change (37% disagreed)
- In NRRM, 9% agreed that their community was doing enough to adapt to climate change (36% disagreed or strongly disagreed and 55% did not know)
- In Tumbler Ridge, an equal amount of respondents (33%) agreed, disagreed and did not know that their community was doing enough to adapt to climate change

Concerns about Effects of a Changing Climate

The top concern across all communities was wildfire (78% of respondents ranked this as something they are most concerned about), followed by flooding (56%), other extreme events such as storms, hail, freezing rain (53%) and extreme rainfall events (51%). The climate impact communities were least concerned about was extreme heat (20%).

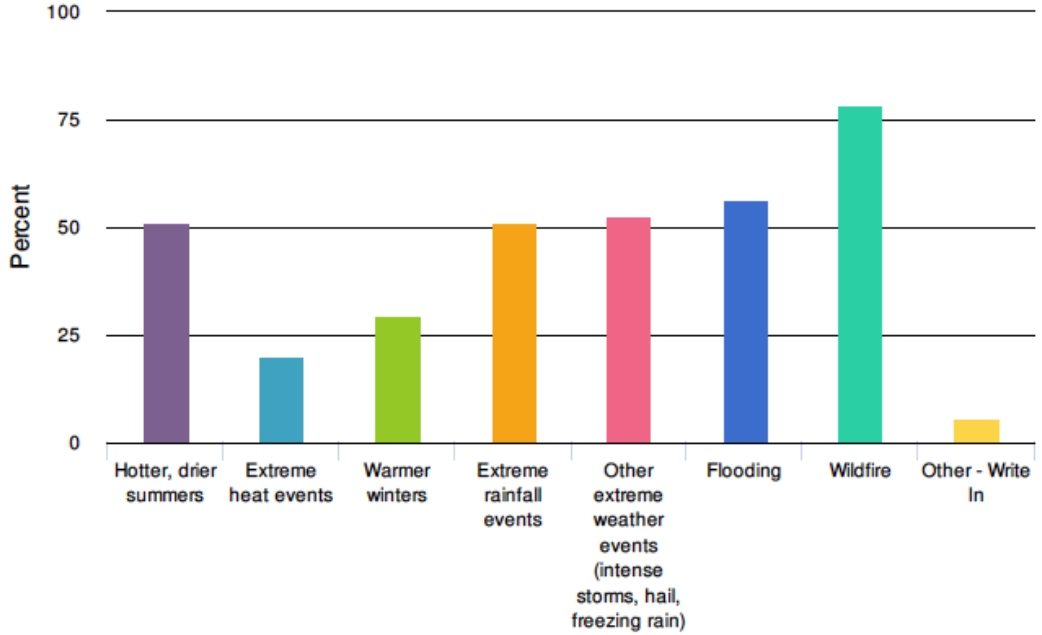


Figure 10. Concerns about effects of climate change

There were some differences across communities related to the top concerns from a changing climate:

- Dawson Creek was the most concerned about flooding and wildfires (both were ranked by 66% of respondents as a top concern)
- Chetwynd was most concerned about flooding (86%);
- NRRM (91%), Tumbler Ridge (100%) and Fort St John (79%) were most concerned about wildfire.

There was a comment/question about whether climate change is having an impact on species (i.e. caribou herds).

Climate Change Impacts on Municipal Services

The top municipal services that communities are concerned will be negatively impacted by climate change:

- Chetwynd: Transportation (86%) and storm drainage (71%)
- Tumbler Ridge: Transportation (100%) and storm drainage (100%)
- Dawson Creek: Relatively equal concern for many municipal services: water supply, storm drainage, transportation, hazard and emergency management (all ranked by 67% of respondents as being negatively impacted)
- Fort St John: Storm drainage (79%) and water supply (63%)
- NRRM: Storm drainage (73%) and relatively equal concern for several other municipal services

About 50% of respondents (across all communities) felt that there are potential positive impacts on parks, green space and economic development (agriculture, industry, tourism).

- There is a sense that the NE will become a more desirable place to live as the winters warm and the population will increase, leading to economic development (Chetwynd)
- Some feel that there will be potential for new crops and agriculture.
- Others see there will be trade-offs and difficult to see this as negative or positive for one region—for example, climate change will have negative impacts for oil and gas (ice roads), but may have positive benefits for agriculture and facilities will require less energy for heating in winter.

Climate Change Adaptation in Your Work

How often to you consider climate change in your work?

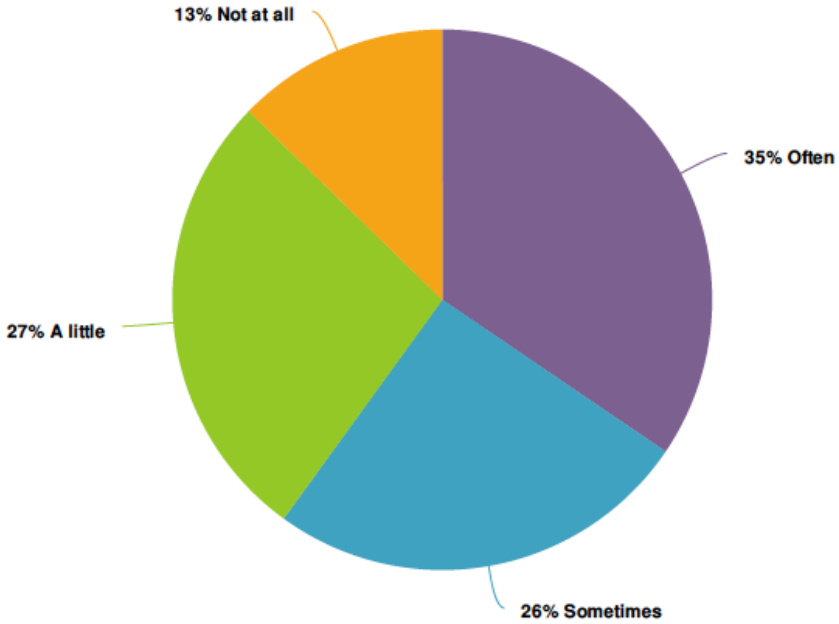


Figure 11. Frequency for considering climate change in one's work.

Differences between communities:

- Dawson Creek reported considering climate change in their work much more often than the rest of the communities (56% often; 11% sometimes; 22% not at all).
- In NRRM several people do not consider climate change in their work at all (36%). (Quote from NRRM: *It is not currently part of regular evaluation or decision-making.)*

Capacity Building

Most respondents said that more information about specific risks and impacts of climate change on their work (67%) would help them to more fully include adaptation in their role. The other top named supports would be 'more data or information about climate change' (60%) and training (60%).

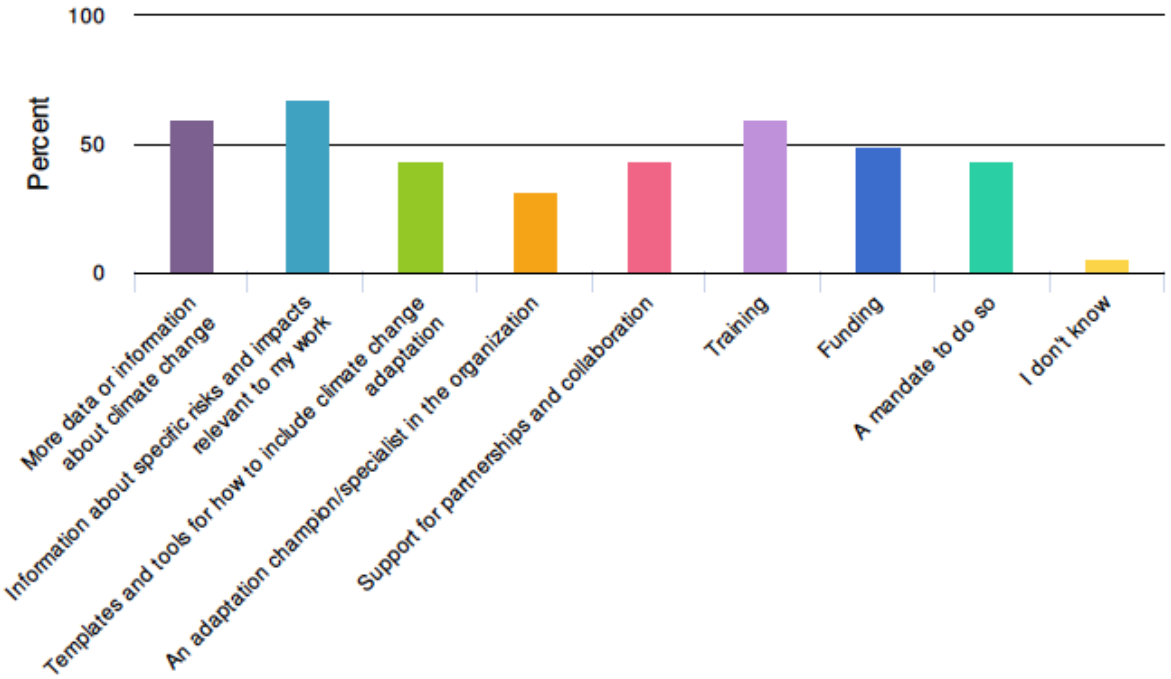


Figure 12. Perception of need for climate change adaptation supports

Barriers to Climate Change Adaptation

The top named barrier to including climate change adaptation in their work across communities was 'insufficient knowledge' (49%) followed by 'insufficient staff time or resources' (47%).

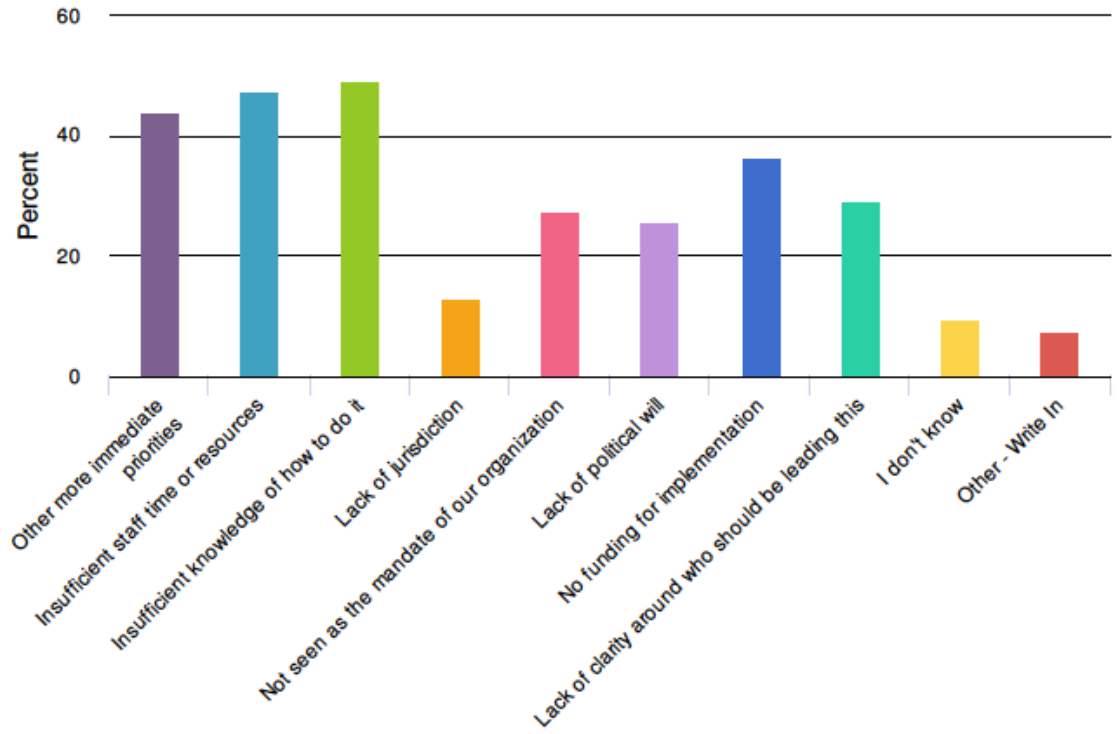


Figure 13. Barriers to climate change adaptation

In some communities, 'lack of political will' was a top barrier (Dawson Creek, 67%) and also 'lack of clarity of who should be leading this' (NRRM, 46%). In Tumbler Ridge, 100% of respondents (3 people) indicated that climate change adaptation was 'not seen as the mandate of their organization'.

Respondents indicated that the key stakeholders that should be involved in developing climate change adaptation measures include local or regional governments, provincial government, health sector, resource and industry, and the private sector (Figure 14). Nearly 75% of indicated all of these sectors needed to be involved in developing adaptation plans and 72% of respondents indicated that all of these sectors should be involved in implementing adaptation plans.

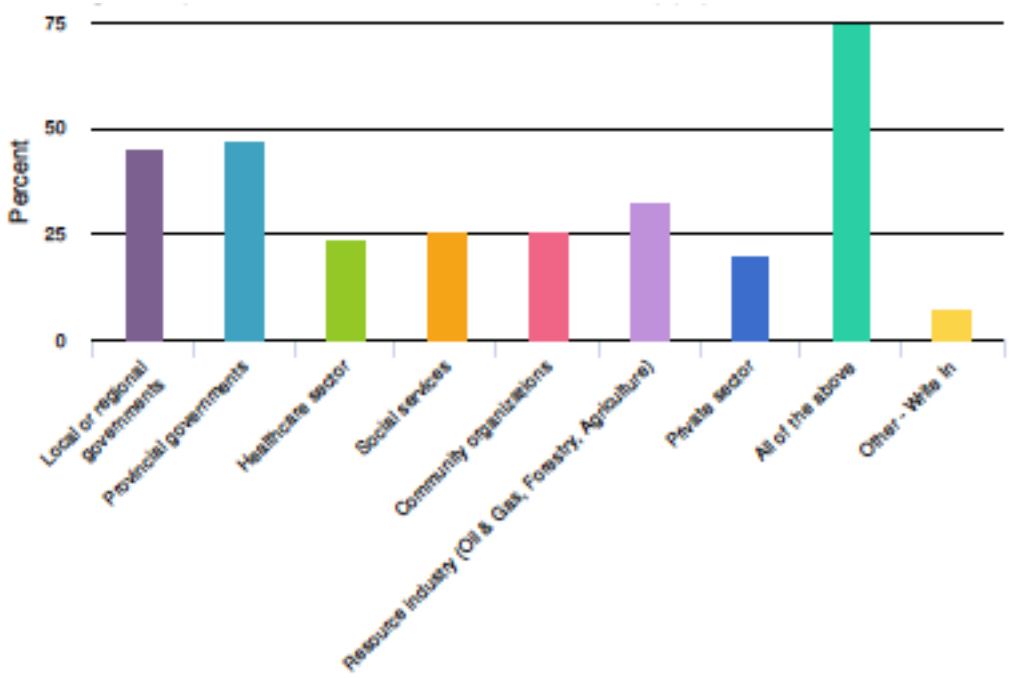


Figure 14. Perception of key stakeholders that should be involved in developing climate change adaptation measures

Other organizations that were named as important to include are:

- NEAT (Northern Environmental Action Team)
- Resource industry and private sector
- Emergency Management BC
- Fire Departments
- Health Authority

Appendix C. Qualitative Vulnerability and Risk Assessment Process

Step 1: Generate Impact Statements

Based on the regional climate projections summarized above, five overall changes to climate conditions were used as a basis for grouping types of impacts that communities in the Northeast are likely to face:

1. Warmer winters
    a. Average and low temperatures in winter will warm
    b. Shorter winter season
    c. Fewer Heating Degree Days
    d. Less ice days
    e. More precipitation falls as rain, and less as snow
    f. Peak flows and snowmelt in spring occur earlier

2. Hotter, drier summers
    a. Number of summer days increases
    b. Average and high temperatures (daytime and night) get hotter
    c. Very hot days are hotter, and occur more frequently
    d. A combination of hotter temperatures and changing precipitation & hydrology patterns leads to greater likelihood of dry periods and drought conditions in summer and fall
    e. Longer potential growing season

3. Increasing frequency and intensity of precipitation
    a. Annual and seasonal precipitation increases, especially in spring and fall
    b. Large precipitation events occur more often
    c. More precipitation falls during large precipitation events
    d. Rain-on-snow events are more likely

4. Increase in extreme weather events (windstorms, hail, extreme heat, forest fires)
    a. Due to a combination of changing conditions, unusual events such as large windstorms and hail events may occur more frequently

b. Due to increasing temperatures and drier periods in summer and fall, extreme heat events and forest fires may occur more frequently

5. Increased riverine flood risk
    a. A changing snowpack, snowmelt timing and increased intensity and frequency of precipitation lead to greater risk of riverine flooding

Within each of these categories, a set of "impact statements" was generated based on information compiled in the Gap Analysis[8]. In the first part of the workshop, participants were asked to "groundtruth" these impact statements, providing any additional information to describe the specific way this would affect their community. In addition, participants were asked to remove any that did not apply to their community, add any that were not already included, and make changes as appropriate. The full list of impact statements and the additional detail provided, is included as Appendix D.

Step 2: Assessing Vulnerability

Vulnerability is a combination of "Sensitivity" and "Adaptive Capacity," as described in Figure 2. In Step 2, participants individually provided ratings for both Sensitivity and Adaptive Capacity, for each impact statement that they felt confident rating. Where there were large discrepancies among group members' ratings for an impact statement, discussion ensued to land on a common rating. Ratings were on a scale of 1 to 5 (see **Error! Reference source not found.** for details). These overall ratings were then used to place the impact statement on a "vulnerability matrix" to sort and identify those that were higher vulnerability. **Error! Reference source not found.** shows the section of the matrix identified as "higher vulnerability" (marked with an asterisk). Those that were categorized as higher vulnerability were then checked with participants in the workshop, with the opportunity to drop any that didn't make sense, and/or make a case to add back in others rated slightly lower. Through this process, an overall list of around 50 impact statements was cut to about half.

[8] In January 2019 a community scoping report was developed for each community that presented an overview of themes and findings from a literature review; a summary of contextual information from regional climate projections reports, priority impacts, identification of gaps and opportunities for adaptation planning and implementation (based on the literature review and interviews), and an assessment rating using the "Climate Adaptation Maturity Scale".

Instructions: Use these rating scales to assess each impact statement at your table

1. Think about: "Is the system / asset / group of people represented in the impact statement subject to existing or anticipated future stress? How will the impact exacerbate existing stress?"

Sensitivity Rating:

2. If the impact occurs, will it affect functionality (the ability of the system / asset / group of people to serve its purpose or provide the use it is designed for)?

1 No: Functionality will stay the same	2 Unlikely: Functionality will likely stay the same	3 Possibly: Functionality is likely to get worse	4 Likely: Functionality will get worse	5 Yes: Functionality will become unmanageable

Adaptive Capacity Rating:

3. Can the system / asset / group of people adjust to the projected impact with minimal cost and disruption?

1 No: will require substantial costs and intervention	2 Unlikely: Will require significant costs and intervention	3 Possibly: Will require some costs and intervention	4 Likely: But will require some slight costs and intervention	5 Yes: Little to no costs or intervention will be necessary

Figure 15. Sensitivity and adaptive capacity rating scales Used in workshop 1 assessment process

	SENSITIVITY	No	Unlikely	Possibly	Likely	Yes
ADAPTIVE CAPACITY		S1	S2	S3	S4	S5
No	AC1			*	*	*
Unlikely	AC2				*	*
Possibly	AC3				*	*
Likely	AC4					
Yes	AC5					

Figure 16. Vulnerability assessment matrix, based on BARC-ICLEI

Step 3: Assessing Risk

Risk is a combination of "Consequence" and "Likelihood," as described above. In Step 3, participants assigned consequence ratings together as a small group. Each of the highest vulnerability impact statements included in Step 2 was assigned a rating from low to high in five categories (affected people, economy, critical infrastructure, environmental, and cultural). These overall consequence ratings were then combined with ratings of likelihood for each of these types of events, provided by expert reviewers (see Appendix E. Heat Map

Risk results for Dawson Creek fall into the high to medium-low range. None of the impacts were assessed as low risk. To be rated high risk, the impact has a combination of high consequence rating and medium or high likelihood rating, high ratings for both, or a medium consequence rating and high likelihood rating as per the heat map below (Figure 17). Note: Each impact statement is indicated by a number, corresponding to Table 10 below.

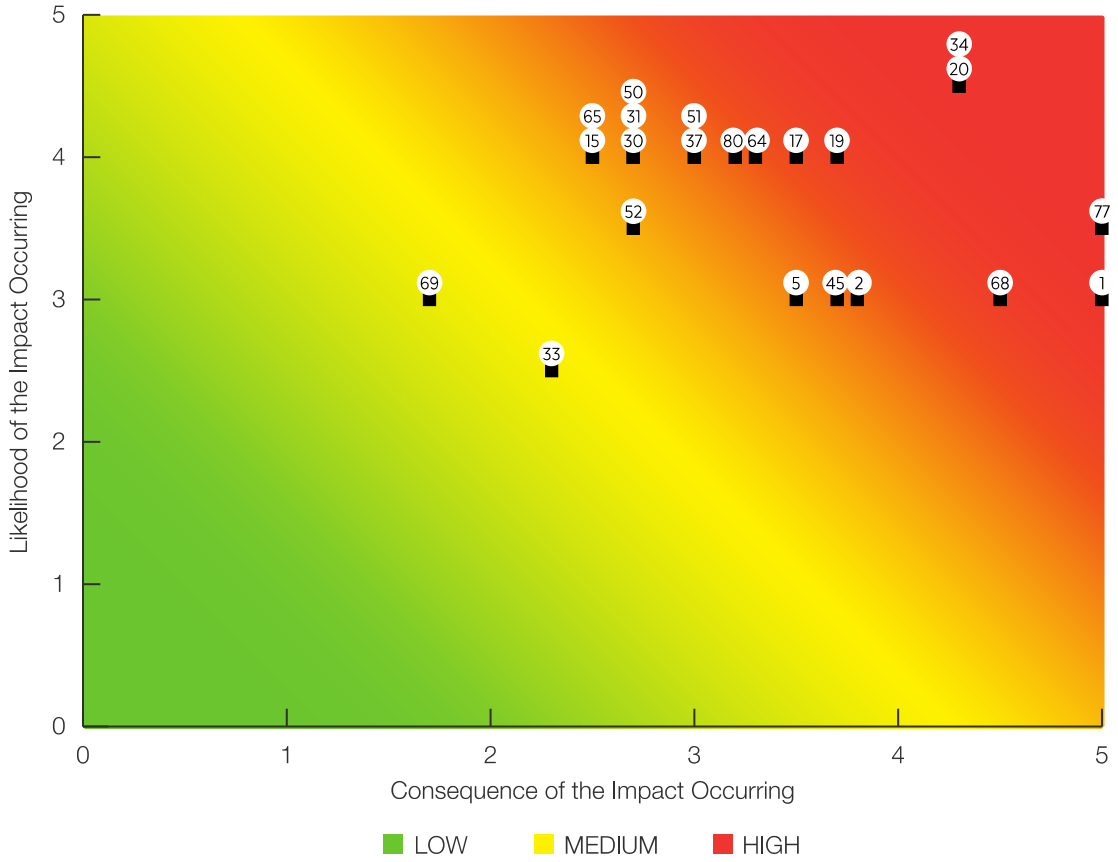


Figure 17. Heat Map characterization of risk ratings for highest vulnerability impact statements.

For the reference of staff as they work with this prioritized set of risks in their planning, the following comments were provided in workshop 2, to modify the placement of top risks based on their professional judgment:

- 77: well-placed
- 1: well-placed
- 68: well-placed, it's flooding that's the major event in our area, is there a route to the hospital, cut off emergency services
- 20: well-placed, modify from "ice-storm" to freezing rain

- 34: move it down because it has a lower likelihood, sewer surcharge backups less frequent, get those occasionally, but not every time
- 19: well-placed
- 2: move it to the left: likelihood is fine, move to lower consequence
- 17: well-placed

Table 10. Highest risks identified for Dawson Creek

Climate Hazard Type	Impact #	High Risk Impact Statements in descending risk score order (Likelihood X Consequence)
	20	Increasing potential for rain-on-snow events (and ice storms) increases the risk of street flooding, street closures, mobility issues and potential damage to nearby buildings
	34	Increasing intensity of rainfall causes more frequent localized flooding and sewer surcharge in parts of the community
	77	Increased flood events cause strain and stress on municipal wastewater systems, and private layouts and dugouts (also private septic and lagoons)
	1	Increased river flow and flood events damage buildings, crops, parkland, infrastructure such as bridges, etc.
	19	Increasing freeze/thaw cycles decrease the durability of infrastructure (such as roads and trails) and increase maintenance needs

	17	More rapid snow melt leads to increasing localized flooding from backed up culverts
	68	Major events (landslide, flood, wildfire) lead to impacted transportation within the community or between communities. (ie. isolation from critical services, jobs, evacuation routes)
	64	The combination of hotter and drier conditions increases potential for drought and decreased water supply in late summer
	80	Rain on snow events increase run-off in non-typical times of the year (January). Catalyst for localized flooding
	51	Increasing extreme events decreases the durability of infrastructure generally, leading to earlier replacement and increased maintenance needs
	37	Increased surface runoff can lead to increased nutrient concentrations in the water and increased sediment load thereby impacting operation of water supply infrastructure
	2	Increased river flow and flood events cause increased avulsions (changes to the river's path) and bank erosion, impacting aquatic habitat.
	45	Increase in extreme events cause more frequent power outages, in turn affecting household power and power to critical infrastructure

	50	Increasing frequency and intensity of extreme events puts pressure on the physical and emotional capacity of community volunteers including ESS and volunteer fire fighters
	30	Situations of increased turbidity due to larger or more frequent precipitation events decrease the number of days that pumping can occur from the river to water supply reservoirs
	31	Heavy rainfall events cause more sewer back-up, which damage buildings and can cause health impacts
 	5	More frequent flood events increase costs and require more capacity for flood clean-up and restoration
	15	Warmer winter temperatures may enable spruce beetle infestations which decreases local forestry incomes

for full list of consequence and likelihood scores).

Appendix D: Impact Statements with Additional Detail

This table includes all impacts generated throughout the adaptation planning process with Dawson Creek with additional notes added from participants in the workshops.

Climate – related hazard (shock): Warmer Winter Conditions		
#	**Impact Statement**	**Vulnerability Detail**
20	Increasing potential for rain-on-snow events (and ice storms) increases the risk of street flooding, street closures, mobility issues and potential damage to nearby buildings	Ice storms increase: -Cost for City re: gravel -Medical slips and falls -Road accidents -Increase variability of high flood events, decrease bank stabilities, increase turbidity in H20 -Benefit: snow melt throughout winter = less peak runoff in spring - easier on infrastructure (decrease snow clearing, increase salting) -Increased need for storm drains thawing (and vulnerable) -Clearing drainage ditches of snow for rain/snow melt
19	Increasing freeze/thaw cycles decrease the durability of infrastructure (such as roads and trails) and increase maintenance needs	- Oil and gas industry shorter construction season, may have to build summer roads - Increase industrial cost/also maybe start earlier - Winter access issues! - City infrastructure, building trades (longer season) - Slower economic shoulder seasons
17	More rapid spring melt leads to increasing localized flooding from backed up culverts	Storm drains Ditches Beaver Damage Increased cost (manpower) - Localized area for floods seem to take longer to dry out again for use - Property management

		- Crop damage - Standing water kills trees -Variability of flows (higher highs and lower lows) in the Kiskatinaw River, the water source for Dawson Creek and Pouce Coupe with high flows in the spring or early summer (caused by freshet and by heavy rainfall events). -Changes in the snowpack are impacting the timing and volume of freshet flows, with the freshet occurring around 3 weeks earlier than before (early- to mid-April) - In April 2018, the freshet flood risk was high, leading to closure of a bridge crossing as a precautionary measure. This was reportedly the first time a serious flood risk has been due to freshet
80	Rain or snow events increase run-off in non-typical times of the year (January). Catalyst for localized flooding	The intensity of rain and snow events has stressed the capacity of the public works department and affected safety and ease of travel (especially of concern for seniors).
15	Warmer winter temperatures may enable spruce beetle infestations which decreases local forestry incomes	- Forestry -Mills -Employment -Economic development -Increased intensity on forest fines -Beetle killed wood - sought after in Asia - unique niche market -Increased carbon release -Wood innovation design building - Prince George -Longer break-ups from wet conditions
69	Increased presence of ticks	Tick larvae can survive warmer winters and persist in region -This affects wildlife (e.g. moose - tick infestation)
16	Increasing pest infestations due to warmer weather would negatively impact agriculture and forestry	Forestry (see #15) -Grass happens -New ones (pests) and diseases
18	Warmer winters and summers lead to decreasing heating requirements and possibly increasing cooling needs,	Strain on healthcare with vulnerable population at risk -Strain on infrastructure needs (increased power usage) -True transition to renewable

	which impact energy bills and building design	-Building design - forces innovation, increase efficiencies (LEED/Passive)
87	Wildlife displacement and migration. Competing with humans for limited resources	
85	Increase in vector-borne illnesses [i.e. West Nile (mosquitos) and Lyme disease (ticks)]	Ecosystem health -Those who rely on hunting as a food source -Wildlife population decline
70	Less snow on the ground means less insulation. Frost goes deeper impacting/damaging infrastructure (and kills recently-planted trees)	
71	Different agricultural crops could become viable	Winter wheat and other fall seeded crops could become viable
72	Perennial fruit crops trees and shrubs waking from dormancy in winter = decrease in plant health and harvest potential	
76	Changing to rain dominated precipitation creates uncertain impacts to streamflow and water supply	
78	Increased streamflow in shoulder seasons/decreased summers leads to inability to use water due to water licence restrictions (high flows in March - water licence kicks in in May)	Increased erosion and decreasing bank stability in developed areas near streams -Water allocations based on past mean annual discharges -Timing of Oil and Gas industry withdrawals may be affected

Climate – related hazard (shock): Increase in other extreme events (storms, hail, extreme heat, wildfires, etc.)		
#	**Impact Statement**	**Vulnerability Detail**
68	Major events (landslide, flood, wildfire) lead to impacted transportation within the community or between communities. (i.e.	2016 - Flood event (division of community through creek water) -2-year increase in precipitation cycle observed

	isolation from critical services, jobs, evacuation routes)	
51	Increasing extreme events decreases the durability of infrastructure generally, leading to earlier replacement and increased maintenance needs	Increased water main leeks -Lagoons have to take more water, increased risk of failure -Infrastructure is not built to handle the changing extreme events
45	Increase in extreme events cause more frequent power outages, in turn affecting household power and power to critical infrastructure	Happened in 2011 -Would affect hospital, water treatment, blu generators, city hall/fire department/Kpac/PRRD office -Increased WTP operator time and burnout -Lift stations require power. If off for too long potential to discharge waste water (raw) to environment (worst case scenario)
50	Increasing frequency and intensity of extreme events puts pressure on the physical and emotional capacity of community volunteers including ESS and volunteer fire fighters	Burnout (i.e. one person having two roles, volunteer EOC and staff) -High expectation of few volunteers -Limited trained volunteers/staff -Recovery efforts require substantial time -Limited resources to deal with events -Limited financial support -Increased heat-related illnesses
52	More frequent / larger scale emergency and disaster events place increasing demands on municipal resources and capacity for mitigation, planning, preparedness, response and recovery	Training requirements (EMBC courses need to be increased in Northern communities) -Lack of staff resources to focus on the preparedness -Mitigation and response -Staff burnout during extended events
65	Increasing number or magnitude of wildfires impacts the health of the community due to poor air quality days and mental health impacts	Increased heat = increased need for air conditioning -Increased smoke - increased need for air purifiers -Decreased recreation = decreased mood -Increased pressure on health services Recent wildfires have not affected Dawson Creek directly, but evacuations to the area have occurred
46	Increasing intensity of snowfall, ice events and rain-on-snow events stretches the capacity of public works to respond and	Increased costs for gravel salt and staff -Public policy and public perception

	increases costs	
47	Wildfires and landslides are more common, impacting evacuation routes and transportation in and out of the community.	
48	Major events lead to isolation from health services or other critical services (due to impacted transportation routes within the municipality)	
49	Unusual weather events such as hail and tornados may increase with damaging effect for buildings, infrastructure and other assets	Increased insurance costs -Rebuilding infrastructure and increased construction industry
51	Increasing extreme events decreases the durability of infrastructure generally, leading to earlier replacement and increased maintenance needs	Increased water main leeks -Lagoons have to take more water, increased risk of failure -Infrastructure is not built to handle the changing extreme events
66	Hotter and drier conditions contribute to increasing wildfire risk in large forested areas.	Health (air quality) -Water quality (increase organics, TOCs, which could lead to increase THM) -Timing of runoff (decrease soil infiltration, mass movement potential) -Water supply - firefighting (interface) -Transportation

Climate – related hazard (shock): Increased Intensity and Frequency of Precipitation		
#	**Impact Statement**	**Vulnerability Detail**
34	Increasing intensity of rainfall causes more frequent localized flooding and sewer surcharge in parts of the community	-Dawson Creek: Various sources of flooding have impacted homes, infrastructure, sewer systems, public lands, and habitat. Significant flood events have led to financial impacts that have been hard to recover from – disaster financial assistance and other publicly funded resources help but are inadequate and uncertain in the future. -Pouce Coupe: Intense rainfall events have contributed to more frequent flood threats from the Pouce Coupe river and Bissett Creek with significant flooding events in 2011 and 2016.

		-Development and land management in the surrounding area will have significant effects on water movement -Promote water and soil conservation land practices within watershed -Need to upgrade/storm-water management -City hall - flood mitigation = tax payers dollars -OCP changes = increased dollars spent
37	Increased surface runoff can lead to increased nutrient concentrations in the water and increased sediment load thereby impacting operation of water supply infrastructure	Increasing surface runoff into the water supply can contribute to greater nutrient transport and turbidity which is harder on treatment and pumping infrastructure, and impacts groundwater recharge rates. New reservoir gives buffer to raw water -Help decrease costs -High turbidity periods in the river -Potential for swimming advisory in the area, affect recreation/tourism and community health
30	Situations of increased turbidity due to bigger or more frequent precipitation events decrease the number of days that pumping can occur from the river to water supply reservoirs	Increased capacity required from reservoirs -Infiltration gallery could offset turbidity effects on pumping this
31	Heavy rainfall events cause more sewer back-up, which damage buildings and can cause health impacts	-Sewage back-ups have been experienced during heavy rain events -Need to uncombine /separate combined sewers -Build/add more sanitary sewer force mains -Can have a stress on health care system -Damaged buildings increase economic development
33	Increasing surface run-off during the rainy season and decreasing recharge during the longer dry spells will impact groundwater and base flows	Use existing knowledge to place groundwater concerns in context for Dawson -Need more groundwater data -Increase storm ponds -Upset farmers in groundwater licenses! -Recharge is minimal in local aquifers -Dependent on land-use management
32	Variability and intensity of precipitation	Increased manpower and supplies

	events in winter decreases safety and ease of travel, especially for mobility challenged individuals (e.g. ice storms)	-Safety - increased freeze/thaw -Also would affect spring thaw -runoff
35	Increasing intensity of rainfall makes crop planting and harvest more difficult for farmers	Promote extension and knowledge transfer to address difficult situations -Increase insurance costs for Ag
36	Increasing run-off carrying more salt (from roads) in the winter, and other contaminants year-round, negatively affects water quality leading to environmental impacts	City is limited to how much salt can be used annually through ministry permit. To use more for increased freeze/thaw -More winter sanding involved -Increased turbidity and increased insurance for windows -Beet juice for roads, they grow great here -Decreased fish habitat, warm or salty = inhabitable

Climate – related hazard (shock): Hotter Drier Summers and Longer Growing Season		
#	**Impact Statement**	**Vulnerability Detail**
64	The combination of hotter and drier conditions increases potential for drought and decreased water supply in late summer	Been through a few dry summers - reduced water supply/restricted water, has gotten to limiting showering etc. - Variability of flows (higher highs and lower lows) in the Kiskatinaw River, the water source for Dawson Creek and Pouce Coupe, with extreme low flows in late summer and early fall. -Increased dust, decreased air quality -Increase in risk of fires -Increased stress on vegetation -If only large rain events, no ability to pump a lot of water from river as rain = turbidity and low flows = reduced water withdrawals and environmental flow needs -Increased evaporation from reservoirs
60	With increasing wildfires, regional forest fire evacuees increase in number and frequency which increases stress on the community's emergency response and emergency social services	
61	Increasing temperatures and variable	Wetspring - hard to get on field

	weather conditions reduces the ability to grow certain crops	-Frost in early Fall prior to longer Fall can still affect crops (i.e. no melons in 2018 due to September frost, re-grow after
62	Increasing temperatures and longer growing seasons enhances the ability to grow certain crops	Horticulture potential -Industry growth in soft fruits and vegetable production -May require irrigation -Victory gardens. Back yard for security/community gardens -Opportunities for new crops, increase profitability and increase crop diversity
63	Change in seasonality and increasing temperature leads to introduction of new invasive species (plants, insects, etc.)	Pine beetle/spruce beetle -Noxious weeds - thistle, scentless chamomile/oxeye daisie -Unpredictable which new ones will thrive -Insects - more diseased
84	Increased heat island effect	
86	Increased power load in summer, requires change in building technology and requirements	Increased pressure on medical and social services -Decreased recreation due to extreme heat -Increased need for coding for buildings, particularly for vulnerable populations

Climate – related hazard (shock): Increased riverine flood risk due to changing snowpack, snowmelt timing and increased intensity and frequency of precipitation

#	Impact Statement	Vulnerability Detail
77	Increased flood events cause strain and stress on municipal wastewater systems, and private layouts and dugouts (also private septic and lagoons)	Decreased ability to harness snowmelt during early season due to permitting -Sewage treatment systems can't handle peak flows from infiltration and runoff - Cross connection issues -Environmental impacts
1	Increased river flow and flood events damage buildings, crops, parkland, infrastructure such as bridges, etc.	Existing bridges are not designed to current flood levels -New builds do take into account climate change (somewhat) -Opportunity to build back better -We look at maintenance and learn from past events -Planning and building for anticipated 2080 climate
2	Increased river flow and flood events cause increased avulsions (changes to the river's path) and bank erosion, impacting aquatic habitat.	Occurring in rivers throughout the region -Increased turbidity -Decreased riparian habitat for filtering -New infrastructure supports and takes into account fish bearing and fish movement

		-Affect safe development - May require changes to planning policies (type of housing)
5	More frequent flood events increase costs and require more capacity for flood clean-up and restoration	Insane costs/loss of insurance protection -Increased preparation costs -Strain on infrastructure and reallocation of funding -Increased legal responsibility for City -Pressures from local government (respond, recover, repair)
6	More frequent flood events contribute to cumulative anxiety, stress and mental health challenges among affected residents and service providers	Strain on businesses and business owners -Homeowners stressed with increased costs -Adapting - experience and building resilience
3	Increased river flows, flood events and associated erosion & avulsion (changes to the river's path), negatively impact the value and uses of areas of land and infrastructure near rivers and streams.	
4	Increased variability in flow volumes in the watersheds that provide water supply, increases uncertainty around planning and water management	Impacts ability to use water licences -Conflict blu licencing windows and when H2O available -Pouce and Keskentine issue in unlicensed H2O use
79	Impacts on private water and septic systems (relates to 77)	Contamination risks -Infrastructure costs -Cross prop contamination

Appendix E. Heat Map

Risk results for Dawson Creek fall into the high to medium-low range. None of the impacts were assessed as low risk. To be rated high risk, the impact has a combination of high consequence rating and medium or high likelihood rating, high ratings for both, or a medium consequence rating and high likelihood rating as per the heat map below (Figure 17). Note: Each impact statement is indicated by a number, corresponding to Table 10 below.

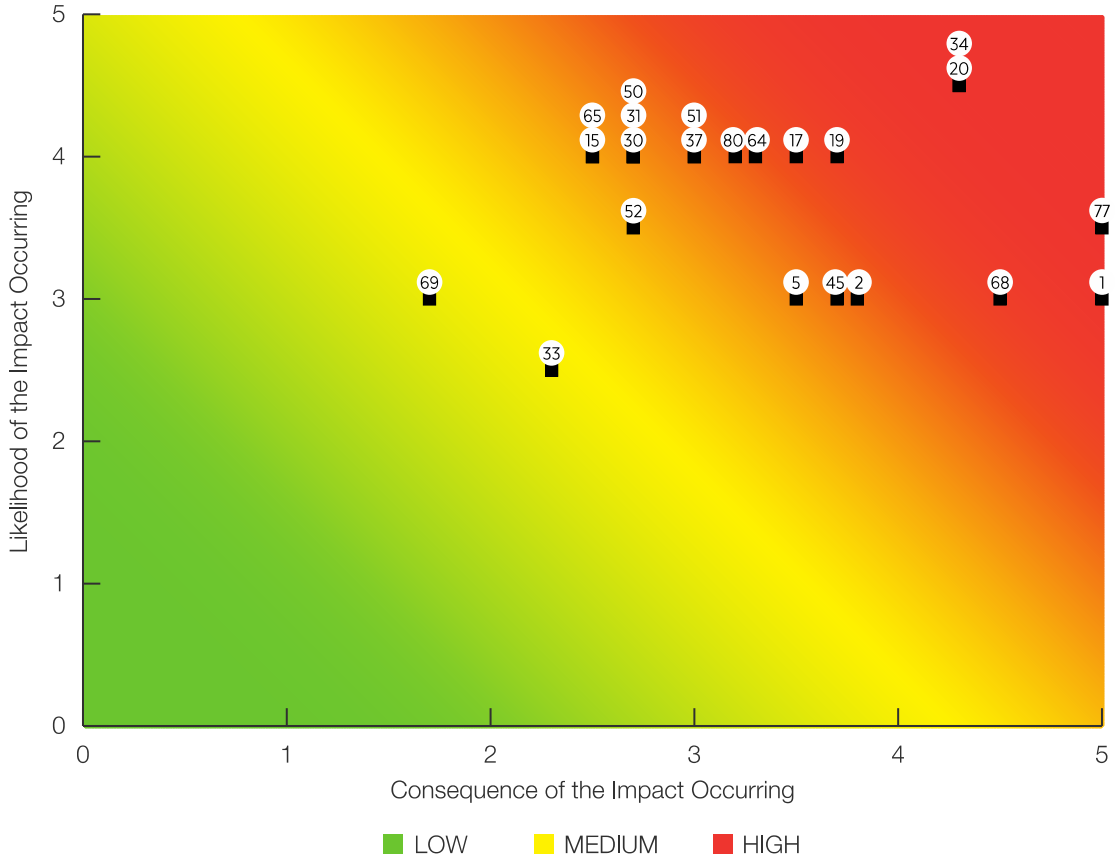


Figure 17. Heat Map characterization of risk ratings for highest vulnerability impact statements.

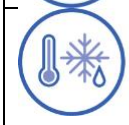
For the reference of staff as they work with this prioritized set of risks in their planning, the following comments were provided in workshop 2, to modify the placement of top risks based on their professional judgment:

- 77: well-placed
- 1: well-placed
- 68: well-placed, it's flooding that's the major event in our area, is there a route to the hospital, cut off emergency services
- 20: well-placed, modify from "ice-storm" to freezing rain

- 34: move it down because it has a lower likelihood, sewer surcharge backups less frequent, get those occasionally, but not every time
- 19: well-placed
- 2: move it to the left: likelihood is fine, move to lower consequence
- 17: well-placed

Table 10. Highest risks identified for Dawson Creek

Climate Hazard Type	Impact #	High Risk Impact Statements in descending risk score order (Likelihood X Consequence)
	20	Increasing potential for rain-on-snow events (and ice storms) increases the risk of street flooding, street closures, mobility issues and potential damage to nearby buildings
	34	Increasing intensity of rainfall causes more frequent localized flooding and sewer surcharge in parts of the community
	77	Increased flood events cause strain and stress on municipal wastewater systems, and private layouts and dugouts (also private septic and lagoons)
	1	Increased river flow and flood events damage buildings, crops, parkland, infrastructure such as bridges, etc.
	19	Increasing freeze/thaw cycles decrease the durability of infrastructure (such as roads and trails) and increase maintenance needs
	17	More rapid snow melt leads to increasing localized flooding from backed up culverts
	68	Major events (landslide, flood, wildfire) lead to impacted transportation within the community or between communities. (ie. isolation from critical services, jobs, evacuation routes)
	64	The combination of hotter and drier conditions increases potential for drought and decreased water supply in late summer
	80	Rain on snow events increase run-off in non-typical times of the year (January). Catalyst for localized flooding

	51	Increasing extreme events decreases the durability of infrastructure generally, leading to earlier replacement and increased maintenance needs
	37	Increased surface runoff can lead to increased nutrient concentrations in the water and increased sediment load thereby impacting operation of water supply infrastructure
	2	Increased river flow and flood events cause increased avulsions (changes to the river's path) and bank erosion, impacting aquatic habitat.
	45	Increase in extreme events cause more frequent power outages, in turn affecting household power and power to critical infrastructure
	50	Increasing frequency and intensity of extreme events puts pressure on the physical and emotional capacity of community volunteers including ESS and volunteer fire fighters
	30	Situations of increased turbidity due to larger or more frequent precipitation events decrease the number of days that pumping can occur from the river to water supply reservoirs
	31	Heavy rainfall events cause more sewer back-up, which damage buildings and can cause health impacts
 	5	More frequent flood events increase costs and require more capacity for flood clean-up and restoration
	15	Warmer winter temperatures may enable spruce beetle infestations which decreases local forestry incomes

Appendix E. Climate Adaptation Teams, Terms of Reference

Purpose

- To build internal capacity for assessing and planning for changing climate conditions
- To build in redundancy to this capacity (i.e. multiple people with understanding, skills, and institutional memory)
- To raise awareness of vulnerabilities and risks due to a changing climate and build buy-in within the organization and community for this knowledge to become more mainstreamed into and across organizational processes
- To maintain momentum by providing mutual support

Consider a balance of these characteristics in choosing who to invite to your team:

- Internal champions and/or those who have some degree of understanding and interest in the impacts of a changing climate for the work of the local government (this could include those who attended workshop 1)
- A range of functions within the local government (e.g. drawn from different departments, and/or responsible for different aspects of this work – for example: a CAO, an engineer, a planner, an EOC operator or Fire Chief, someone from finance/asset management, an elected official)
- Those who are responsible for key climate risks
- Positional authority – a combination of higher-level decision-makers with others who get things done on the ground
- At this time we are suggesting that this be an internal team; however, in the smaller communities you may want to include an external stakeholder for the extra capacity or strategic role they may play in supporting the work moving forward.

Function:

- This team will be tasked with providing guidance and leadership to your climate adaptation effort in this next phase of the work.
- For the time being, this is likely to be an informal working group. As this advances, becomes more understood, and/or is established as a priority within your organizations, you may decide to establish a steering committee and/or formalize the role of this group (or your organization may be ready to make this formal already!)
- The scope of this group's work will depend on capacity and need. In the next two steps of the Climate Vulnerability Assessment we will be exploring what actions you may want to pursue in the near term. This will inform the "terms of reference" you may want to set for this group. For the duration of this project, this will include:
    - Participating in workshop 2 on June 11th, in Chetwynd (all day)
    - Participating in drafting an action plan, with support from SHIFT (early fall, 2019) (up to 2 coaching calls with SHIFT; 2-4 hours to draft your action plan)

- Meeting with the NECRN in the fall to share your action plan, learn from others, and coordinate regionally around areas of shared interest and priority. (3 hours)
- Meeting monthly or bi-weekly as a team to provide leadership on implementing your action plan, from fall of 2019 (at this stage you may want to reconsider membership in the Climate Adaptation Team, and/or establishing a broader steering committee)

Appendix G. Detailed Action Plan

2.0 Increased Intensity and Frequency of Precipitation							
High Risk Impacts: #34: Increasing intensity of rainfall causes more frequent localized flooding and sewer surcharge in parts of the community #31: Heavy rainfall events cause more sewer back-up, which damage buildings and can cause health impacts							
Action #	**Action**	**Action Description**	**Status: Underway, Act Now/by X year, Monitor, Investigate further**	**Lead Department**	**Effort: Range of funding / HR from low to high**	**Next Step**	**Evaluation Notes: How well this action addresses evaluation criteria**
2.1	Mapping and data sharing	- Heat traced culverts - Frequently flooded culverts - Storm drain backups - Asset management need	Act now	Public Works / Dev. services	low	- Review the flow data after one year. Assess highest risk areas. - Document affected assets within the City's GIS Mapping Records, possibly using "Collector", an Arc GIS Application.	- Resiliency building - Flexibility - Co-benefits (Contribute to community values)
2.2	Emergency management and response	- Communicate road closures & evacuation routes	On-going	Emergency Services (Incident Command)	medium	- Determine who is the administrator for Emergency Operation Centre Trainings	- No regret - Resilience building

		- Robust staff training				- Continue to train new and existing staff - Develop a partnership with PRRD for level 3 emergencies	- Co-benefits
2.3	Public engagement	- Educate affected homeowners - Real-time warnings (Everbridge software notifications)	On-going	EOC, Admin, Watershed Stewardship Program	low	- Public info bulletins to citizens annually on the impacts of flood risks and the City's current flood mitigation status - Make flood maps publicly accessible once created - Partner with the PRRD to encourage uptake of Everbridge - Internal communication and education on current flood projects	- No regrets - Co-benefits - Internal implementation - Cost is low relative to inaction
2.4	Reduce the ability for water to Infiltrate and inflow (I & I) to sanitary collection system	- Will reduce the amount of peak loading in our sanitary system - Introduce an I & I program	Investigate	Water & Environment	- Grant funding	- Research possible grants	- Resiliency - No regret action (extends the useful life of our sewage treatment) - Co-benefits
2.5	Increase use of bio-swale	- Neighborhood community plan	On-going	Dev. Services / Watershed Stewardship Program	On-going maintenance cost	- Identify current bio-swales…. Are they working?	- Window of opportunity exists

						- Upon completion of the Flood Mapping Project, conduct an assessment on natural assets and their potential impact on overland flow	- Robust (effective across future scenarios) - Risk reduction
2.6	Build natural assets (slow, spread and sink)	- Continue to investigate options - Look into the Municipal Natural Asset Initiative (MNAI)	On-going,	Dev. Services / Watershed Stewardship Program	Grant funded	- integrate into flood mapping and mitigation work - Partner on natural asset management strategy with MNAI - Identify cost- benefits of this approach	- Risk reduction - Resiliency building - Funding sources
2.7	Incentivizing low impact development (rain gardens, xeriscaping, etc.)	- Opportunities for Parks to transition from flower beds to xeriscape - Incentivize developers - Development "Bonusing" - Nursery initiative	Monitor, On-going	City wide	Grants	- Identify where this has worked in similar climatic zones - Could partner with local nurseries for incentivizing 'hardy plants'/ drought tolerant perennials	- Ease (internal control) - Window of opportunity - No regrets
2.8	Increase mandatory park space in new development for runoff mitigation	- Parkland dedication - Natural Asset integration	Monitor	Dev. Services / Watershed Stewardship Program	??	- Identify costs and benefits of this approach	- Risk reduction - Resiliency building - No regrets

2.9	Development Cost Charge rebate for parks/open space beyond minimum	- Work with developers to potentially trade water retention/ natural asset integration with other City owned property or other property owned by the developer	Monitor	Dev. Services	??	- Investigate if this is something that has been assessed in the past or is currently used in other municipalities	- Resiliency building - Local control - Window of opportunity
2.10	Incentivize/encourage retrofits for downspout connection to splash pads	- New homes drain to splash pads - Old homes are tied into the sanitary sewer collection		Dev. Services		Identify how	Identify cost-benefits/business case *City doesn't allow connections to storm drains, just splash pads*
2.11	Rain barrels	- People can purchase on their own - Look for opportunities for subsidies through grants	Monitor	All Staff	Grant	- Explore retail sale partnership opportunities	- No regret - Resiliency building

3.0 Increased creek flood risk due to changing snowpack, snowmelt timing and increased intensity and frequency of precipitation

High Risk Impacts:

#77 - Increased flood events cause strain and stress on municipal wastewater systems, and private layouts and dugouts (also private septic & lagoons)

#1 - Increased creek flow and flood events damage buildings, parkland, infrastructure such as bridges, etc.

#2 - Increased creek flow and flood events cause increased avulsions (changes to the creek's path) and bank erosion, impacting

aquatic habitat #5 - More frequent flood events increase costs and require more capacity for flood clean-up and restoration							
Action #	**Action**	**Action Description**	**Status: Underway, Act Now/by X year, Monitor, Investigate further**	**Lead Department**	**Effort: Range of funding / HR from low to high**	**Next Step**	**Evaluation Notes: How well this action addresses evaluation criteria**
3.1	Urban Flood mapping Project	- Geomorphic Assessment - Hydrologic Assessment - Hydraulic Assessment - Risk Assessment - Model Development - Recommendations for next steps	Underway	Watershed Stewardship Program	Grant funded	- Move to Options Assessment, see next point	- Robust - Risk reduction - Resiliency building - Planning support
3.2	Completion of a Flood Mitigation Options Assessment	- Update and evaluate options in more detail through the completion of an Options Assessment - Use the combined updated risk assessment and the flood mapping model	2020	Watershed Stewardship Program	Grant?	- Look into CEPF UBCM Funding	- Robust - Risk Reduction - Resiliency building - Benefits the vulnerable - Cost effective

		to prioritize issues, and evaluate specific mitigation options. Example activities include: - Characterize the locations of problem crossings of the creek that are likely to continue to cause issues in the future. - Assess the feasibility of upstream storage or other structural options. - Evaluate and identify preferred options (and tradeoffs) for multiple options (structural and non-structural). - Produce a class 'C' cost estimate for the structural options.					in the long run
3.3	Update zoning and OCP policies	Amend with new floodplain mapping, *initial update to 2016 floodplain in ZBL.*	2020	Dev. Services	Low	- March 2020 targeted completion of floodplain mapping; project in progress	- Resilience building - Co-benefits
3.4	Creek Beaver Management	- Spring and fall	2020	Parks & Facility Manager	Low	- Annual cleanout activity	- Risk Reduction

	and Debris Cleanout	cleanout of the creek - Beaver Maintenance contract				- Shift timing to spring and fall to reduce the impacts of dams on soil stability along the creek.	- No regret - Benefits to vulnerable. Those who may be impacted by flooding in the future will benefit from this work. - Positive effect on ecosystem
3.5	Manhole Plugs	- Assist with stormwater inflow & mitigation to sanitary sewer collection system by adding manhole plugs to rims that submerge.	Investigate	Dev Services/ Water and Environment/ Public Works	?	- Explore means and methods to reduce inflow and infiltration to sanitary sewer collection system.	- Risk reduction - Flexibility - Local implementation
3.6	Emergency Management	- See Section 2.2	On-going	City wide	Low	- See Section 2.2	

4.0 Warmer Winters and Increased Extreme Events

High Risk Impacts:

#20 - Increasing potential for rain-on-snow events and freezing rain increases the risk of street flooding, street closures, mobility issues and potential damage to nearby buildings

#19- Increasing freeze/thaw cycles decrease the durability of infrastructure (such as roads and trails) and increase maintenance needs

#17- More rapid snow melt leads to increasing localized flooding from backed up culverts

#80- Rain or snow events increase run-off in non-typical times of the year (January). Catalyst for localized flooding

Acti	Action	Action Description	Status:	Lead	**Effort:**	Next Step	Evaluation Notes:

on #			Underway, Act Now/by X year, Monitor, Investigate further	Department	**Range of funding / HR from low to high**		How well this action addresses evaluation criteria
4.1	Communication (Ploughing, social media)	- City App used to mark backed up culverts	interdepartmental	Admin/Public Works (Yards Clerk)	low	- Start discussions with Dawn and Rich to see if this would assist, as there may already be a system in place.	- Timing- Low lag time, quick action - A window of opportunity currently exists
4.2	Installation of snow sensor	- Used for planning and tracking snow volumes and snow water equivalent (SWE) runoff - Use for ploughing bylaw	Underway	Watershed Stewardship Program	$10,000 installation & $360 annual running cost	- Order equipment and install for winter 2019 - Train staff on how to read the data and apply it	- No regret action - More accurate response to large snowfalls (cost benefit) - Assist in planning new snow dumping location - Could support future watershed research opportunities
4.3	Installation of pluvial (all	- Track rain in winter for rain on snow	Underway	Watershed Stewardship	Low	- Install snow sensor at watershed stewardship	- No regret

	weather rain gauge)	events - SWE volumes		Program		program worksite	action - No cost
4.4	Planning	Review quantity of road salt/sand required during winter months	Underway	Public Works	variable	Review weather records annually as compared with salt/grit use	- Flexibility, taking this action would not affect our ability to choose a different course in the future. - Implement ation is within local control
4.5	Planning	Selecting the right media (salt/sand/gravel)	Investigate	Public Works	unknown	Review salt/grit use vs. weather conditions	- Flexibility, taking this action would not affect our ability to choose a different course in the future. - Internal implement ation

							- Resiliency building
4.6	Planning	What does the next 24 hour period look like for weather and environmental changes	Monitor	Public Works	low	Monitor weather forecasts	- No regret - Internal implement ation - Implement ation cost is low relative to inaction
4.7	Planning	Steaming Culverts (weighing the cost/benefit of steaming vs heat tracing)	Monitor/und erway	Public Works	variable	Review number of culverts steamed and culverts with heat tracing installations	- No regret - Robust as it could be effective across a wide range of plausible future scenarios
4.8	Education	Public Warnings: Ever bridge? City website? App?	Investigate further	PRRD Partnership or Administration	low	Continue to utilize the City app and partner with the PRRD on regional warnings.	- No regrets - Build partnershi ps - Robust - Resiliency building

							- Low cost

5.0 Increase in other extreme events (storms, hail, extreme heat, wildfires)

High Risk Impacts:

#68 - Major events (landslide, flood, and wildfire) lead to impacted transportation within the community or between communities. (ie. isolation from critical services, jobs, evacuation routes)

#51 - Increasing extreme events decreases the durability of infrastructure generally, leading to earlier replacement and increased maintenance needs

#45 - Increase in extreme events cause more frequent power outages, in turn affecting household power and power to critical infrastructure

#50 - Increasing frequency and intensity of extreme events puts pressure on the physical and emotional capacity of community volunteers including Emergency Social Services and volunteer fire fighters

Action #	Action	Action Description	Status: Underway, Act Now/by X year, Monitor, Investigate further	Lead Department	**Effort: Range of funding / HR from low to high**	Next Step	Evaluation Notes: How well this action addresses evaluation criteria
5.1	Identify areas at Risk	- Flood Mapping - Simulations of flood model - Slope Stability Assessment of future risk	Components underway, however additional opportunities available with funding	Watershed Stewardship Program	- Medium - High - Grant funded?	- Speak to senior staff and council for direction	- Risk reduction potential - Urgency (impacts are already occurring) - Benefits to vulnerable - Actions would need to be taken now to

							be effective - No regret (Going to happen regardless of climate change) - Implementation is within local control
5.2	Establish evacuation routes	- Create routes - Inform residents	Investigate further	Fire hall / Admin	Low	- Discuss with MOTI - PRRD collaboration	- Implementation within local control - No regrets
5.3	Train City staff in Emergency Operation Centre Courses	- Maintain an adequate number of staff trained in each EOC unit (finance, planning, etc.) -	Underway	Fire hall/ Watershed Coordinator/ Emergency Social Services Coordinator	Low	- Assess 2019 training and gaps - Create Staff Directory	- No regrets - Build resiliency - Reduce loss in insurance claims as everyone is trained the same.
5.4	Encourage residents to use the PRRD's Communication Tool: Everbridge	- Find avenues to get the app out to residents (online, mail, newspaper)	Underway?	Administration	LOW- Potential to work or assist the PRRD in their initiatives	Assess the training needs of the first responders in community evacuations and firefighting	- No regrets - Window of opportunity exists - Effective across a wide range of

							future scenarios - Benefits to vulnerable
5.5	Back up generators (preferably natural gas) on critical infrastructure	- Installation of natural gas back-up generators at critical infrastructure such as reservoirs, the City's lift stations, and treatment plants	Investigate	Water & Environment	Grant?	- Investigate grant options	- No regret - Robust - Resiliency building - Cost effective in long run

6.0 Increased Intensity and Frequency of Precipitation in Watershed

High Risk Impacts:

#30: Situations of increased turbidity due to larger or more frequent precipitation events decrease the number of days that pumping can occur from the river to water supply reservoirs

#37: Increased surface runoff can lead to increased nutrient concentrations in the watershed and increased sediment load thereby impacting operation of water supply infrastructure

Action #	Action	Action Description	Status: Underway, Act Now/by X year,	Lead Department	**Effort: Range of funding / HR from**	Next Step	Evaluation Notes: How well this action addresses evaluation criteria

			Monitor, Investigate further		**low to high**		
6.1	South Dawson Reservoir	2018 construction. 2019 fill	Filling	W& E	Grant	- Currently underway	
6.2	Infiltration Gallery at Arras	- This design could decrease turbidity and increase lifespan of pumps - Decrease the frequency of pump down time due to high turbidity	By 2021	W& E	Capital	- RFP?	- Robust - Risk reduction - Co-benefits
6.3	Complete a road crossing assessment	- Road crossings have been proven to be one largest contributors of sediment into streams.	Investigate	W & E	Medium	- Source Water Protection Plan Inventory - Follow up on Ministry of Environment study on riparian health in the Kiskatinaw Watershed - Field Visits	- Robust - Flexibility - Resiliency building
6.4	Complete an assessment of riparian health and restoration opportunities	- A watershed with good riparian health benefits from the natural buffer it provides to runoff including sediment, nutrients, and bacteria. It also can provide stream stabilization and it buffers stream temperatures to support healthy aquatic	Investigate	W& E	Medium	- Source Water Protection Plan Inventory - Work with livestock producers to restore lost riparian areas - Work with oil and gas companies to protect riparian areas	- Robust - Flexibility - Resiliency building - No regrets

		ecosystems.					

Appendix H. Climate Adaptation Maturity Scale

The following pages are the checklist portion of the "Climate Adaptation Maturity Scale" published by the Federation of Canadian Municipalities' "Municipalities for Climate Innovation Program." The full document is available at: https://fcm.ca/home/programs/municipalities-for-climate-innovation-program/climate-adaptation-maturity-scale.htm

Competency: Policy

Putting in place policy and objectives related to the development of an environment and vision that supports local climate adaptation.

	1		2		3		4		5	
	Concept Level		**Preliminary Level**		**Implementation Level**		**Operational Level**		**Continuous Improvement Level**	
	Working on Level 1 ☐	Completed on Level 1 ☐	Working on Level 2 ☐	Completed on Level 2 ☐	Working on Level 3 ☐	Completed on Level 3 ☐	Working on Level 4 ☐	Completed on Level 4 ☐	Working on Level 5 ☐	Completed on Level 5 ☐
Maturity level →	We have set expectations for our work on climate adaptation. We have the support we need to begin preparing a policy.		We have drafted a climate adaptation policy and have prepared strategic guidelines that will inform the development of an adaptation plan and other adaptation initiatives.		We have adopted our climate adaptation policy and are using it to guide our actions, and have drafted an adaptation plan. We have established performance measures to monitor progress.		We have a climate adaptation plan in place and are managing climate risks. We are using performance measures to track the progress and outcomes of our climate adaptation initiatives.		We are continually improving our understanding of climate risks and our approach to managing these risks.	
Outcomes	You have achieved a specific maturity level when you can demonstrate evidence of the outcomes below.									
Policy and objectives	☐ We have looked into policy issues and constraints surrounding climate change adaptation within our community.		☐ We have developed a policy that details our organizational commitment to climate adaptation. ☐ Senior management and council have endorsed the policy.		☐ We are starting to use the policy objectives to guide our broader corporate plans and actions. ☐ We have drafted an adaptation plan detailing specific initiatives and processes.		☐ Senior management and council have endorsed the adaptation plan. ☐ Climate risks are managed in terms of levels of service, operations, and maintenance, in accordance with the policy.		☐ We are validating and refining corporate, service and adaptation objectives based on the evolving needs of our community.	
Strategy and framework	☐ We have defined objectives and committed to taking a concerted approach to managing climate risks.		☐ We have engaged senior leadership in identifying strategic-level climate risk categories across the municipality.		☐ We are beginning to integrate climate risk considerations into our asset management practices.		☐ There are clear links between the climate adaptation plan, asset management practices, and other strategic corporate efforts.		☐ We are continually improving our understanding and management of strategic-level climate risks.	
Measurement and monitoring	☐ We have articulated the expected benefits and outcomes of climate adaptation to council and internal stakeholders.		☐ We have developed guidelines and criteria for local or regional adaptation initiatives.		☐ We have established performance measures to monitor progress on climate adaptation, outcomes, and community benefits.		☐ We monitor progress on the climate adaptation plan and the implementation of adaptation initiatives.		☐ We are monitoring performance and using the feedback to prioritize and make ongoing refinements and improvements.	

Competency: Human resources and governance

Ensuring staff and council are equipped with the mandate, understanding, skills and knowledge needed to support local climate adaptation.

	1		2		3		4		5	
	Concept Level		**Preliminary Level**		**Implementation Level**		**Operational Level**		**Continuous Improvement Level**	
	Working on Level 1 ☐	Completed on Level 1 ☐	Working on Level 2 ☐	Completed on Level 2 ☐	Working on Level 3 ☐	Completed on Level 3 ☐	Working on Level 4 ☐	Completed on Level 4 ☐	Working on Level 5 ☐	Completed on Level 5 ☐
Maturity level →	We have council support[1] to establish a cross-functional climate adaptation team.[2]		We have established a clear mandate for our climate adaptation steering committee.[2] Council has approved use of funding for internal or external awareness raising regarding climate risks and potential adaptation initiatives.		Our climate adaptation steering committee and team[2] have clear responsibility and the support needed for preparing a draft climate adaptation plan.		Our climate adaptation plan is in place. Our climate adaptation team[2] is guiding and supporting climate adaptation on an ongoing basis, and has ongoing council support. Adaptation-related roles and responsibilities are operationalized.		Our staff and council are continually improving our understanding of climate risks and our approach to managing them.	
Outcomes	You have achieved a specific maturity level when you can demonstrate evidence of the outcomes below.									
Cross-functional groups	☐ We have appointed a climate adaptation team to examine current and future climate change risks and to identify potential adaptation opportunities or initiatives.		☐ We have appointed a cross-functional climate adaptation steering committee[2] to oversee planning and deployment of climate adaptation initiatives by the climate adaptation team.		☐ The climate adaptation team, with oversight from the steering committee, is developing and will manage a climate adaptation plan.		☐ Our climate adaptation team has been made permanent to provide ongoing communication, support and guidance on adaptation across the organization.		☐ Our climate adaptation team and steering committee support the continuous improvement of our climate adaptation initiatives.	
Aligned culture	☐ Staff/council have a basic understanding of risks posed by climate change to infrastructure, natural assets and operations.		☐ Our climate adaptation team raises awareness of local climate risks and builds buy-in for potential adaptation initiatives.		☐ Climate-adaptation-related roles and responsibilities are clearly identified and communicated for staff in key departments.		☐ Climate risks are managed in terms of levels of service across our organisation.		☐ Climate change considerations are influencing how we optimise decisions on assets and service delivery.	
Stakeholder engagement	☐ We have identified climate change and adaptation stakeholders within the community.		☐ We have completed some community consultation on our climate change vulnerability assessment and potential adaptation initiatives (see Level 2 of the Technical and Risk Management Capacity competency).		☐ We have completed community consultation on the climate change vulnerability assessment, potential adaptation initiatives, and climate impacts on levels of service.		☐ We communicate regarding climate change adaptation initiatives and progress on climate adaptation plan implementation, internally and externally.		☐ Staff or council members are recognized by peers and external stakeholders as adaptation resources, and engage with them to exchange knowledge. ☐ There are ongoing mechanisms through which the community can be engaged in discussions or activities relating to local climate adaptation.	

[1] Council support is defined as a formal council resolution or adoption of bylaws, studies, master plans or policies that confirm formal support from elected officials.

[2] Members of the climate adaptation team or steering committee may wear many hats within their organization, and may also hold responsibility for other initiatives (e.g. asset management). It is also recognized that in smaller municipalities, members may sit on both the climate adaptation team and climate adaptation steering committee. Some municipalities may choose to engage external stakeholders in their climate adaptation team or climate adaptation steering committee, or in both groups, but it is recommended that there be a strong level of internal representation.

Competency: Technical and risk management capacity

Preparing the tools needed to deliver adaptation initiatives and manage operations in a way that minimizes climate risk (e.g. software, hardware, maps, models, etc.).

	1		2		3		4		5	
	Concept Level		**Preliminary Level**		**Implementation Level**		**Operational Level**		**Continuous Improvement Level**	
	Working on Level 1 ☐	Completed on Level 1 ☐	Working on Level 2 ☐	Completed on Level 2 ☐	Working on Level 3 ☐	Completed on Level 3 ☐	Working on Level 4 ☐	Completed on Level 4 ☐	Working on Level 5 ☐	Completed on Level 5 ☐
Maturity level →	We are exploring our technical needs and data gaps so that we can take steps to better manage our assets and reduce their vulnerability to climate change.		We have defined our technical gaps and are acquiring the necessary data and tools to conduct a vulnerability assessment of our infrastructure-based services.		We understand the priority climate risks to key infrastructure systems and are planning our monitoring and management approach for addressing them.		We understand ongoing climate risks to our assets and levels of service, and are planning adaptation initiatives to address them. We have data collection and analysis processes in place to support risk management and adaptation initiatives.		We continually improve our approach to strategic adaptation planning and reducing climate risk over the longer term.	
Outcomes	You have achieved a specific maturity level when you can demonstrate evidence of the outcomes below.									
Data and performance management	☐ We are compiling available data and identifying gaps related to asset performance, as well as observed and expected local climate change impacts. ☐ We are conducting a needs assessment for an information system to manage and track asset and climate data.		☐ We are filling data gaps related to asset performance and local climate change impacts. ☐ We have established appropriate operational and customer levels of service for priority assets. ☐ We have completed the needs assessment for our information system, and are exploring suitable options.		☐ We have identified our priority assets for risk management, and are establishing processes for ongoing data collection on asset performance and climate change impacts. ☐ We have acquired an information system for managing and tracking data, and are currently implementing it and training relevant staff.		☐ We have implemented our information system, trained relevant staff, and established processes for ongoing data collection related to asset performance. ☐ Our approach to climate change risk management and ensuring levels of service is well-documented.		☐ We continually improve our approach to data collection and management; and practices and tools are in place to manage the quality and consistency of data. ☐ Flexibility is built into the processes and tools to make it easy to adapt them to a changing reality or changing conditions.	
Technical tools	☐ N/A		☐ We are conducting a needs assessment for other technical tools (e.g. models, software, maps, etc.) to support analysis of climate change impacts on established levels of service.		☐ We have acquired or developed other technical tools and have completed a vulnerability assessment of our assets. ☐ We are identifying measures to address climate risks to levels of service, operations and maintenance, and capital projects as needed.		☐ We are using our tools to monitor the effectiveness of our risk management practices and adaptation measures.		☐ We continually improve our tools for analyzing climate impacts on established levels of service and managing climate risk.	

Table continued on next page →

Table continued from previous page

Economic considerations	☐ We are exploring costs for accessing relevant data sources or acquiring necessary technical tools and systems for conducting a climate risk assessment of our assets.	☐ We have allocated funding for acquiring relevant data, technical tools and systems, and/or training needed to conduct a detailed vulnerability assessment of our assets.	☐ We are assessing costs related to adaptation initiatives that address immediate risks to our assets or levels of service.	☐ We have allocated annual funding to implement priority adaptation initiatives and to manage operations in a way that reduces climate risks to our assets and service levels.	☐ Our climate adaptation initiatives are fully funded and our operations are managed in a way that minimizes climate risk to our assets and service levels over the longer term.