Stantec

Project # 1634_01530

Climate Change Impacts on Yellow Quill First Nation Infrastructure

Yellow Quill First Nation, Saskatchewan

December 3, 2019

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

Yellow Quill is a Saulteaux First Nation community located approximately 300kms east of Saskatoon and 12kms east of Rose Valley, Saskatchewan. Most recent statics (http://fnp-ppn.aadnc- aandc.gc.ca/FNP/Main/Search/FNRegPopulation.aspx?BAND_NUMBER=376&lang=eng) indicate Yellow Quill First Nation have approximately 3,086 registered band members, with approximately 920 residing on Yellow Quill reserve lands and the remaining membership living off reserve and in the cities of Regina and Saskatoon and other urban centres outside Saskatchewan.

The Yellow Quill community has been susceptible to multiple episodes of flooding. Flooding in 2005 and 2006 prompted the community to complete extensive drainage improvements to mitigate further flooding (completed in 2007). In May 2018, Lori Bradford, an Assistant Professor in the School of Environment and Sustainability at the University of Saskatchewan and Myron Neapetung obtained a First Nations Adapt Program grant to investigate the community's vulnerability to more frequent flooding brought on by the effects of climate changes (Source: https://indigenousclimatehub.ca/2019/08/preparing-for-the-future-how-yellow-quill-first-nation-is-using-indigenous-knowledge-and-science-to-mitigate-the-risk-of-flooding/). As part of that project, Stantec Consulting Ltd. (Stantec) was requested to complete a climate risk assessment (CRA) of the Yellow Quill community infrastructure using the First Nation Infrastructure Resilience Toolkit (FN-IRT), developed in partnership with Ontario First Nations Technical Service Corporation (OFNTSC). The objectives of the study are to:

- Identify Yellow Quill infrastructure vulnerabilities to current and future severe weather events associated with the impacts of climate change.
- Establish a climate risk profile for the infrastructure selected by the community.
- Provide adaption strategies and recommendations for mitigating climate risks with the highest consequences and impacts to the community's infrastructure assets.

Between August 13 and August 22, 2019, four FN-IRT workshops were completed. Workshops 1 and 2, were completed as WebEx workshops. Workshops 3 and 4 were held at the Yellow Quill band hall August 20 and 22, 2019. Participants in the workshops included Yellow Quill community members, councillors and Project Team members from Stantec and the University of Saskatchewan.

Workshops 1 and 2 focused on identifying the Yellow Quill infrastructure to be assessed for current and future climate risks. The Project Team selected four categories of infrastructure to assess.

- Community Buildings
- Water and Wastewater Treatment Systems
- Housing
- Roads and Drainage

The balance of workshops 1 and 2 focused on defining Yellow Quill specific inputs required to use with the FN-IRT and complete the climate risk assessment. These included:

- Discussion of weather-related impacts on infrastructure, and the completion and review of the Yellow Quill severity of impacts scale.
- Review and agreement of proposed probability scale for climate events.
- Review/selection of climate data (past climate events and impacts on infrastructure) and introduction to climate thresholds.
- Introduction of infrastructure performance considerations (structural, operational, functional) as they relate to the impacts of current and future climate events.

- Introduction of the FN-IRT climate vulnerability assessment process and the Risk Matrix worksheet.
- Development of the Yellow Quill First Nation (YQFN) Severity of impacts scale.

Workshops 3 and 4 were held at the Yellow Quill Band Hall and were open to the community to participate in the climate risk assessment. The Project Team and workshop participants further reviewed current meteorological/climate events that may have impacted or affected Yellow Quill FN infrastructure by causing infrastructure and operations disruptions and/or failures. This also included defining the threshold or intensity level of the climate events that would possibly cause damage or service disruptions should a component of the infrastructure be adversely affected by the event. The climate events selected by the Project Team and community members for the Climate Resilience Assessment (CRA) included the following.

- Extreme Cold Temperatures (>-30º C) – Yellow Quill often experiences periods of cold temperatures during the winter months, where temperatures are often below -30ºC for several days and sometimes weeks at a time.
- Heat Waves – Defined as periods of three of more consecutive days when the daytime high is >30º C and the overnight temperature remains >18º C.
- Winter Storms – Yellow Quill area often experience winter storms that bring high winds, snow, reduced visibility, snow drifts often result in reduced mobility for travel.
- Tornados – Yellow Quill has not had a tornado directly impact the community, though community members report seeing funnel clouds and tornadoes in the area. However, given the potential for severe damage, tornadoes were included due the possible severe to catastrophic impact on the community's infrastructure.
- Summer Storms – Summer storms were divided into three types of climate events with potential impacts to the community's infrastructure.
  - High Wind Events (straight line winds/microbursts) associated with strong summer storms.
  - Short Duration Intense Rainfall – Defined as 25-50mm of rain in a 1-hour period.
  - Golf-ball sized hail
- Flooding - Yellow Quill continues to be exposed to flooding risks during the spring melt. Rapid snow melts sometimes accompanied by spring rains when the ground remains frozen increase the risks of floods.

Yellow Quill Climate Profile

Due to the lack of available climate data, Stantec was requested to complete a climate profile for the Yellow Quill First Nation lands. Using an area centered on the Yellow Quill FN Band Hall, seven historical weather monitoring stations were identified as possible sources for climate data. There are currently no active weather monitoring stations in the study area.

Four of the stations were eliminated due to inadequate data ranges or poor data availabilities. Two stations (Mckague 2 and Paswegin 2) and the CANGRD data (a data set interpolating between existing stations) were compared as candidate weather monitoring stations. Given the CANGRD data is longer and more complete, and since the

Mckague 2 station is located 32km south of the Yellow Quill First Nation, CANGRD data was selected to represent the climate in the vicinity of the Yellow Quill study area.

Future climate projections are based on the Intergovernmental Panel on Climate Change (IPCC) RCP 8.5 scenario, which is considered the global “business as usual” greenhouse gas emissions track (IPCC, 2018). The full climate profile report is provided in Appendix F for reference.

Future Climate Trends

The following are expected climate trends for the Yellow Quill area. See Appendix F for additional information.

Temperature – Mean summer and winter temperatures have been rising over the past 30 years, and this trend is expected to continue in the future (CANGRD, RCP 8.5). The average change in mean annual summer temperature is expected to increase by an estimated 3.5^{0}C in the 2050s (2041 to 2070) to 5.9^{0}C in the 2080s (2071 to 2100). Similarly mean annual winter temperatures are expected to increase by an estimated 3.7^{0}C in the 2050s to 6.2^{0}C in the 2080s above the 1981-2010 baseline due to climate change.

Precipitation - Average annual precipitation in the prairies is highly variable, due to influences from the El Niño-Southern Oscillation (ENSO) and the Pacific-North American (PNA) circulation which can cause variable rainfall from one year to the next and intermittent droughts (Gan, 2005). This variability is reflected in the Yellow Quill area where, while the annual precipitation is expected to increase in the future, total summer precipitation which has increased over the past 30 years is expected to decrease in the future, and total winter precipitation, which has decreased over the past 30 years is expected to further decrease on the future. Spring and fall precipitation are also predicted to increase in the future. The resulting lower summer precipitation may result in more periods of drought, which have shown a steady increase in frequency over the last 30 years.

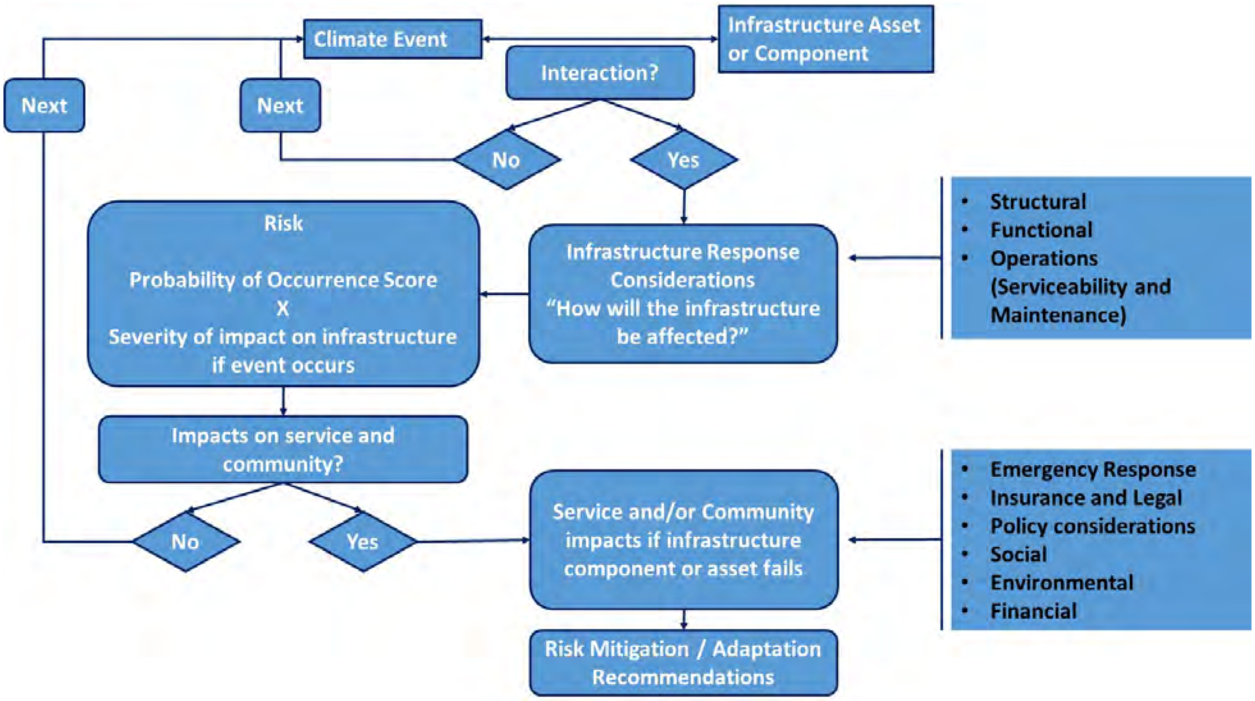
Winds - Measured historic windspeeds from the Wynyard (located approximately 70km away from the Yellow Quill Band Hall) and Wynyard AUT weather stations show a historic trend of slightly decreasing windspeeds. Since windspeeds have reduced slightly in recent decades, it is assumed there will be no change or a slight decrease in windspeeds as the Yellow Quill area continues to experience these climate changes.

It should be noted the projected impacts of climate change with respect to wind patterns are not as well understood as variables such as temperature and precipitation. However, given the warming climate and expectation of increased extreme weather events, strong wind events - which could include straight line winds and down bursts, associated with summer storms, are expected to increase in frequency under future climate.

Tornados - A total of five tornados have occurred historically within a 50km radius of the Yellow Quill Band Hall (Canadian National Tornado Database (1980-2009)). Future projection data for tornados is not available due to their meteorological complexity. However, discussions during Workshops 3 and 4 suggest funnel clouds have been spotted close to the Yellow Quill area, so it was felt the probability of tornadoes in the YQ area will increase in the future.

FN PIEVC Risk Assessment

The FN-IRT risks assessment process is illustrated in the decision tree model below.

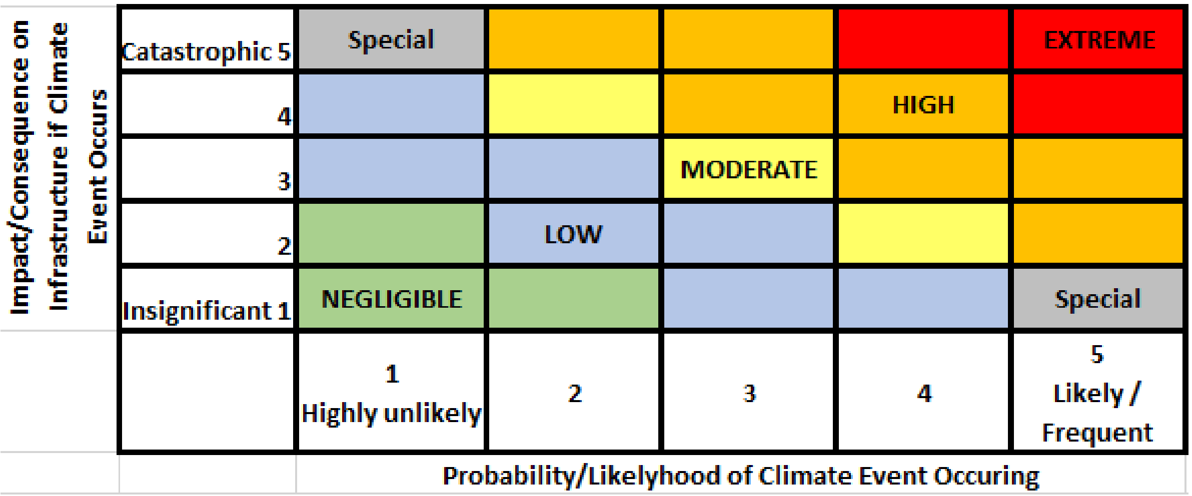


The first step in completing the risk matrix worksheet is to determine if there is an interaction between an infrastructure component and the climate event selected for the analysis. Only those infrastructure assets components that are determined by the Project Team to be exposed or interact with a selected climate event are assessed for risks. If the infrastructure component is determined to interact with the climate event, then the Project Team evaluates the type of performance response (structural, functional, operations) the climate event will have on the component and assigns a severity score (1 to 5) using the Yellow Quill Severity of impacts scale for each type of performance response. Severity scores are assigned for three types of possible infrastructure responses — structural integrity, functional and operations.

Once the severity of the impact of the climate event is determined for each performance response, the risk to the infrastructure component is determined by multiplying the severity score for each performance response by the probability of the climate event occurring.

RISK = SEVERITY OF IMPACT X PROBABILITY OF OCCURRENCE OF CLIMATE EVENT

The probability/likelihood and impact/severity scores are each ranked on a 1 to 5 scale. For the Yellow Quill climate risk assessment, the risk scores or threshold have been further divided and colour coded as shown in the risk matrix below.



Impact/Consequence on Infrastructure if Climate Event Occurs					
Catastrophic 5	Special				EXTREME
4				HIGH	
3			MODERATE		
2		LOW			
Insignificant 1	NEGLIGIBLE				Special
	1 Highly unlikely	2	3	4	5 Likely / Frequent
	Probability/Likelyhood of Climate Event Occuring				

	RISK SCORE	ADAPTATION RESPONSE
Extreme:	≥ 20	Immediate control required
High:	10 - 16	High priority control measures required
Moderate:	8 - 9	Some control measures required to reduce risks to lower levels
Low:	3 - 6	Control likely not required
Negligible:	< 3	Risk events do not require further consideration
Special Case:		Further analysis may be required; monitor
	• P=1 & S=5	Special Case - Very low probability but high Severity
	• P=5 & S=1	Special Case - High probability of occurring but insignificant impact or severity

The moderate to extreme risk scores for the Yellow Quill FN PIEVC risk assessment are summarized in the following table. Key highlights from the risk assessment include the following.

1. There were no extreme risks under current climate and only one extreme risk found under future climate projections, related to functional risk of third-party services (power/hydro). However, if infrastructure is not replaced as the end of the assets service life, the number of extreme risks increases to 7 (700% increase). The increase is associated with the school and health center that both have currently a general condition rating of 6.

2. Tornadoes were found to have a broad impact on all infrastructure studied. While the occurrence of a tornado under current climate was low (probability score of 2), the Project Team felt the occurrence of a tornado under future climate was much higher (probability score of 4). The resulting changes largely explains the 400% increase in moderate risks under future climate considerations.

3. Winds (Gusts over 80 km/h) and winds associated with summer storms (microbursts/straight-line winds) were found to result in moderate structural, functional and operational risks, mostly related to building roof structures and the grounds around buildings.

4. Winds were a significant risk to third party services (power/electrical supply and telecommunications). This substantiates previous known impacts on the community associated with prolonged power outages.

5. Heavy rains (i.e. High intensity/short duration – 25-50mm in two hours) were a high risk under future climate, due to the increased possibility of local flooding. House foundations and cisterns for houses not on municipal services were the primary infrastructure at risk.

Risk Score Counts			Main Climate Events	Principal Infrastructure/Components Affected
Score	**Current Climate Count**	**Future (2050s) Climate**		
EXTREME	**0**	1	• High Winds-Gusts > 80 km/h	• Third Party Services (Electrical Power/Hydro supply) – Functional risks to service delivery
HIGH	**26**	**166**	• Winter Storm – Heavy snow combined with high winds; possible wind chill	• School and Safe House – Structural and operational risk to electrical and HVAC systems; Operational risks to cisterns • Wastewater Treatment – Operational risk to pipes and valves
			• Extreme Cold – Temp <-30C	• School – Functional risk to HVAC system • Booster Station - Risks to pipes and valves
			• High Winds-Gusts > 80 km/h (Includes straight line winds from summer storms)	• School - Operation/Functional risks to roof and grounds • Health Centre/Headstart/Firehall - Operation/Functional risks to roof • Water treatment Plant/Well House – Structural /Operational risk to communication/SCADA • Roads- -Operational/functional risks to lighting • Third Party Services (Electrical Power/Hydro & Communications)) – Structural/functional/operational risks to service delivery
			• Tornado	• Risks ONLY associated with future climate (higher probability) • Structural/operational/functional risks to all community buildings (school, Safe House, Headstart, Health Centre, Firehall), Water and Wastewater Buildings (WTP/Booster Station, garage, shop) and Housing • Third Party Services (Electrical Power/Hydro & Communications)) – Structural/functional/operational risks to service delivery • Roads – Structural risk to lighting
			Heavy Rain – 25-50mm in 1 hour (summer storms)	• Housing – Structural risks to foundations; structural and functional risks to cisterns (serviced housing).
MODERATE	**139**	**40**	See Current and Future Risk Matrices in Appendix E	See Current and Future Risk Matrices in Appendix E

Climate Risk Adaptation Measures

Climate change and the associated climate risks are being realized as a significant tangible threat to First Nation community infrastructure. Community infrastructure that is kept in a state of good repair through proper operations and maintenance practices, will often be able to withstand additional loading associated with most current climate events. However, the increasing frequency and intensity of future climate events will require communities to take actions to create more resilient infrastructure and develop adaptation strategies to reduce climate related risks to their infrastructure now and into the future.

Climate mitigation measures are actions taken to reduce and curb greenhouse gas (GHG) emissions, which are the single most important cause of climate change. Mitigation measures like reducing green GHG need to be addressed on a global scale to have any hope of reversing the current trend in global warming. On the other hand, climate adaptation acknowledges that even if GHG emissions were to be substantially reduced or stopped today, the current atmospheric concentration of carbon dioxide and other greenhouse gases would remain well above normal levels for years and potentially decades to come. Mitigation therefore looks at addressing the causes of climate change, while adaptation is about building resilience in community infrastructure by reducing the vulnerability and addressing the impacts of climate change on community infrastructure.

Workshop 1, 2 and 3 of the Yellow Quill First Nation PIEVC climate risk assessment, examined selected community infrastructure and determined the risk scores for infrastructure components for both current and future climate scenarios. During Workshop 4, the Project Team and community members developed adaptation and resiliency strategies to mitigate the highest risk to community infrastructure from current and future climate. The results of the workshop adaptation and resilience discussions are shown in the table below.

The climate adaptation and resilience strategies developed during the Yellow Quill FN-IRT climate risks assessment are a first step towards reducing climate-related risks to Yellow Quill infrastructure. With present building codes lacking design criteria to address future climate impacts, it is not possible to construct infrastructure to be fully resilient to climate change. However, communities like Yellow Quill can narrow the gap between the current resilience capacity of their infrastructure, and the resilience capacity needed to prepare for future climate change impacts by implementing adaptation measures that reduce exposure and vulnerability to climate events, creating more climate resilient communities.

CLIMATE EVENT	INFRASTRUCTURE AND RISK ADAPTATION MEASURES
Extreme Cold **(Temperature <-30C)**	**HVAC Systems** (Community buildings/residential housing) • Perform regular O&M to maintain HVAC system in optimal operation condition • Have emergency back-up power system for critical community infrastructure • Install back-up heating system (wood stoves/fireplaces) in homes • Develop an emergency response plan (ERP) – include a community communications plan in the ERP so everyone is aware of what to do in case of an emergency. • Focus on taking care of elders/others in the community that may need assistance during extreme cold events. • Develop a community warming center – publish location and times on multiple medias (radio/Facebook/television). Include in emergency response plan. **W/WW Piping** (Booster Station-Pipes & Valves) • Exercise valves frequently – develop regular maintenance plan. • Drain water truck fill piping. • Set up truck fill piping to be self draining.
Winter Storms (Heavy Snow/High Winds/freezing rain)	**Roads and Drainage** • Equip trucks with snowplows to assist with snow removal. • Keep emergency routes open – build into emergency response plan. **W/WW Systems** (pipes/valves/hydrants) • Mark hydrants and valve for easy location during heavy snow and drifting. • Exercise valves frequently – develop regular maintenance plan. • For new pipe installations, ensure pipes are below maximum frost level in ground. Install insulating material above pipes as additional protect for freezing.
Heat Wave (Temperature > 30C during Day and >18C Overnight)	**HVAC Systems** • Perform regular O&M to maintain HVAC system in optimal operation condition to provide cooling during periods of high demand. • Develop a community cooling center – publish location and times on multiple medias (radio/Facebook/television). Include in emergency response plan. • Equip new houses/buildings with air conditioning and HRV (Heat Recovery Ventilation) systems. • Install air conditioning in homes for Elders who currently don't have AC. **Buildings - Grounds** • Plant shade trees around houses and buildings to provide a natural barrier to solar heating.
Tornado	**Community Buildings/W/WW Systems/Housing** • Develop an emergency response plan (ERP) – include a community communications plan in the ERP so everyone is aware of what to do in case of an emergency. • Educate the community (classrooms/information sessions) about how to remain safe during a tornado/severe climate event. Discuss risks of flying debris and how to mitigate those risks. • Develop a Tornado/Severe Weather Alert Warning System for the community (i.e. tornado/sever weather siren). • Consider having an emergency satellite communications system if cellular system damaged/unavailable. • Have a community Safe House/location where community members can assemble during severe climate events like tornadoes. • Plan Ahead – have sufficient spare parts for critical assets. Combine with consistent O & M.

	Adaptation/Resiliency Strategies (Construction/Design) • Insure newly constructed buildings include climate risks in the design • Install hurricane clips of roof rafters. • Install metal roofs rather than asphalt shingles. • Develop an O&M program to check connections of metal roof panels.
High Winds **(Gusts>80km/h)** **Summer Storms** **Microburst/straight line winds**	**Community Buildings/W/WW Systems/Housing** • *Risks and associated adaptation measures similar to those outlined for tornadoes (See above).*
Summer Storms **Heavy Precipitation (25-50mm rain in 2 hours)/Atmospheric Discharge (Lightning Strikes)**	**Localized Flooding – Houses and Community Buildings/ Roads and Drainage** • Landscape around buildings to divert surface water away from foundation walls and prevent ponding that could cause infiltration into buildings. • Properly maintain culverts/ditches to allow water to flow freely to reduce risks of local flooding. • New construction – Consider alternative house designs that eliminate or minimize living space below grade, to mitigate the effects of basement flooding and associated long-term mold issues. • Install water proofing materials on the exterior of foundation walls, to improve resistance to seepage during flooding events. • Educate home owners on how to reduce the risks of flooding in their homes. • Plan future housing and community building developments on land not susceptible to flooding (i.e. using information from current U of S watershed planning study). **Un-serviced Housing – Cisterns** • When installing cisterns, add flexible rubber gaskets between well sections to avoid infiltration of ground/surface waters. • Provide waterproof gasket for fill lid on top of cistern to prevent contamination of water. • Expand community water system to include houses currently on trucked water/cisterns. • Install Point of Entry water treatment systems (Portable Reverse Osmosis/Ultraviolet (UV) Disinfections Systems) water disinfection systems to reduce risks of water contamination to home owners on cisterns.

LIST OF ABBREVIATIONS

ACRS	Asset Condition Reporting System
CAIS	Condition Asset Inventory System
CRA	Climate Risk Assessment
COO	Chiefs of Ontario
FN-IRT	First Nations - Infrastructure Resiliency Toolkit
HVAC	Heating, ventilation and air conditioning
ICMS	Integrated Capital Management System
INAC	Indigenous and Northern Affairs Canada
IPCC	Intergovernmental Panel on Climate Change
ISC	Indigenous Services Canada
O&M	Operations and Maintenance
OCCIAR	Ontario Centre for Climate Impacts and Adaptation Resources
OFNTSC	Ontario First Nations Technical Services Corporation
PIEVC	Public Infrastructure Engineering Vulnerability Committee
SCADA	Supervisory Control and Data Acquisition
WTP	Water Treatment Plant (potable water)
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

Severe weather and climate uncertainty represent risks to public safety in Canada and around the world, as well as to the safety of engineered systems and the services they provide. In this context, an increasing number of public agencies and organizations that provide public services address climate change adaptation as part of their primary mandate—protecting the public interest, which includes life, health, property, economic interests, and the environment.

The impacts of severe weather add to the existing stresses on infrastructure and the services it provides. In addition to factors that reduce the capacity and performance of these assets (e.g. age, increased demand, material weathering, design and construction inadequacies, lack of maintenance, or extension of service life beyond design), the increased intensity of weather events can produce an incremental load that could cause asset failure.

Infrastructure vulnerability and risk assessments are the foundations to ensure climate change is considered in engineering design, operations and maintenance of public infrastructure, buildings, and facilities. Early identification of the services and related assets that are highly vulnerable to climate change impacts is important to allow time to plan and implement cost-effective solutions to adapt to these new weather risks.

This report presents the results of the Climate Risk Assessment (CRA) conducted by Stantec Consulting Ltd. (“Stantec”) for Yellow Quill First Nation using the First Nations Infrastructure Resiliency Toolkit (FN-IRT), a methodology adapted from Engineers Canada’s Public Infrastructure Engineering Vulnerability Committee (PIEVC) Engineering Protocol [https://pievc.ca/protocol].

1.1 COMMUNITY DESCRIPTION

Yellow Quill is a Saulteaux First Nation located approximately 300kms east of Saskatoon and 12kms east of Rose Valley, Saskatchewan. Yellow Quill First Nation is a signatory of Treaty No. 4, which was signed by Chief Yellow-Quill on August 24, 1876.

Yellow Quill First Nation have approximately 3,086 registered band members. Approximately 920 reside on the Yellow Quill reserve with the remaining membership living in the cities of Regina and Saskatoon and other urban centres outside Saskatchewan (Source: http://fnp-ppn.aadnc-aandc.gc.ca/FNP/Main/Search/FNRegPopulation.aspx?BAND_NUMBER=376&lang=eng).

The land base of Yellow Quill is composed primarily of four Reserves:

- The main reserve is approximately 14,477 acres and is the site for the community of Yellow Quill, Saskatchewan;
- 160 acres are associated with Yellow Quill Indian Reserve 90-8;
- 480 acres are associated with Yellow Quill Indian Reserve 90-18; and
- 92 acres are associated with Treaty Four Reserve Grounds (Indian Reserve 77), which is shared with 32 other First Nations.

As of March 2011, over 16,000 acres of Treaty Land Entitlement (TLE) lands were converted to reserve status by Canada. The remaining equity acres available for Yellow Quill First Nation to purchase and convert to reserve status are an additional 100,000 acres as per the TLE Framework Agreement. (Source: Yellow Quill First Nation Website, https://yqfn.ca/yellow-quill-first-nation/community-profile/)

Figure 1: Satellite view of Yellow Quill Community and surrounding area

(Source: https://earth.google.com/web/@52.30434905,-103.62314792,549.95234002a,1316.74380246d,35y)

The weather in the region is characterized as having warm summers and cold winters. Summer temperatures range from 10 - 35 degrees Celsius. Winter temperatures can range from -10 to -40 degrees Celsius. Frigid Arctic winds from the north can produce more drastic temperatures due to the wind chill factor.

1.2 SCOPE OF THE STUDY

The objectives of the study are to:

- Identify Yellow Quill infrastructure vulnerabilities to current and future severe weather events associated with the impacts of climate change. Yellow Quill infrastructure considered in the study is discussed further in Section 1.6.
- Establish a climate risk profile for the identified infrastructure.
- Provide adaption strategies and recommendations for mitigating risks with the highest consequences and impacts to the community's infrastructure assets.

1.3 PROJECT TIMELINE

The project was completed under an accelerated project schedule as shown in Table 1.

Table 1: Project Timeline

Phase	Completion Date
Project Kick-off meeting	August 2, 2019
Workshop 1: Project Definition (online)	August 13, 2019

Phase	Completion Date
Workshop 2: Data Collection (current climate, infrastructure to assess) (online)	August 14, 2019
Workshop 3: Complete the FN-IRT risk assessment (on site)	August 20, 2019
Workshop 4: Prepare community adaption and resiliency recommendations to address highest risks (on site)	August 22, 2019
FN-IRT Climate Risk Assessment Final Report	November 29, 2019

1.4 PROJECT TEAM

The Project Team included key staff from Yellow Quill First Nation, OFNTSC, the University of Saskatchewan, supported by subject matter experts from Stantec Consulting Ltd. The members of the Project Team are listed in Table 2. The project team was further supported community members that attended Workshops 3 and 4 which were hosted in the Yellow Quill community hall.

Table 2: Project Team

<table>
<tr><th colspan="2">Project Team</th></tr>
<tr><td>Yellow Quill First Nation
• Myron Neapetung, Councillor
• Community members attending workshops

University of Saskatchewan
• Dr. Lori Bradford, Assistant Professor
• Lalita Bharadwaj, Associate Professor</td><td>Ontario First Nations Technical Services Corporation (OFNTSC)
• Elmer Lickers, Senior O&M Advisor

Subject Matter Experts Support Team
• Guy Félio, Senior Advisor (Stantec)
• Wayne Penno, Senior Engineer (Stantec)
• Riley Morris, Climate Specialist (Stantec)</td></tr>
</table>

2.0 PROJECT DEFINITION

This first step of the Climate Risks Assessment (CRA) using the FN IRT involves setting the general boundary conditions for the project. The CRA project team identifies the infrastructure to be assessed and its key attributes, such as location, condition, known concerns, etc. The team identifies the overall climatic elements that affect the infrastructure and past weather events that have caused disruptions or failures to the service(s) provided by the asset(s).

Due to a compressed project schedule, Workshops 1 and 2 were completed online through a WebEx session, facilitated with the assistance of the University of Saskatchewan.

Workshop 1, presented on August 13, 2019, introduced the First Nations Infrastructure Resiliency Toolkit (FN-IRT) and the vulnerability assessment process, and provided a summary of the objectives of the project. Outcomes of Workshop 1 included the following. A copy of Workshop 1 presentation is included in Appendix A for reference.

- Established a list of Yellow Quill infrastructure to be assessed, and any Infrastructure performance concerns related to current climate.
- Created a list of past climate events that may have impacted the Yellow Quill infrastructure.
- Introduced concept of Climate Severity Scale and relationship to the FN-IRT Risk Matrix.

The Project Team decided to assess the climate (current and future) risks for a variety of Yellow Quill infrastructure assets. The infrastructure was divided into four main areas. Details of the infrastructure assets to be assessed is found in Section 1.6.

- Community Buildings – School, Safe House, Fire Hall, Health Centre, Headstart building
- Water and Wastewater Treatment Systems – WTP building/booster station, pump house, waste treatment system
- Housing – Houses on community services, houses/farms not on community services
- Drainage – Culverts and ditches

Workshop 2 was held on Wednesday August 14, 2019 and started with a review of the outcomes from Workshop 1. The remainder of the workshop focused on the risk assessment process using the FN-IRT, including a more detailed discussion on past climate events and impacts on Yellow Quill community and infrastructure. Outcomes from the workshop included the following (a copy of Workshop 2 presentation is included in Appendix B for reference).

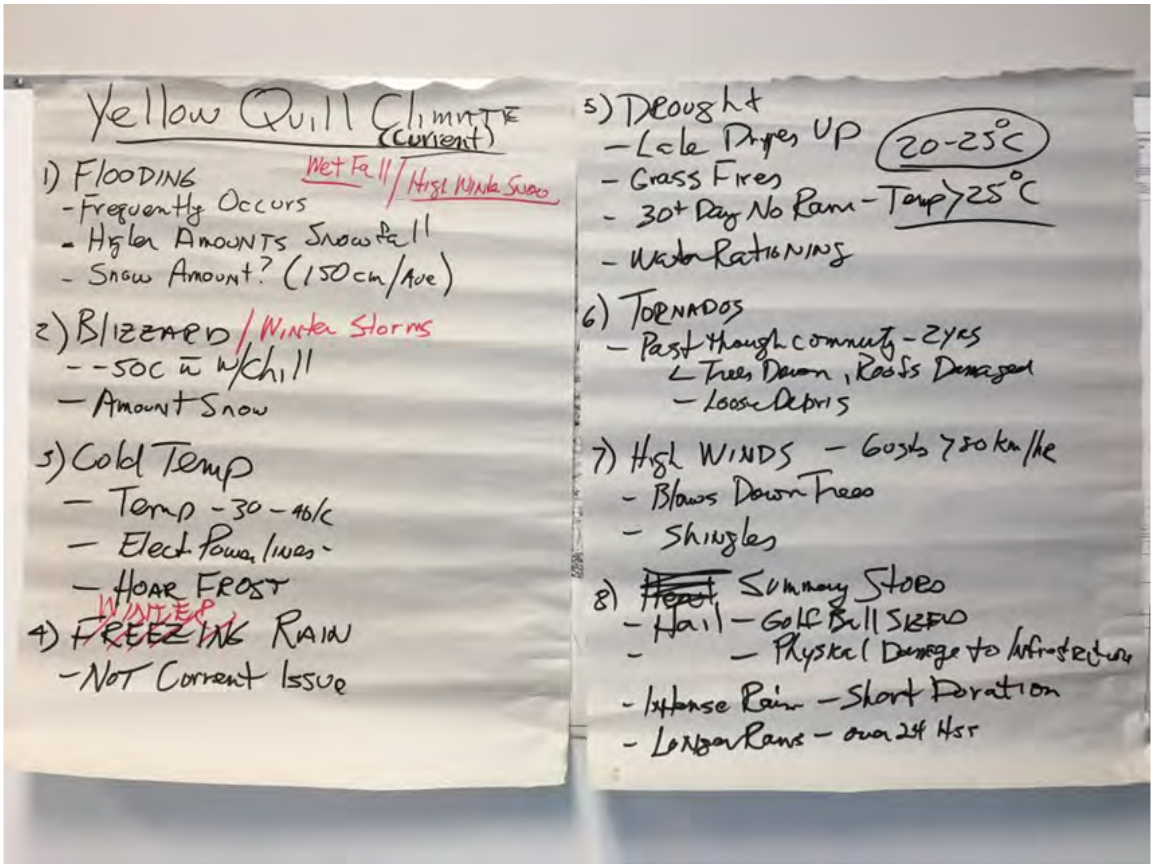
- Completion and review of the Yellow Quill severity of impacts scale.
- Review and agreement of proposed probability scale for climate events.
- Review/selection of climate data (past climate events and impacts on infrastructure) and introduction to climate thresholds.
- Introduction of infrastructure performance considerations (structural, operational, functional) as they relate to the impacts of current and future climate event.
- Introduction of the FN-IRT climate vulnerability assessment process and the Risk Matrix worksheet.

2.1 CLIMATE RELATED CONCERNS

The first part of Workshop 3 (presented on site) focused on the reviewing current meteorological/climate events that may have impacted or affecting Yellow Quill FN infrastructure. More specifically, a list of any climate events that have in the past or are currently causing infrastructure and operations disruptions and failures was created. This also included defining the threshold or intensity level of the event that would possibly cause damage or service disruptions should a component of the infrastructure be adversely affected by the event. A copy of Workshop 3 presentation is included in Appendix C for reference.

The climate events selected for the Yellow Quill community infrastructure Climate Resilience Assessment (CRA) are listed below and shown in Figure 2.

- Extreme Cold Temperatures (>-30° C) – Yellow Quill often experiences periods of cold temperatures during the winter months, where temperatures often are below -30ºC for several days and sometimes weeks at a time.
- Heat Waves – Defined as periods of three of more consecutive days when the daytime high is >30° C and the overnight temperature remains >18° C.
- Winter Storms – Yellow Quill area often experiences winter storms that bring high winds, snow, reduced visibility, Snow drifts often result in reduced mobility for travel.
- Tornados – Yellow Quill has not had a tornado directly impact the community, though community members report seeing funnel clouds and tornadoes in the area. However, given the potential for sever damage, tornadoes were included due the possible severe to catastrophic impact on the community's infrastructure.
- Summer Storms – Summer storms were divided into three types of climate events with potential impacts to the community's infrastructure.
  - High Wind Events (straight line winds/microbursts) associated with strong summer storms.
  - Short Duration Intense Rainfall – Defined as 25-50mm of rain in a 1-hour period.
  - Golf-ball sized hail
- Flooding - Yellow Quill continues to be exposed to flooding risks during the spring melt. Rapid snow melts sometimes accompanied by spring rains when the ground remains frozen increase the risks of floods.



Yellow Quill Climate (Current)

1) FLOODING Wet Fall / High Winds Snow
- Frequently Occurs
- Higher AMOUNTS Snowfall
- Snow Amount? (150cm/Ave)

2) Blizzard / Winter Storms
- -50C c̄ w/Chill
- Amount Snow

3) Cold Temp
- Temp -30 - 40/c
- Elect Power lines
- HOAR FROST

4) ~~FREEZING~~ WINTER RAIN
- NOT Current Issue

5) Drought
- Lake Dries UP (20-25°C)
- Grass Fires
- 30+ Day No Rain - Temp > 25°C
- Water Rationing

6) TORNADOS
- Past though community - 2 yrs
  - Trees Down, Roofs Damaged
  - Loose Debris

7) High WINDS - Gusts > 80 km/hr
- Blows Down Trees
- Shingles

8) ~~Heat~~ Summer Storms
- Hail - Golf Ball Sized
- - Physical Damage to Infrastructure
- Intense Rain - Short Duration
- Longer Rains - over 24 Hrs

Figure 2: Yellow Quill - Current Climate Events (Source: CRA Workshop 3)

2.2 INFRASTRUCTURE TO BE CONSIDERED

During Workshop 1, the Project Team listed the following infrastructure to be assessed for climate risks. The condition of the assets was determined by using the condition assessments in the community's latest ACRS reports[1] and modified as required with input from project team and community members attending Workshops 3 and 4.

1. Community Buildings
   a. School (Nawigizigweyas Education Centre)
   b. Safe House
   c. Health centre
   d. HeadStart building.
   e. Fire Hall
2. Water and Wastewater Treatment systems
   a. Water treatment plant
   b. Raw water intake building
   c. Booster station
   d. Sewage pump station
   e. Lagoons.
3. Housing
   a. Residential housing subdivision
   b. Residences on cisterns
   c. Farms
4. Drainage
   a. Culverts

2.3 TIME HORIZON FOR THE STUDY

The time horizons selected for the study were as follows.

1. Current conditions (1950-2019) - used to establish baseline risks.
2. 2050s (2041-2070[2]) for future climate conditions.

Many of the Yellow Quill infrastructure assets were constructed in the 1990's and early 2000's. Given the current state of their infrastructure, a number of the Yellow Quill assets will be in an advanced stage of their service life and quite possibly exceeded their designed service life under the future climate time horizon selected for this assessment. It is important to continue to monitor the condition of all community assets to assess their vulnerability to climate events, since the risks of failure increase as the condition of the asset worsens with time and insufficient investments in Operations and Maintenance.

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[1] ACRS Reports:
Buildings, Water, Sewer and Fire Protection; Bullée Consulting Ltd., 2017
Roads, Associated Engineering, 2016

[2] Climate is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of meteorological variables such as temperature, precipitation and wind over a period of time, typically 30 years. (Source: World Meteorological Organization). The "2050s" projected climate is therefore the projected average over the 30-year period from 2035 to 2065.

3.0 DATA COLLECTION

3.1 INVENTORY OF INFRASTRUCTURE COMPONENTS

Yellow Quill infrastructure assets were divided into four areas for assessment. Most of the community assets were visually inspected during an automobile tour of the community. With exception of the band hall, no interior inspection of the assets was completed. Additional information on the community assets is primarily based on the Yellow Quill ACRS reports provided to Stantec for reference. The locations of the community's assets being assessed are show in Figures 3 and 4.

3.1.1 Community Buildings

NAWIGIZIGWEYAS EDUCATION CENTRE

The Nawigizigweyas Education Centre (Photo source: Stantec) is a single-story 3,450 m^2 cinder block building on a concrete slab/block foundation with a metal roof and a stone/stucco exterior. The school was constructed in 1999. It has a general condition rating of 6 (fair) and an estimated remaining life of 25 years (Source: 2017 ACRS Report).

The building houses 16 classrooms, a gymnasium, a library, and an industrial arts room. Interior finishing's include vinyl sheet tile flooring, and painted drywall ceiling and walls. The building is equipped with safety equipment such as smoke detectors, fire alarms, sprinkler system, fire extinguishers, emergency exit signs, emergency lighting, security cameras, door panic hardware, and handicap access. The building HVAC system includes two natural gas-powered boilers, a humidifier, and a hot water heater.

The grounds around the school include a fenced play area equipped with outdoor equipment. There are two baseball diamonds behind the school, but they are overgrown and do not appear to be in use. Water is supplied from the community water treatment system. The building is connected to the community wastewater system.

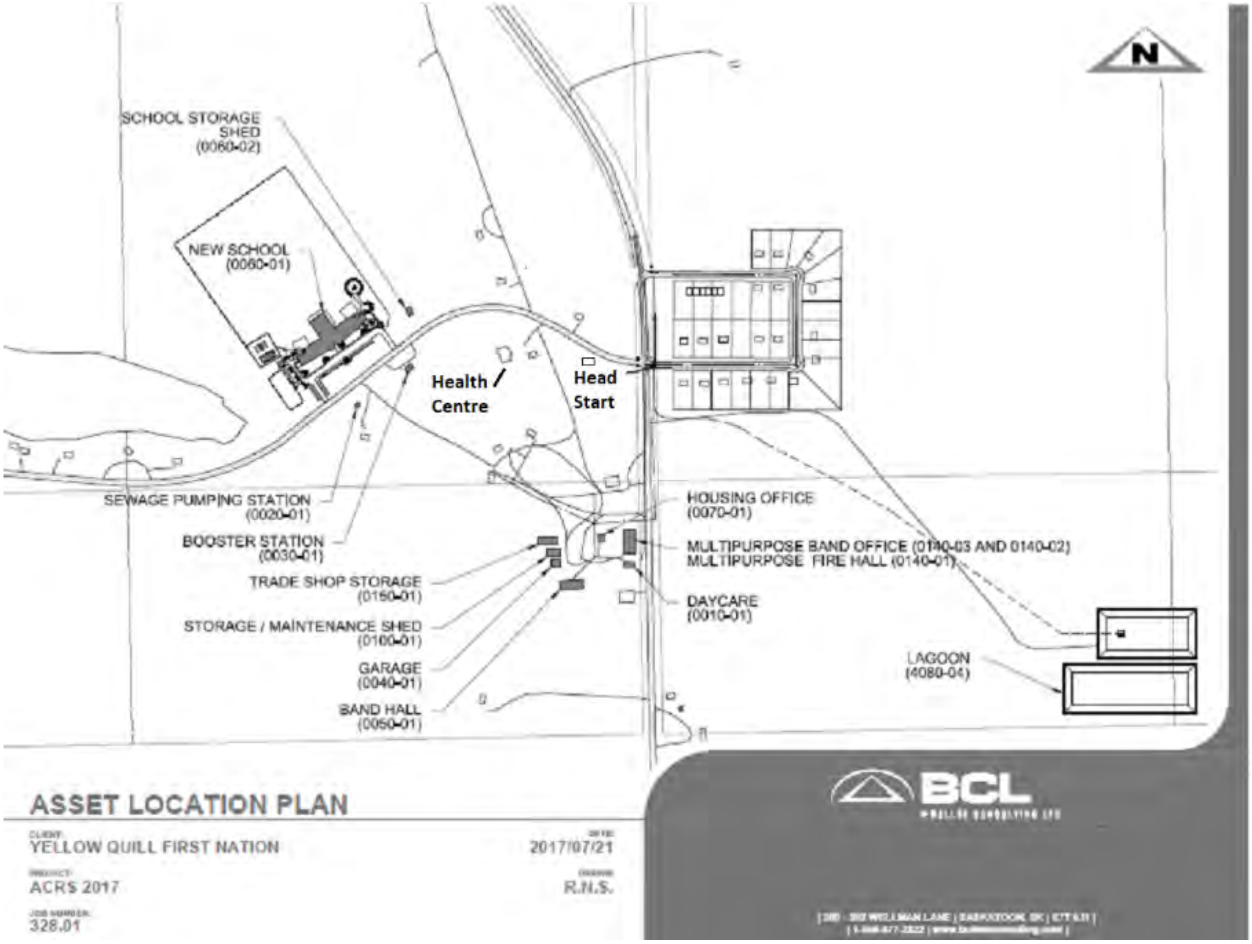


Figure 3: Yellow Quill First Nation – Community Asset Location Plan (Source: Yellow Quill First Nation, Asset Condition Reporting System (ACRS Report), Buildings, Water, Sewer and Fire Protection Bullée Consulting Ltd., 2017)

HEALTH CENTRE

The Health Centre is located approximately 220 metres east of the Nawigizigweyas Education Centre. The building is a single-storey timber framed structure on a concrete basement foundation with prefinished metal roofing and stucco exterior. The building has prefinished metal soffits, fascia and eaves troughs. There is a metal communication tower located on the north side of the building. The health has a general condition rating of 6 (fair) and an estimated remaining life of 25 years (Source: 2017 ACRS Report).

The grounds around the are comprised of grassed area at the sides and rear of the building. A large gravel parking lot is situated in front of the building (Photos source: Stantec).

HEADSTART BUILDING

The Headstart building (Photo source: Stantec) is located east of the Health Center. The building is a single storey a timber frame structure with wooden siding and asphalt shingled roof. The large playground at the rear is fenced and encloses several pieces of playground equipment.

The Headstart building is newly constructed and is not found in the Yellow Quill 2017 ACRS report. Its general condition rating is assumed to be 10 (new).

FIRE HALL

The multipurpose fire hall (Photo source: 2017 ACRS Report) is located in the core area of the community. The building is currently used for storage as the fire truck is now out of service. The building is a timber framed structure with asphalt shingles and hard board exterior. The building also has prefinished metal soffits, fascia and eaves troughs. Lighting for the facility is provided by fluorescent light fixtures. The building is insulated and is equipped with a natural gas unit heater (Source: 2017 ACRS Report).

3.1.2 Water and Wastewater Treatment Systems

3.1.2.1 Water Treatment System Components

The water treatment system is comprised of a water treatment plant, booster station, well pump house, evaporation pond and distribution piping. The location of the water infrastructure is shown in Figures 3 and 4.

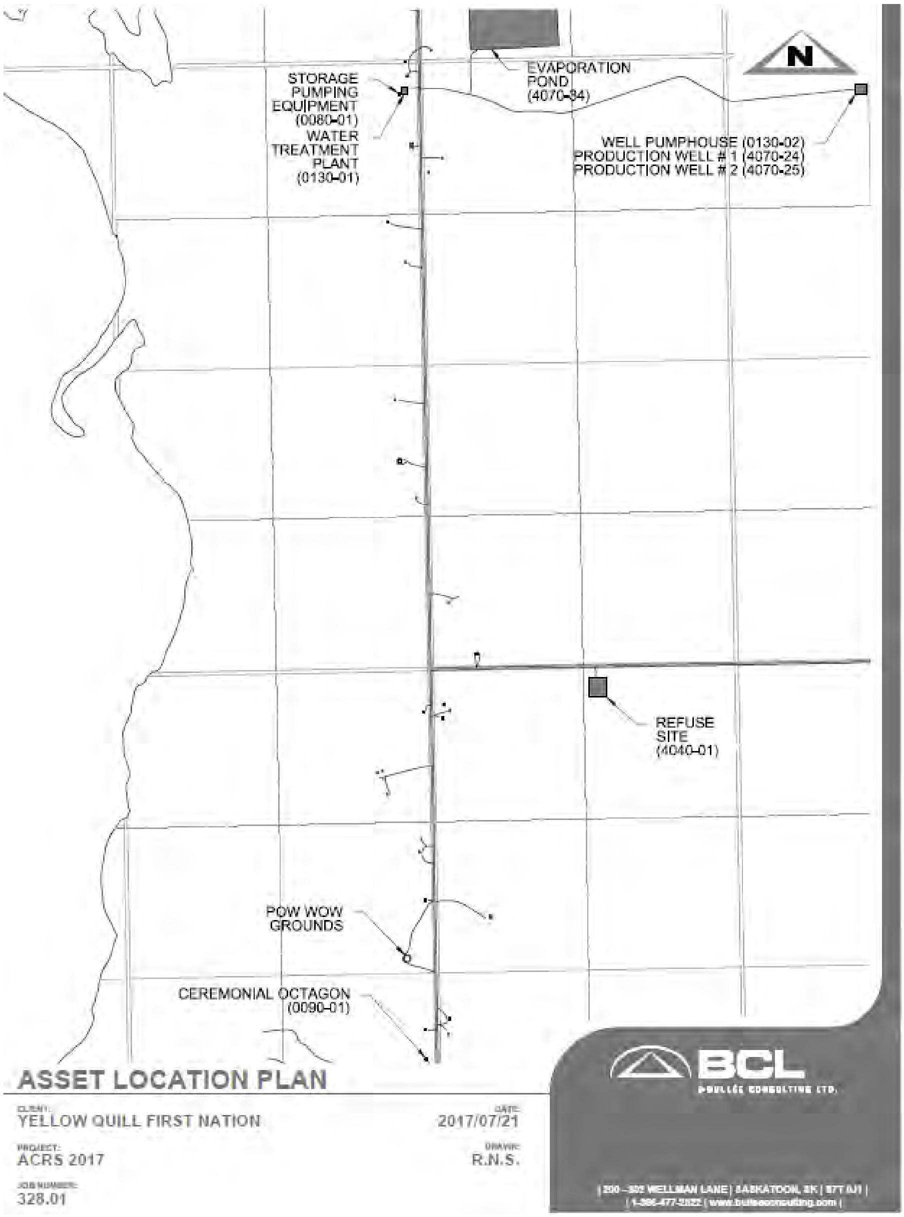


Figure 4: Yellow Quill First Nation – North Section-Community Asset Location Plan (Source: Yellow Quill First Nation, Asset Condition Reporting System (ACRS Report), Buildings, Water, Sewer and Fire Protection Bullee Consulting Ltd., 2017)

WATER TREATMENT PLANT BUILDING

The water treatment plant is located approximately 12.2 km northwest of the core area of the community. The building is a cinderblock structure built upon a concrete reservoir foundation. The building exterior is finished with prefinished metal roofing, soffits, fascia and eaves troughs (Source: 2017 ACRS Report). The SCADA communication equipment is mounted on the metal roof. The building was constructed in 2011, has a general condition rating of 9, and an estimated remaining life of 25 years (Photos source: Stantec).

The building contains the reverse osmosis (RO) treatment equipment, electrical panels and process control, high lift distribution pumps, piping, and valves. The building is equipped with an office, lab facility and washroom. A truck fill station is located on the north side of the building. A backwash/water reject tank and pumping equipment is located in a fenced area on the south side of the plant. Backwash water is pumped from the water treatment plant to the evaporation ponds to allow settling of solids prior to discharge into the local watershed.

WELL PUMP HOUSE

The well pumphouse is located approximately 2.4 km east of the water treatment plant. The building is cinder block on a concrete pad foundation, with a metal roof. SCADA communication equipment is fastened to the metal roof. The building is equipped with a natural gas unit heater and emergency generator. The building was constructed in 2003, has a general condition rating of 8 (good), and an estimated remaining life of 25 years (Source: 2017 ACRS Report).

Raw water is provided from two drilled wells located east of the pump house. The well heads are protected by four concrete bollards installed around each well head. (Photos source: Stantec)

BOOSTER STATION

The booster station is located approximately 11 km south of the water treatment plant, across from the Nawigizigweyas Education Centre. The building is a cinderblock structure on a concrete reservoir foundation with metal roofing, and stone and prefinished metal exterior. The building was constructed in 1999, has a general condition rating of 7 (good), and an estimated remaining life of 30 years (Source: 2017 ACRS Report; Photo: Stantec).

The building houses a concrete reservoir beneath the concrete floor, and a truck fill station on the east side of the building. The building is equipped with safety equipment such as fire extinguishers, emergency lighting, and a natural gas backup generator. The HVAC system consists of a natural gas heater, large ventilation fan and ventilation louvre.

3.1.2.2 Wastewater Treatment System Components

SEWAGE LIFT STATION

Yellow Quill has a single sewage lift station located north of the booster station across from the Nawigizigweyas Education Centre. The building is timber frame construction on a concrete wet well, with metal siding and roof. There is no emergency back-up power generator. The building was constructed in 1999, has a general condition rating of 8 (good), and a remaining life of 25 years (Source: 2017 ACRS Report; Photo: Stantec).

The submersible sewage pumps are located inside the concrete wet well. Access is by two flush mounted steel doors in the floor. The electrical panels, ventilation system, heater and lighting are mounted on the walls inside the building.

LAGOON

The lagoon site is comprised of two rectangular treatment cells constructed in 1993 to service the community core and subdivision. Raw sewage enters the northern 75m x 145m primary cell. A concrete ramp at the end of the access road permits sewage pump trucks to discharge raw sewage into the west side of the cell. Effluent from the primary cell is discharged in the spring and fall into the 70m x 205m secondary (polishing?) cell to the south. The outfall from the secondary cell discharges into a creek that flows into a small lake/swampy area west of the lagoons. The berms around the lagoons were heavily vegetated at the time of the site visit. The lagoon has a general condition rating of 5 (fair) and an estimated remaining life of 5 years (Source: 2017 ACRS Report; Photos: Stantec).

3.1.3 Housing

A new housing subdivision was constructed off the main Yellow Quill Road Northeast of the band hall. The subdivision currently includes 18 single family home and one multiplex building. Houses in the subdivision are serviced by the community water and wastewater systems. There are 123 private water connections and a total of 33 private connections to the gravity waste collection system (Source: 2017 ACRS Report).

The houses not connected to the community water and wastewater system, receive potable water by truck delivery. Water trucks load water from the truck loading stations at the water treatment plant and/or the booster station, and delivery the water to cisterns at the residences. The cisterns are constructed of circular concrete sections buried in the ground with a concrete cap. Water is pumped from the cistern to the residence through buried pipes. Water from the cisterns is used mainly for household activities and is often not used as a drinking water source.

3.1.4 Roads and Drainage

The Yellow Quill road network is shown in Figure 5. All roads are gravel and have a general condition rating between 4 and 8 (ACRS Report - Roads, 2016), with the majority in the 6-8 range or good condition. Culverts were identified as a component of roads to study, given there have been automobile fatalities associated with flooded ditches, which may in part be caused by drainage restrictions in culverts.

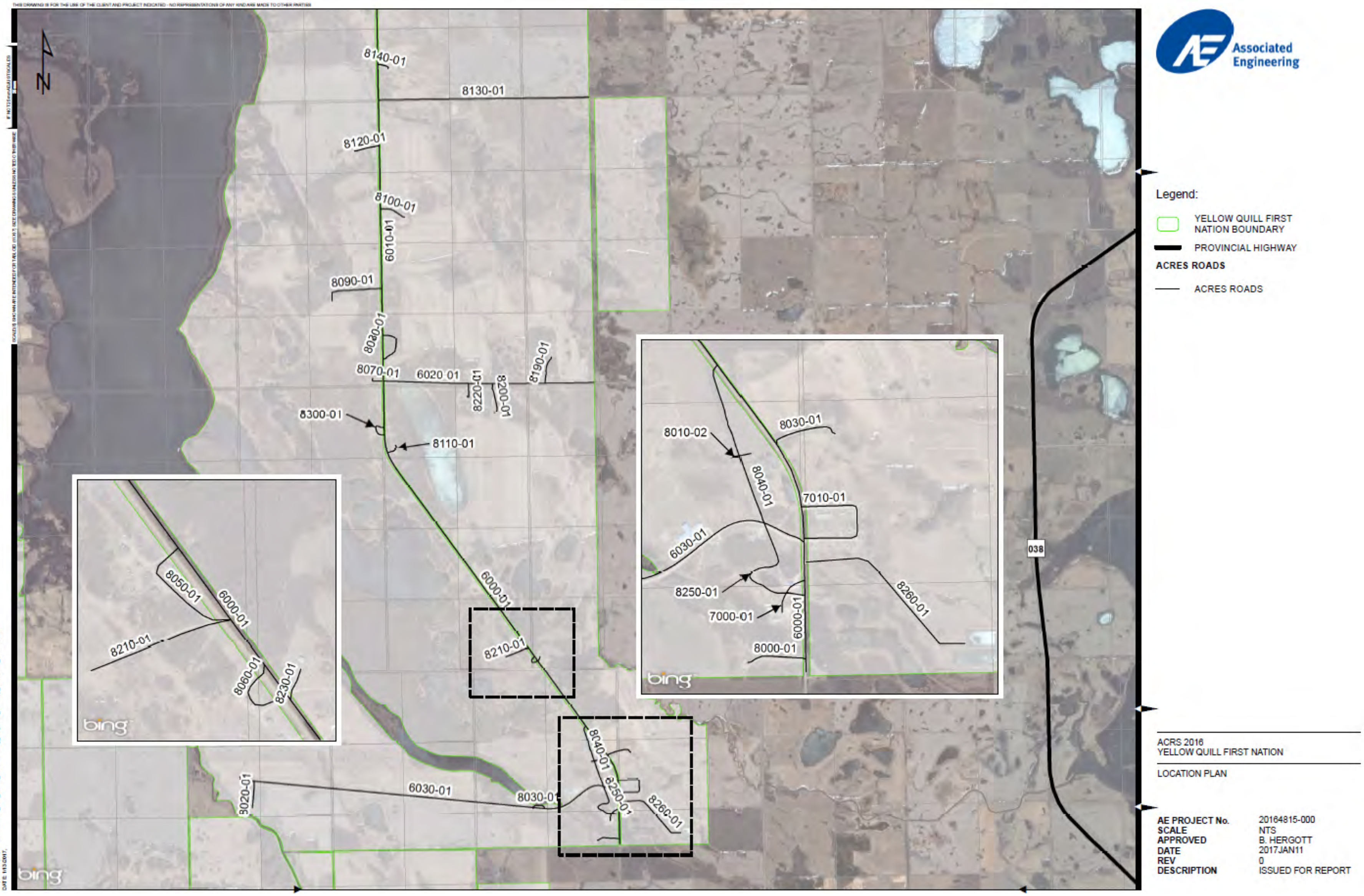


Figure 5: **Yellow Quill First Nation – Roads/Asset Location Plan (Source: Yellow Quill First Nation, Asset Condition Reporting System ACRS Report – ROADS, Associated Engineering, 2016)**

3.2 CONDITION OF INFRASTRUCTURE COMPONENTS

An automobile tour of the Yellow Quill community infrastructure was completed as part of Workshops 3 and 4. No detailed field inspection was completed by the Project Team to assess the condition/performance rating of the assets. The condition ratings referenced in this CRA study are based exclusively on the asset condition and performance information in the 2016 and 2017 ACRS Reports provided by Yellow Quill First Nation.

The Integrated Capital Management System (ICMS) used by Indigenous Serves Canada (ISC) provides an overall condition rating for each infrastructure asset on a scale from 0 to 10. The ACRS reports use the same rating scale when estimating asset condition. The ICMS rating does not provide a description of the condition of the asset performance, deterioration or needs as the asset or its components.

3.2.1 Infrastructure Components – ACRS Summary

A summary of the Yellow Quill infrastructure is provided in the 2017 ACRS report. Information on the condition of the infrastructure considered in this climate risks assessment are provided in Table 4.

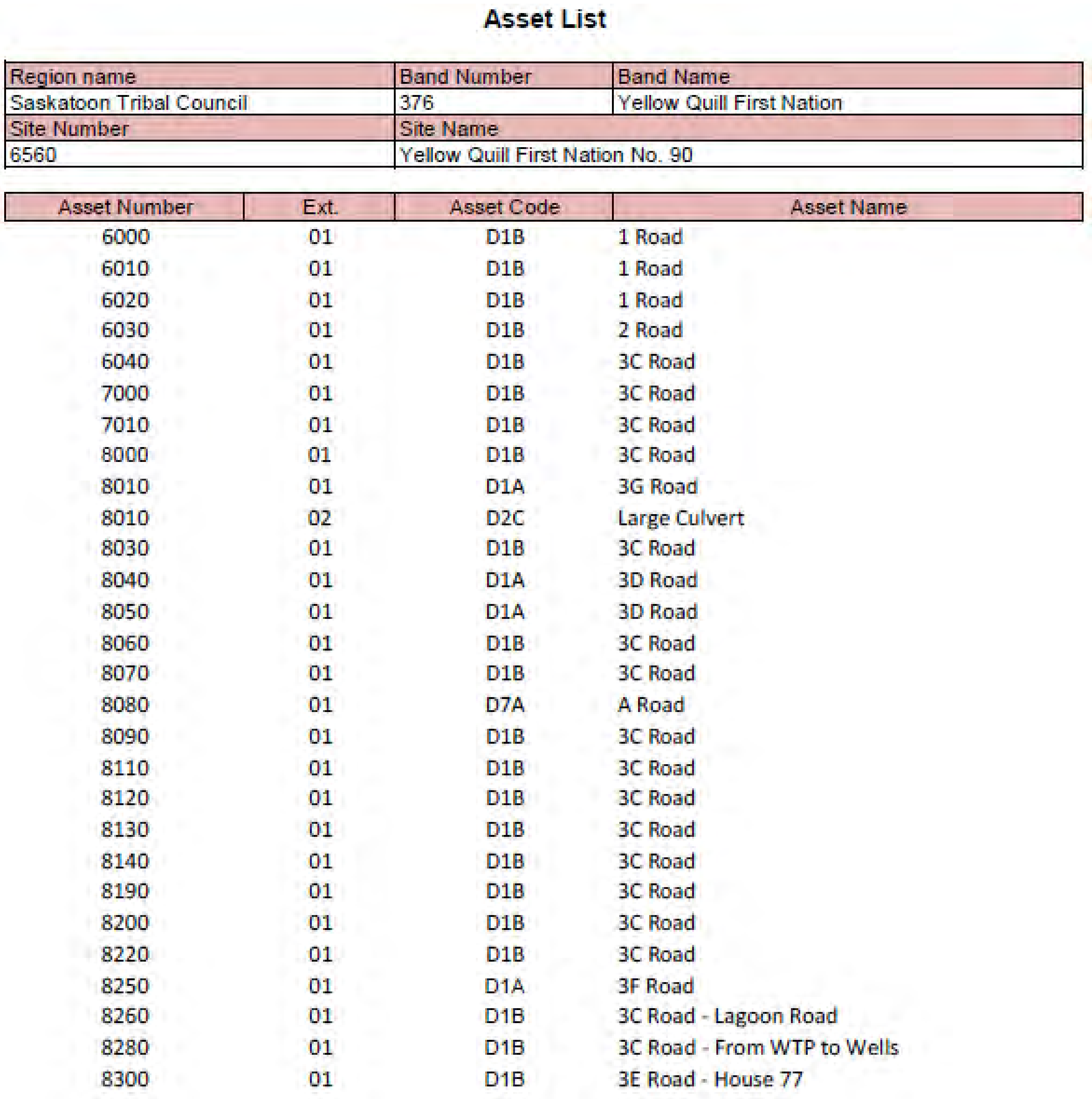
Table 3: ACRS data on Yellow Quill Infrastructure Assets considered in the climate risks assessment

ASSET #	EXT #	ASSET CODE	ASSET NAME/COMPONENTS	YEAR BUILT	CAIS QUANTITY	GENERAL CONDITION RATING	O&M RATING
0000	01	A3C A	HEALTH CENTRE (NEW ASSET)			6	2
0020	01	A5B A	SEWAGE PUMPING STATION	1999	13.00	8	2
0030	01	A5A A	BOOSTER STATION	1999	107.50	7	2
0050	01	A6A A	BAND HALL	1993	503.60	6	2
0060	01	A3A A	NEW SCHOOL	1999	3452.00	6	1
0080	01	A2C A	STORAGE PUMPING EQUIP	2008	56.30	7	2
0130	01	A5A A	WATER TREATMENT PLANT	2011	455.00	9	3
0130	02	A5A A	WELL PUMPHOUSE	2003	18.67	8	3
0140	01	A3H A	MULTIPURPOSE FIREHALL	1989	84.73	5	1
4070	22	B1H C	WATER PUMPING STATION	1999	1.00	8	2
4070	23	B1E B	STORAGE RESERVOIR	1999	1.00	9	2
4070	24	B1F D	PRODUCTION WELL #1	2002	1.00	7	2
4070	25	B1F D	PRODUCTION WELL #2	2011	1.00	9	2
4070	31	B2H C	BACKWASH WATER LIFT STATION	2002	1.00	7	2
4070	33	B1H C	DISTRIBUTION PUMPING	2011	1.00	9	2
4070	35	B1C A	TREATMENT SYSTEM	2011	1.00	9	2
4070	36	B1D C	PRE-TREATMENT SYSTEM	2011	1.00	8	2
4070	37	B1E B	STORAGE RESERVOIR	2011	1.00	8	2
4080	02	B2H C	SEWAGE LIFT STATION	1993	1.00	8	2
4080	04	B2E A	LAGOON	1993	1.00	5	2
			HEADSTART BLDG (NEW?)			10	
			SAFE HOUSE				

Details of the condition of these assets are available in the 2017 ACRS report. In general, assets listed are mostly in Good to Fair condition, some at the lower end of the Fair range, indicating that the assets or some of their critical components are showing signs of deterioration and are performing at a lower level than originally intended. Some components of the asset are likely becoming physically deficient and maintenance costs exceed acceptable standards and norms and are increasing.

A summary of the Yellow Quill Roads and Culverts infrastructure is provided in Table 4. Information on the condition and remaining service life of the Yellow Quill roads and culverts infrastructure can be found in 2016 ACRS Roads Report.

Table 4: ACRS data on Yellow Quill Roads Infrastructure Assets considered in the climate risks assessment



Asset List

Region name	Band Number	Band Name
Saskatoon Tribal Council	376	Yellow Quill First Nation
Site Number	Site Name	
6560	Yellow Quill First Nation No. 90	

Asset Number	Ext.	Asset Code	Asset Name
6000	01	D1B	1 Road
6010	01	D1B	1 Road
6020	01	D1B	1 Road
6030	01	D1B	2 Road
6040	01	D1B	3C Road
7000	01	D1B	3C Road
7010	01	D1B	3C Road
8000	01	D1B	3C Road
8010	01	D1A	3G Road
8010	02	D2C	Large Culvert
8030	01	D1B	3C Road
8040	01	D1A	3D Road
8050	01	D1A	3D Road
8060	01	D1B	3C Road
8070	01	D1B	3C Road
8080	01	D7A	A Road
8090	01	D1B	3C Road
8110	01	D1B	3C Road
8120	01	D1B	3C Road
8130	01	D1B	3C Road
8140	01	D1B	3C Road
8190	01	D1B	3C Road
8200	01	D1B	3C Road
8220	01	D1B	3C Road
8250	01	D1A	3F Road
8260	01	D1B	3C Road - Lagoon Road
8280	01	D1B	3C Road - From WTP to Wells
8300	01	D1B	3E Road - House 77

The Yellow Quill road and culvert assets are mostly in fair to good condition, with a few unused roads at the lower end of the fair range due to lack of maintenance. Most roads have an estimated remaining service life between 10 and 20 years. All roads are gravel. The two large culverts on asset 8010-02 are in good condition (rating 9) with an estimated service life of 20 years.

3.3 CLIMATE CONSIDERATIONS

3.3.1 Climate Profile Study

Due to the lack of available climate data, Stantec was requested to complete a climate profile for the Yellow Quill First Nation lands. Using an area centered on the Yellow Quill Band Hall, seven historical weather monitoring stations were identified that could provide climate data (See Table 5). There are currently no active weather monitoring stations in the study area. The full climate profile report is included in Appendix F for reference.

Table 5: Weather monitoring stations in the vicinity of Yellow Quill site (Source: Environment Canada).

Weather Monitoring Station	Station ID	Distance from approximate Site Location (centered on the YQ Band Hall)	Data Range	Data Availability	
				Temperature	Precipitation
Archerwill	4080200	21 km	1951-1982	6%	96%
Kelvington	4083720	24 km	1953-1967	92%	91%
Mckague	4085050	31 km	1971-2001	13%	67%
McKague 2	4085052	32 km	1985-2015	89%	91%
Paswegin (1)	4015960	35 km	1921-1963	14%	18%
Paswegin (2)	4015960	35 km	1964-2003	99%	99%
CanGrd[3]	-	-	1950-2013	100%	100%

Four of the stations in Table 5 have either inadequate data ranges or poor data availabilities. Two stations and CanGrd (highlighted in yellow) were compared as candidate weather monitoring stations to represent the climate conditions of the Yellow Quill area.

To help determine the best proxy station for the site, Figures 6 and 7 illustrate a comparison of the mean temperature and total annual precipitation accumulation data for each of these stations.

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[3] CanGrd is a gridded network of data produced through data interpolation from nearby weather stations.

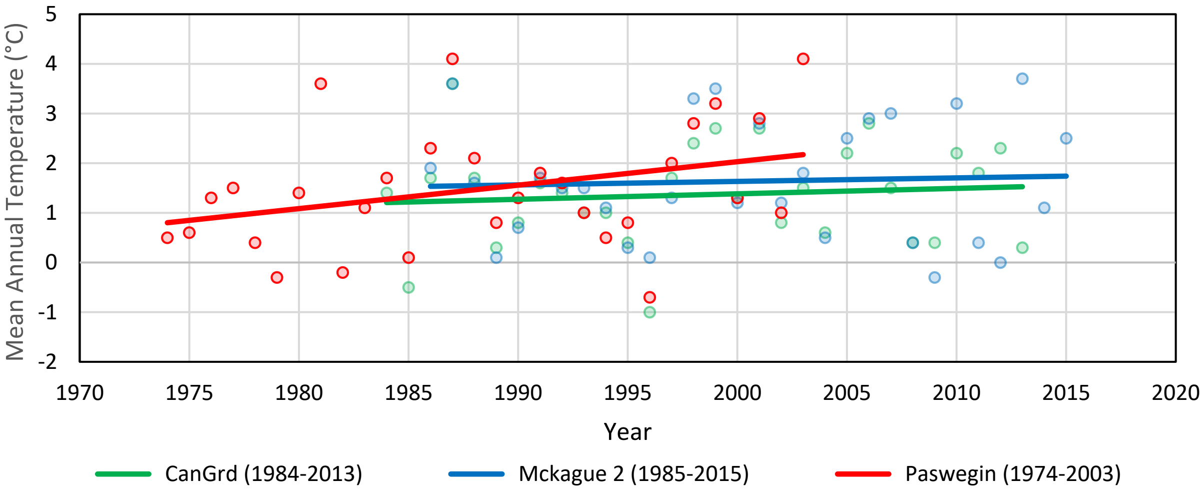

Figure 6: Comparison of historical mean annual temperature trends for the Mckague 2 (ID: 4085052) and Paswegin (ID: 4015960) weather stations and CANGRD data.

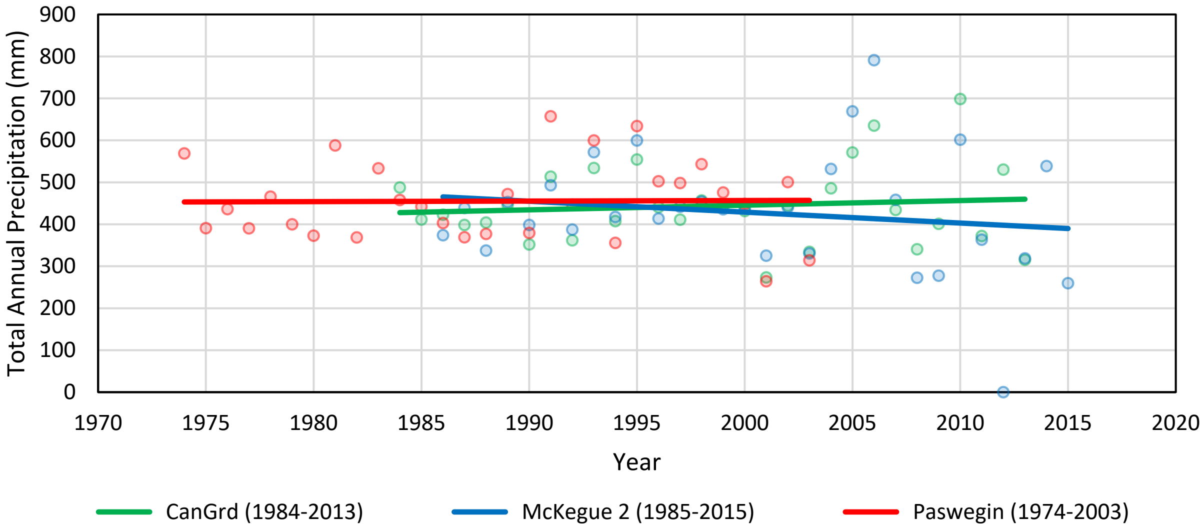

Figure 7: Comparison of historical total annual precipitation trends for the Mckague 2 (ID: 4085052) and Paswegin (ID: 4015960) weather stations and CANGRD data.

The temperature and precipitation plots show the more complete CanGrd data tends to align well with the Mckague 2 weather station. Given the CanGrd data is longer and more complete, and since the Mckaque 2 station is located 32km south of the Yellow Quill First Nation, CanGrd data was selected to represent the climate in the vicinity of the Yellow Quill study area.

Climate events were part of the discussions at each of the four workshops of the project. In Workshop 1 and 2, participants were asked to recall weather events that may have caused damage or disruptions to the Yellow Quill infrastructure. During Workshops 3, the Project Team members reviewed and confirmed the list of suggested weather events and selected the most relevant climate events to use as part of the FN-IRT climate risk assessment.

The climate considerations presented in this report are the result of discussions with Project Team and community members during the project workshops, research into public information and news reports, Risk Science

International's Climate Change Hazards Information Portal (CCHIP), and with reference to the following reports, articles, and tools.

- Intergovernmental Panel on Climate Change (IPCC), 2018: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.
- Bush, E. and Lemmen, D.S., editors (2019): Canada's Changing Climate Report; Government of Canada, Ottawa, ON.
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- Gan, T.Y. 2005. Reducing Vulnerability of Water Resources of Canadian Prairies to Potential Droughts and Possible Climatic Warming. Water Resources Management 14: 111-135.
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3.3.2 Climate Trends and Projections

The main source of current and future projected climate data for the Yellow Quill First Nation climate risk assessment was from Canadian Gridded Temperature and Precipitation Anomalies (CANGRD), which provides a gridded interpolation of historical climate data.

Future climate projections are based on the Intergovernmental Panel on Climate Change

> The IPCC is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.
>
> IPCC assessments provide a scientific basis for governments at all levels to develop climate related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). The assessments are policy-relevant but not policy-prescriptive: they may present projections of future climate change based on different scenarios and the risks that climate change poses and discuss the implications of response options, but they do not tell policymakers what actions to take.

(IPCC) RCP[4] 8.5 scenario, which is considered the global “business as usual” greenhouse gas emissions track (IPCC, 2018). The figures below provide examples of data used for the study. The full climate profile report is provided in Appendix F for reference.

3.3.2.1 Temperature

The Canadian prairies have experienced average annual mean temperature changes of 1.9°C and seasonal mean changes ranging from 1.1°C in the autumn to 3.1°C in the winter between 1948 and 2016 (Bush and Lemmen, 2019). Regional projections under RCP 8.5 anticipate a further increase in annual mean temperature of 2.3°C and 6.5°C from 2031-2050 and 2081-2100 respectively for the Canadian Prairies (Bush and Lemmen, 2019). It is noted that climate changes in the region are expected to be more pronounced during the winter months than through the summer (Bush and Lemmen, 2019). These climate changes are reflected in the projection information presented in the following figures and tables, which are more specific to the Yellow Quill area (Source: Yellow Quill First Nation Climate Profile, Stantec Report, November 12, 2019. See Appendix F).

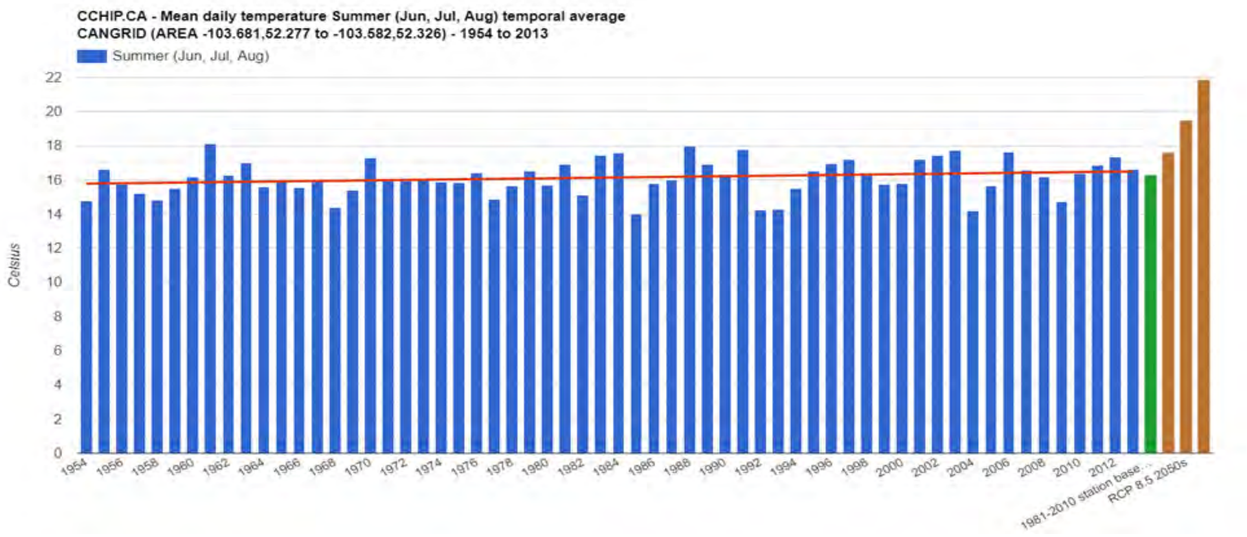

Figure 8: Mean Daily Temperature for Summer - Historical Trend and Future Climate Projection (CanGrd data, RCP 8.5, 60-year period)

Table 6: Occurrence of Maximum Temperatures, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Maximum Temperature Threshold	Annual Occurrence of Days above Max. Temp (Days/year)			
	Historical 1981-2010	RCP 8.5		
		2020s	2050s	2080s
25°C	34.59	49.1	68.7	95.2
30°C	5.41	10.1	20.8	43.1
35°C	0.19	0.7	2.4	8.5

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[4] RCP: Representative Concentration Pathways – a greenhouse gas concentration (not emissions) trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5) in 2014.

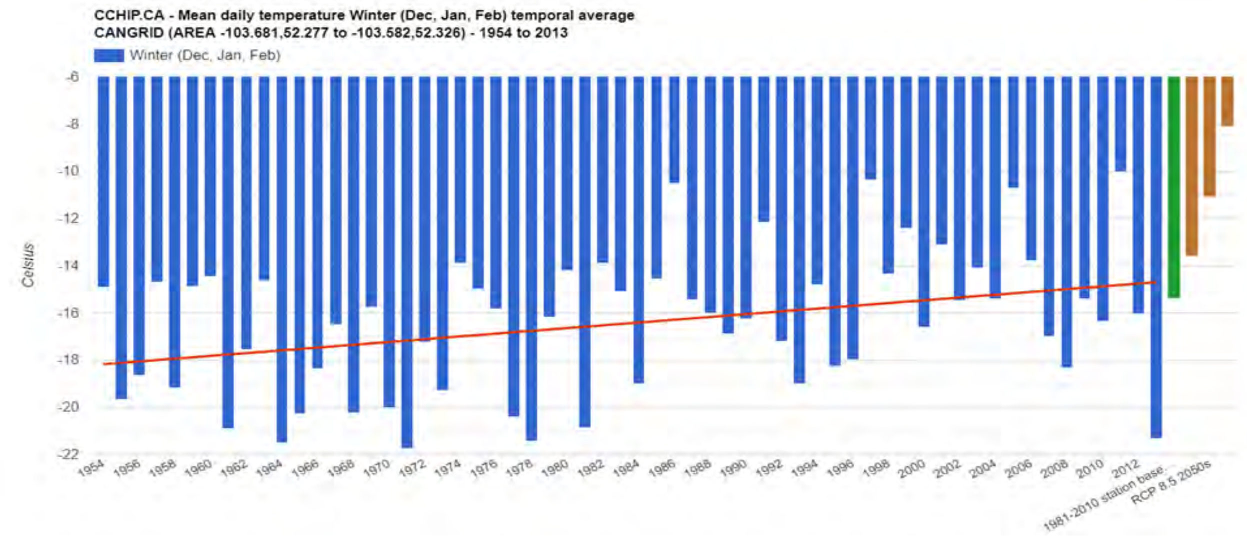


Figure 9: Mean Daily Temperature for Winter - Historical Trend and Future Climate Projection (CanGrd Data, RCP 8.5, 60-year period)

Table 7: Occurrence of Minimum Temperatures, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Minimum Temperature Threshold	Annual Occurrence of Days below Min. Temp (Days/year)			
	Historical 1981-2010	RCP 8.5		
		2020s	2050s	2080s
-30°C	16.50	11.6	6.0	1.6
-35°C	5.53	2.5	0.9	0.02
-40°C	0.78	0.1	0.00	0.00

3.3.2.2 Precipitation – Annual Totals

In the Canadian prairies, the average annual precipitation has increased by 7% between 1948 and 2012 (Bush and Lemmen, 2019, Vincent et al., 2015). The amount of precipitation during these periods is noted to vary seasonally, ranging from a decrease of 5.9% in the winter months to an increase of 13.6% in the spring (Bush and Lemmen, 2019, Johnson et al., 2005, Vincent et al., 2015).

Precipitation in the prairie region is highly variable due to influences from the El Niño-Southern Oscillation (ENSO) and the Pacific-North American (PNA) circulation which can cause variable rainfall from one year to the next and intermittent droughts (Gan, 2005). This unstable precipitation pattern is reflected in the historical data presented in the following figures and tables (e.g. Figure 12 shows a downward trend at this location in the winter while the future climate projection is trending upward). The uncertainty in the historical precipitation data in the area does not affect the projected future trends, which rely on global climate model results relative to the climate normal values for the station (Source: Yellow Quill First Nation Climate Profile, Stantec Report, See Appendix F).

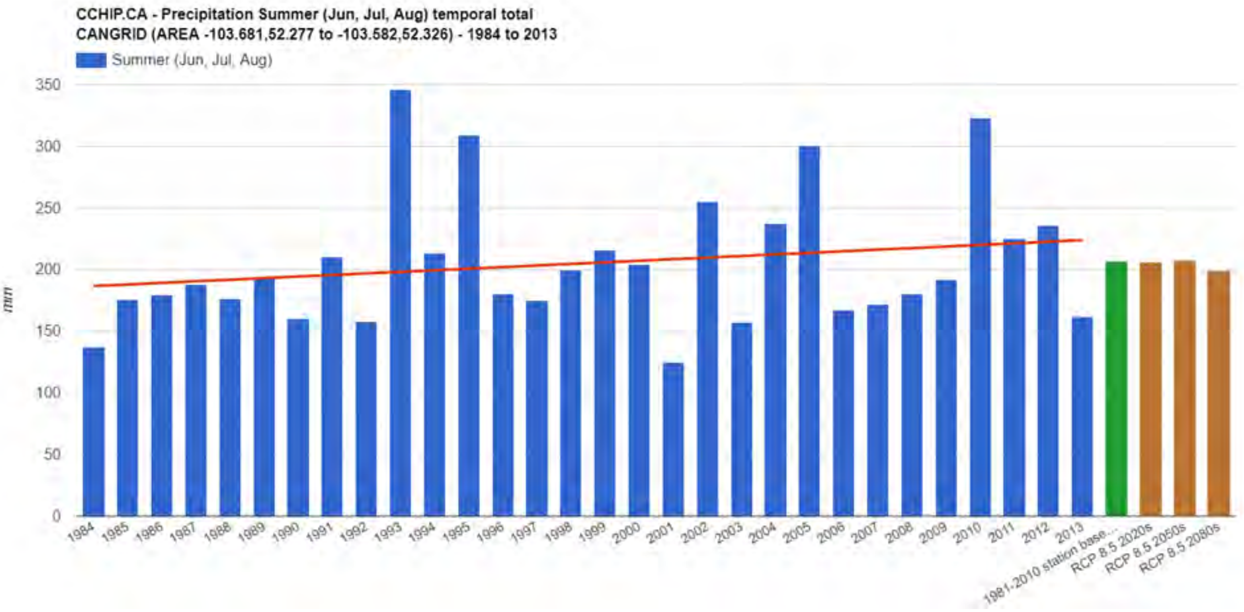


Figure 10: Total Precipitation during Summer Months - Historical Trend and Future Climate Projection (CanGrd Data, RCP 8.5, 30-years)

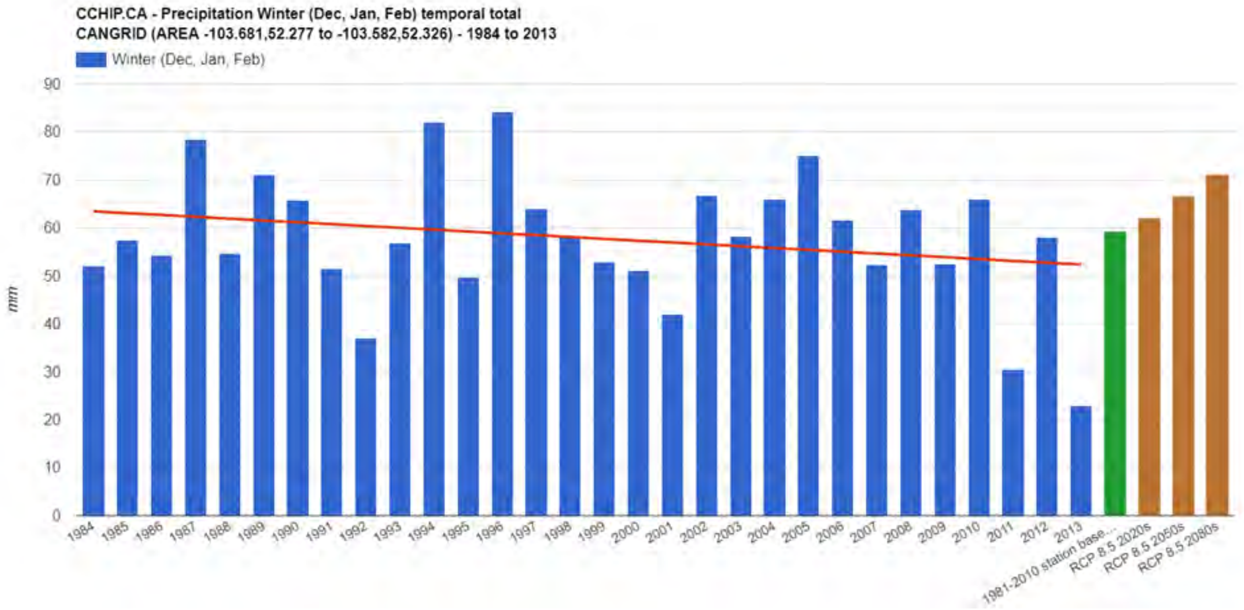


Figure 11: Total Precipitation during Winter Months - Historical Trend and Future Climate Projection (CanGrd Data, RCP 8.5, 30-years)

Table 8: Average Percent Change in Total Annual and Seasonal Precipitation from 1981-2010 Baseline, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Season	1981-2010 (mm)	Average Percent Change in Total Precipitation from 1981-2010 Baseline (%)		
		RCP 8.5		
		2020s	2050s	2080s
Annual	449.8	2.9	7.3	9.7
Winter	59.3	4.7	12.2	20.1
Spring	89.6	5.4	15.1	23.4
Summer	206.2	-0.1	0.5	-3.7
Autumn	95.5	3.9	7.5	11.0

3.3.2.3 Precipitation Event Accumulation

Tables 9 and 10 illustrate total precipitation amounts (mm) for specific time intervals (5 minutes to 24 hours) for various return periods (2 years to 100 years) (ICLR, 2019). The results indicate an increase in precipitation accumulation can be expected for all rainfall events. The projected percentage increase from the historical data to the period of 2041 - 2100 for precipitation events under RCP 8.5 range from 10.8% to 26.9%.

Table 9: Historical Precipitation Event Accumulation, Ungauged Location (Lat: 52.304º, Lon: -103.625º)

T (years)	2	5	10	20	25	50	100
5 min	5.97	8.43	10.15	11.92	12.44	14.24	16.11
10 min	8.68	12.57	15.28	18.04	18.86	21.66	24.58
15 min	10.45	15.30	18.71	22.23	23.28	26.88	30.67
30 min	12.86	19.40	24.43	30.01	31.77	38.06	45.17
1 h	15.76	23.26	28.99	35.33	37.31	44.46	52.56
2 h	19.27	27.06	33.06	39.95	42.07	50.15	59.74
6 h	27.30	35.06	40.61	47.04	48.90	56.50	65.79
12 h	32.79	44.36	52.32	60.69	63.11	71.89	81.47
24 h	39.96	54.68	64.58	74.57	77.44	87.32	97.51

Table 10: Projected Precipitation Event Accumulation, Ungauged Location (Lat: 52.304º, Lon: -103.625º), RCP 8.5, 2041-2100

T (years)	2	5	10	20	25	50	100
5 min	6.62	9.69	12.13	14.77	15.52	17.86	20.45
10 min	9.62	14.44	18.25	22.36	23.53	27.18	31.20
15 min	11.58	17.58	22.36	27.56	29.04	33.73	38.92
30 min	14.25	22.28	29.19	37.20	39.63	47.75	57.32
1 h	17.46	26.72	34.64	43.80	46.55	55.77	66.70
2 h	21.35	31.07	39.51	49.52	52.49	62.92	75.82
6 h	30.24	40.26	48.53	58.31	61.01	70.89	83.49
12 h	36.33	50.95	62.52	75.22	78.74	90.19	103.40
24 h	44.27	62.80	77.17	92.43	96.61	109.55	123.74

3.3.3 Climate Elements Selected to Affect the Infrastructure

Table 11 is a list of climate parameters and associated thresholds selected for the Yellow Quill climate risk assessment. The climate events were determined though discussions with community and Project Team members at the various workshops. Where possible traditional knowledge about current and past climate events was obtained through discussions with community Elders. The climate events were evaluated on their impacts of infrastructure-weather interactions and selected on the potential to cause structural or functional failures, or service disruptions on the community infrastructure being assessed.

Table 11: Climate Elements and Thresholds Selected for the Yellow Quill FN Climate Risk Assessment

Climate Element	Climate Event	Description/Comment/Threshold
Temperature	Winter Storm	Windchill, snowfall combined with high winds, strong winds, and possible freezing rain
	Extreme Cold	Cold temperatures of <u><</u>-30°C
	Heat Wave	Temperatures >30°C and >18°C overnight
Precipitation	Summer Storms (1)	25-50mm of Rain in 2 hours
	Summer Storms (2)	Hail (golf ball-sized)
Wind	Tornados	F0-F2, Trees bring down power lines
	High Winds	Wind gusts of 80 km/h of more
	Summer Windstorm	Microburst or straight-line winds (1:50yr return period)

4.0 FN-IRT CLIMATE RISK ASSESSMENT PROCESS

The First Nation IRT risk assessment process is illustrated in the flow chart shown in Figure 13.

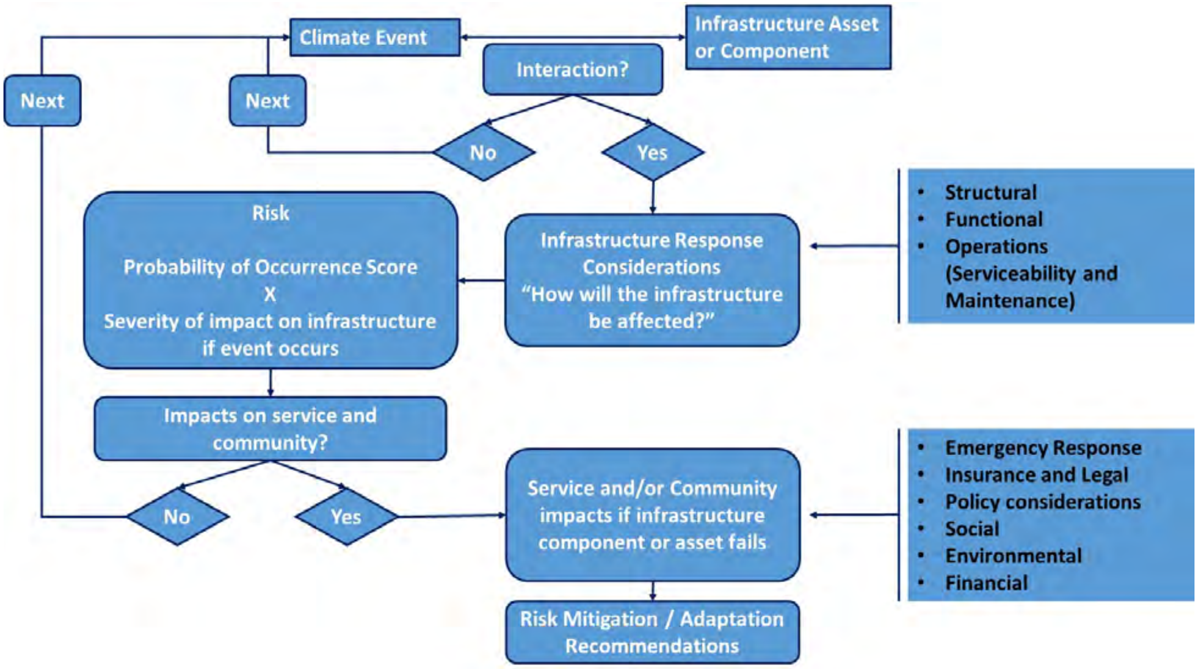


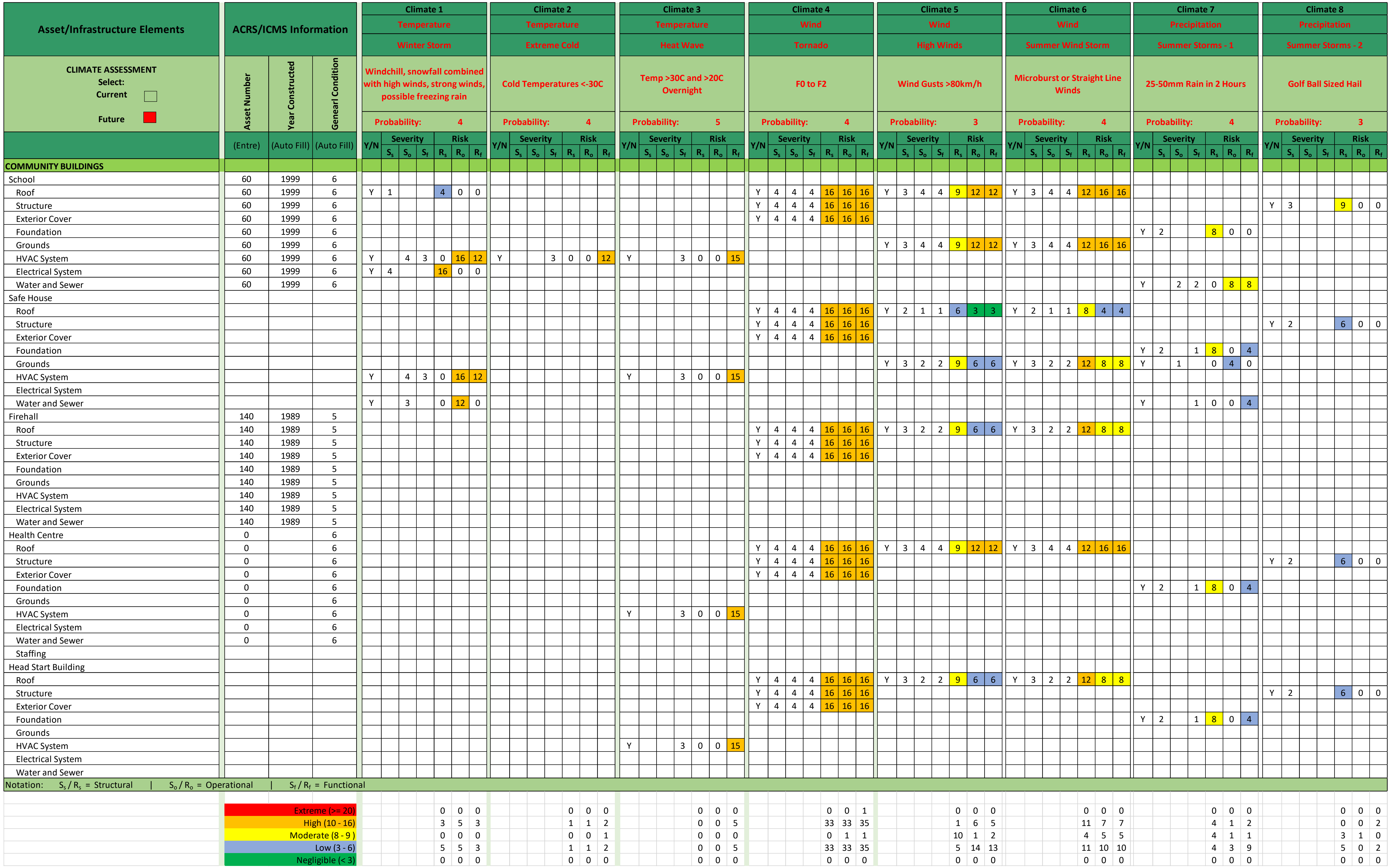
Figure 12: FN-IRT Risk Assessment Process Flowchart

The first step in completing the risk matrix worksheet (See Figure 14 and Appendix E) is to decide if there is an interaction between an infrastructure component and a climate event. Only those infrastructure assets components that are determined by the Project Team to be exposed or interact with a selected climate event are assessed for risks. If the infrastructure component is determined to interact with the climate event, then the Project Team evaluates the type of performance response (structural, functional, operations) the climate event will have on the component and assigns a severity score (1 to 5) using the Yellow Quill Severity Scale (See Section 4.4 Table 16) for each type of performance response. The performance response considerations used for this CRA are:

Structural Integrity – The climate event results in physical damage or deterioration to the infrastructure component. Examples include fracture or failure, material fatigue or weakening, cracking, deflection or permanent deformation of the component.

Functional Response (Functionality) – The climate event results in a reduction in the capacity of the infrastructure component to perform its design function at its original/current condition. Examples include a partially blocked culvert has a reduced ability to allow water to flow through; and an aging HVAC unit will not be able to provide heating/cooling at the same level as when it was in new condition.

Operations Response – The effect the climate event will have on the ability of staff to perform repairs, O & M requirements and additional inspections for external support, and the resulting impacts on O&M and capital budgets. For example, the climate event results in additional operations and maintenance time/costs, staff increases due to overtime, emergency response considerations and so forth.



Asset/Infrastructure Elements	ACRS/ICMS Information			Climate 1							Climate 2							Climate 3							Climate 4						
				Temperature							Temperature							Temperature							Wind						
				Winter Storm							Extreme Cold							Heat Wave							Tornado						
CLIMATE ASSESSMENT Select: Current ☐ Future 🟥	Asset Number	Year Constructed	Genearl Condition	Windchill, snowfall combined with high winds, strong winds, possible freezing rain							Cold Temperatures <-30C							Temp >30C and >20C Overnight							F0 to F2						
				Probability:					4		Probability:					4		Probability:					5		Probability:					4	
	(Entre)	(Auto Fill)	(Auto Fill)	Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk		
					S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f
COMMUNITY BUILDINGS																															
School	60	1999	6																												
Roof	60	1999	6	Y	1			4	0	0															Y	4	4	4	16	16	16
Structure	60	1999	6																						Y	4	4	4	16	16	16
Exterior Cover	60	1999	6																						Y	4	4	4	16	16	16
Foundation	60	1999	6																												
Grounds	60	1999	6																												
HVAC System	60	1999	6	Y		4	3	0	16	12	Y			3	0	0	12	Y			3	0	0	15							
Electrical System	60	1999	6	Y	4			16	0	0																					
Water and Sewer	60	1999	6																												
Safe House																															
Roof																									Y	4	4	4	16	16	16
Structure																									Y	4	4	4	16	16	16
Exterior Cover																									Y	4	4	4	16	16	16
Foundation																															
Grounds																															
HVAC System				Y		4	3	0	16	12								Y			3	0	0	15							
Electrical System																															
Water and Sewer				Y		3		0	12	0																					
Firehall	140	1989	5																												
Roof	140	1989	5																						Y	4	4	4	16	16	16
Structure	140	1989	5																						Y	4	4	4	16	16	16
Exterior Cover	140	1989	5																						Y	4	4	4	16	16	16
Foundation	140	1989	5																												
Grounds	140	1989	5																												
HVAC System	140	1989	5																												
Electrical System	140	1989	5																												
Water and Sewer	140	1989	5																												
Health Centre	0		6																												
Roof	0		6																						Y	4	4	4	16	16	16
Structure	0		6																						Y	4	4	4	16	16	16
Exterior Cover	0		6																						Y	4	4	4	16	16	16
Foundation	0		6																												
Grounds	0		6																												
HVAC System	0		6															Y			3	0	0	15							
Electrical System	0		6																												
Water and Sewer	0		6																												
Staffing																															
Head Start Building																															
Roof																									Y	4	4	4	16	16	16
Structure																									Y	4	4	4	16	16	16
Exterior Cover																									Y	4	4	4	16	16	16
Foundation																															
Grounds																															
HVAC System																		Y			3	0	0	15							
Electrical System																															
Water and Sewer																															
	Extreme (>= 20)							0	0	0					0	0	0					0	0	0					0	0	1
	High (10 - 16)							3	5	3					1	1	2					0	0	5					33	33	35
	Moderate (8 - 9)							0	0	0					0	0	1					0	0	0					0	1	1
	Low (3 - 6)							5	5	3					1	1	2					0	0	5					33	33	35
	Negligible (< 3)							0	0	0					0	0	0					0	0	0					0	0	0

Asset/Infrastructure Elements	Climate 5							Climate 6							Climate 7							Climate 8						
	Wind							Wind							Precipitation							Precipitation						
	High Winds							Summer Wind Storm							Summer Storms - 1							Summer Storms - 2						
CLIMATE ASSESSMENT Select: Current ☐ Future 🟥	Wind Gusts >80km/h							Microburst or Straight Line Winds							25-50mm Rain in 2 Hours							Golf Ball Sized Hail						
	Probability:					3		Probability:					4		Probability:					4		Probability:					3	
	Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk		
		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f
COMMUNITY BUILDINGS																												
School																												
Roof	Y	3	4	4	9	12	12	Y	3	4	4	12	16	16														
Structure																						Y	3			9	0	0
Exterior Cover																												
Foundation															Y	2			8	0	0							
Grounds	Y	3	4	4	9	12	12	Y	3	4	4	12	16	16														
HVAC System																												
Electrical System																												
Water and Sewer															Y		2	2	0	8	8							
Safe House																												
Roof	Y	2	1	1	6	3	3	Y	2	1	1	8	4	4														
Structure																						Y	2			6	0	0
Exterior Cover																												
Foundation															Y	2		1	8	0	4							
Grounds	Y	3	2	2	9	6	6	Y	3	2	2	12	8	8	Y		1		0	4	0							
HVAC System																												
Electrical System																												
Water and Sewer															Y			1	0	0	4							
Firehall																												
Roof	Y	3	2	2	9	6	6	Y	3	2	2	12	8	8														
Structure																												
Exterior Cover																												
Foundation																												
Grounds																												
HVAC System																												
Electrical System																												
Water and Sewer																												
Health Centre																												
Roof	Y	3	4	4	9	12	12	Y	3	4	4	12	16	16														
Structure																						Y	2			6	0	0
Exterior Cover																												
Foundation															Y	2		1	8	0	4							
Grounds																												
HVAC System																												
Electrical System																												
Water and Sewer																												
Staffing																												
Head Start Building																												
Roof	Y	3	2	2	9	6	6	Y	3	2	2	12	8	8														
Structure																						Y	2			6	0	0
Exterior Cover																												
Foundation															Y	2		1	8	0	4							
Grounds																												
HVAC System																												
Electrical System																												
Water and Sewer																												
Extreme (>= 20)					0	0	0					0	0	0					0	0	0					0	0	0
High (10 - 16)					1	6	5					11	7	7					4	1	2					0	0	2
Moderate (8 - 9)					10	1	2					4	5	5					4	1	1					3	1	0
Low (3 - 6)					5	14	13					11	10	10					4	3	9					5	0	2
Negligible (< 3)					0	0	0					0	0	0					0	0	0					0	0	0

Notation: S_s / R_s = Structural | S_o / R_o = Operational | S_f / R_f = Functional

Figure 13: Partial Sample of Yellow Quill Risk Matrix Worksheet

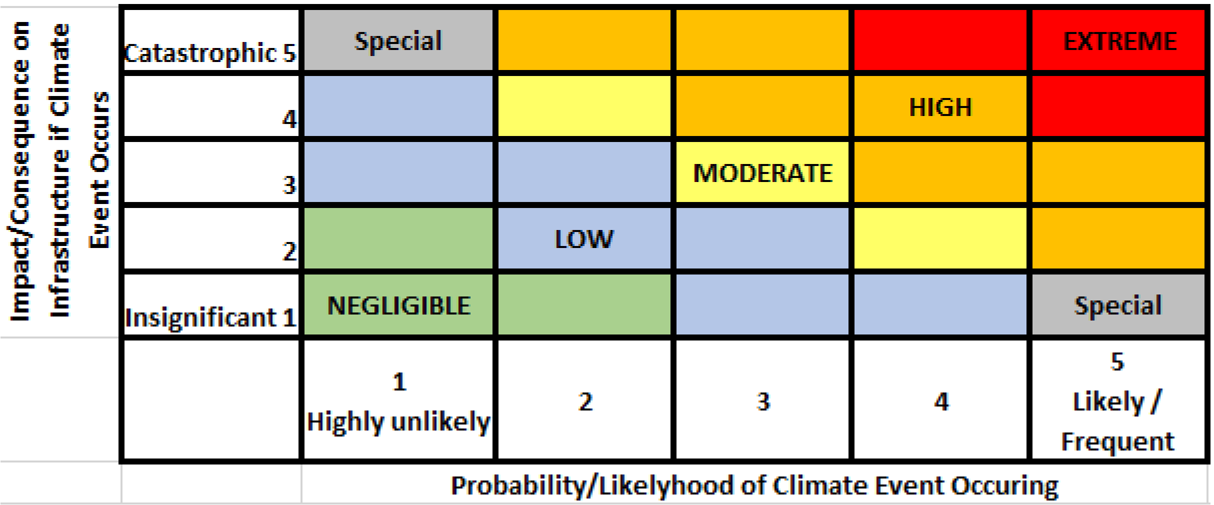
Once the severity of the impact of the climate event is determined for each performance response, the risk to the infrastructure component is determined by multiplying the severity score by the probability of the climate event occurring.

RISK = SEVERITY OF IMPACT X PROBABILITY OF OCCURRENCE OF CLIMATE EVENT

Risks are tabulated for structural, functional and operational responses for the affected infrastructure components, and calculated for both current and future climate scenarios. The final step in developing risk adaption and resiliency strategies for the highest risk infrastructure components.

4.1 RISK THRESHOLDS

Risk is defined as the combination of the likelihood or probability of an event occurring and the resulting impact or consequences should the event occur. In the FN PIEVC protocol, the ***risk is defined as the probability of a climate event occurring and the impact or severity of damage to the infrastructure component should the climate event occur***. The probability/likelihood and impact/severity scores are each ranked on a 1 to 5 scale as shown in the Figure 15.



Impact/Consequence on Infrastructure if Climate Event Occurs	Catastrophic 5	Special	🟧	🟧	🟥	EXTREME
	4	🟦	🟨	🟧	HIGH	🟥
	3	🟦	🟦	MODERATE	🟧	🟧
	2	🟩	LOW	🟦	🟨	🟧
	Insignificant 1	NEGLIGIBLE	🟩	🟦	🟦	Special
		1 Highly unlikely	2	3	4	5 Likely / Frequent
		Probability/Likelyhood of Climate Event Occuring				

Figure 14: FN PIEVC Risk Matrix

For the Yellow Quill climate risk assessment, the risk scores or threshold have been further divided and colour coded as shown in Table 12.

Table 12: Risk Scores and Adaptation Responses

	RISK SCORE	ADAPTATION RESPONSE
Extreme:	≥ 20	Immediate control required
High:	10 - 16	High priority control measures required
Moderate:	8 - 9	Some control measures required to reduce risks to lower levels
Low:	3 - 6	Control likely not required
Negligible:	< 3	Risk events do not require further consideration
Special Case:		Further analysis may be required; monitor
	• P=1 & S=5	Special Case - Very low probability but high Severity
	• P=5 & S=1	Special Case - High probability of occurring but insignificant impact or severity

4.2 CLIMATE PROBABILITY SCORING

The FN PIEVC rates the probability of the climate events occurring (current and future climate) as follows:

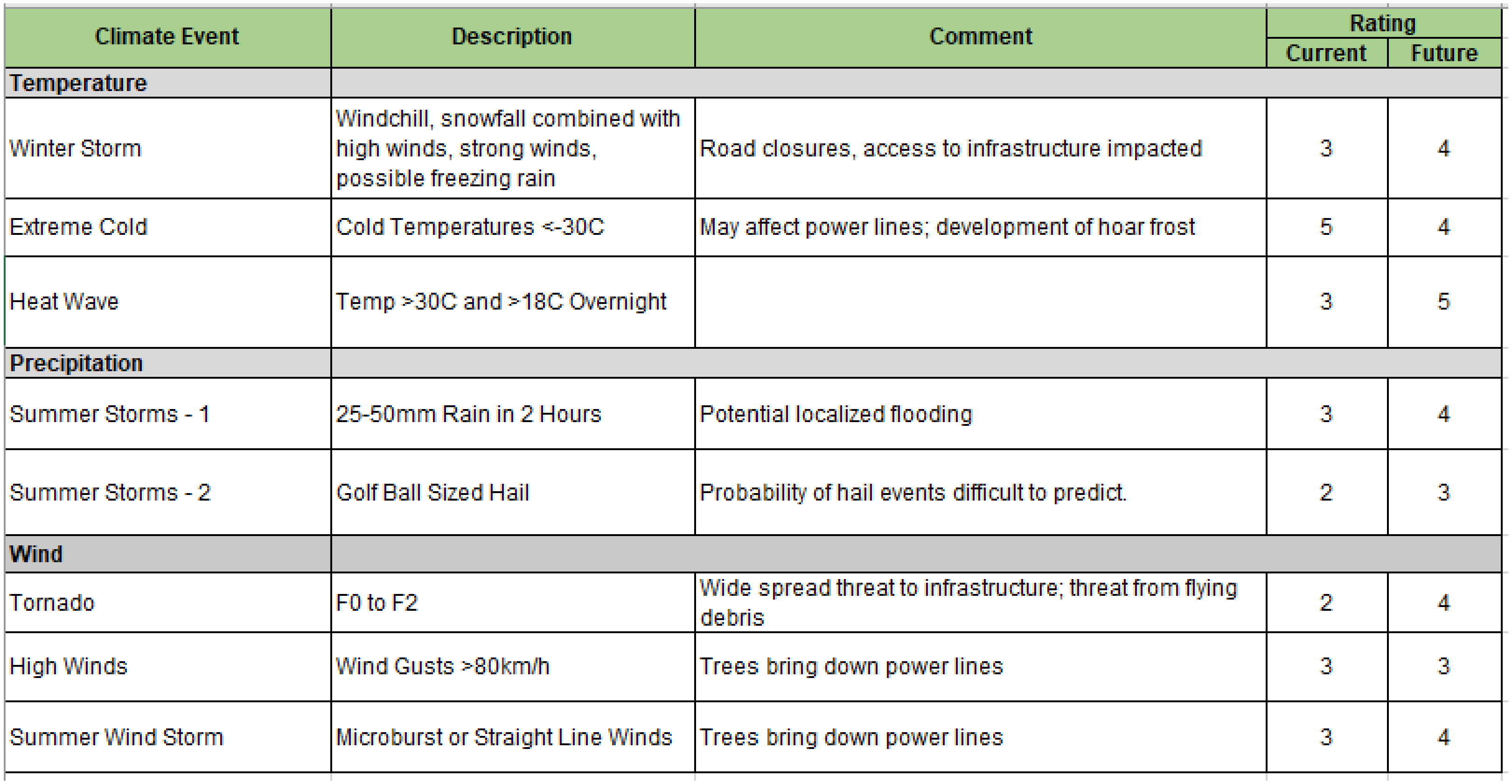
Table 13: FN-IRT Probability Scoring

Rating	**Occurrence**	**Qualitative Descriptor**	**Quantitative Descriptor**
1	**>1:50 year**	Highly Unlikely	• Not likely to occur in assessment period; or • Not likely to increase in intensity and/or duration during the assessment period
2	**1:10-50 year**	Remotely Possible	• Likely to occur once between 10-50 years; or • Likely to increase in intensity and/or duration over a 10 to 50 year period
3	**1:1-10 year**	Occasional	• Likely to occur at least once a decade; or • Likely to increase in intensity and/or duration over a decade
4	**10/year to 1:1**	Normal	• Likely to occur between 1-10 times annually; or • Likely to increase in intensity and/or duration on an annual basis
5	**>10/year**	Frequent	• Likely to occur more than 10 times annually

The following table presents the results of the climate analysis (current trends and future projections), and the corresponding FN-IRT probability scores used in the Yellow Quill Climate Risk Assessment.

Table 14: Probability Scores for Selected Yellow Quill Climate Events

Note: Where climate data was not available (i.e. hail and winter storms), the professional judgement of the Project Team based on local experience and knowledge was used.



Climate Event	Description	Comment	Rating	
			Current	Future
Temperature				
Winter Storm	Windchill, snowfall combined with high winds, strong winds, possible freezing rain	Road closures, access to infrastructure impacted	3	4
Extreme Cold	Cold Temperatures <-30C	May affect power lines; development of hoar frost	5	4
Heat Wave	Temp >30C and >18C Overnight		3	5
Precipitation				
Summer Storms - 1	25-50mm Rain in 2 Hours	Potential localized flooding	3	4
Summer Storms - 2	Golf Ball Sized Hail	Probability of hail events difficult to predict.	2	3
Wind				
Tornado	F0 to F2	Wide spread threat to infrastructure; threat from flying debris	2	4
High Winds	Wind Gusts >80km/h	Trees bring down power lines	3	3
Summer Wind Storm	Microburst or Straight Line Winds	Trees bring down power lines	3	4

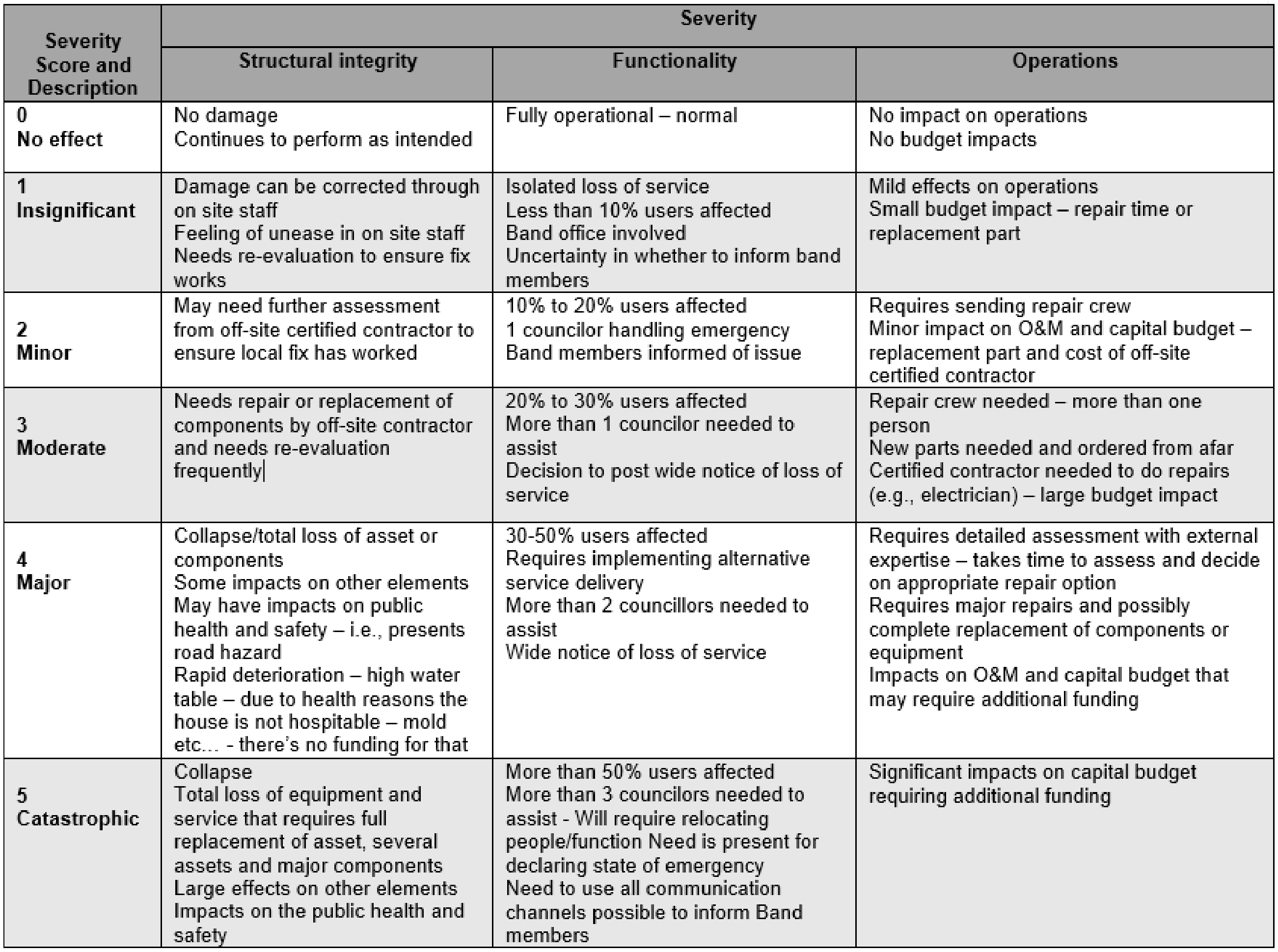
4.3 INFRASTRUCTURE SEVERITY OF IMPACTS SCORING

Climate Risk is defined as the probability of a climate event occurring multiplied by the severity of the damage to the infrastructure assuming the infrastructure is exposed to the climate event. During workshops 1 and 2, the Yellow Quill Project Team members were asked to develop a severity rating scale that reflects the community's understanding of the impact on their infrastructure.

The severity scale uses a scale between zero (0) and five (5), with 0 being defined as having no effect on the infrastructure, and 5 being catastrophic, (i.e., having the greatest impact on the infrastructure). To further determine the type of impact the climate event will have on the infrastructure component, each severity scale unit was divided into three categories of performance criteria — structural integrity, functionality and operations.

The Project Team was asked to describe the type of impact the climate event would have on an infrastructure element for each severity ranking from 0 to 5, and for each type of exposure category. The severity rating scale developed by Yellow Quill Project Team is shown in Table 15.

Table 15: Yellow Quill First Nation – FN PIEVC Assessment – Severity Rating Scale



Severity Score and Description	Severity		
	Structural integrity	**Functionality**	**Operations**
0 **No effect**	No damage Continues to perform as intended	Fully operational – normal	No impact on operations No budget impacts
1 **Insignificant**	Damage can be corrected through on site staff Feeling of unease in on site staff Needs re-evaluation to ensure fix works	Isolated loss of service Less than 10% users affected Band office involved Uncertainty in whether to inform band members	Mild effects on operations Small budget impact – repair time or replacement part
2 **Minor**	May need further assessment from off-site certified contractor to ensure local fix has worked	10% to 20% users affected 1 councilor handling emergency Band members informed of issue	Requires sending repair crew Minor impact on O&M and capital budget – replacement part and cost of off-site certified contractor
3 **Moderate**	Needs repair or replacement of components by off-site contractor and needs re-evaluation frequently	20% to 30% users affected More than 1 councilor needed to assist Decision to post wide notice of loss of service	Repair crew needed – more than one person New parts needed and ordered from afar Certified contractor needed to do repairs (e.g., electrician) – large budget impact
4 **Major**	Collapse/total loss of asset or components Some impacts on other elements May have impacts on public health and safety – i.e., presents road hazard Rapid deterioration – high water table – due to health reasons the house is not hospitable – mold etc… - there's no funding for that	30-50% users affected Requires implementing alternative service delivery More than 2 councillors needed to assist Wide notice of loss of service	Requires detailed assessment with external expertise – takes time to assess and decide on appropriate repair option Requires major repairs and possibly complete replacement of components or equipment Impacts on O&M and capital budget that may require additional funding
5 **Catastrophic**	Collapse Total loss of equipment and service that requires full replacement of asset, several assets and major components Large effects on other elements Impacts on the public health and safety	More than 50% users affected More than 3 councilors needed to assist - Will require relocating people/function Need is present for declaring state of emergency Need to use all communication channels possible to inform Band members	Significant impacts on capital budget requiring additional funding

5.0 CLIMATE RISK ASSESSMENT

5.1 INFRASTRUCTURE COMPONENTS SELECTED

The Project Team selected four categories of infrastructure to assess for climate risks – community buildings, water and water systems, housing and roads and drainage. Within in each category the Project Team selected specific infrastructure assets for the assessment; i.e. each of the infrastructure assets considered were further divided into components or systems that comprise the infrastructure. The climate risk assessment evaluates the severity of the impacts on each component of the infrastructure to the selected climate events. The following tables list the Yellow Quill infrastructure and the associated asset components to be evaluated for climate risk in this study.

COMMUNITY BUILDINGS					
	SCHOOL	**SAFE HOUSE**	**FIRE HALL**	**HEALTH CENTRE**	**HEADSTART**
ASSET COMPONENTS	Roof	Roof	Roof	Roof	Roof
	Structure	Structure	Structure	Structure	Structure
	Exterior Cover	Exterior Cover	Exterior Cover	Exterior Cover	Exterior Cover
	Foundation	Foundation	Foundation	Foundation	Foundation
	Grounds	Grounds	Grounds	Grounds	Grounds
	HVAC System	HVAC System	HVAC System	HVAC System	HVAC System
	Electrical System	Electrical System	Electrical System	Electrical System	Electrical System
	Water and Sewer	Water and Sewer	Water and Sewer	Water and Sewer	Water and Sewer

WATER AND WASTEWATER TREATMENT					
	WTP BUILDING/ BOOSTER STATION	**RW PUMP HOUSE**	**WASTEWATER TREATMENT SYSTEM**	**PUBLIC WORKS GARAGE**	**SHOP**
ASSET COMPONENTS	Roof	Pumphouse Building	Pipes and Valves	Roof	Roof
	Structure	Drilled Wells	Electrical System	Structure	Structure
	Exterior Cover	SCADA/Communication Equipment	Lagoon and Outfall	Exterior Cover	Exterior Cover
	Foundation			Foundation	Foundation
	Grounds			Grounds	
	HVAC System			HVAC System	HVAC System
	Electrical System			Electrical System	Electrical System

HOUSING			ROADS & CULVERTS	3rd PARTY SERVICES
	Serviced Housing	**Unserviced Housing/Farms**		
ASSET COMPONENTS	Roof	Roof	Road Deck (Gravel)	Power/Hydro
	Structure	Structure	Ditches	Gas
	Exterior Cover	Exterior Cover	Culverts	Telecommunications
	Foundation	Foundation	Lighting	
	Grounds	Grounds	Guard Rails	
	HVAC System	HVAC System		
	Electrical System	Electrical System		
		Cistern		
		Septic Tank and Bed		

5.2 SUMMARY OF RISK RESULTS

Table 16 presents a summary of the risk counts (moderate, high, and extreme) under current and future climate expectations. Key highlights from the risk assessment include:

3. There were no extreme risks under current climate and only one extreme risk found under future climate projections, related to functional risk of third-party services (power/hydro).

4. Tornadoes were found to have a broad impact on all infrastructure studied. While the occurrence of a tornado under current climate was low (probability score of 2), the Project Team felt the occurrence of a tornado under future climate was much higher (probability score of 4). The resulting changes largely explains the 400% increase in moderate risks under future climate considerations.

5. Winds (Gusts over 80 km/h) and winds associated with summer storms (microbursts/straight-line winds) were found to result in moderate structural, functional and operational risks, mostly related to building roof structures and the grounds around buildings.

6. Winds were a significant risk to third party services (power/electrical supply and telecommunications). This substantiates previous known impacts on the community associated with prolonged power outages.

7. Heavy rains (i.e. High intensity/short duration – 25-50mm in two hours) were a high risk under future climate, due to the increased possibility of local flooding. House foundations and cisterns for houses not on municipal services were the primary infrastructure at risk.

5.2.1 Flood Risks

The Yellow Quill community has a history of significant flooding events. This FN-IRT climate risk assessment forms part of a much larger flood mitigation study being completed by the University of Saskatchewan.

As flooding is not a single climate event, but more a result of a combination of climate and other non-climate related factors, such as high accumulation of snow, rapid thawing of the winter snow pack combined with other climate factors like winter rains, prolonged spring rain events resulting in abnormally high accumulation of water, the FN-IRT climate risk assessment did not look specifically at flooding as part of the risk assessment.

Table 16: Risk Summary - Moderate, High and Extreme Risks

Risk Score Counts			Main Climate Events	Principal Infrastructure/Components Affected
Score	**Current Climate Count**	**Future (2050s) Climate**		
EXTREME	**0**	1	• High Winds-Gusts > 80 km/h	• Third Party Services (Electrical Power/Hydro supply) – Functional risks to service delivery
HIGH	**26**	**166**	• Winter Storm – Heavy snow combined with high winds; possible wind chill	• School and Safe House – Structural and operational risk to electrical and HVAC systems; Operational risks to cisterns • Wastewater Treatment – Operational risk to pipes and valves
			• Extreme Cold – Temp <-30C	• School – Functional risk to HVAC system • Booster Station - Risks to pipes and valves
			• High Winds-Gusts > 80 km/h (Includes straight line winds from summer storms)	• School - Operation/Functional risks to roof and grounds • Health Centre/Headstart/Firehall - Operation/Functional risks to roof • Water treatment Plant/Well House – Structural /Operational risk to communication/SCADA • Roads- -Operational/functional risks to lighting • Third Party Services (Electrical Power/Hydro & Communications)) – Structural/functional/operational risks to service delivery
			• Tornado	• Risks ONLY associated with future climate (higher probability) • Structural/operational/functional risks to all community buildings (school, Safe House, Headstart, Health Centre, Firehall), Water and Wastewater Buildings (WTP/Booster Station, garage, shop) and Housing • Third Party Services (Electrical Power/Hydro & Communications)) – Structural/functional/operational risks to service delivery • Roads – Structural risk to lighting
			Heavy Rain – 25-50mm in 1 hour (summer storms)	• Housing – Structural risks to foundations; structural and functional risks to cisterns (serviced housing).
MODERATE	**139**	**40**	See Current and Future Risk Matrices in Appendix E	See Current and Future Risk Matrices in Appendix E

5.2.2 Influence of the Infrastructure Condition on Risk Scores

The condition of the infrastructure is a key element to establishing risks. While the current condition ratings of the Yellow Quill infrastructure are available from the 2017 ACRS Report, estimating the future condition of the infrastructure is a complex process. It requires forecasting annual expenditures on operations, maintenance, and capital investments in the infrastructure to:

- Maintain the infrastructure in a state of good repair over its expected service life and,
- Replacing the infrastructure when it has reached the end of its service life.

As the long-term O&M and capital investment plans for the Yellow Quill infrastructure are not known, the worst-case scenario (Condition 2) is that none will be replaced during the study time horizon and current maintenance procedures cannot be sustained due to funding pressures. This results in a higher vulnerability to the climate hazards identified. Table 17 presents the comparison between the risks to the infrastructure replaced at the end of its design life and maintained in a state of good repair, and the risks with deteriorated infrastructure.

Table 17: Forecast Increased Risks for Yellow Quill Infrastructure – Impacts of Asset Condition over Infrastructure Service Life

Future Climate Risk Score Counts - Yellow Quill Infrastructure			
Risk Rating	**Infrastructure replaced at end of design life and well maintained** **Condition 1**	**Infrastructure deteriorated (not replaced or poorly maintained)** **Condition 2**	**Asset Condition Impact on Risk**
Moderate	167	168	< 1%
High	1	7	+ 700%

Although the total number of risks is small, it represents a significant increase in high risks to the infrastructure; these risks are associated with the school and health care building that have current general condition ratings of six.

5.3 INFRASTRUCTURE RISKS AND COMMUNITY IMPACTS

Resilient infrastructure is necessary to provide resilient services that, in turn, contribute to the resilience of the community. The loss of performance or function of infrastructure can have an impact on the whole community in a variety of ways as described below.

1. **Emergency response** services can be impacted in following manners:

    a. Increased demand due to higher number of emergencies or broad area covered by the event;
    b. Impacts to the facilities, equipment and personnel that are used to provide emergency services; and
    c. Loss of functionality of roads or other routes to access the locations where emergencies occur

2. **Insurance and legal impacts** may result from a failure in the services or damages from the collapse of public assets. For example: basement flooding due to loss of stormwater system capacity; fallen public trees on private property; failure of wastewater systems resulting in temporary facilities' closures or environmental damage.

3. **Policy considerations** relate to the processes, procedures and guidelines developed by Chief and council that affect the performance and availability of community infrastructure to provide the required levels of service for the community members. Operating and maintaining infrastructure in a state of good repair and re-capitalizing the assets in a timely manner needs to be part of long-term community risk adaptation and resiliency strategy.

4. **Social and cultural** impacts often result from the loss of services provided by a community's infrastructure. It is important to develop adaptation, mitigation and resiliency strategies that involve all community members, from the young to the Elders, to work together to find solutions that align with the community's social and cultural beliefs and their traditional ways.

5. **Environmental impacts** may result in short or long-term impacts to the community. Contamination of the community's raw water source will have an immediate impact on the community in terms of providing potable water, but the effects on the community may be much worse in the long term if the community needs to relocate to find a new water source.

6. **Financial impacts** may redirect resources from other planned investments or priority areas in the community. With limited sources of funding available, the Community may have to take extraordinary measures to address its financial situation. This could result in the lowering or removal of certain levels of services in the community.

6.0 CLIMATE ADAPTATION AND CREATING RESILIENT INFRASTRUCTURE

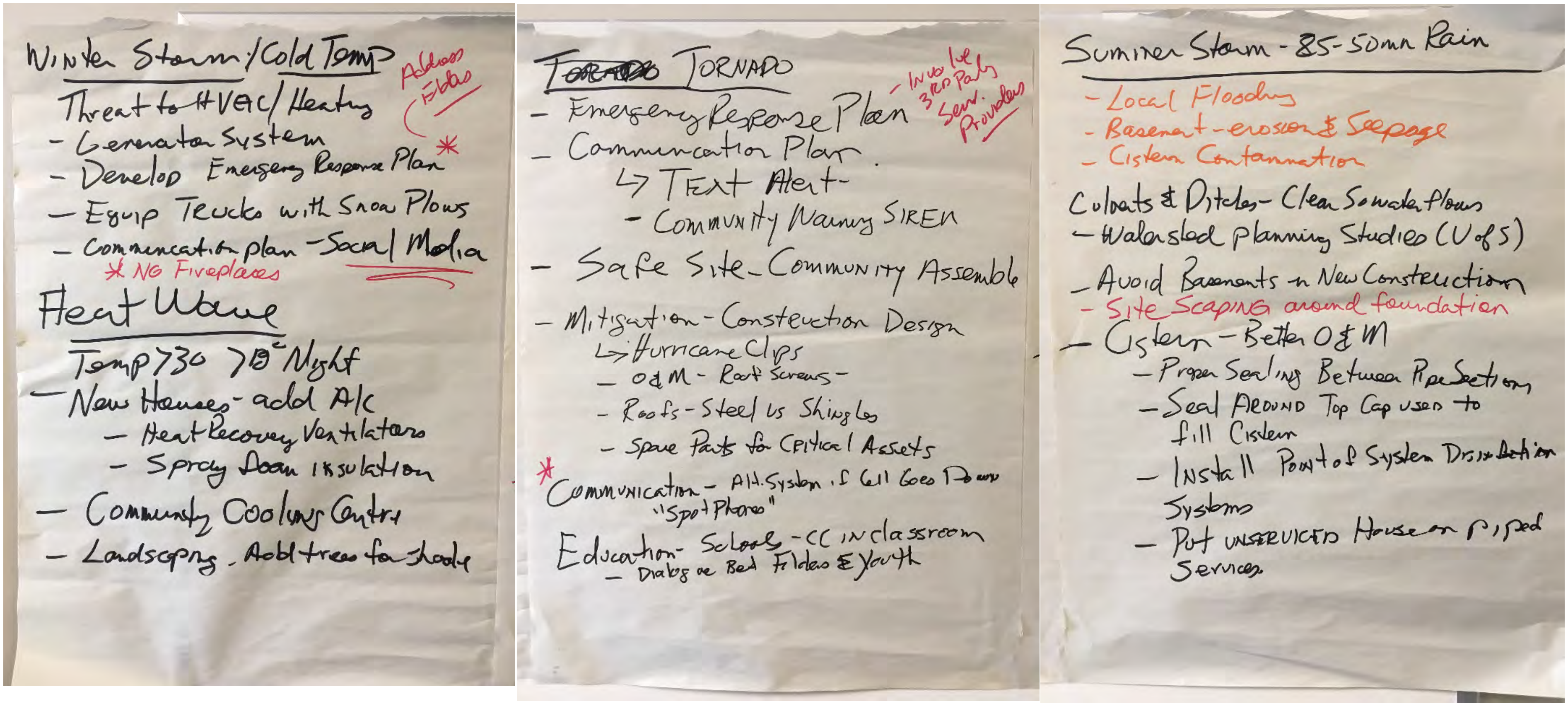
Climate change and the associated climate risks are being realized as a significant tangible threat to First Nation community infrastructure. Community infrastructure that is kept in a state of good repair through proper operations and maintenance practices, will often be able to withstand additional loading associated with most current climate events. However, the increasing frequency and intensity of future climate events will require communities to take actions to create more resilient infrastructure and develop adaptation strategies to reduce climate related ricks to their infrastructure now and into the future.

Climate mitigation measures are actions taken to reduce and curb greenhouse gas (GHG) emissions, which are the single most important cause of climate change. Mitigation measures like reducing green GHG need to be addressed on a global scale to have any hope of reversing the current trend in global warming. On the other hand, climate adaptation acknowledges that even if GHG emissions were to be substantially reduced or stopped today, the current atmospheric concentration of carbon dioxide and other greenhouse gases would remain well above normal levels for years and potentially several decades to come. Mitigation therefore looks at addressing the causes of climate change, while adaptation is about building resilience of community infrastructure by reducing the vulnerability and addressing the impacts of climate change on community infrastructure.

Workshop 1, 2 and 3 of the Yellow Quill First Nation FN-IRT climate risk assessment, examined selected community infrastructure and determined the risk scores for infrastructure components for both current and future climate scenarios. During Workshop 4, the Project Team and community members developed adaptation and resiliency strategies to mitigate the highest risk to community infrastructure from current and future climate. The results of the workshop adaptation and resilience discussions are illustrated in Figures 16 and listed in Table 18.

The climate adaptation and resilience strategies developed during the Yellow Quill FN-IRT climate risks assessment are a first step towards reducing climate-related risks to Yellow Quill infrastructure. With present building codes lacking design criteria to address current and future climate impacts, it is not possible to construct infrastructure to be fully resilient to climate change. However, communities like Yellow Quill can narrow the gap between the current resilience capacity of their infrastructure, and the resilience capacity needed to prepare for future climate change impacts by implementing adaptation measures that reduce exposure and vulnerability to climate events, creating more climate resilient communities.

Figure 15: Adaption and resiliency strategies developed by Project Team – Workshop 4



Winter Storm/Cold Temp

Address Elders

Threat to HVAC/Heating
- Generator System
- Develop Emergency Response Plan *
- Equip Trucks with Snow Plows
- Communication plan - Social Media

* NO Fireplaces

Heat Wave

Temp >30 >18° Night
- New Houses - add A/C
  - Heat Recovery Ventilators
  - Spray foam insulation
- Community Cooling Centre
- Landscaping - Add trees for shade

~~TORNADO~~ TORNADO
- Emergency Response Plan
- Involve 3rd Party Serv. Providers
- Communication Plan.
  - ↳ TEXT Alert -
    - Community Warning SIREN
- Safe Site - Community Assemble
- Mitigation - Construction Design
  - ↳ Hurricane Clips
  - O&M - Roof Screws -
  - Roofs - Steel vs Shingles
  - Spare Parts for Critical Assets

* Communication - Alt. System if Cell Goes Down "Spot Phones"

Education - Schools - CC in classroom
  - Dialogue Bet. Elders & Youth

Summer Storm - 85-50mm Rain
- Local Flooding
- Basement - erosion & Seepage
- Cistern Contamination

Culverts & Ditches - Clean So water flows
- Watershed planning Studies (U of S)
- Avoid Basements in New Construction
- Site Scaping around foundation
- Cistern - Better O&M
  - Proper Sealing Between Pipe Sections
  - Seal AROUND Top Cap used to fill Cistern
  - Install Point of System Distribution Systems
  - Put UNSERVICED House on piped Services.

Table 18: Yellow Quill Risk Mitigation and Adaptation Measures

CLIMATE EVENT	INFRASTRUCTURE AND RISK ADAPTATION MEASURES
Extreme Cold **(Temperature <-30C)**	**HVAC Systems** (Community buildings/residential housing) • Perform regular O&M to maintain HVAC system in optimal operation condition • Have emergency back-up power system for critical community infrastructure • Install back-up heating system (wood stoves/fireplaces) in homes • Develop an emergency response plan (ERP) – include a community communications plan in the ERP so everyone is aware of what to do in case of an emergency. • Focus on taking care of elders/others in the community that may need assistance during extreme cold events. • Develop a community warming center – publish location and times on multiple medias (radio/Facebook/television). Include in emergency response plan. **W/WW Piping** (Booster Station-Pipes & Valves) • Exercise valves frequently – develop regular maintenance plan. • Drain water truck fill piping. • Set up truck fill piping to be self draining.
Winter Storms (Heavy Snow/High Winds/freezing rain)	**Roads and Drainage** • Equip trucks with snowplows to assist with snow removal. • Keep emergency routes open – build into emergency response plan. **W/WW Systems** (pipes/valves/hydrants) • Mark hydrants and valve for easy location during heavy snow and drifting. • Exercise valves frequently. • For new pipe installations, ensure pipes are below maximum frost level in ground. Install Styrofoam above pipes as additional protect for freezing.
Heat Wave (Temperature > 30C during Day and >20C Overnight)	**HVAC Systems** • Perform regular O&M to maintain HVAC system in optimal operation condition to provide cooling during periods of high demand. • Develop a community cooling center – publish location and times on multiple medias (radio/Facebook/television). Include in emergency response plan. • Equip new houses/buildings with air conditioning and HRV (Heat Recovery Ventilation) systems. • Install air conditioning in homes for Elders who currently don't have AC. **Buildings - Grounds** • Plant shade trees around houses and buildings to provide a natural barrier to solar heating.
Tornado	**Community Buildings/W/WW Systems/Housing** • Develop an emergency response plan (ERP) – include a community communications plan in the ERP so everyone is aware of what to do in case of an emergency. • Educate the community (classrooms/information sessions) about how to remain safe during a tornado/severe climate event. Discuss risks of flying debris and how to mitigate those risks. • Develop a Tornado/Severe Weather Alert Warning System for the community (i.e. tornado/sever weather siren). • Consider having an emergency satellite communications system if cellular system damaged/unavailable.

	• Have a community Safe House/location where community members can assemble during severe climate events like tornadoes. • Plan Ahead – have sufficient spare parts for critical assets. Combine with consistent O & M. **Adaptation/Resiliency Strategies** (Construction/Design) • Insure newly constructed buildings include climate risk in the design • Install hurricane clips of roof rafters. • Install metal roove rather than asphalt shingles. • Develop an O&M program to check connections of metal roof panels.
High Winds **(Gusts>80km/h)** **Summer Storms** **Microburst/straight line winds**	**Community Buildings/W/WW Systems/Housing** • *Risks and associated adaptation measures similar to those outlined for tornadoes (See above).*
Summer Storms **Heavy Precipitation (25-50mm rain in 2 hours)/Atmospheric Discharge (Lightning Strikes)**	**Localized Flooding – Houses and Community Buildings/ Roads and Drainage** • Landscape around foundations to divert surface water away from foundation walls and prevent ponding that could cause infiltration into buildings. • Properly maintain culverts/ditches to allow water to flow freely to reduce risks of local flooding. • New construction – Consider alternative house designs that eliminate or minimize living space below grade, to mitigate the effects of basement flooding and associated long-term mold issues. • Install water proofing materials on the exterior of foundation walls, to improve resistance to seepage during flooding events. • Educate home owners on how to reduce the risks of flooding in their homes. • Plan future housing and community building developments on land not susceptible to flooding (i.e. using information from current U of S watershed planning study). **Unserviced Housing – Cisterns** • When installing cisterns, add flexible rubber gaskets between well sections to avoid infiltration of ground/surface waters. • Provide waterproof gasket for fill lid on top of cistern to prevent contamination of water. • Expand community water system to include houses currently on trucked water/cisterns. • Install Point of Entry water treatment systems (Portable Reverse Osmosis/Ultraviolet (UV) Disinfections Systems) water disinfection systems to reduce risks of water contamination to home owners on cisterns.

APPENDIX A

WORKSHOP 1 POWERPOINT PRESENTATION

Ontario First Nations
Technical Services
Corporation

Yellow Quill First Nation
FN-IRT Climate Vulnerability Assessment
Workshop #1- Infrastructure Exposure

Dr. Guy Félio, P.Eng., FCSCE, IRP[Climate]
Senior Advisor, Stantec

Wayne Penno, MBA, P.Eng.
Project Manager, Stantec

Tuesday August 13, 2019

Stantec

Stop & Talk: Hand Tool Safety

Health, Safety, Security, & Environment

The wide variety of hand and portable power tools available on the market today allow us to perform more tasks more efficiently. However, if used improperly, hand and power tools can cause injury. Use protective equipment and follow proper work practices in order to operate hand and power tools safely.

Below are five basic safety rules that can help prevent hazards:

1. Keep all tools in good condition with regular maintenance.
2. Use the right tool for the job.
3. Examine each tool for damage before use and do not use damaged tools.
4. Operate tools according to the manufacturers' instructions.
5. Provide and properly use the right personal protective equipment.

Click on the following link for more information related to tool safety
https://www.grainger.com/content/qt-188-tool-safety

Below are general guidelines for safe tool use:

- Keep cords and hoses away from heat, oil, and sharp edges.
- Disconnect tools when not using them, before servicing and cleaning them, and when changing accessories such as blades, bits, and cutters.
- Secure work with clamps or a vise, freeing both hands to operate the tool.
- Avoid accidental starting. Do not hold fingers on the switch button while carrying a plugged-in tool.
- Be sure to keep good footing and maintain good balance when operating power tools.
- Remove all damaged portable electric tools from use and tag them: "Do Not Use".

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If you have questions, please contact your supervisor, Office Safety and Environment Coordinator (OSEC), or local HSSE representative

HSSE Stop & Talk are written for educational purposes and are not intended to replace safe work practices or procedures.
ver. August 2019

Ontario First Nations Technical Services Corporation

YELLOW QUILL FIRST NATION #90

TREATY 4

Workshop 1 - Objectives

- Introduction of workshop participants.
- Introduction to the First Nations Infrastructure Resiliency Toolkit (FN-IRT) and the FN PIEVC vulnerability assessment process.
- Definition of the global project parameters and boundary conditions for the vulnerability assessment.
  - Review and selection of Yellow Quill infrastructure to be assessed.
  - Location, current use, strategic importance of selected infrastructure.
  - Review of past weather-related performance issues and concerns.
    - Discussion: Infrastructure concerns related to current climate.
- Roles and responsibilities of the team members.
- Next steps – Workshop 2

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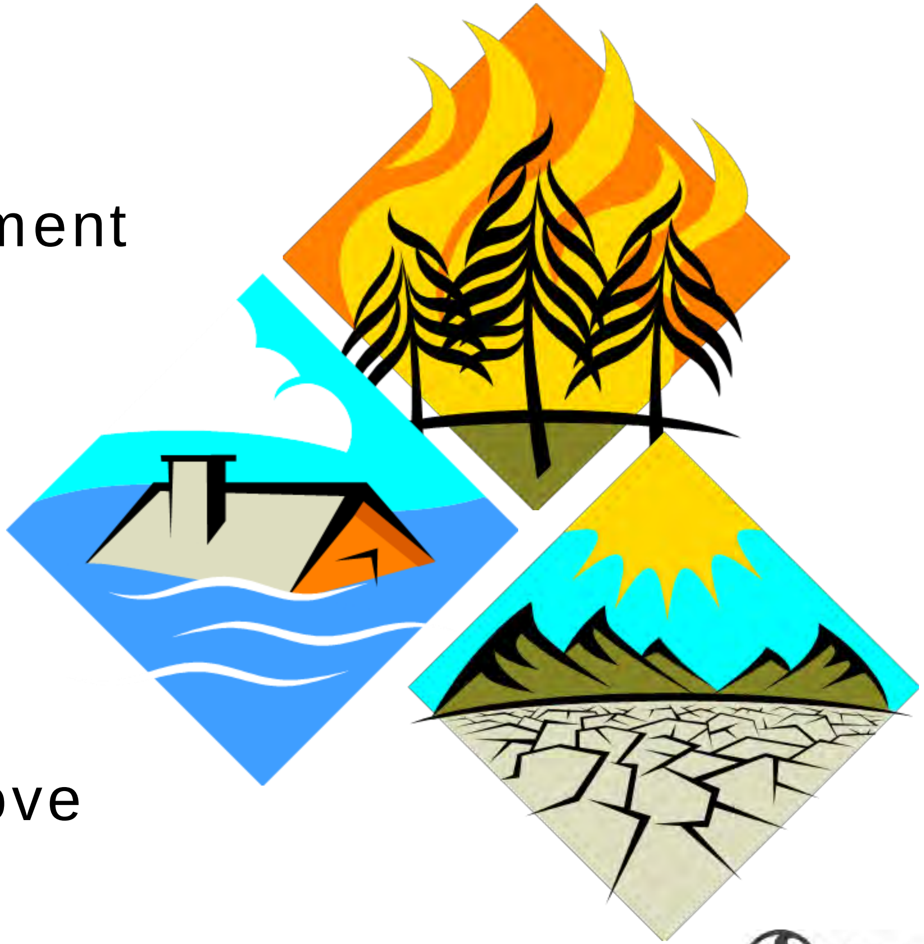
Why Define Infrastructure Risks?

- Minimize service disruptions
- Protect people, property and the environment
- Optimize service
  - Manage lifecycle
  - Manage operations
  - Avoid surprises
  - Reduce/avoid costs
- To deal with the uncertainties of future climate
- First step in risk reduction planning to improve (climate) resilience



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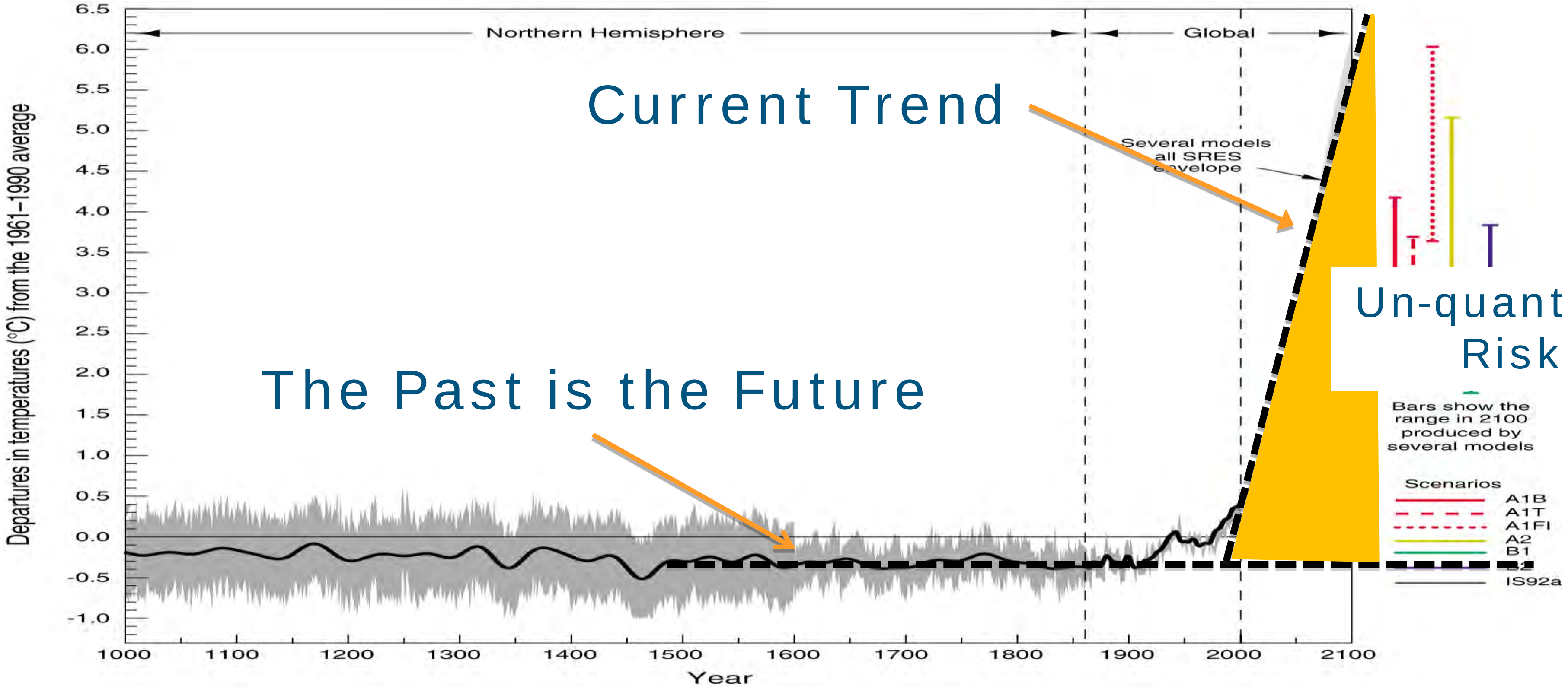
Corporation

YELLOW QUILL FIRST NATION #90
TREATY 4

Infrastructure Vulnerability to CC

From planning, design, operations and maintenance



Current Trend

The Past is the Future

Un-quantified Risk

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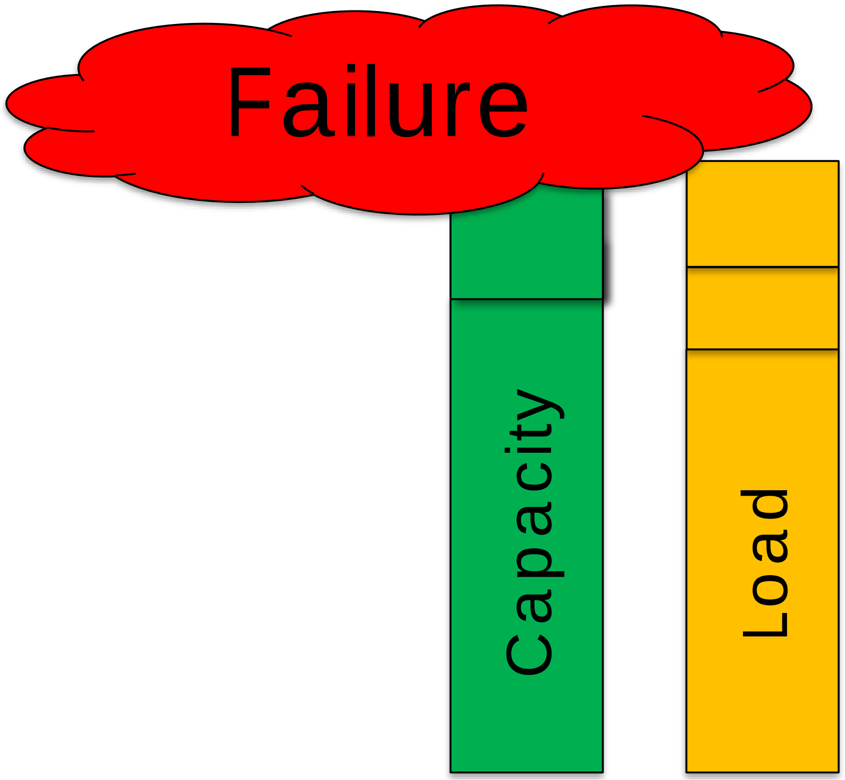
Ontario First Nations Technical Services Corporation

How do Small Changes Lead to Catastrophic Failure?



- Design Capacity
- Safety Factor
- Impact of age on structure
- Impact of unforeseen weathering

- Design Load
- Change of use over time
  - e.g. population growth
- Severe climate event

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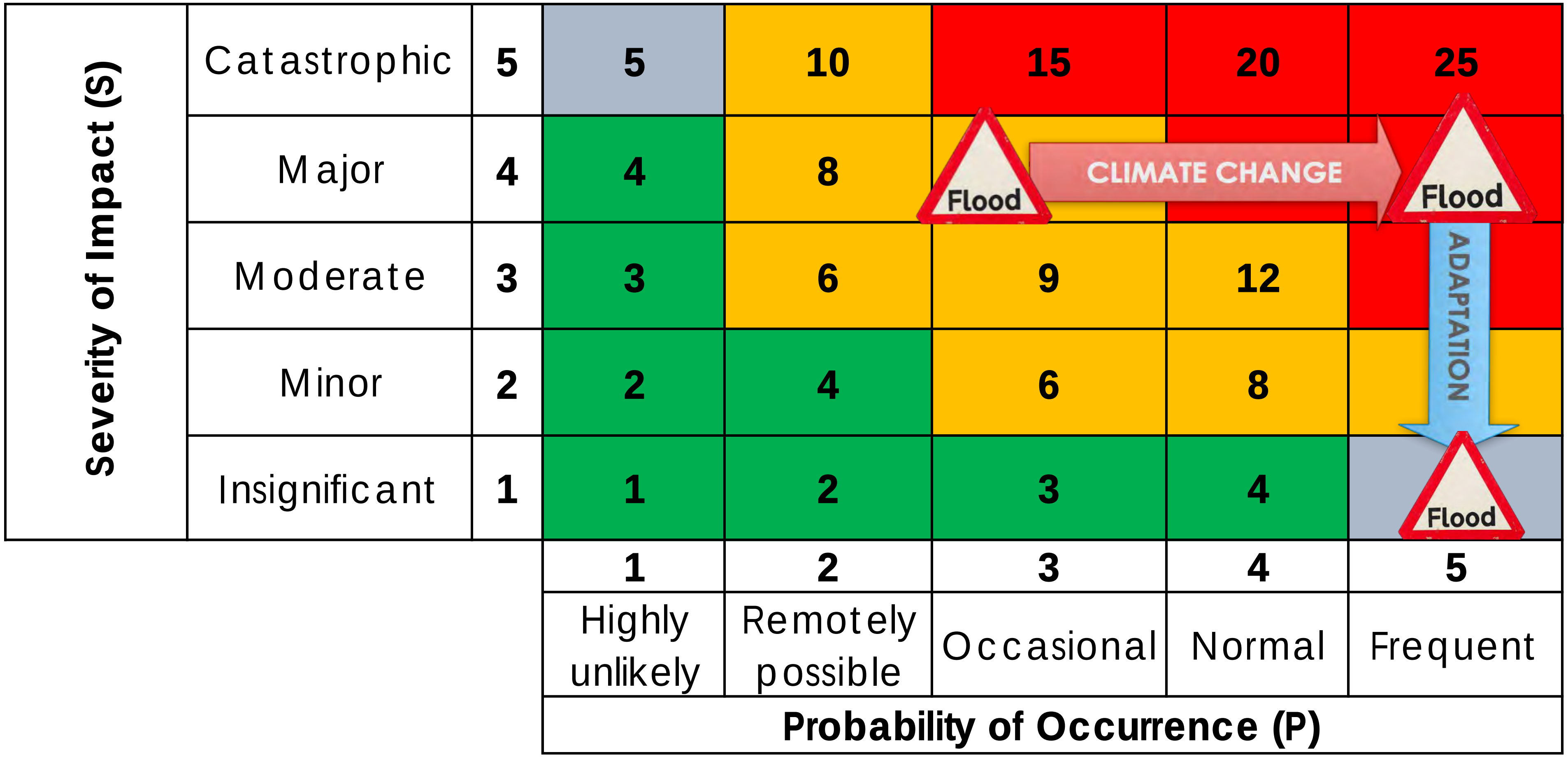

Severity of Impact (S)	Catastrophic	5	5	10	15	20	25
	Major	4	4	8			
	Moderate	3	3	6	9	12	
	Minor	2	2	4	6	8	
	Insignificant	1	1	2	3	4	
			1	2	3	4	5
			Highly unlikely	Remotely possible	Occasional	Normal	Frequent
			Probability of Occurrence (P)				

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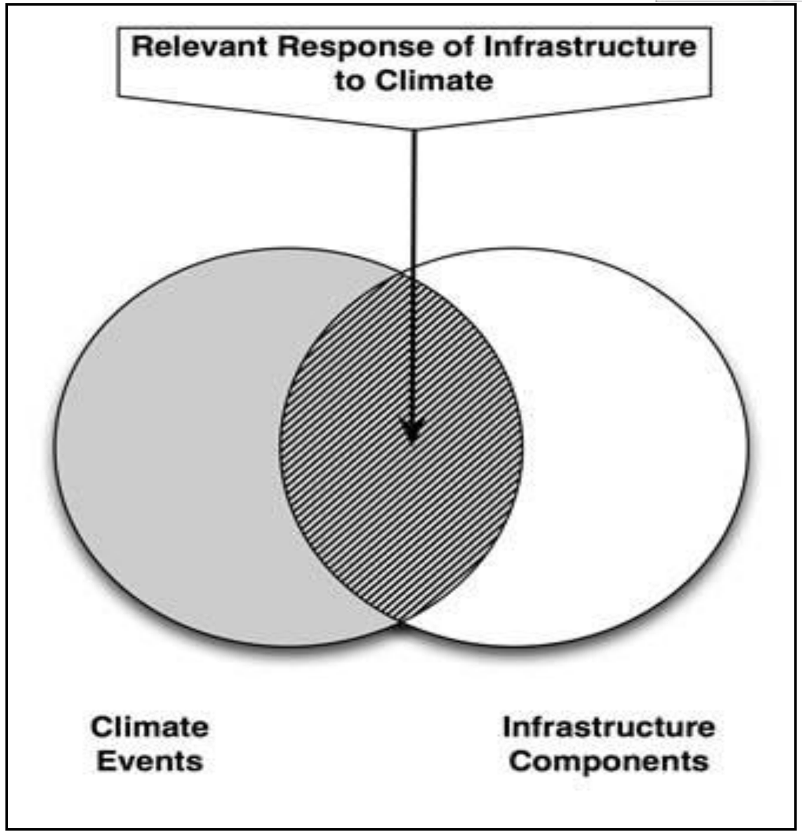
The FN-PIEVC Protocol

- Four-step evaluation process
- A tool derived from standard risk management methodologies
- Intended for use by qualified professionals
- Requires contributions from those with pertinent local knowledge and experience
- Focused on the principles of vulnerability and resiliency



engineerscanada ingénieurscanada

Public Infrastructure Engineering Vulnerability Committee (PIEVC)

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First Nation Infrastructure Resiliency Toolkit (FN-IRT)

- Based on Engineers Canada’s PIEVC Protocol
- License rights belong to Ontario First Nations Technical Services Corporation (OFNTSC)
- Specifically designed for use with First Nation Communities
    - Use local and existing knowledge (Elders)
    - Uses existing data common to all FN Communities (e.g., ACRS and ICMS data, PSAB- etc.)

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TREATY 4

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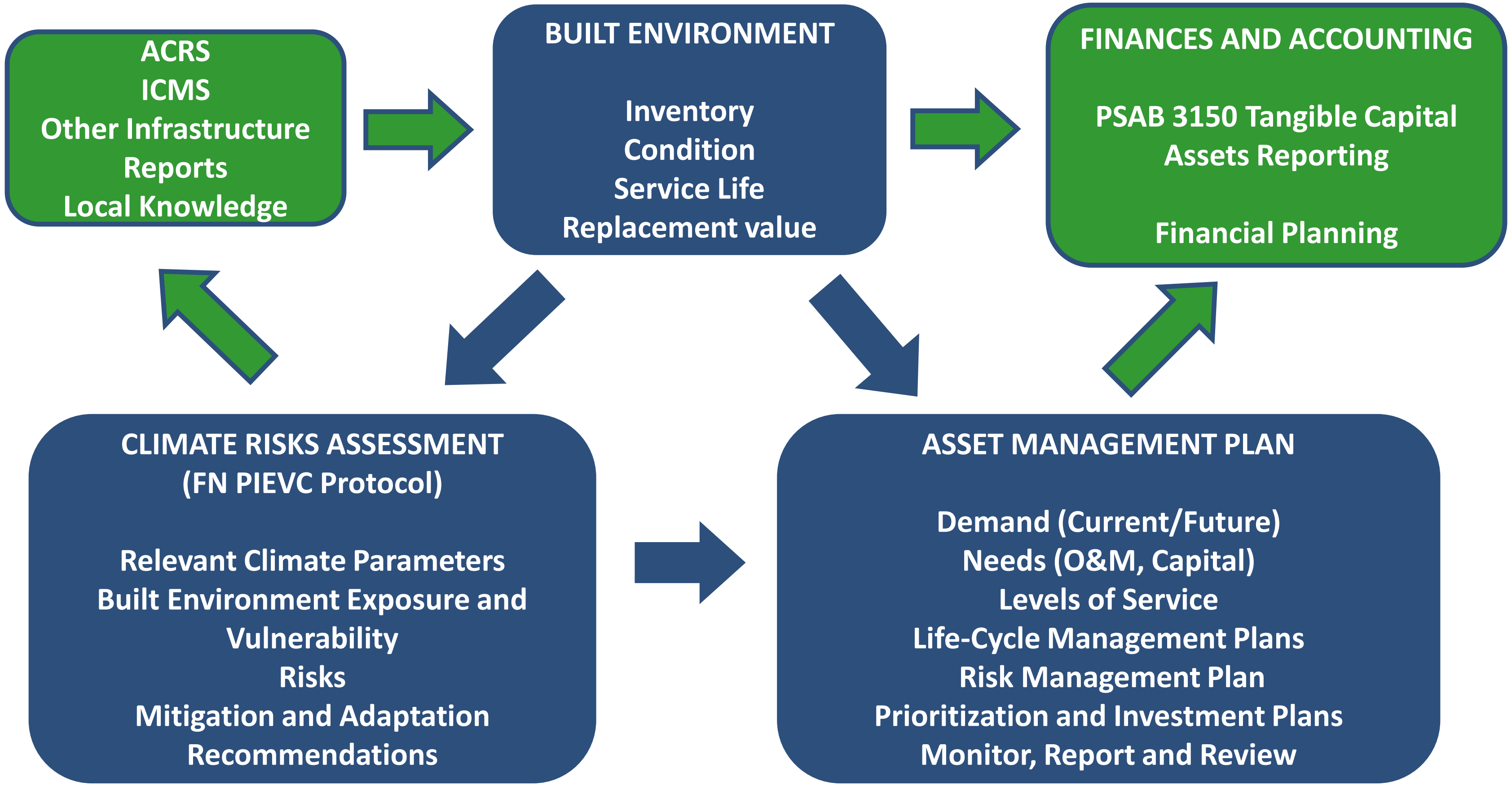
FN Infrastructure Resilience/AM Toolkit



ACRS
ICMS
Other Infrastructure Reports
Local Knowledge

BUILT ENVIRONMENT

Inventory
Condition
Service Life
Replacement value

FINANCES AND ACCOUNTING

PSAB 3150 Tangible Capital Assets Reporting

Financial Planning

CLIMATE RISKS ASSESSMENT
(FN PIEVC Protocol)

Relevant Climate Parameters
Built Environment Exposure and Vulnerability
Risks
Mitigation and Adaptation Recommendations

ASSET MANAGEMENT PLAN

Demand (Current/Future)
Needs (O&M, Capital)
Levels of Service
Life-Cycle Management Plans
Risk Management Plan
Prioritization and Investment Plans
Monitor, Report and Review

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Ontario First Nations Technical Services Corporation

Based on Engineers Canada's PIEVC Protocol

FN PIEVC Climate Change Infrastructure Vulnerability Assessment Process

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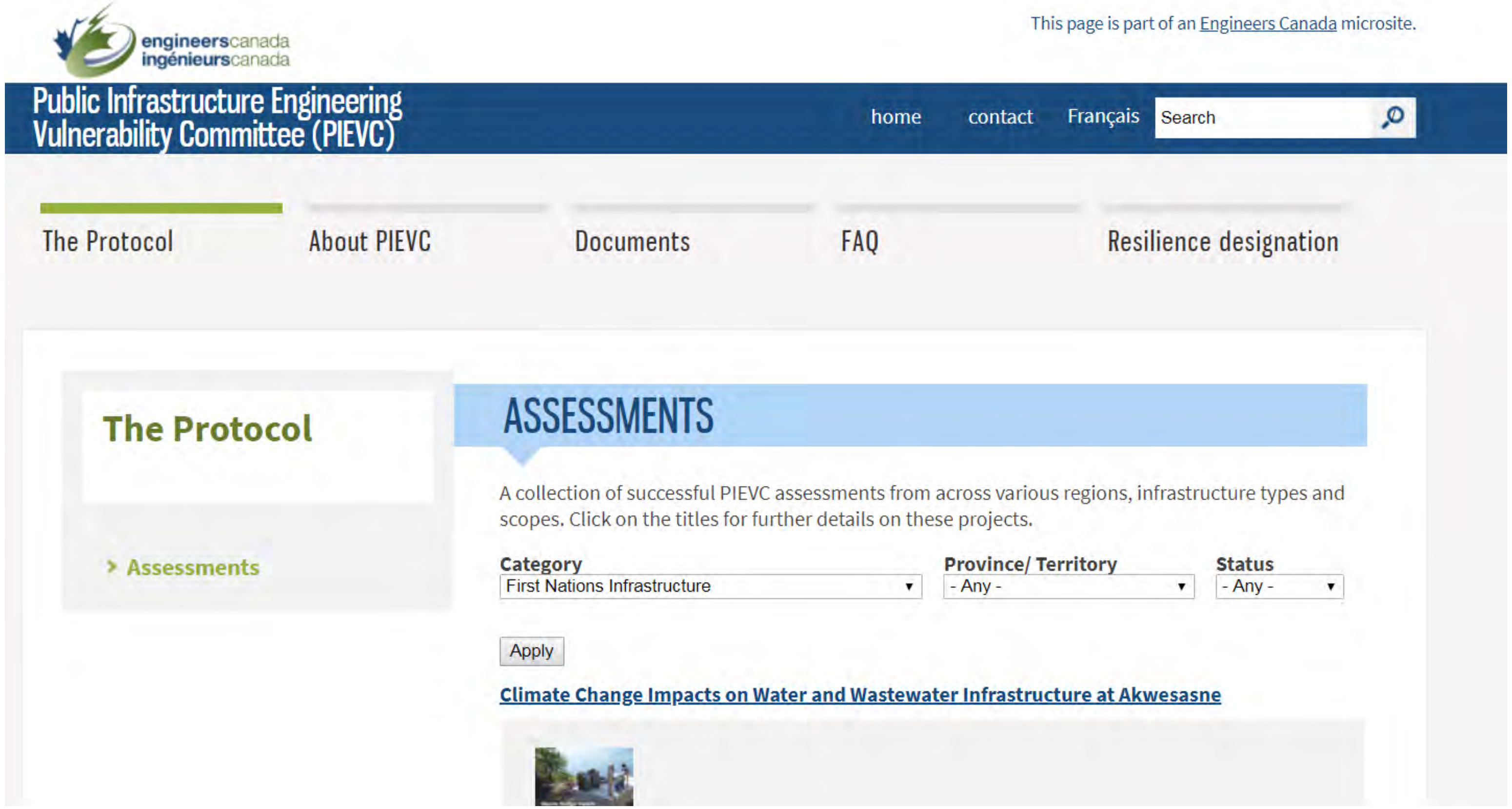
FN PIEVC Case Studies

www.PIEVC.ca

FN Infrastructure assessments:

- Moose Factory
- Oneida
- Akwesasne



This page is part of an Engineers Canada microsite.

ASSESSMENTS

A collection of successful PIEVC assessments from across various regions, infrastructure types and scopes. Click on the titles for further details on these projects.

Category: First Nations Infrastructure
Province/ Territory: - Any -
Status: - Any -

Climate Change Impacts on Water and Wastewater Infrastructure at Akwesasne

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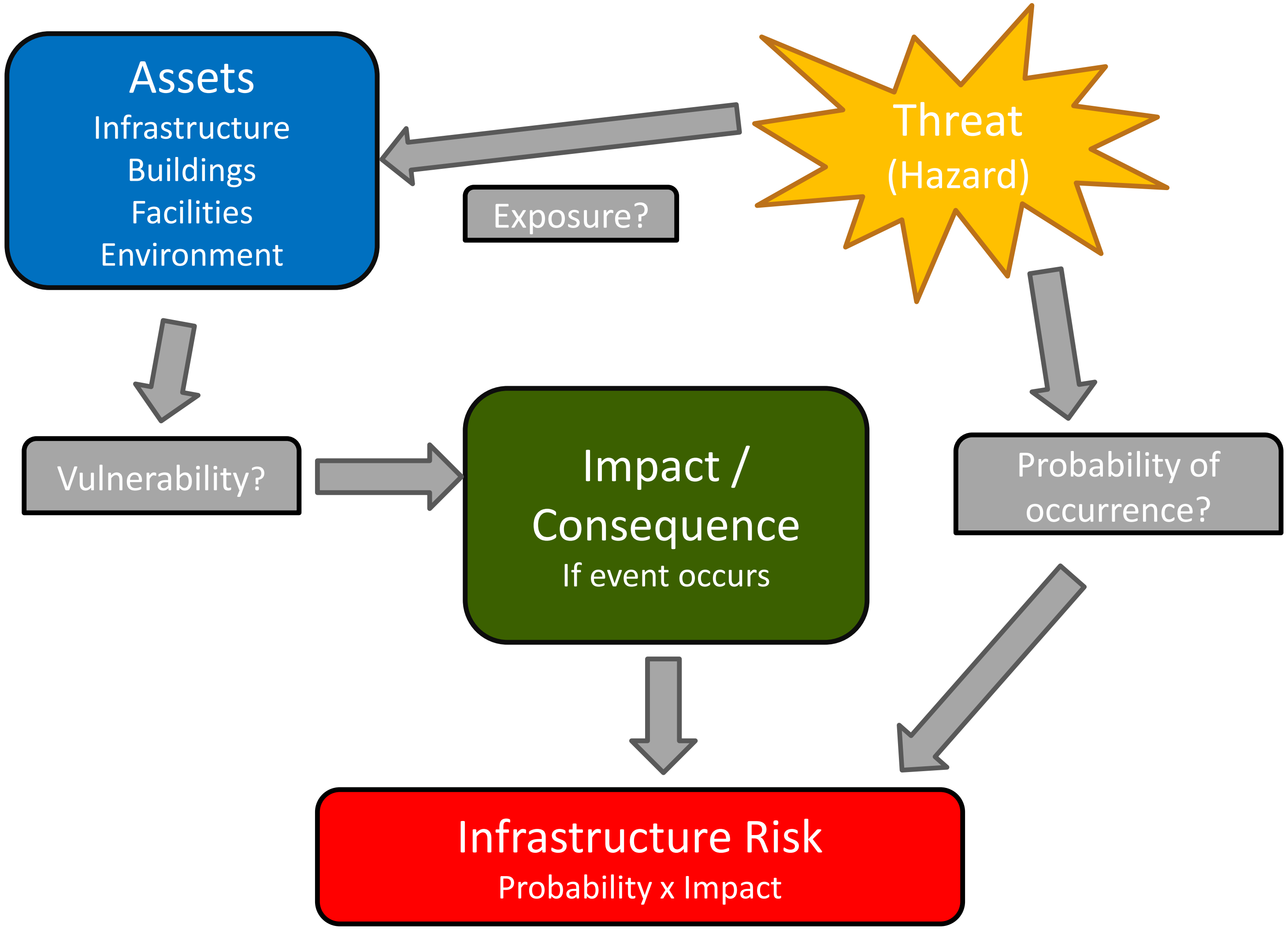

Assets
Infrastructure
Buildings
Facilities
Environment

Threat
(Hazard)

Exposure?

Vulnerability?

Impact / Consequence
If event occurs

Probability of occurrence?

Infrastructure Risk
Probability x Impact

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YELLOW QUILL FIRST NATION #90
TREATY 4

Assessing Infrastructure Vulnerability to Climate Change

Infrastructure Definition Process

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Yellow Quill

Identify the components of the infrastructure to be assessed in general terms

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Infrastructure Definition

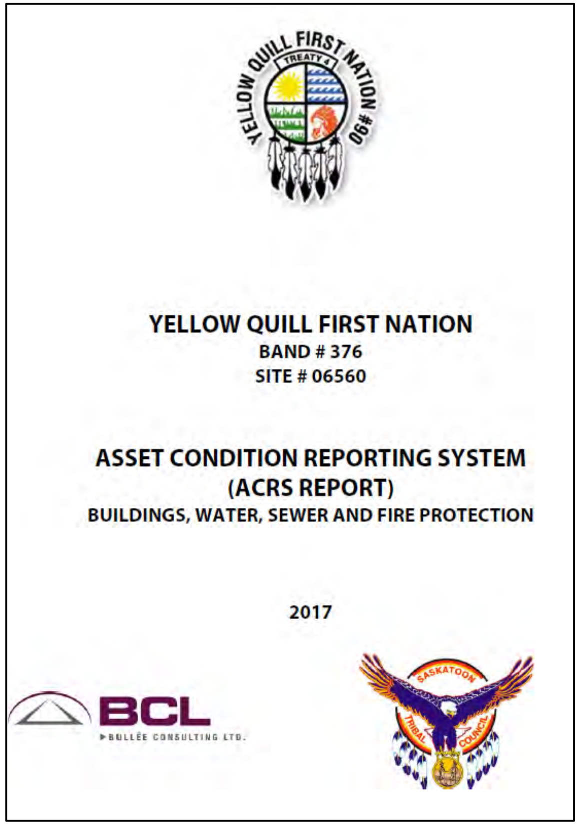
- Define the global project parameters and boundary conditions for the climate vulnerability assessment.
  - Which infrastructure and infrastructure components are being assessed?
  - Its location?
  - Climatic, geographic considerations?
  - Define performance criteria, and
  - Uses of the infrastructure and related services provided.

☑ First step of narrowing the focus to allow efficient data acquisition and vulnerability assessment.

Determine the Infrastructure List

Main components

- Potable Water System
  - Source, treatment, distribution, storage
- Wastewater System
  - Collection and treatment
- Administration and operations
  - Health Center
  - Band office, ceremonial Octagon, residential housing
  - Public works buildings
- Roads, bridges, culverts
- Others?



YELLOW QUILL FIRST NATION
BAND # 376
SITE # 06560

ASSET CONDITION REPORTING SYSTEM
(ACRS REPORT)
BUILDINGS, WATER, SEWER AND FIRE PROTECTION

2017

Ontario First Nations
Technical Services
Corporation

Discussion

What infrastructure will be assessed?

What information is available?

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YELLOW QUILL FIRST NATION #90

TREATY 4

Assessing Infrastructure Vulnerability to Climate Change

Infrastructure Performance Criteria

How will the infrastructure be affected by climate events?

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Recommended Performance Criteria

Structural:

- Load carrying capacity
- Fracture / collapse
- Material fatigue and weakening
- Access
- Deflection / permanent deformation
- Cracking and deterioration

Functionality/Capacity:

- Effective capacity of the infrastructure to provide the intended service:
  - Short term
  - Medium term
  - Long term

Operations, maintenance, and materials performance:

- Occupational safety
- Access to worksite
- Equipment performance
- Maintenance and replacement cycles
- Electricity demand
- Fuel use
- Materials Performance
- Changes from design expectation

Assessing Infrastructure Vulnerability to Climate Change

Climate Events

Discussion

What weather-related events have caused infrastructure failures or service disruptions in the past?

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Next Steps

Workshop 2

- Infrastructure performance considerations: Development of Yellow Quill severity scale.
- Review/selection of climate data - past climate events and impacts
- Introduction to FN PIEVC Risk Matrix

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TREATY 4

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Technical Services
Corporation

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Thank You Miigwech

APPENDIX B

WORKSHOP 2 POWERPOINT PRESENTATION

Yellow Quill First Nation
Workshop #2
FN PIEVC Infrastructure Vulnerability Assessment
Infrastructure Exposure and Climate Considerations

Dr. Guy Félio, P.Eng., FCSCE, IRP[Climate]
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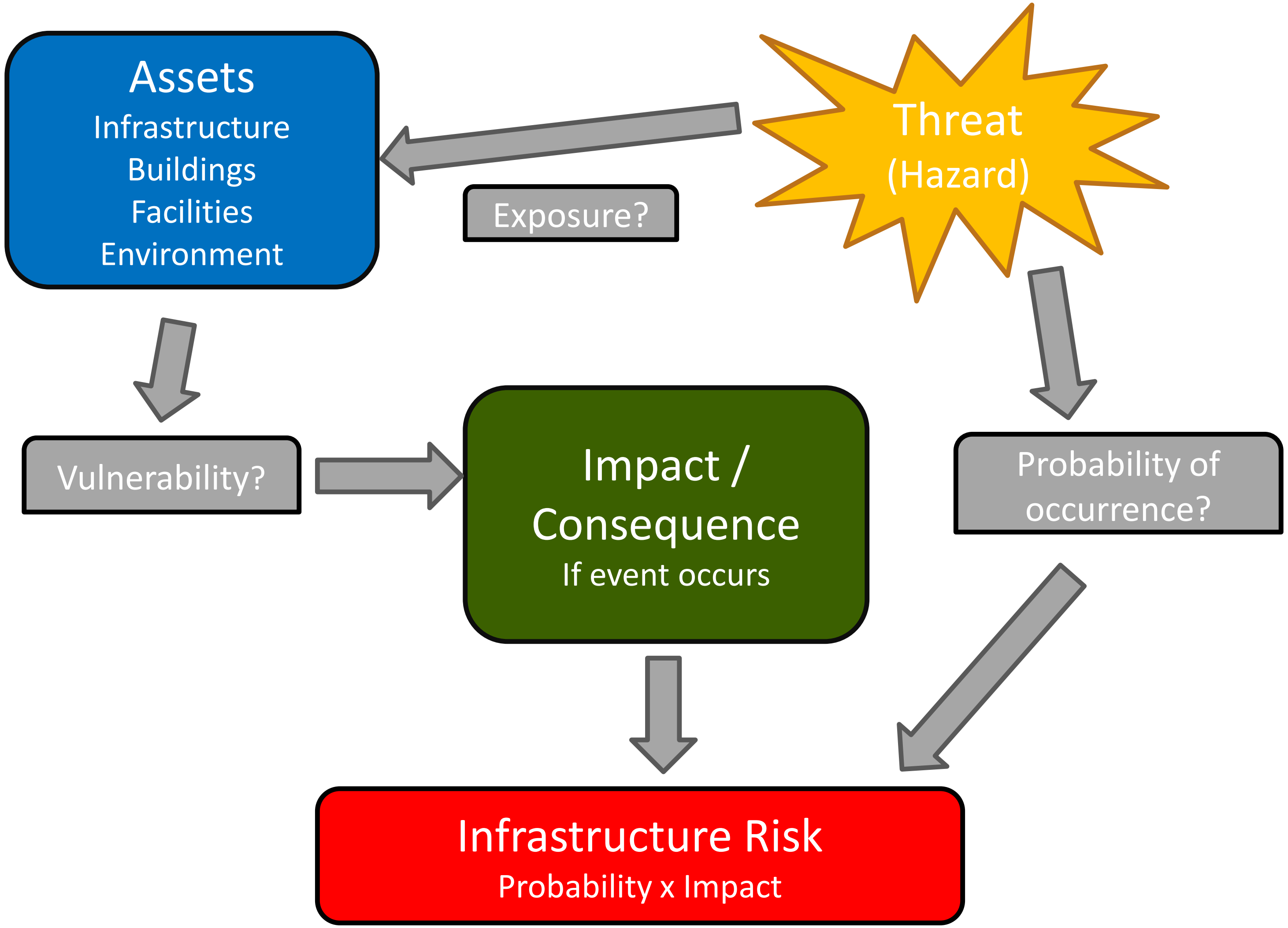
Project Manager, Stantec

Wednesday August 14, 2019



Assets

Infrastructure

Buildings

Facilities

Environment

Threat

(Hazard)

Exposure?

Vulnerability?

Impact / Consequence

If event occurs

Probability of occurrence?

Infrastructure Risk

Probability x Impact

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FN PIEVC Risk Matrix

Asset/Infrastructure Elements	ACRS/ICMS Information			Climate 1							Climate 2							Climate 3							Climate 4						
				Temperature							Temperature							Precipitation							Precipitation						
CLIMATE ASSESSMENT Select: Current ■ Future ☐	Asset #	Year constructed	General condition	Heat Wave Three consecutive days >30C; Evenings >20C							Seasonal Variation Cooling Degree Days >240							50mm Rain in 1 Hour							Freezing Rain 15-25mm acummulation						
				Probability: 5							Probability: 3							Probability: 2							Probability: 3						
				Y/	Severity			Risk			Y/	Severity			Risk			Y/	Severity			Risk			Y/	Severity			Risk		
				N	S_s	S_o	S_f	R_s	R_o	R_f	N	S_s	S_o	S_f	R_s	R_o	R_f	N	S_s	S_o	S_f	R_s	R_o	R_f	N	S_s	S_o	S_f	R_s	R_o	R_f
WATER SYSTEM																															
Water Intake - Surface Water Source		2001	4	Y	0	0	0	0	0	0	N							Y		3		6			N						
Pipes - includes valves		1999	7	N							N							N							Y	0	0	0	0	0	0
WTP		2001	6																												
Roof-flat		2001	6	Y	1	1		5	5		N							Y		3		6			Y		1	1		3	3
Structure		2001	6	N							N							N							N						
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HVAC System		2001	5	Y		3	3		15	15	Y		2	2	6	6		Y		2	2	4	4		Y		2	2		6	6
Treatment Equipment		2010	6	N							N							N							N						
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COMMUNITY CENTRE																															
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Back-up Power		2012	7	Y	0	0	0	0	0	0	Y		1	1		3	3	N							Y	1	1	1	3	3	3
WW SYSTEM																															

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Climate Vulnerability Assessment of Yellow Quill FN Infrastructure

Infrastructure to be Assessed

From Workshop 1

Infrastructure List

- Community Buildings
  - School, Safe House, Firehall, Health Centre, Headstart Building
- Water and Wastewater Systems
- Houses- Serviced and Unserviced
- Roads and Drainage – Culverts
- Third Party Services
  - Power/Hydro, Gas, Telecommunications

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YELLOW QUILL FIRST NATION #90 TREATY 4

“If a climate event impacts the infrastructure, how will the condition and performance be affected?”

Establish the Infrastructure Performance Criteria

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Recommended Performance Criteria

Structural:

- Load carrying capacity
- Fracture / collapse
- Material fatigue and weakening
- Access
- Deflection / permanent deformation
- Cracking and deterioration

Functionality/Capacity:

- Effective capacity of the infrastructure to provide the intended service:
  - Short term
  - Medium term
  - Long term

Operations, maintenance, and materials performance:

- Occupational safety
- Access to worksite
- Equipment performance
- Maintenance and replacement cycles
- Electricity demand
- Fuel use
- Materials Performance
- Changes from design expectation

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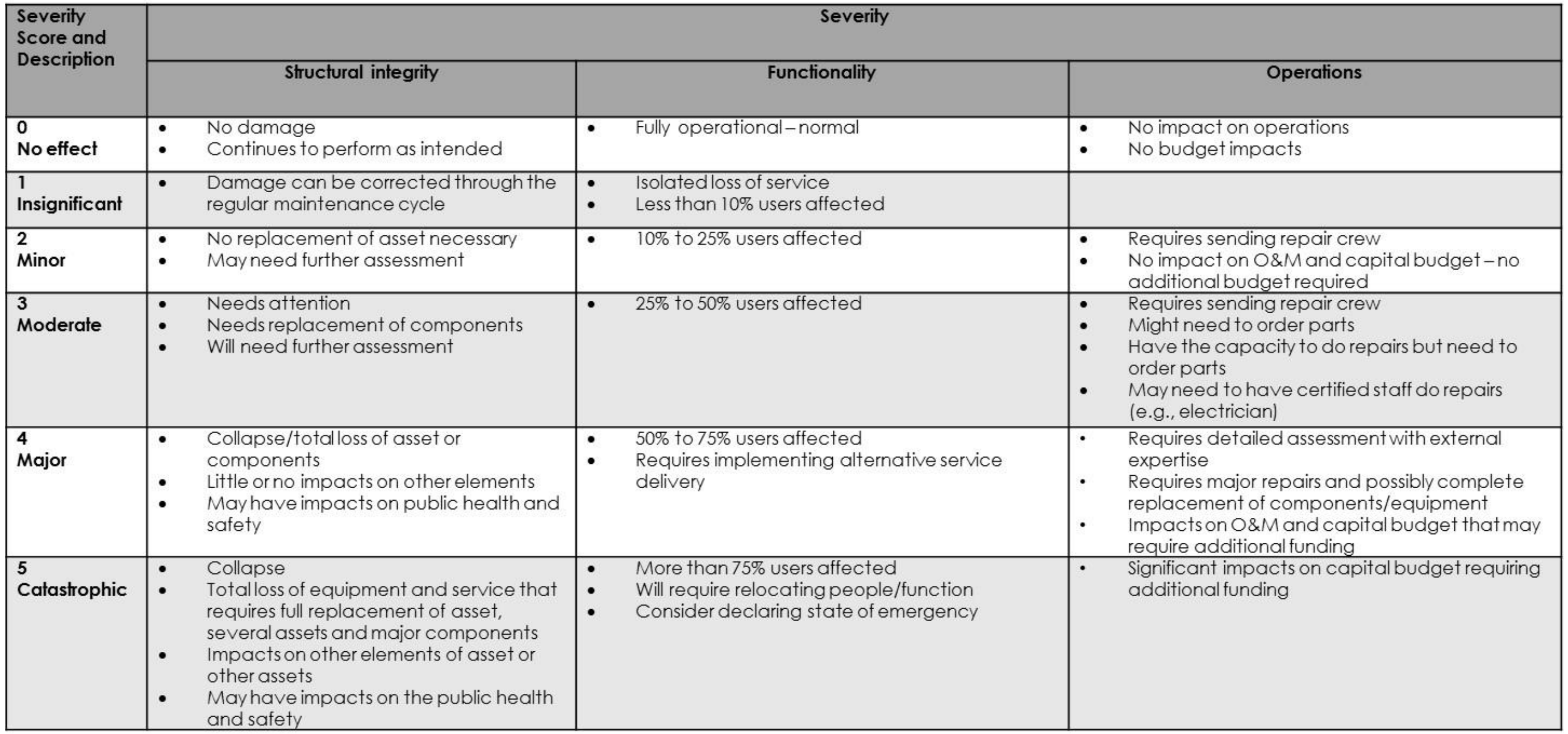
Example - Severity of impacts

- See separate handout



Severity Score and Description	Severity		
	Structural integrity	Functionality	Operations
0 **No effect**	No damage Continues to perform as intended	Fully operational – normal	No impact on operations No budget impacts
1 **Insignificant**	Damage can be corrected through the regular maintenance cycle	Isolated loss of service Less than 10% users affected	
2 **Minor**	No replacement of asset necessary May need further assessment	10% to 25% users affected	Requires sending repair crew No impact on O&M and capital budget – no additional budget required
3 **Moderate**	Needs attention Needs replacement of components Will need further assessment	25% to 50% users affected	Requires sending repair crew Might need to order parts Have the capacity to do repairs but need to order parts May need to have certified staff do repairs (e.g., electrician)
4 **Major**	Collapse/total loss of asset or components Little or no impacts on other elements May have impacts on public health and safety	50% to 75% users affected Requires implementing alternative service delivery	Requires detailed assessment with external expertise Requires major repairs and possibly complete replacement of components/equipment Impacts on O&M and capital budget that may require additional funding
5 **Catastrophic**	Collapse Total loss of equipment and service that requires full replacement of asset, several assets and major components Impacts on other elements of asset or other assets May have impacts on the public health and safety	More than 75% users affected Will require relocating people/function Consider declaring state of emergency	Significant impacts on capital budget requiring additional funding

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Group develops project rating scale

Severity Score and Description	Severity		
	Structural integrity	Functionality	Operations
0 **No effect**			
1 **Insignificant**			
2 **Minor**			
3 **Moderate**			
4 **Major**			
5 **Catastrophic**			

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Yellow Quill
Climate Elements to Consider

General information on projections

Discussion on past events that have caused infrastructure disruptions and/or damage

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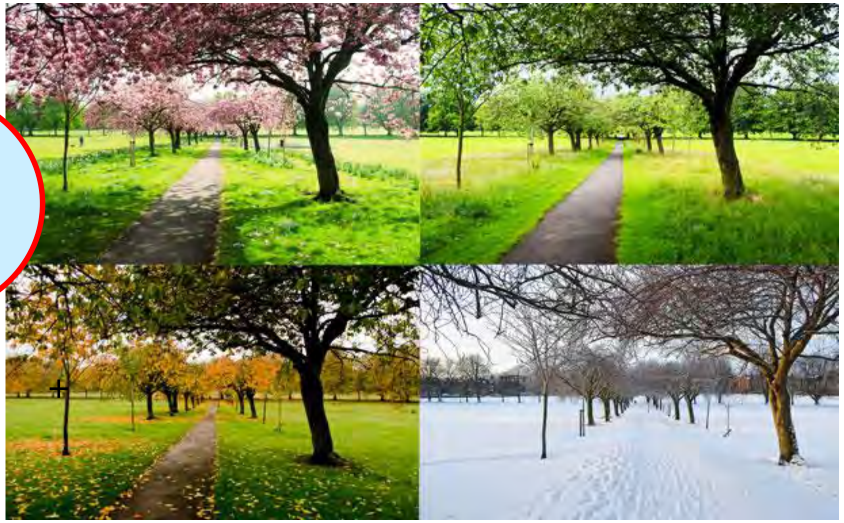
YELLOW QUILL FIRST NATION #90 TREATY 4

Weather vs Climate: Is it “news” or is it “history”?

VS.



Weather (*what you get*):

- Conditions today and over the next few days;
- “We *operate* infrastructure day-to-day on the basis of weather”

Climate (*what you typically expect*):

- Weather over time;
- “We *plan* and *design* for the longer
- term on the basis of climate” (*includes local to global scales*)

* https://briff.me/2015/01/08/umbrella/umbrella-8-cats-under-umbrella/
+ https://www.publicdomainpictures.net/en/view-image.php?image=26731&picture=the-four-seasons

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Weather, Climate and Roads

Weather: can change in minutes (*operations*)

vs

Climate: changes over seasons to decades+ (*design*)

Winter road maintenance*

Road/bridge design and rehabilitation+

* http://www.mto.gov.on.ca
\+ https://mymuskopkanow.com

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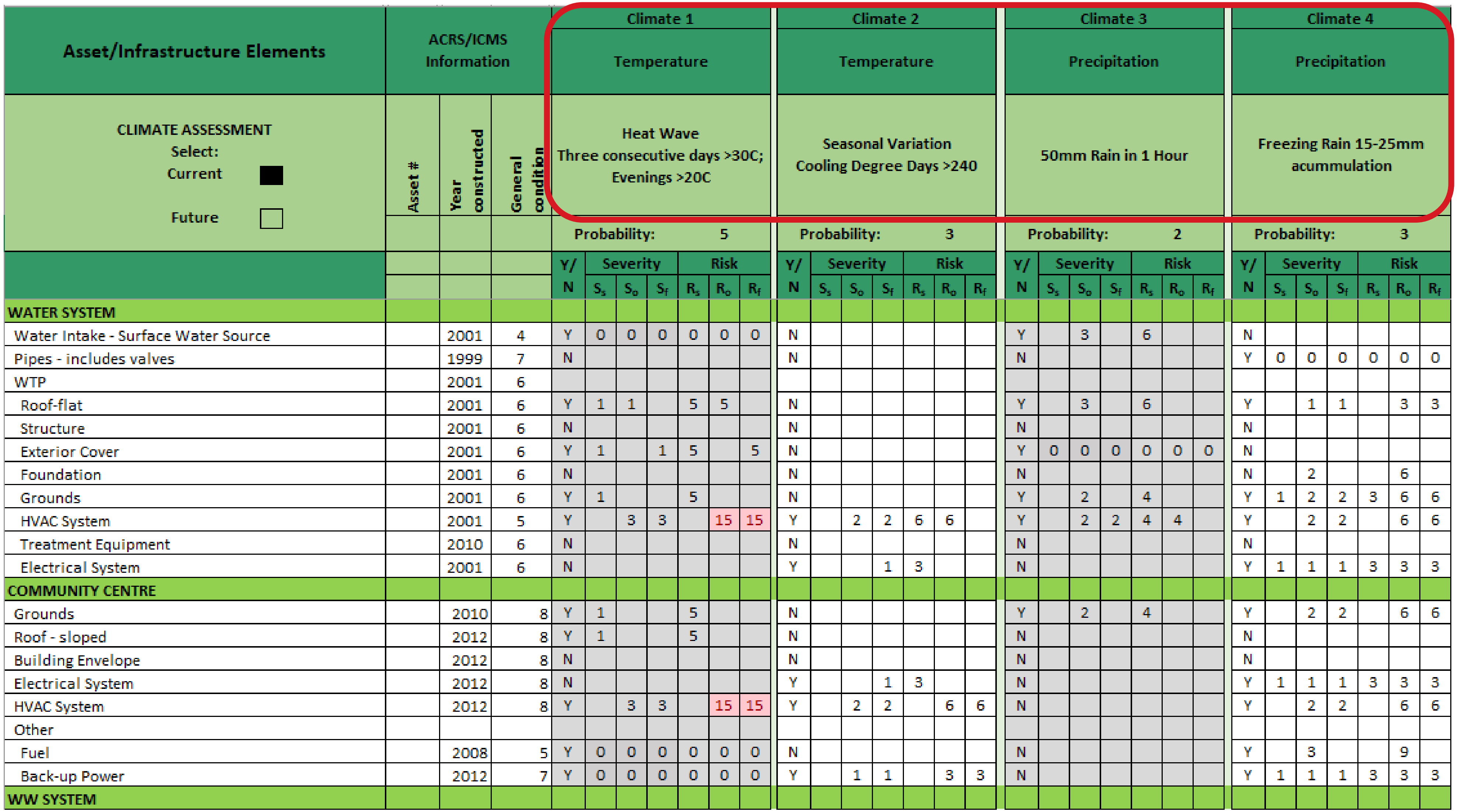
FN PIEVC Risk Matrix



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					S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f
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WW SYSTEM																															

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Discussion

How is the climate changing in Yellow Quill?

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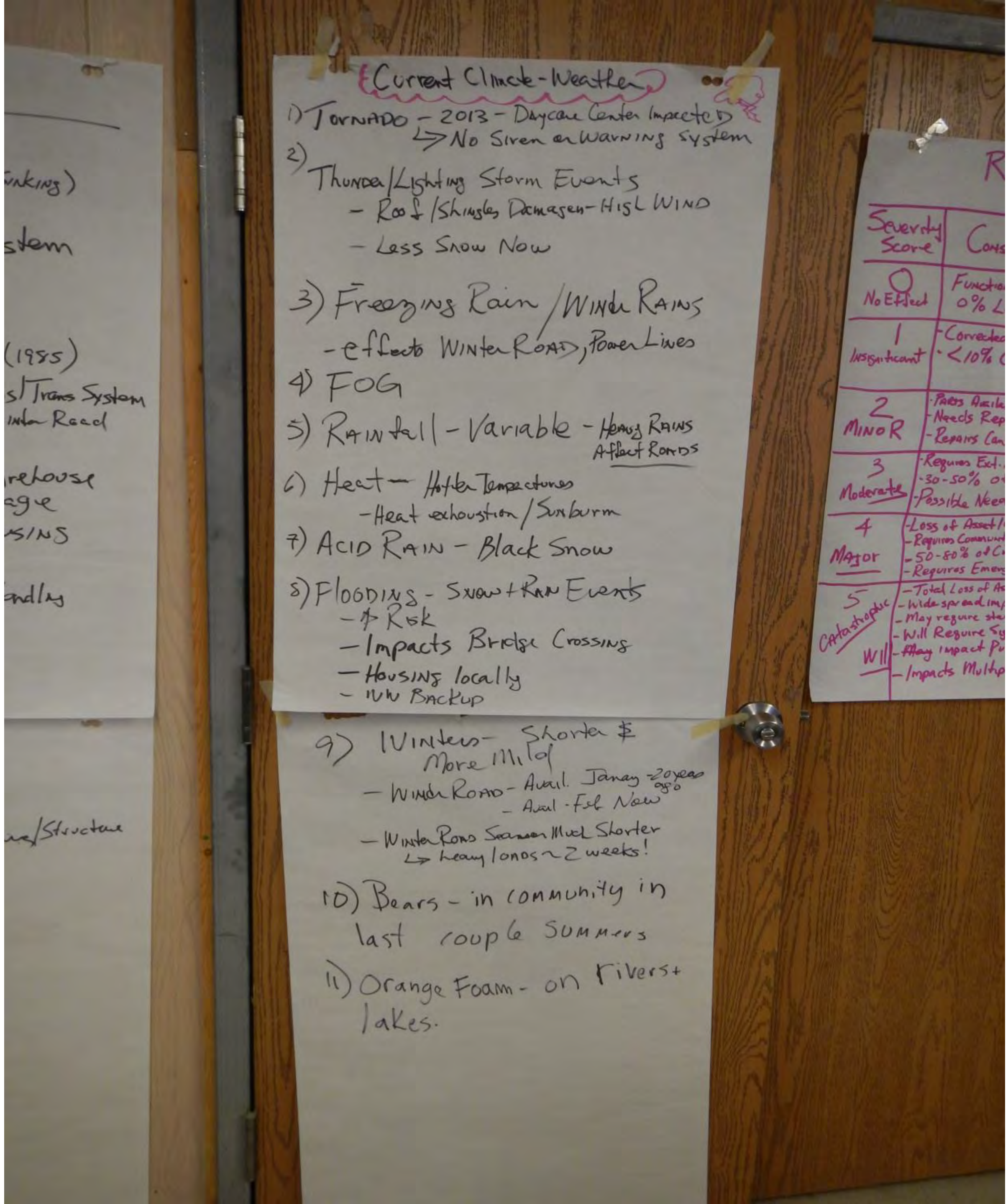
CREATE A LIST OF CLIMATE EVENTS THAT HAVE CAUSED INFRASTRUCTURE DAMAGE OR DISRUPTIONS



Current Climate-Weather

1) Tornado - 2013 - Daycare Center Impacted
↳ No Siren or Warning System
2) Thunder/Lighting Storm Events
- Roof/Shingles Damagen - High Wind
- Less Snow Now
3) Freezing Rain / Winter Rains
- effects Winter Road, Power Lines
4) FOG
5) Rainfall - Variable - Heavy Rains Affect Roads
6) Heat - Hotter Temperatures
- Heat exhaustion / Sunburn
7) Acid Rain - Black Snow
8) Flooding - Snow + Rain Events
- ↑ Risk
- Impacts Bridge Crossings
- Housing locally
- WW Backup
9) Winters - Shorter & More Mild
- Winter Road - Avail. January - 20 years ago
- Avail - Feb Now
- Winter Road Season Much Shorter
↳ heavy loads ~ 2 weeks!
10) Bears - in community in last couple summers
11) Orange Foam - on rivers + lakes.

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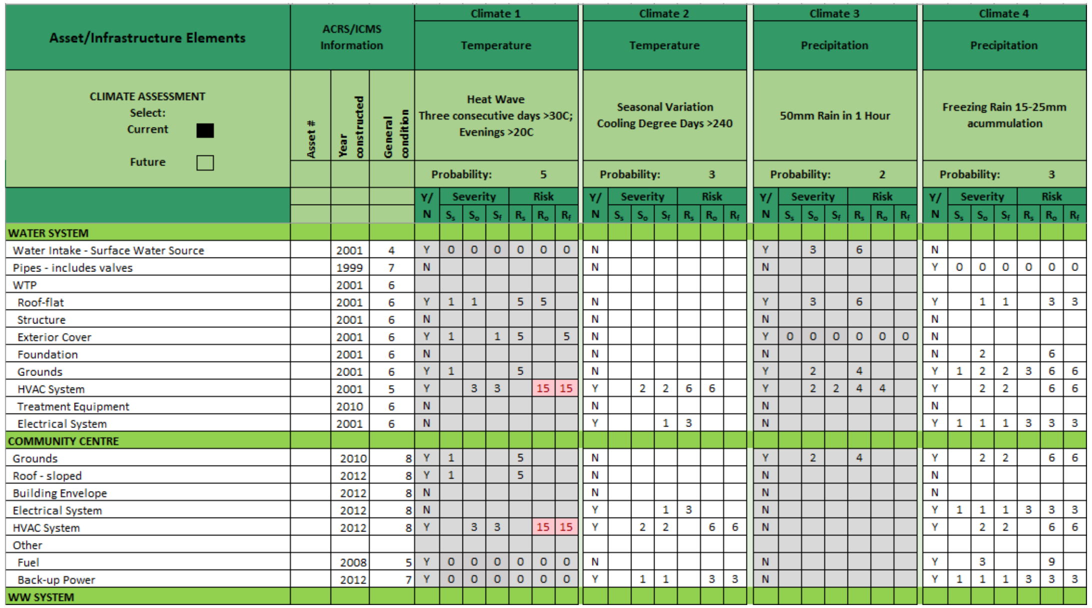
Next Steps

Workshops 3 and 4

- Validation of Infrastructure and Climate
- Risk Matrix
- Adaptation measures



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					S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f
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Foundation		2001	6	N							N							N							N		2			6	
Grounds		2001	6	Y	1			5			N							Y		2		4			Y	1	2	2	3	6	6
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WW SYSTEM																															

Dr. Guy Felio

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Wayne Penno, MBA, P.Eng

Wayne.Penno@Stantec.com

Thank You Miigwech

APPENDIX C

WORKSHOP 3 POWERPOINT PRESENTATION

Ontario First Nations Technical Services Corporation

Yellow Quill First Nation

FN PIEVC Infrastructure Vulnerability Assessment

Risk Assessment Workshop #3

Wayne L. E. Penno, MBA, P.Eng

Project Manager, Stantec

Tuesday August 20, 2019

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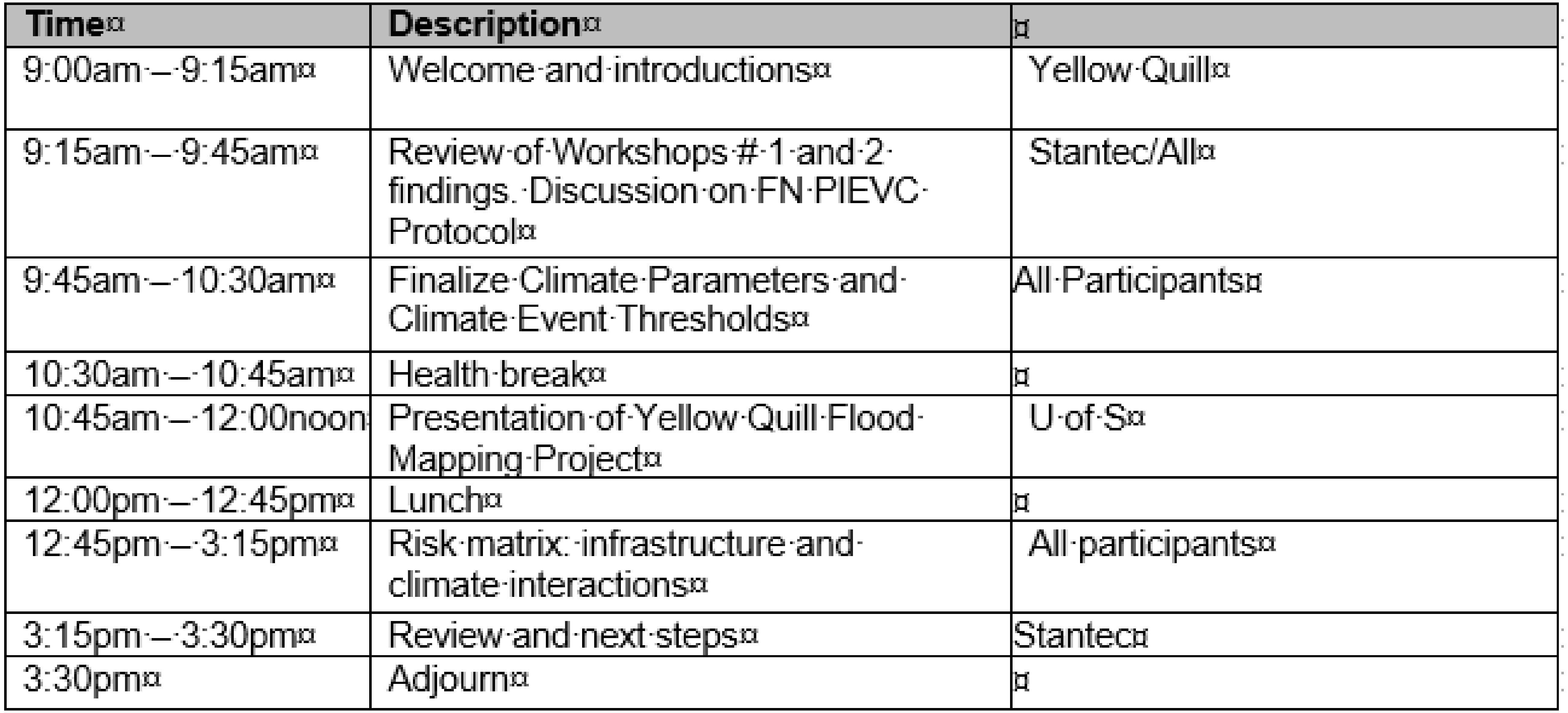
Agenda



Time	Description	
9:00am – 9:15am	Welcome and introductions	Yellow Quill
9:15am – 9:45am	Review of Workshops # 1 and 2 findings. Discussion on FN PIEVC Protocol	Stantec/All
9:45am – 10:30am	Finalize Climate Parameters and Climate Event Thresholds	All Participants
10:30am – 10:45am	Health break	
10:45am – 12:00noon	Presentation of Yellow Quill Flood Mapping Project	U of S
12:00pm – 12:45pm	Lunch	
12:45pm – 3:15pm	Risk matrix: infrastructure and climate interactions	All participants
3:15pm – 3:30pm	Review and next steps	Stantec
3:30pm	Adjourn	

Objectives

- Review of Workshop 1 and 2
- Identification and validation of the climate parameters for the study
- Risk matrix: infrastructure-climate interactions
- Risk Matrix: climate probability ratings, severity of impacts scores and risk calculations
- Summary
- Next steps - Workshop 4

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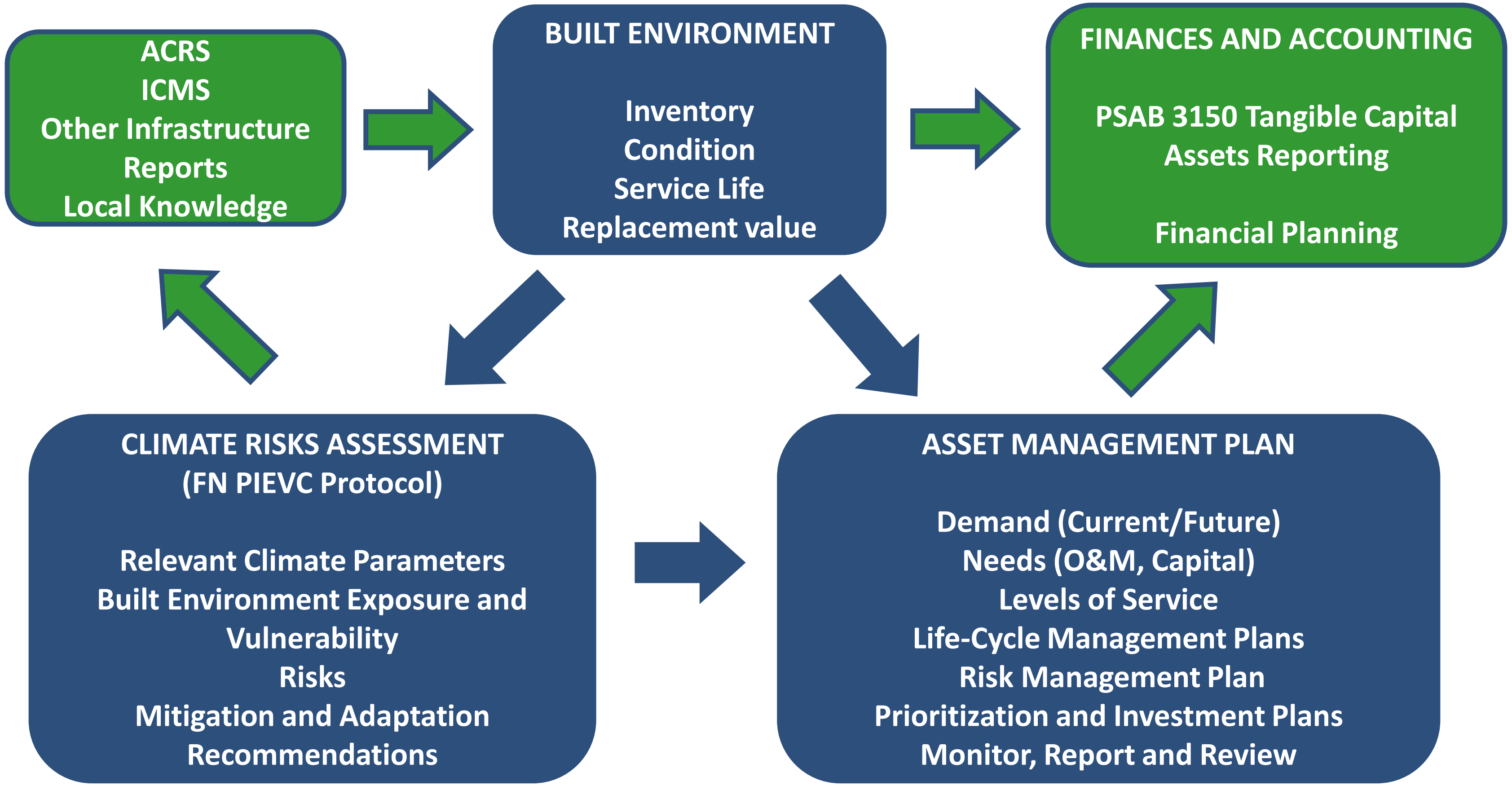
FN Infrastructure Resilience/AM Toolkit



ACRS
ICMS
Other Infrastructure Reports
Local Knowledge

BUILT ENVIRONMENT

Inventory
Condition
Service Life
Replacement value

FINANCES AND ACCOUNTING

PSAB 3150 Tangible Capital Assets Reporting

Financial Planning

CLIMATE RISKS ASSESSMENT
(FN PIEVC Protocol)

Relevant Climate Parameters
Built Environment Exposure and Vulnerability
Risks
Mitigation and Adaptation Recommendations

ASSET MANAGEMENT PLAN

Demand (Current/Future)
Needs (O&M, Capital)
Levels of Service
Life-Cycle Management Plans
Risk Management Plan
Prioritization and Investment Plans
Monitor, Report and Review

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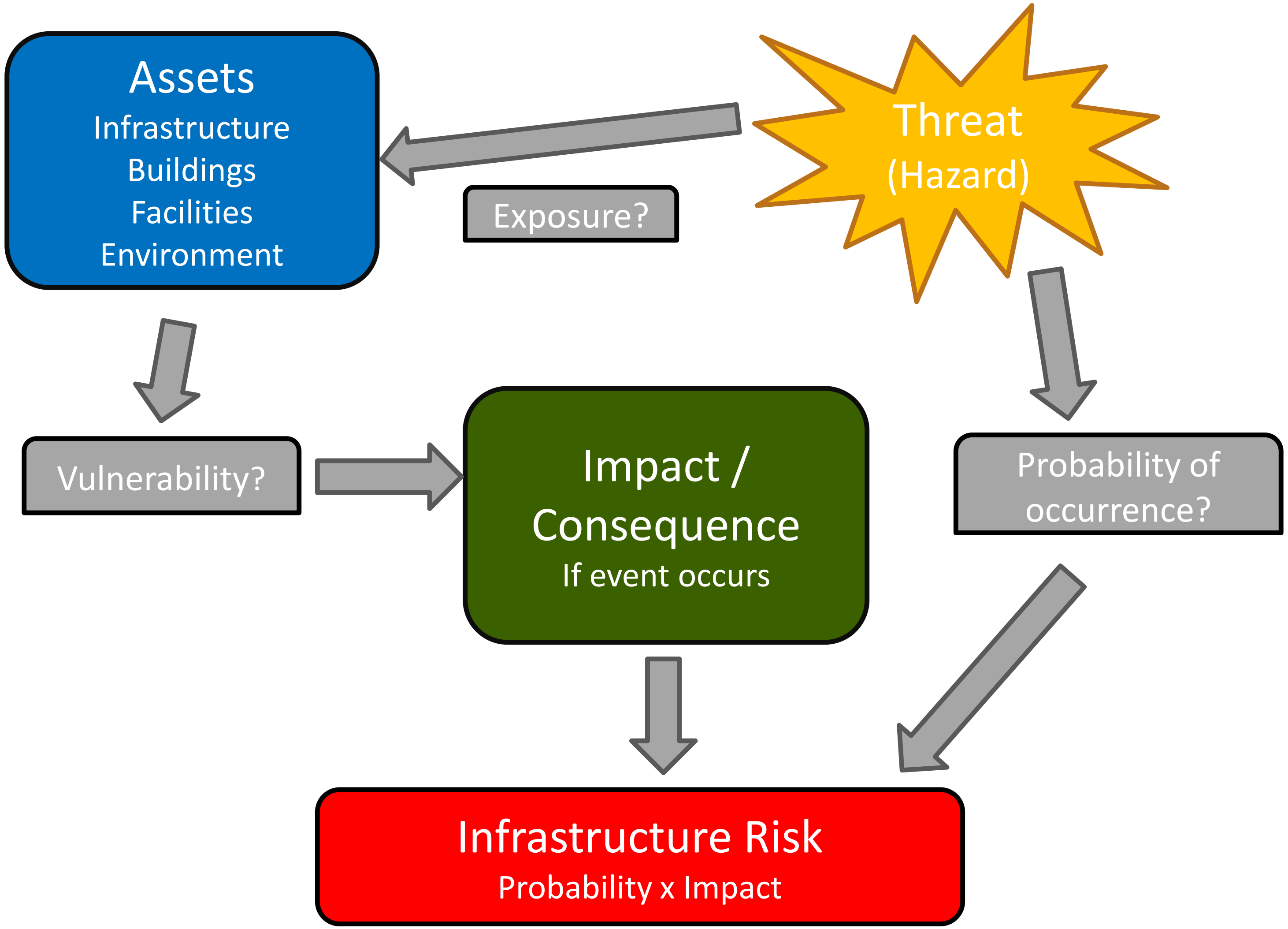


Assets

Infrastructure
Buildings
Facilities
Environment

Threat (Hazard)

Exposure?

Vulnerability?

Impact / Consequence

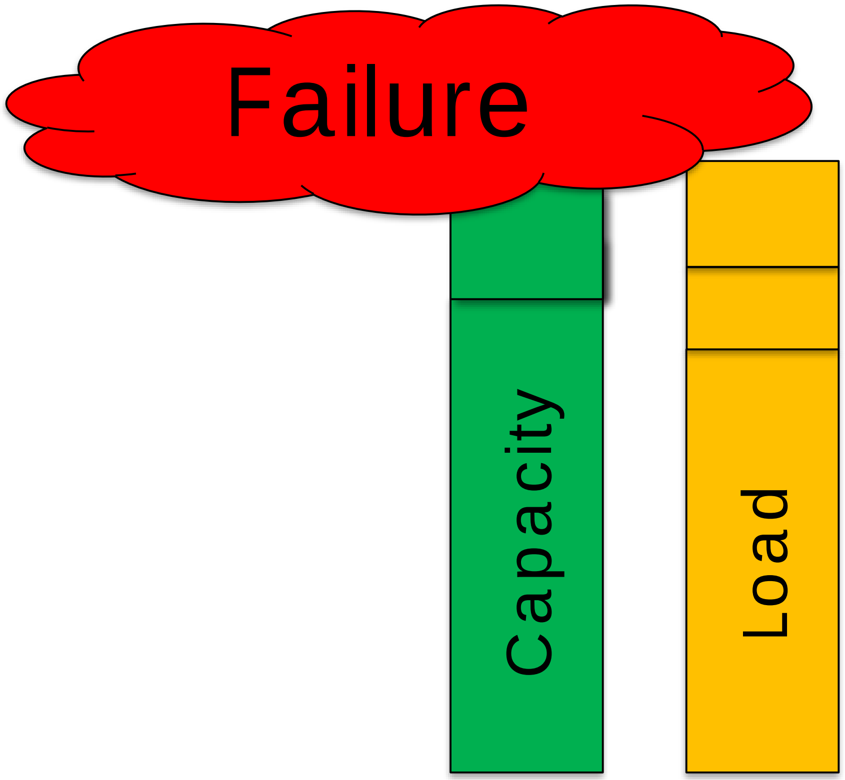
If event occurs

Probability of occurrence?

Infrastructure Risk

Probability x Impact

How do Small Changes Lead to Catastrophic Failure?



- Design Capacity
- Safety Factor
- Impact of age on structure
- Impact of unforeseen weathering

- Design Load
- Change of use over time
  - e.g. population growth
- Severe climate event

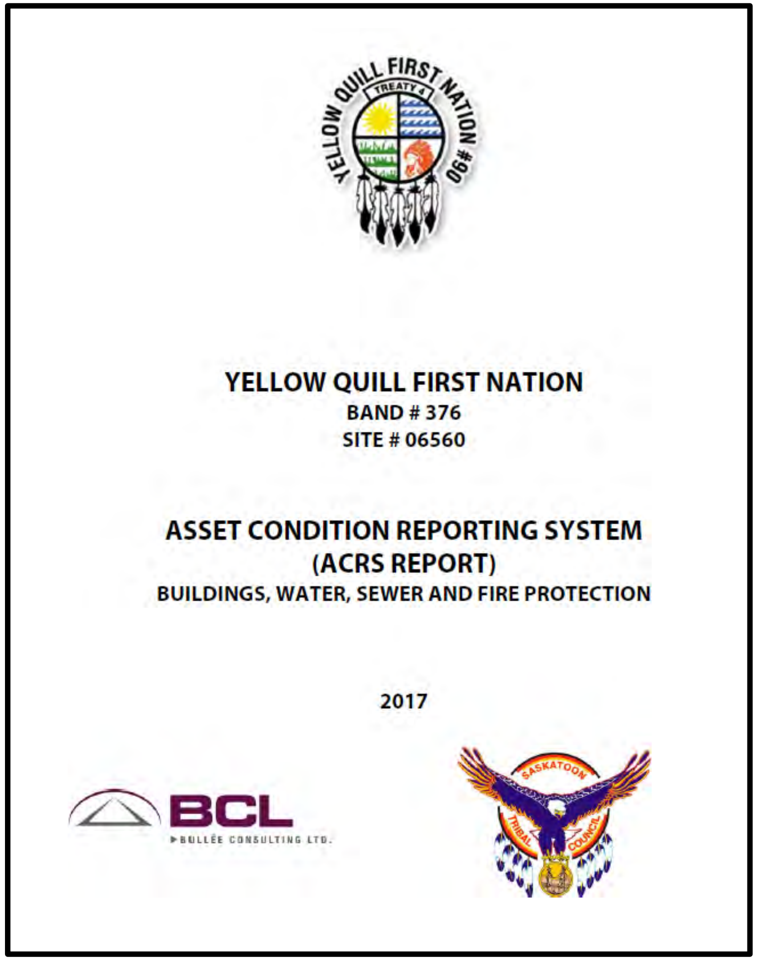
Yellow Quill

Identify the components of the infrastructure to be assessed in general terms

Determine Yellow Quill Infrastructure List

Four Main Infrastructure Classifications

1. *Community Buildings* –School, band office, safe house, health centre, fire hall
2. *Water and Waste Water Treatment Systems*
    - Includes public works buildings
3. *Housing* – focus on residential infrastructure
    - Look at specific subdivisions
    - Farms
4. *Roads and Drainage*
    - Culverts



YELLOW QUILL FIRST NATION
BAND # 376
SITE # 06560

ASSET CONDITION REPORTING SYSTEM
(ACRS REPORT)
BUILDINGS, WATER, SEWER AND FIRE PROTECTION

2017

Ontario First Nations Technical Services Corporation

List Sub Components of Infrastructure Possibly Impacted by Climate

YELLOW QUILL FIRST NATION #90 TREATY 4

Buildings

- Roof (sloped/flat)
- Building envelope
- Mechanical/HVAC
- Foundation
- Grounds
- Back-up power
- Fuel supply
- Staffing

WTP

- WTP Building
- Treatment Equipment
- Water reservoir(s)
- RW Intake/Pump Stn
- Distribution piping
- Staffing

Roads, Bridges, Culverts

- Road deck (asphalt, gravel)
- Road base
- Ditches
- Culverts
- Lighting, signage
- Bridge abutments, foundations, deck
- Staffing

COMMUNICATION SYSTEMS

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YELLOW QUILL FIRST NATION #90
TREATY 4

FN PIEVC Risk Matrix

Asset/Infrastructure Elements	ACRS/ICMS Information			Climate 1							Climate 2							Climate 3							Climate 4						
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WW SYSTEM																															

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YELLOW QUILL FIRST NATION #90
TREATY 4

Yellow Quill
Climate Elements to Consider

What past weather/climate events have caused disruptions and/or damage to Yellow Quill FN infrastructure?

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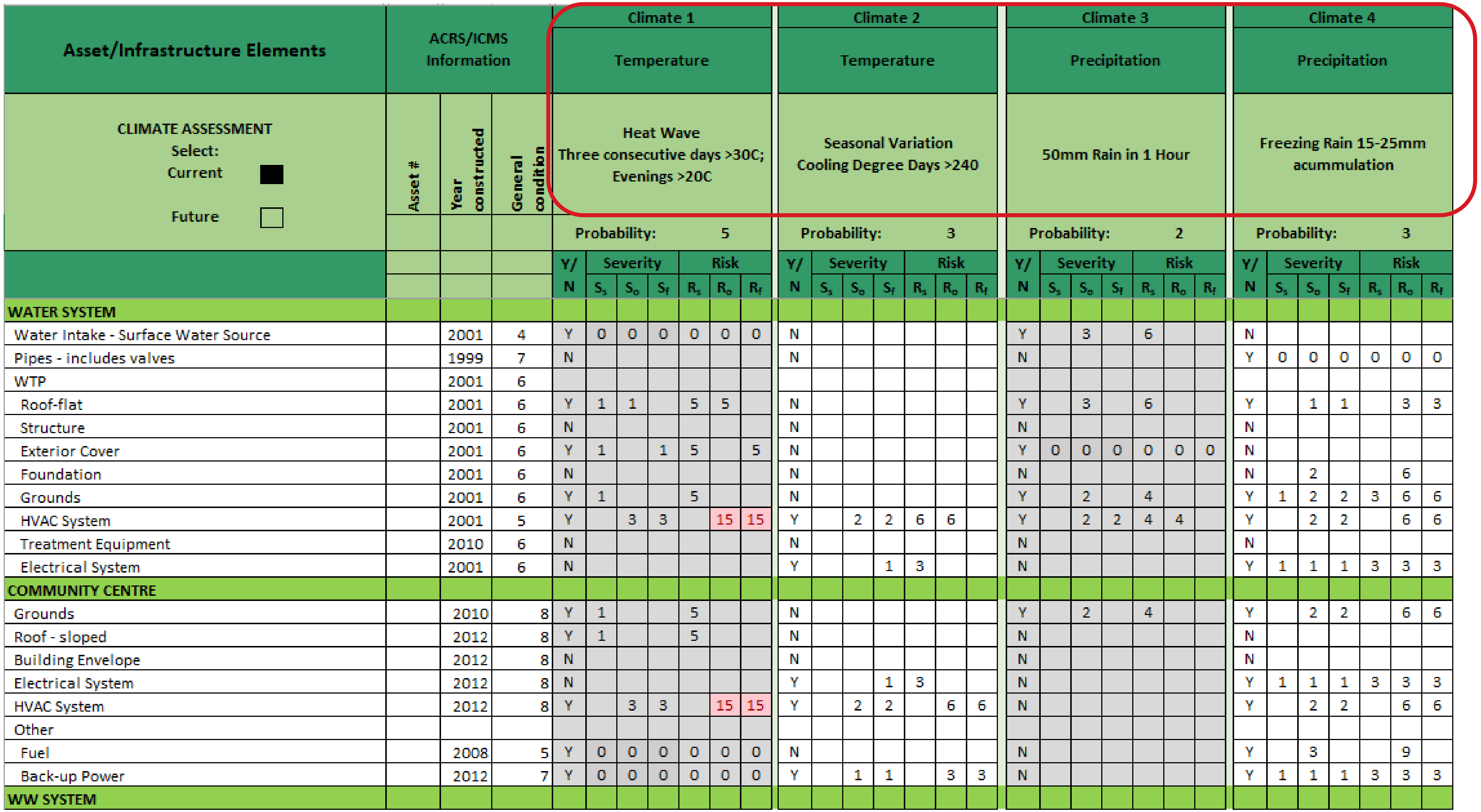
FN PIEVC Risk Matrix



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WATER SYSTEM																															
Water Intake - Surface Water Source		2001	4	Y	0	0	0	0	0	0	N							Y		3		6			N						
Pipes - includes valves		1999	7	N							N							N							Y	0	0	0	0	0	0
WTP		2001	6																												
Roof-flat		2001	6	Y	1	1		5	5		N							Y		3		6			Y		1	1		3	3
Structure		2001	6	N							N							N							N						
Exterior Cover		2001	6	Y	1		1	5		5	N							Y	0	0	0	0	0	0	N						
Foundation		2001	6	N							N							N							N		2			6	
Grounds		2001	6	Y	1			5			N							Y		2		4			Y	1	2	2	3	6	6
HVAC System		2001	5	Y		3	3		15	15	Y		2	2	6	6		Y		2	2	4	4		Y		2	2		6	6
Treatment Equipment		2010	6	N							N							N							N						
Electrical System		2001	6	N							Y			1	3			N							Y	1	1	1	3	3	3
COMMUNITY CENTRE																															
Grounds		2010	8	Y	1			5			N							Y		2		4			Y		2	2		6	6
Roof - sloped		2012	8	Y	1			5			N							N							N						
Building Envelope		2012	8	N							N							N							N						
Electrical System		2012	8	N							Y			1	3			N							Y	1	1	1	3	3	3
HVAC System		2012	8	Y		3	3		15	15	Y		2	2		6	6	N							Y		2	2		6	6
Other																															
Fuel		2008	5	Y	0	0	0	0	0	0	N							N							Y		3			9	
Back-up Power		2012	7	Y	0	0	0	0	0	0	Y		1	1		3	3	N							Y	1	1	1	3	3	3
WW SYSTEM																															

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Discussion

How is the climate changing in Yellow Quill?

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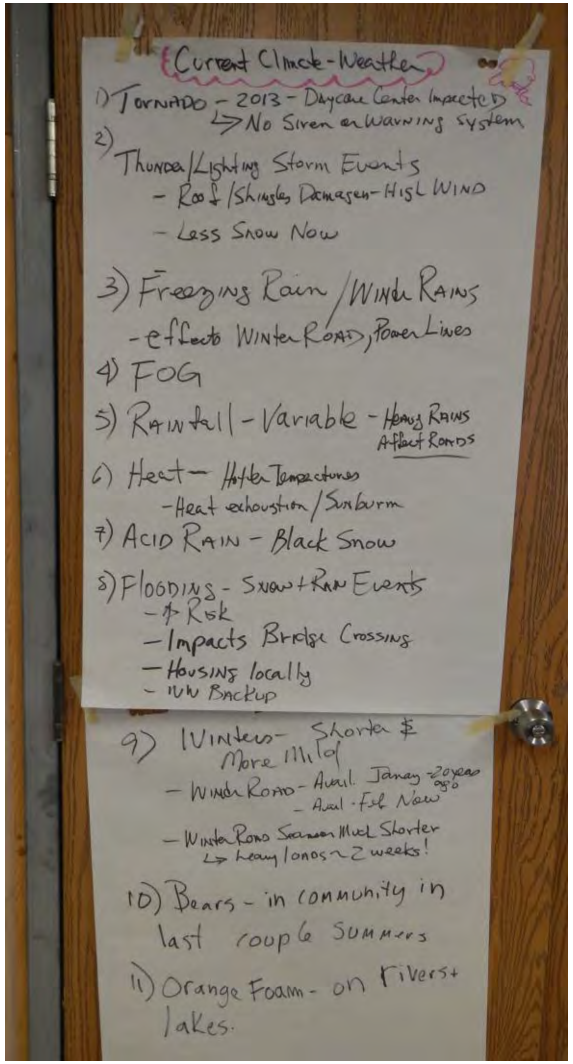
Climate Elements Exercise



Current Climate-Weather

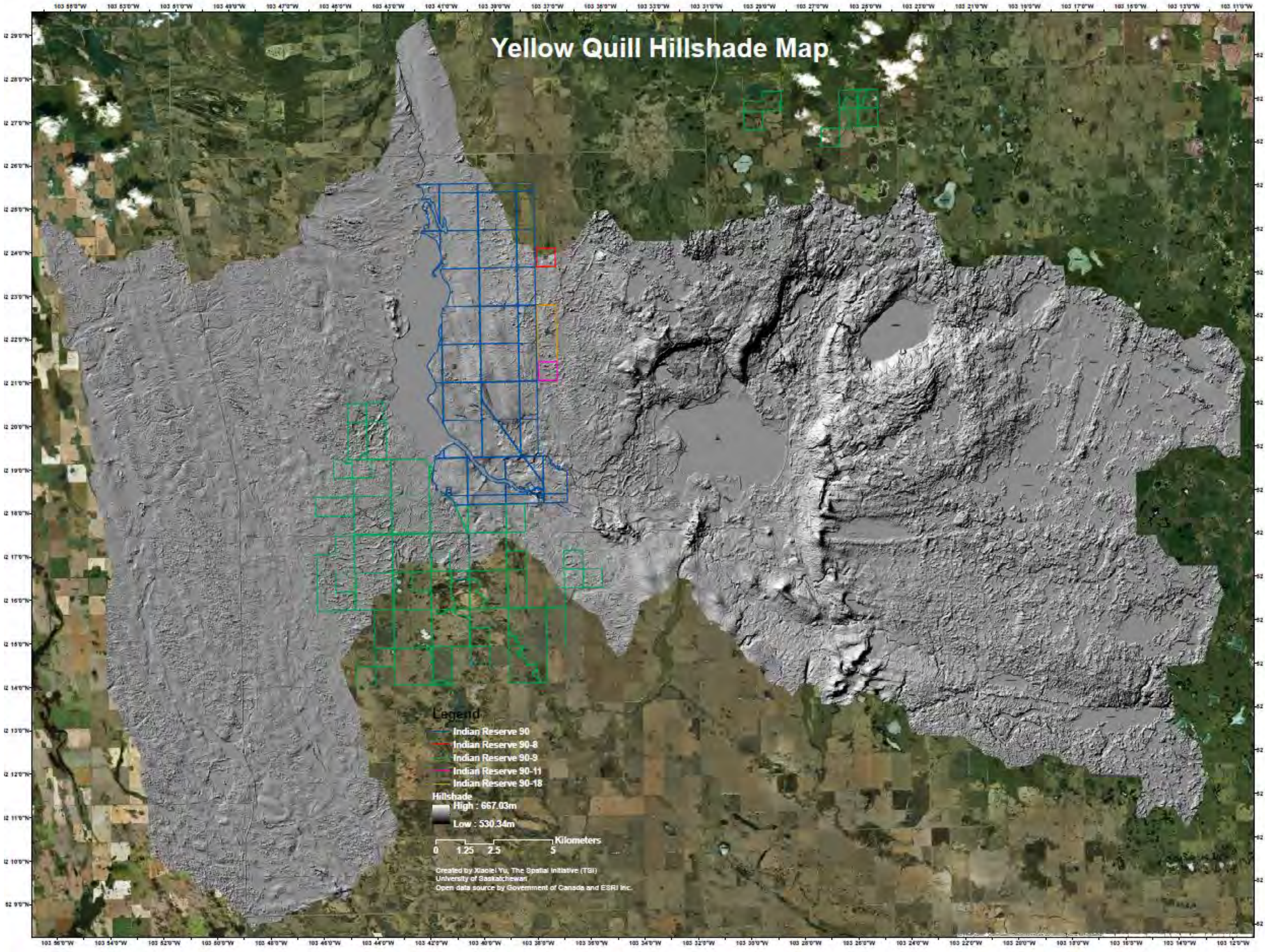
1) Tornado - 2013 - Daycare Center Impacted
↳ No Siren or Warning System
2) Thunder/Lighting Storm Events
- Roof/Shingles Damages - High Wind
- Less Snow Now
3) Freezing Rain/Winds Rains
- effects Winter Road, Power Lines
4) FOG
5) Rainfall - Variable - Heavy Rains Affect Roads
6) Heat - Hotter Temperatures
- Heat exhaustion/Sunburn
7) Acid Rain - Black Snow
8) Flooding - Snow + Rain Events
- ↑ Risk
- Impacts Bridge Crossing
- Housing locally
- WW Backup
9) Winters - Shorter & More Mild
- Winter Road - Avail. January - 20 years ago
- Avail. Feb Now
- Winter Road Season Much Shorter
↳ heavy loads ~2 weeks!
10) Bears - in community in last couple summers
11) Orange Foam - on rivers + lakes.

Climate Elements

Temperature 5 consecutive days with temp. > 30 deg.				Temperature 10 consecutive days with temp. < -35 deg.				Blizzard > 50cm snow in 24 hour period				Rain 3 consecutive days with total rainfall of > 100mm				Climate event 5			
Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R	Y/N	P	S	R

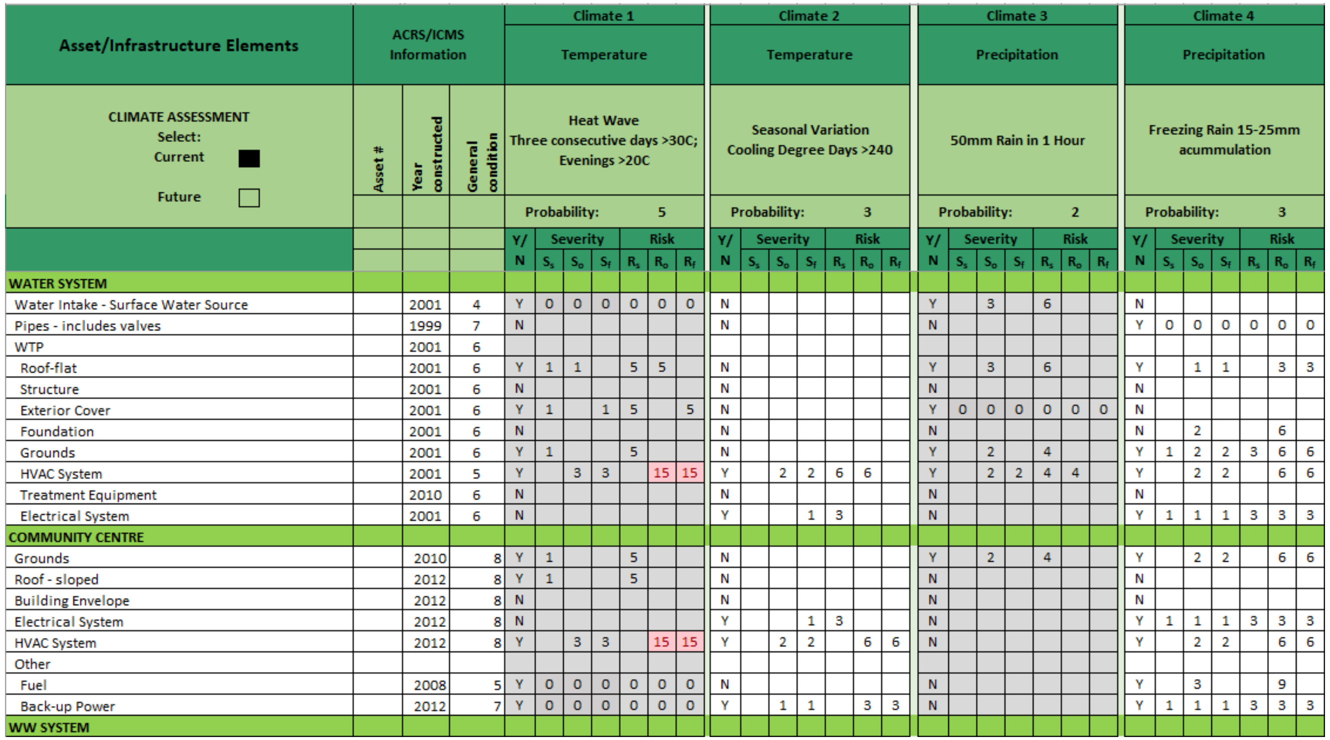
What weather/climate events have caused disruptions and/or damage to Yellow Quill FN infrastructure?

Yellow Quill First Nation Flood Mapping Project



Completing the Risk Matrix

- ✓ Infrastructure List and attributes (from ACRS)
- ✓ Climate parameters and thresholds
- ✓ Response (performance) considerations
- ✓ Severity impacts to infrastructure if climate event occurs [S]
- ✓ Probability of Climate Events(Current and Future) [P]
- ✓ Risk Calculation [R = P x S]



Asset/Infrastructure Elements	ACRS/ICMS Information			Climate 1							Climate 2							Climate 3							Climate 4						
				Temperature							Temperature							Precipitation							Precipitation						
CLIMATE ASSESSMENT Select: Current ■ Future ☐	Asset #	Year constructed	General condition	Heat Wave Three consecutive days >30C; Evenings >20C							Seasonal Variation Cooling Degree Days >240							50mm Rain in 1 Hour							Freezing Rain 15-25mm acummulation						
				Probability: 5							Probability: 3							Probability: 2							Probability: 3						
				Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk		
					S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f
WATER SYSTEM																															
Water Intake - Surface Water Source		2001	4	Y	0	0	0	0	0	0	N							Y		3		6			N						
Pipes - includes valves		1999	7	N							N							N							Y	0	0	0	0	0	0
WTP		2001	6																												
Roof-flat		2001	6	Y	1	1		5	5		N							Y		3		6			Y		1	1		3	3
Structure		2001	6	N							N							N							N						
Exterior Cover		2001	6	Y	1		1	5		5	N							Y	0	0	0	0	0	0	N						
Foundation		2001	6	N							N							N							N		2			6	
Grounds		2001	6	Y	1			5			N							Y		2		4			Y	1	2	2	3	6	6
HVAC System		2001	5	Y		3	3		15	15	Y		2	2	6	6		Y		2	2	4	4		Y		2	2		6	6
Treatment Equipment		2010	6	N							N							N							N						
Electrical System		2001	6	N							Y			1	3			N							Y	1	1	1	3	3	3
COMMUNITY CENTRE																															
Grounds		2010	8	Y	1			5			N							Y		2		4			Y		2	2		6	6
Roof - sloped		2012	8	Y	1			5			N							N							N						
Building Envelope		2012	8	N							N							N							N						
Electrical System		2012	8	N							Y			1	3			N							Y	1	1	1	3	3	3
HVAC System		2012	8	Y		3	3		15	15	Y		2	2		6	6	N							Y		2	2		6	6
Other																															
Fuel		2008	5	Y	0	0	0	0	0	0	N							N							Y		3			9	
Back-up Power		2012	7	Y	0	0	0	0	0	0	Y		1	1		3	3	N							Y	1	1	1	3	3	3
WW SYSTEM																															

Performance Criteria

Structural:

- Load carrying capacity
- Fracture / collapse
- Material fatigue and weakening
- Access
- Deflection / permanent deformation
- Cracking and deterioration

Functionality/Capacity:

- Effective capacity of the infrastructure to provide the intended service:
  - Short term
  - Medium term
  - Long term

Operations, maintenance, and materials performance:

- Occupational safety
- Access to worksite
- Equipment performance
- Maintenance and replacement cycles
- Electricity demand
- Fuel use
- Materials Performance
- Changes from design expectation

Yellow Quill FN Severity Rating Scale

Severity Score and Description	**Severity**		
	Structural integrity	**Functionality**	**Operations**
0 **No effect**	No damage Continues to perform as intended	Fully operational – normal	No impact on operations No budget impacts
1 **Insignificant**	Damage can be corrected through on site staff Feeling of unease in on site staff Needs re-evaluation to ensure fix works	Isolated loss of service Less than 10% users affected Band office involved Uncertainty in whether to inform band members	Mild effects on operations Small budget impact – repair time or replacement part
2 **Minor**	May need further assessment from off-site certified contractor to ensure local fix has worked	10% to 20% users affected 1 councilor handling emergency Band members informed of issue	Requires sending repair crew Minor impact on O&M and capital budget – replacement part and cost of off-site certified contractor
3 **Moderate**	Needs repair or replacement of components by off-site contractor and needs re-evaluation frequently	20% to 30% users affected More than 1 councilor needed to assist Decision to post wide notice of loss of service	Repair crew needed – more than one person New parts needed and ordered from afar Certified contractor needed to do repairs (e.g., electrician) – large budget impact
4 **Major**	Collapse/total loss of asset or components Some impacts on other elements May have impacts on public health and safety – i.e., presents road hazard Rapid deterioration – high water table – due to health reasons the house is not hospitable – mold etc… - there's no funding for that	30-50% users affected Requires implementing alternative service delivery More than 2 councilors needed to assist Wide notice of loss of service	Requires detailed assessment with external expertise – takes time to assess and decide on appropriate repair option Requires major repairs and possibly complete replacement of components or equipment Impacts on O&M and capital budget that may require additional funding
5 **Catastrophic**	Collapse Total loss of equipment and service that requires full replacement of asset, several assets and major components Large effects on other elements Impacts on the public health and safety	More than 50% users affected More than 3 councilors needed to assist - Will require relocating people/function Need is present for declaring state of emergency Need to use all communication channels possible to inform Band members	Significant impacts on capital budget requiring additional funding

Effects of Asset Condition

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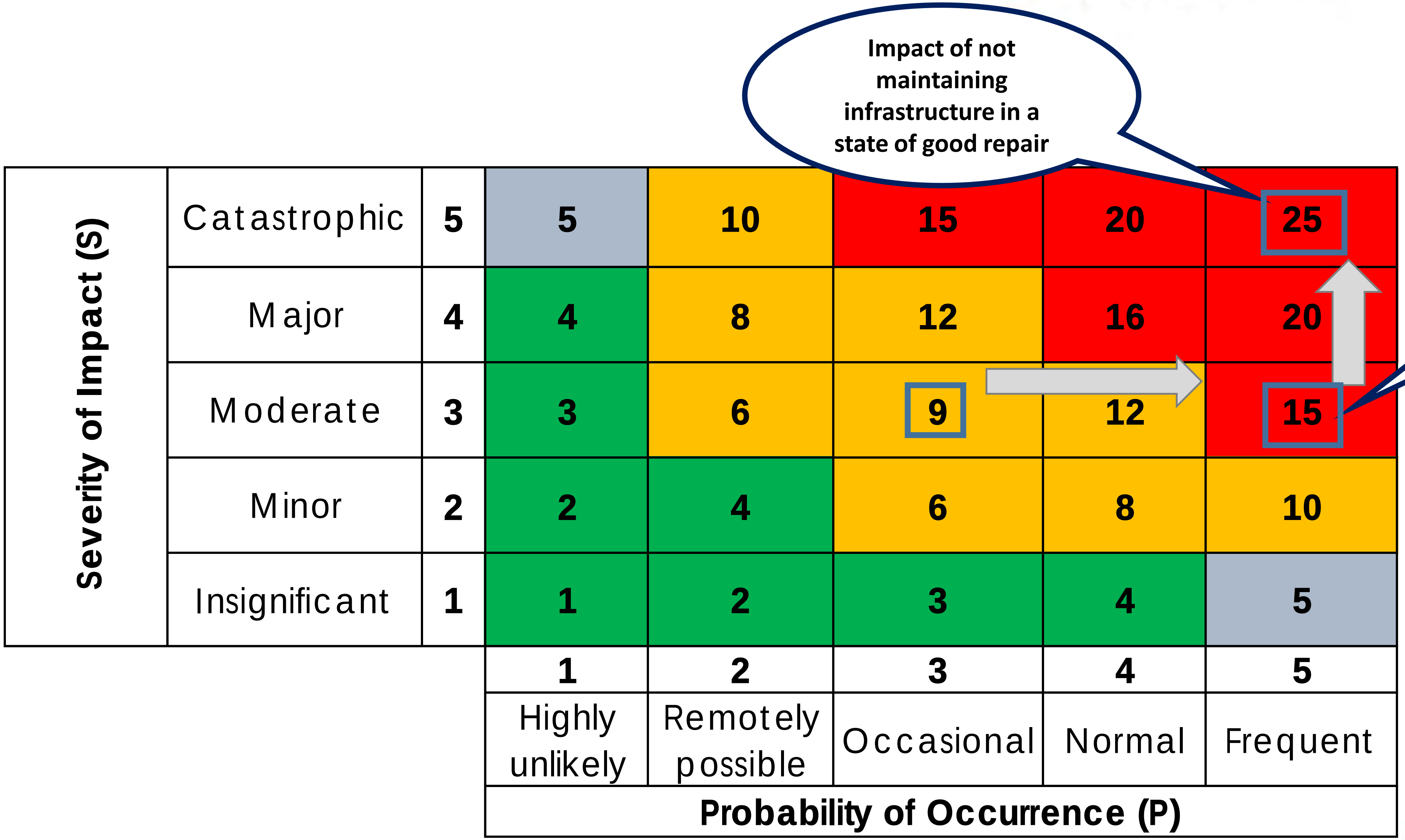
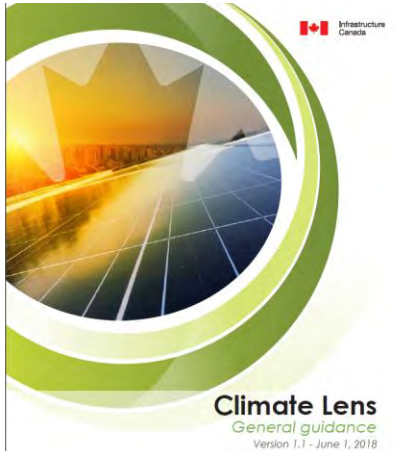
YELLOW QUILL FIRST NATION #90
TREATY 4



Severity of Impact (S)	Catastrophic	5	**5**	**10**	**15**	**20**	**25**
	Major	4	**4**	**8**	**12**	**16**	**20**
	Moderate	3	**3**	**6**	**9**	**12**	**15**
	Minor	2	**2**	**4**	**6**	**8**	**10**
	Insignificant	1	**1**	**2**	**3**	**4**	**5**
			1	**2**	**3**	**4**	**5**
			Highly unlikely	Remotely possible	Occasional	Normal	Frequent
			Probability of Occurrence (P)				

Impact of not maintaining infrastructure in a state of good repair

Impact of climate changes



Infrastructure Canada

Climate Lens
General guidance
Version 1.1 - June 1, 2018

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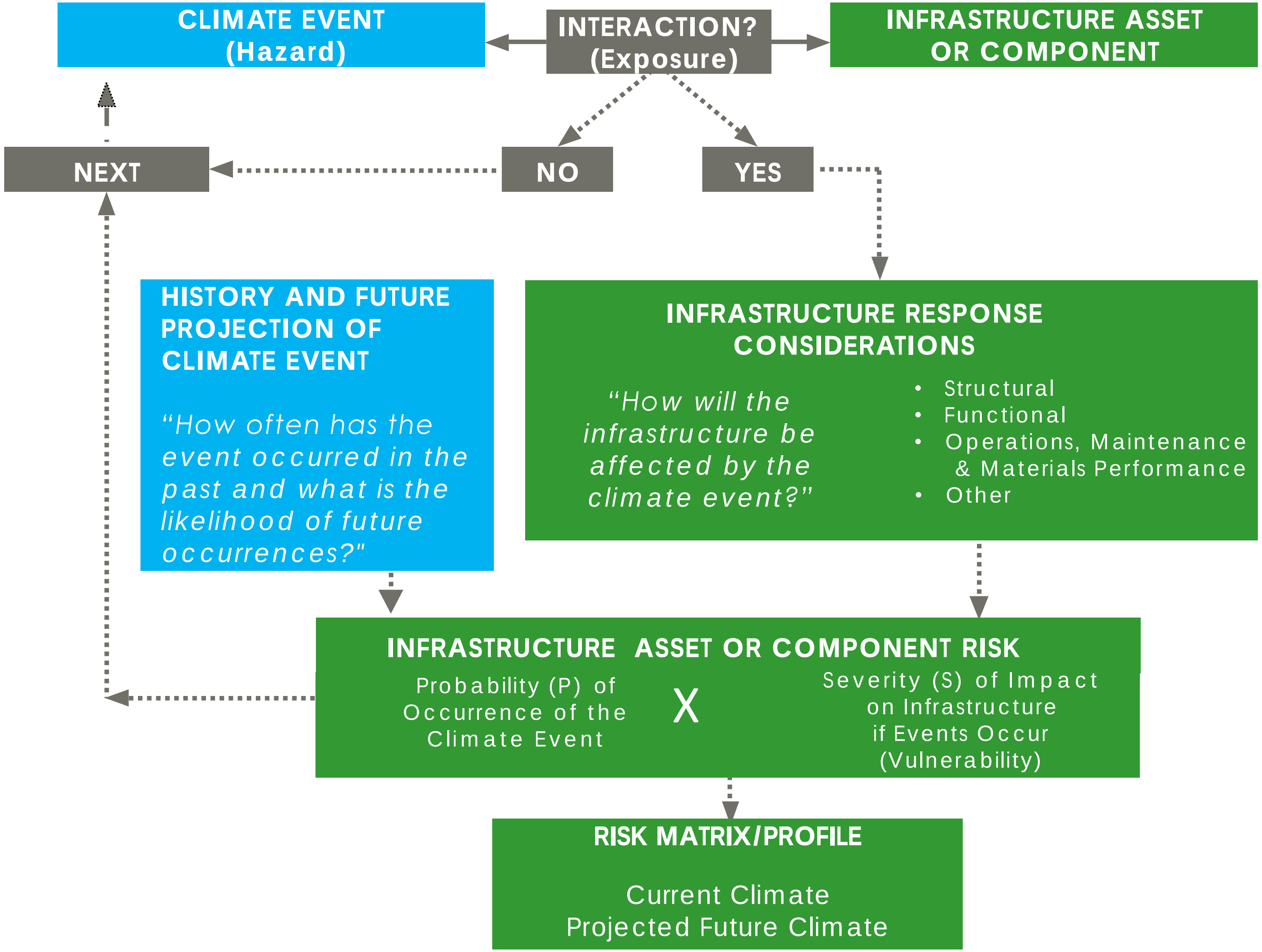
FN PIEVC Process

Ontario First Nations Technical Services Corporation

YELLOW QUILL FIRST NATION #90 TREATY 4



CLIMATE EVENT (Hazard)

INTERACTION? (Exposure)

INFRASTRUCTURE ASSET OR COMPONENT

NEXT

NO

YES

HISTORY AND FUTURE PROJECTION OF CLIMATE EVENT

"How often has the event occurred in the past and what is the likelihood of future occurrences?"

INFRASTRUCTURE RESPONSE CONSIDERATIONS

"How will the infrastructure be affected by the climate event?"

- Structural
- Functional
- Operations, Maintenance & Materials Performance
- Other

INFRASTRUCTURE ASSET OR COMPONENT RISK

Probability (P) of Occurrence of the Climate Event X Severity (S) of Impact on Infrastructure if Events Occur (Vulnerability)

RISK MATRIX/PROFILE

Current Climate

Projected Future Climate

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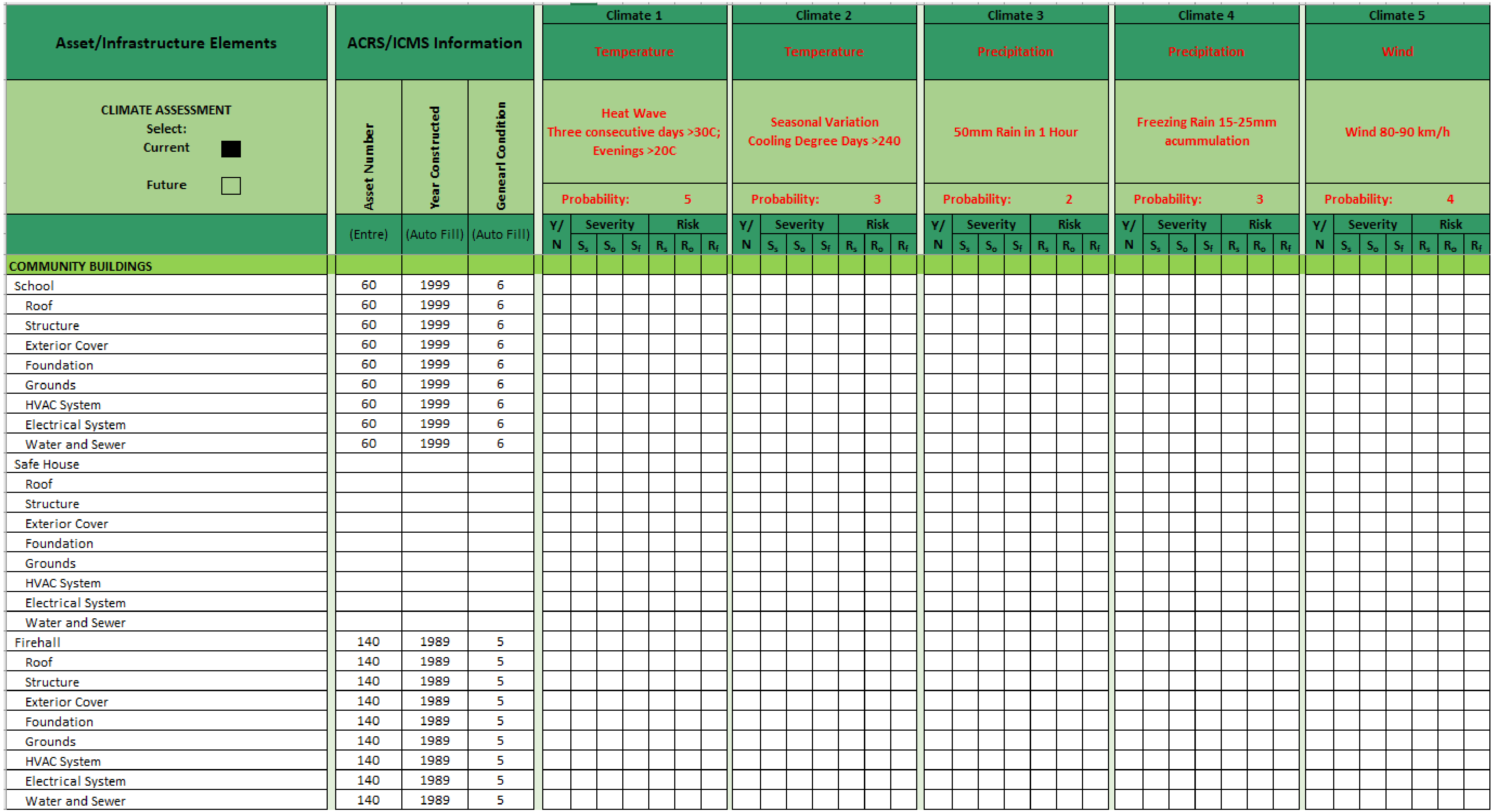
The Yellow Quill FN PIEVC Risk Matrix



Asset/Infrastructure Elements	ACRS/ICMS Information			Climate 1							Climate 2							Climate 3							Climate 4							Climate 5						
				Temperature							Temperature							Precipitation							Precipitation							Wind						
CLIMATE ASSESSMENT Select: Current ■ Future ☐	Asset Number	Year Constructed	Genearl Condition	Heat Wave Three consecutive days >30C; Evenings >20C							Seasonal Variation Cooling Degree Days >240							50mm Rain in 1 Hour							Freezing Rain 15-25mm acummulation							Wind 80-90 km/h						
				Probability: 5							Probability: 3							Probability: 2							Probability: 3							Probability: 4						
	(Entre)	(Auto Fill)	(Auto Fill)	Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk		
					S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f
COMMUNITY BUILDINGS																																						
School	60	1999	6																																			
Roof	60	1999	6																																			
Structure	60	1999	6																																			
Exterior Cover	60	1999	6																																			
Foundation	60	1999	6																																			
Grounds	60	1999	6																																			
HVAC System	60	1999	6																																			
Electrical System	60	1999	6																																			
Water and Sewer	60	1999	6																																			
Safe House																																						
Roof																																						
Structure																																						
Exterior Cover																																						
Foundation																																						
Grounds																																						
HVAC System																																						
Electrical System																																						
Water and Sewer																																						
Firehall	140	1989	5																																			
Roof	140	1989	5																																			
Structure	140	1989	5																																			
Exterior Cover	140	1989	5																																			
Foundation	140	1989	5																																			
Grounds	140	1989	5																																			
HVAC System	140	1989	5																																			
Electrical System	140	1989	5																																			
Water and Sewer	140	1989	5																																			

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YELLOW QUILL FIRST NATION #90
TREATY 4

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Wayne L. E. Penno, MBA, P.Eng

Wayne.Penno@Stantec.com

Thank You Miigwech

APPENDIX D

WORKSHOP 4 POWERPOINT PRESENTATION

Ontario First Nations
Technical Services
Corporation

Yellow Quill First Nation
FN PIEVC Infrastructure Vulnerability Assessment

Workshop #4

Risk Mitigation and Adaptation Measures

Wayne L. E. Penno, MBA, P.Eng
Project Manager, Stantec

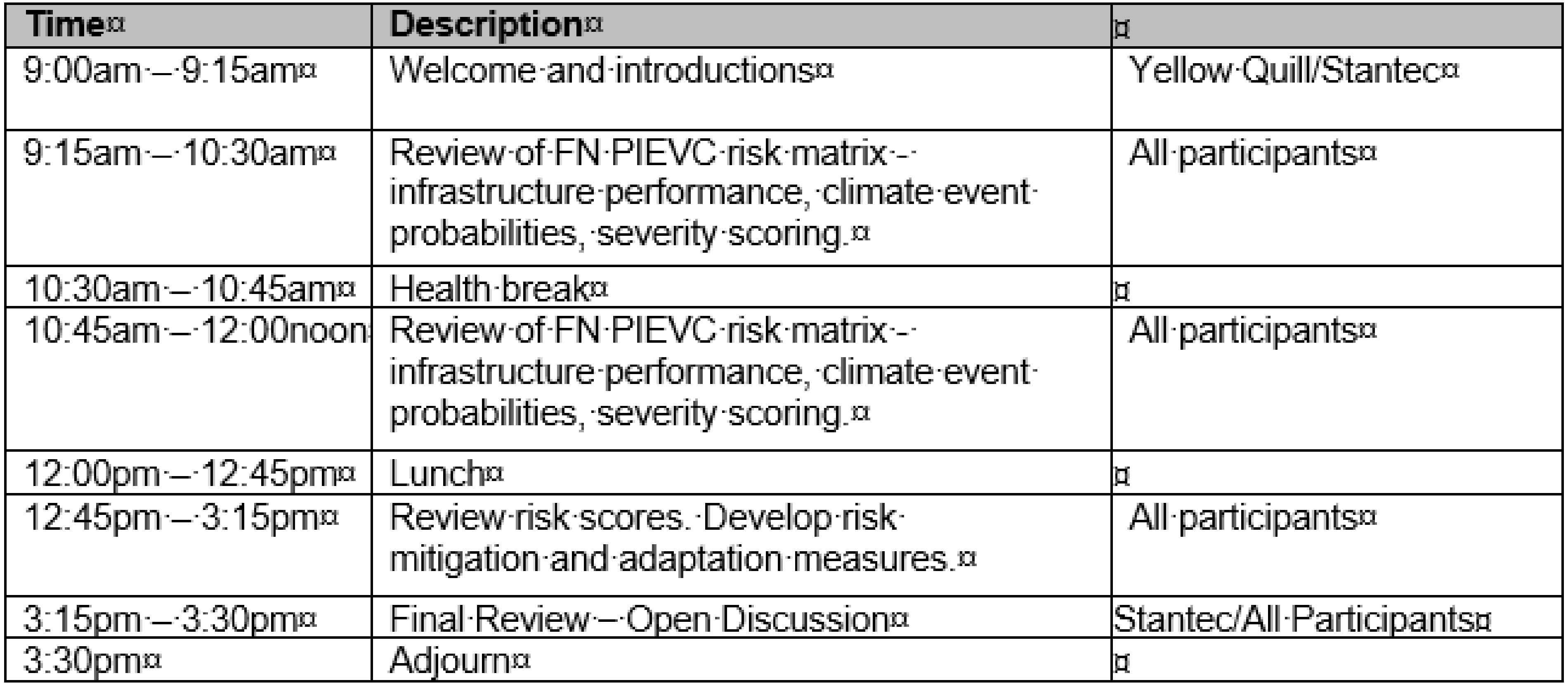
Thursday, August 22, 2019

In Collaboration with:

University of
Saskatchewan

Stantec

Agenda



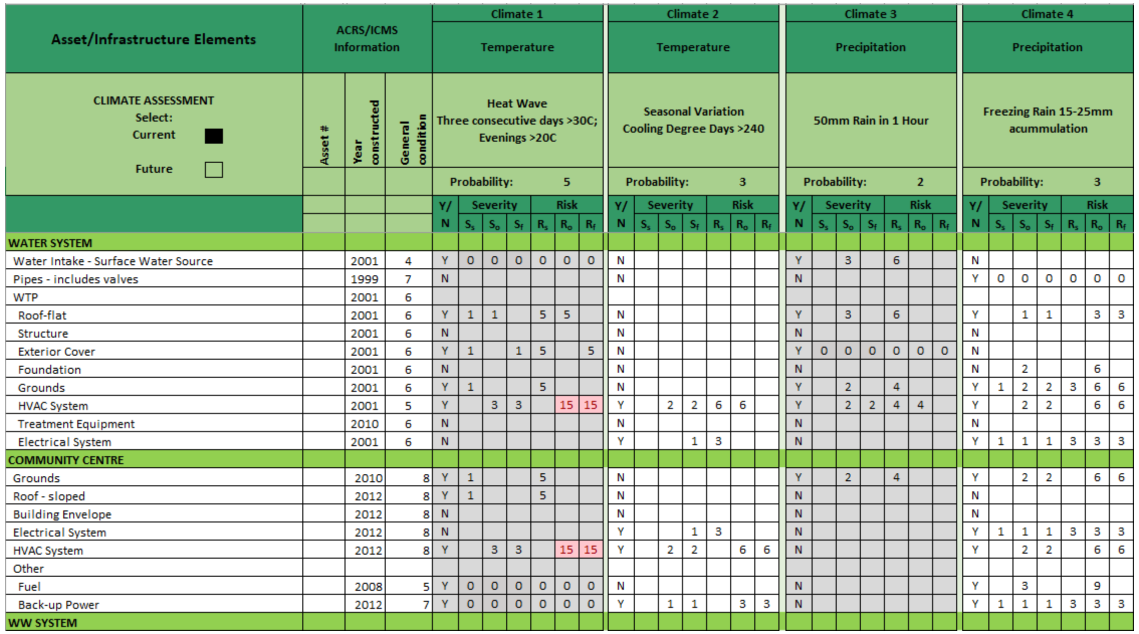
Time	Description	
9:00am – 9:15am	Welcome and introductions	Yellow Quill/Stantec
9:15am – 10:30am	Review of FN PIEVC risk matrix - infrastructure performance, climate event probabilities, severity scoring.	All participants
10:30am – 10:45am	Health break	
10:45am – 12:00noon	Review of FN PIEVC risk matrix - infrastructure performance, climate event probabilities, severity scoring.	All participants
12:00pm – 12:45pm	Lunch	
12:45pm – 3:15pm	Review risk scores. Develop risk mitigation and adaptation measures.	All participants
3:15pm – 3:30pm	Final Review – Open Discussion	Stantec/All Participants
3:30pm	Adjourn	

Workshop Objectives

- Review, revise as necessary, and agree on the current and future climate risks (risk matrices)
- Identify risk mitigation measures for the highest risks
- Recommend actions for immediate risks
- Discuss potential mitigation/adaptation measures to reduce the risks under future climate conditions
- Next steps
- Adjoun

Review of the Risk Matrix

- ✓ Infrastructure list
- ✓ Performance considerations
- ✓ Climate parameters
- ✓ Probabilities of Climate Events (Current and Future)
- ✓ Severity if climate event occurs
- ✓ Identified Risks (Current and Future)



Asset/Infrastructure Elements	ACRS/ICMS Information			Climate 1							Climate 2							Climate 3							Climate 4						
				Temperature							Temperature							Precipitation							Precipitation						
CLIMATE ASSESSMENT Select: Current ■ Future ☐	Asset #	Year constructed	General condition	Heat Wave Three consecutive days >30C; Evenings >20C							Seasonal Variation Cooling Degree Days >240							50mm Rain in 1 Hour							Freezing Rain 15-25mm acummulation						
				Probability: 5							Probability: 3							Probability: 2							Probability: 3						
				Y/ N	Severity			Risk			Y/ N	Severity			Risk			Y/ N	Severity			Risk			Y/ N	Severity			Risk		
					S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f
WATER SYSTEM																															
Water Intake - Surface Water Source		2001	4	Y	0	0	0	0	0	0	N							Y		3		6			N						
Pipes - includes valves		1999	7	N							N							N							Y	0	0	0	0	0	0
WTP		2001	6																												
Roof-flat		2001	6	Y	1	1		5	5		N							Y		3		6			Y		1	1		3	3
Structure		2001	6	N							N							N							N						
Exterior Cover		2001	6	Y	1		1	5		5	N							Y	0	0	0	0	0	0	N						
Foundation		2001	6	N							N							N							N		2			6	
Grounds		2001	6	Y	1			5			N							Y		2		4			Y	1	2	2	3	6	6
HVAC System		2001	5	Y		3	3		15	15	Y		2	2	6	6		Y		2	2	4	4		Y		2	2		6	6
Treatment Equipment		2010	6	N							N							N							N						
Electrical System		2001	6	N							Y			1	3			N							Y	1	1	1	3	3	3
COMMUNITY CENTRE																															
Grounds		2010	8	Y	1			5			N							Y		2		4			Y		2	2		6	6
Roof - sloped		2012	8	Y	1			5			N							N							N						
Building Envelope		2012	8	N							N							N							N						
Electrical System		2012	8	N							Y			1	3			N							Y	1	1	1	3	3	3
HVAC System		2012	8	Y		3	3		15	15	Y		2	2		6	6	N							Y		2	2		6	6
Other																															
Fuel		2008	5	Y	0	0	0	0	0	0	N							N							Y		3			9	
Back-up Power		2012	7	Y	0	0	0	0	0	0	Y		1	1		3	3	N							Y	1	1	1	3	3	3
WW SYSTEM																															

Proposed Risk Rating

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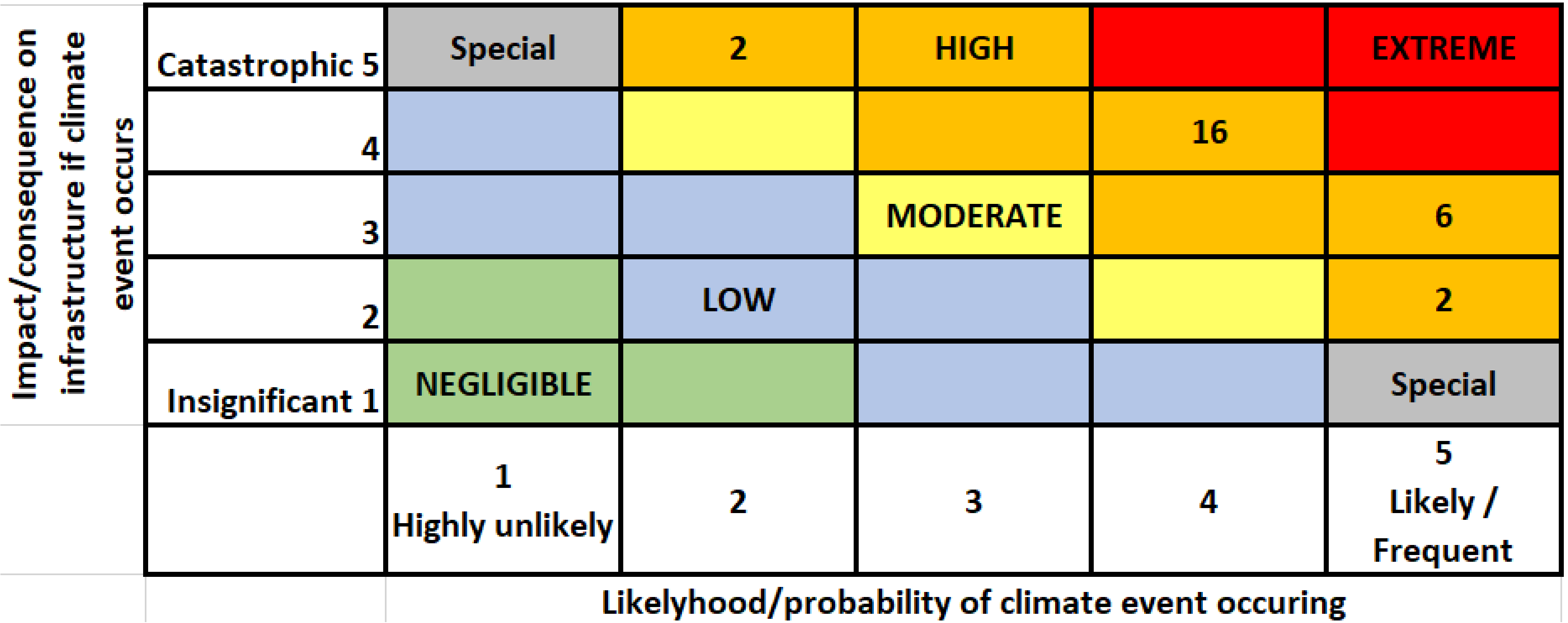

Impact/consequence on infrastructure if climate event occurs

Catastrophic 5	Special	2	HIGH		EXTREME
4				16	
3			MODERATE		6
2		LOW			2
Insignificant 1	NEGLIGIBLE				Special
	1 Highly unlikely	2	3	4	5 Likely / Frequent

Likelyhood/probability of climate event occuring

Extreme:	>= 20	Immediate control required
High:	10 - 16	High priority control measures required
Moderate:	8 - 9	Some control measures required to reduce risks to lower levels
Low:	3 - 6	Control likely not required
Negligible:	< 3	Risk events do not require further consideration
Special:		Further analysis may be required; monitor

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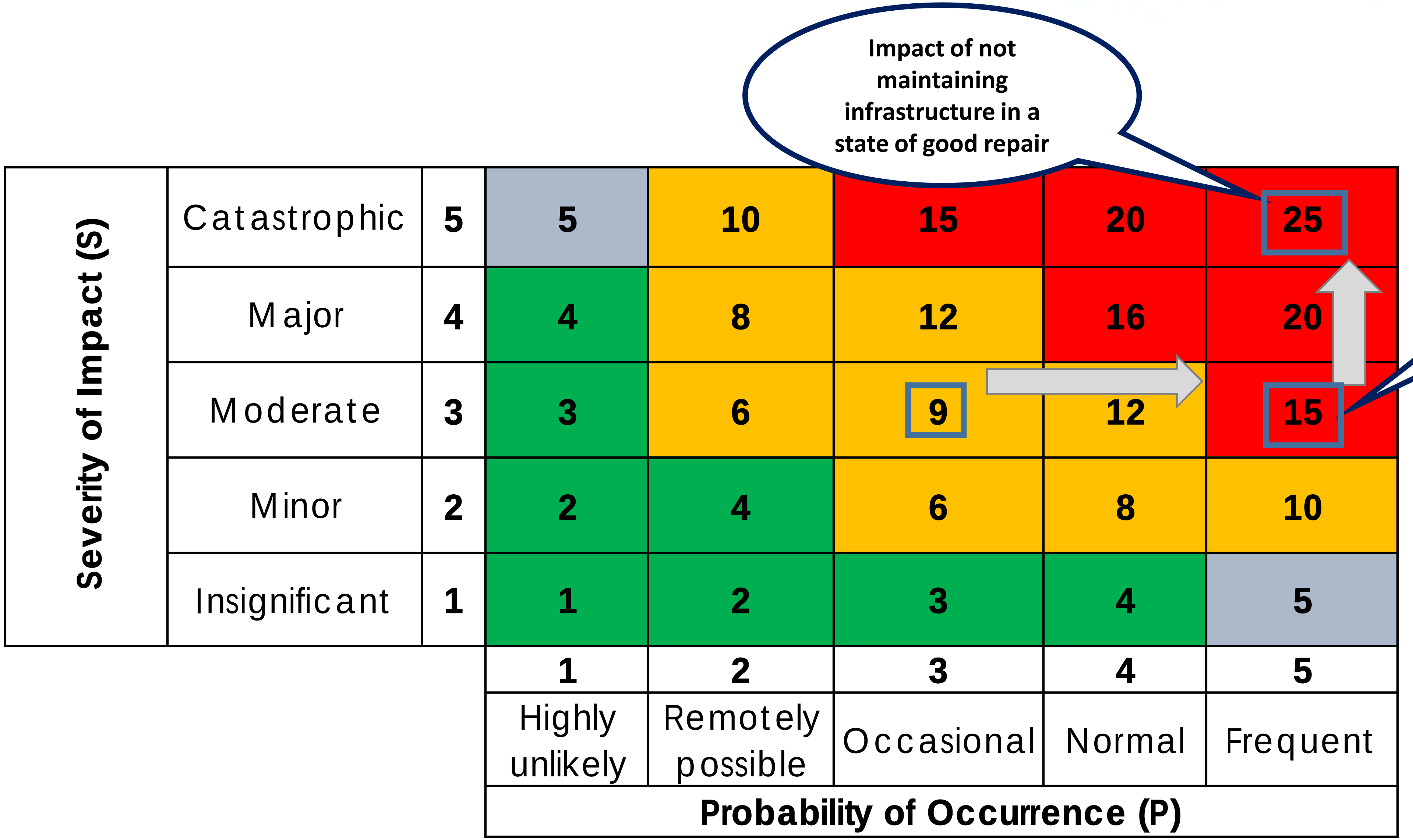
Effects of Asset Condition

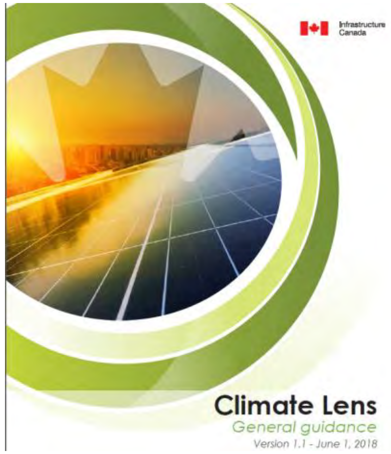
Ontario First Nations Technical Services Corporation



Impact of not maintaining infrastructure in a state of good repair

Impact of climate changes

Severity of Impact (S)	Catastrophic	5	5	10	15	20	25
	Major	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Minor	2	2	4	6	8	10
	Insignificant	1	1	2	3	4	5
			1	2	3	4	5
			Highly unlikely	Remotely possible	Occasional	Normal	Frequent
			Probability of Occurrence (P)				



Infrastructure Canada

Climate Lens

General guidance

Version 1.1 - June 1, 2018

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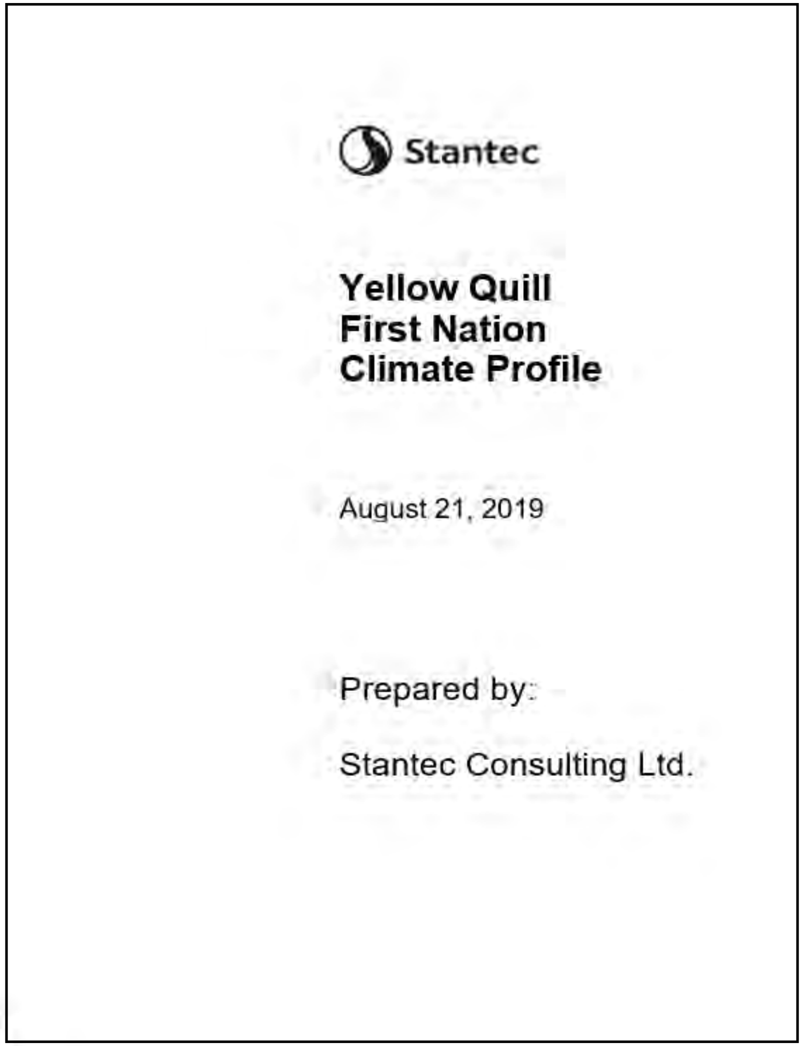
YELLOW QUILL FIRST NATION

Current and Future Climate



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Yellow Quill
First Nation
Climate Profile

August 21, 2019

Prepared by:

Stantec Consulting Ltd.

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YELLOW QUILL FIRST NATION #90
TREATY 4

What are the potential impacts on the services or the community if the infrastructure fails?

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1. Emergency Response

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Procedures and systems to address:
  - Severe storm events
  - Flooding
  - Ice dams
  - Water damage

2. Insurance and Legal Considerations

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Insurance rates
- The ability to acquire insurance
- Insurance policy limitations and exclusions
- Legal impacts and liability

3. Policy Considerations

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Codes
- Guidelines
- Standards
- Internal operations and maintenance policies and procedures
- Levels of Service policy
- Land use planning

4. Social Effects

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may affect:

- Accessibility to critical facilities such as hospitals, fire and police services
- Energy supply to a community
- Dislocation of affected populations
- Provision of basic services such as potable water distribution and wastewater collection
- Closure of schools and other public services
- Destruction or damage to heritage buildings, monuments, etc. or historically important resources

5. Environmental Effects

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may cause:

- Release of toxic, controlled or deleterious substances
- Degradation of water quality
- Damage to sensitive ecosystems
- Physical harm to birds and animals
- Contamination of potable water supplies
- Public perception and interaction

6. Fiscal Impacts

With respect to the infrastructure or infrastructure component being assessed, a loss of performance or failure due to climate loading may cause:

- Drain on current/future financial resources to deal with unplanned repairs, maintenance and/or replacements
- Shifting financial resources from other community priorities
- Impacts on services and/or levels of service
- Community economic impacts and/or hardships

Ontario First Nations Technical Services Corporation

Yellow Quill First Nation

Mitigating Climate Risks and Developing Adaptation Strategies

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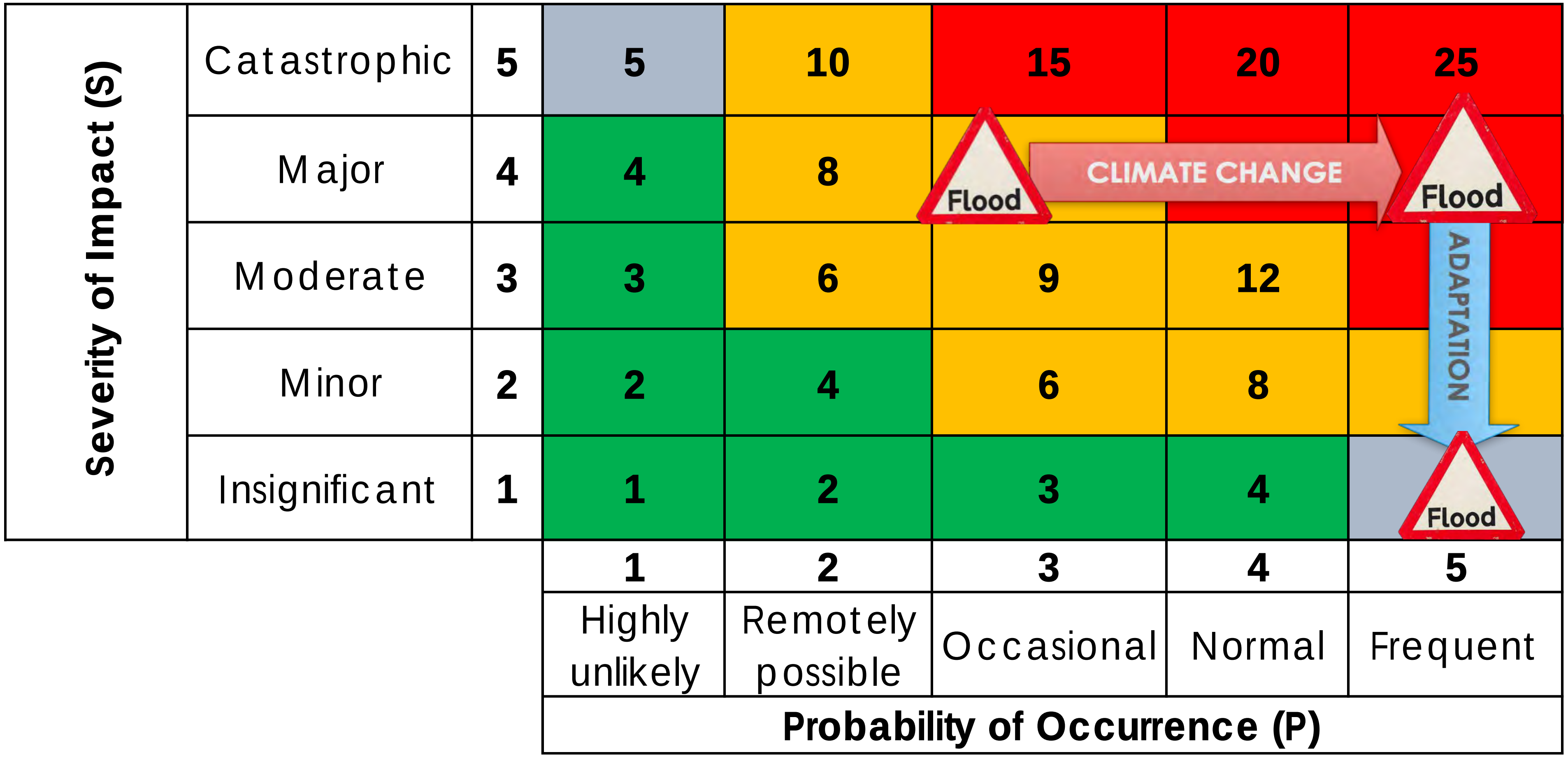
Technical Services
Corporation

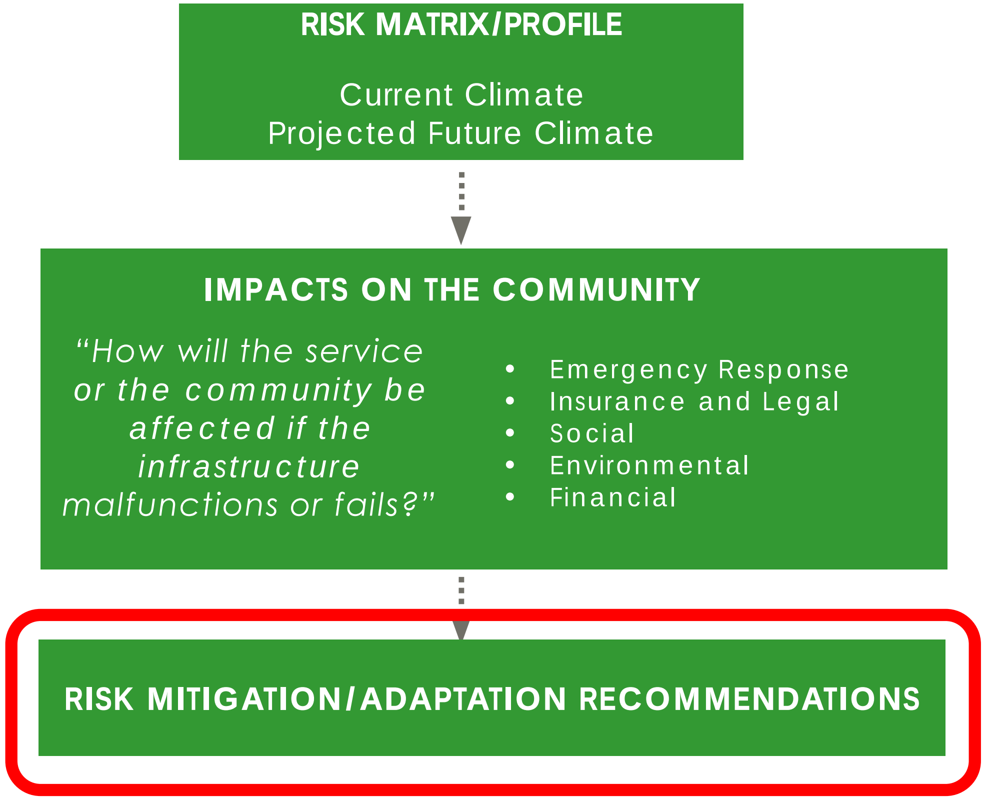
Climate Mitigation/Adaption



Severity of Impact (S)	Catastrophic	**5**	**5**	**10**	**15**	**20**	**25**
	Major	**4**	**4**	**8**			
	Moderate	**3**	**3**	**6**	**9**	**12**	
	Minor	**2**	**2**	**4**	**6**	**8**	
	Insignificant	**1**	**1**	**2**	**3**	**4**	
			1	**2**	**3**	**4**	**5**
			Highly unlikely	Remotely possible	Occasional	Normal	Frequent
			Probability of Occurrence (P)				

Stantec

Risk Mitigation and Adaption



RISK MATRIX/PROFILE

Current Climate
Projected Future Climate

IMPACTS ON THE COMMUNITY

"How will the service or the community be affected if the infrastructure malfunctions or fails?"

- Emergency Response
- Insurance and Legal
- Social
- Environmental
- Financial

RISK MITIGATION/ADAPTATION RECOMMENDATIONS

YQFN Risk Summary
RCP 8.5 scenario for future climate

Risk Rating	Current Climate	Future Climate	Future Climate + Infrastructure in worse condition
Extreme (R>=20)	TBD	TBD	???
High (R10-16)	TBD	TBD	???
Moderate (R8-9)	TBD	TBD	???

Group Exercise-Developing CC Adaption/Mitigation Strategies

Ontario First Nations
Technical Services
Corporation

WHAT ARE POSSIBLE MITIGATION AND ADAPTION MEASURES THAT WILL ADDRESS THE HIGHEST CLIMATE RISK EVENTS TO YELLOW QUILL FN INFRASTRUCTURE?

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YELLOW QUILL FIRST NATION #90
TREATY 4

Ontario First Nations
Technical Services
Corporation

Wayne L. E. Penno, MBA, P.Eng
Wayne.Penno@Stantec.com

Thank You Miigwech

APPENDIX E

YELLOW QUILL RISK MATRIX WORKSHEETS

First Nations Infrastrcuture Resilience Toolkit

Yellow Quill First Nation Worksheet

Asset/Infrastructure Elements	ACRS/ICMS Information			Climate 1							Climate 2							Climate 3							Climate 4						
				Temperature							Temperature							Temperature							Wind						
				Winter Storm							Extreme Cold							Heat Wave							Tornado						
CLIMATE ASSESSMENT Select: Current 🟥 Future ☐	Asset Number	Year Constructed	Genearl Condition	Windchill, snowfall combined with high winds, strong winds, possible freezing rain							Cold Temperatures <-30C							Temp >30C and >18C Overnight							F0 to F2						
				Probability: 4							Probability: 5							Probability: 3							Probability: 2						
	(Entre)	(Auto Fill)	(Auto Fill)	Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk		
					S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f
COMMUNITY BUILDINGS																															
School	60	1999	6																												
Roof	60	1999	6	Y	1			4	0	0															Y	4	4	4	8	8	8
Structure	60	1999	6																						Y	4	4	4	8	8	8
Exterior Cover	60	1999	6																						Y	4	4	4	8	8	8
Foundation	60	1999	6																												
Grounds	60	1999	6																												
HVAC System	60	1999	6	Y		4	3	0	16	12	Y			3	0	0	15	Y			3	0	0	9							
Electrical System	60	1999	6	Y	4			16	0	0																					
Water and Sewer	60	1999	6																												
Safe House																															
Roof																									Y	4	4	4	8	8	8
Structure																									Y	4	4	4	8	8	8
Exterior Cover																									Y	4	4	4	8	8	8
Foundation																															
Grounds																															
HVAC System					Y		4	3	0	16	12								Y			3	0	0	9							
Electrical System																															
Water and Sewer					Y		3		0	12	0																					
Firehall	140	1989	5																												
Roof	140	1989	5																						Y	4	4	4	8	8	8
Structure	140	1989	5																						Y	4	4	4	8	8	8
Exterior Cover	140	1989	5																						Y	4	4	4	8	8	8
Foundation	140	1989	5																												
Grounds	140	1989	5																												
HVAC System	140	1989	5																												
Electrical System	140	1989	5																												
Water and Sewer	140	1989	5																												
Health Centre	0		6																												
Roof	0		6																						Y	4	4	4	8	8	8
Structure	0		6																						Y	4	4	4	8	8	8
Exterior Cover	0		6																						Y	4	4	4	8	8	8
Foundation	0		6																												
Grounds	0		6																												
HVAC System	0		6														Y			3	0	0	9								
Electrical System	0		6																												
Water and Sewer	0		6																												
Staffing																															
Head Start Building																															
Roof																									Y	4	4	4	8	8	8
Structure																									Y	4	4	4	8	8	8
Exterior Cover																									Y	4	4	4	8	8	8
Foundation																															
Grounds																															
HVAC System																		Y			3	0	0	9							
Electrical System																															
Water and Sewer																															
WATER AND WASTE WATER TREATMENT SYSTEMS																															
WTP Building/Booster Station	130	2011	9																												
Roof	130	2011	9																						Y	4	4	4	8	8	8
Structure	130	2011	9																						Y	4	4	4	8	8	8
Exterior Cover	130	2011	9																						Y	4	4	4	8	8	8

Asset/Infrastructure Elements	Climate 5							Climate 6							Climate 7							Climate 8						
	Wind							Wind							Precipitation							Precipitation						
	High Winds							Summer Wind Storm							Summer Storms - 1							Summer Storms - 2						
CLIMATE ASSESSMENT Select: Current 🟥 Future ☐	Wind Gusts >80km/h							Microburst or Straight Line Winds							25-50mm Rain in 2 Hours							Golf Ball Sized Hail						
	Probability: 3							Probability: 3							Probability: 3							Probability: 2						
	Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk		
		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f
COMMUNITY BUILDINGS																												
School																												
Roof	Y	3	4	4	9	12	12	Y	3	4	4	9	12	12														
Structure																						Y	3			6	0	0
Exterior Cover																												
Foundation															Y	2			6	0	0							
Grounds	Y	3	4	4	9	12	12	Y	3	4	4	9	12	12														
HVAC System																												
Electrical System																												
Water and Sewer															Y		2	2	0	6	6							
Safe House																												
Roof	Y	2	1	1	6	3	3	Y	2	1	1	6	3	3														
Structure																						Y	2			4	0	0
Exterior Cover																												
Foundation															Y	2		1	6	0	3							
Grounds	Y	3	2	2	9	6	6	Y	3	2	2	9	6	6	Y		1		0	3	0							
HVAC System																												
Electrical System																												
Water and Sewer															Y			1	0	0	3							
Firehall																												
Roof	Y	3	2	2	9	6	6	Y	3	2	2	9	6	6														
Structure																												
Exterior Cover																												
Foundation																												
Grounds																												
HVAC System																												
Electrical System																												
Water and Sewer																												
Health Centre																												
Roof	Y	3	4	4	9	12	12	Y	3	4	4	9	12	12														
Structure																						Y	2			4	0	0
Exterior Cover																												
Foundation															Y	2		1	6	0	3							
Grounds																												
HVAC System																												
Electrical System																												
Water and Sewer																												
Staffing																												
Head Start Building																												
Roof	Y	3	2	2	9	6	6	Y	3	2	2	9	6	6														
Structure																						Y	2			4	0	0
Exterior Cover																												
Foundation															Y	2		1	6	0	3							
Grounds																												
HVAC System																												
Electrical System																												
Water and Sewer																												
WATER AND WASTE WATER TREATMENT SYSTEMS																												
WTP Building/Booster Station																												
Roof	Y	3	2	2	9	6	6	Y	3	2	2	9	6	6														
Structure																												
Exterior Cover																												

First Nations Infrastrcuture Resilience Toolkit

Yellow Quill First Nation Worksheet

Foundation	130	2011	9																																																						
Grounds	130	2011	9																																																						
HVAC System	130	2011	9																																																						
Treatment Equipment	130	2011	9																																																						
Pipes and Valves (Booster Station)	130	2011	9	Y	3	3	3	12	12	12	Y	3	3	3	15	15	15																																										
Electrical System	130	2011	9																																																						
RW Pump House	130	2011	9																																																						
Pump Building	130	2011	9																					Y	4	4	4	8	8	8	Y	3	2	2	9	6	6	Y	3	2	2	9	6	6														
Drilled Wells	130	2011	9																																																						
Communication/SCADA System	130	2011	9																					Y	4	4	4	8	8	8	Y	4	4	3	12	12	9	Y	4	4	3	12	12	9	Y		1	1	0	3	3	Y	3	3	4	6	6	8
Waste Water Treatment System	4070	1988	8																																																						
Pipes and Valves	4070	1988	8	Y		3		0	12	0																																															
Electrical System	4070	1988	8																																																						
Outfall	4960	-	-																																																						
Public Works Garage	40	1985	4																																																						
Roof	40	1985	4																					Y	4	4	4	8	8	8																												
Structure	40	1985	4																					Y	4	4	4	8	8	8																												
Exterior Cover	40	1985	4																					Y	4	4	4	8	8	8																												
Foundation	40	1985	4																																																						
Grounds	40	1985	4																																																						
HVAC System	40	1985	4																																																						
Electrical System	40	1985	4																																																						
Shop	150	1980	4																																																						
Roof	150	1980	4																					Y	4	4	4	8	8	8																												
Structure	150	1980	4																					Y	4	4	4	8	8	8																												
Exterior Cover	150	1980	4																					Y	4	4	4	8	8	8																												
Foundation	150	1980	4																																																						
HVAC System	150	1980	4																																																						
Electrical System	150	1980	4																																																						
HOUSING																																																											
Serviced Housing																																																											
Roof				Y	1			4	0	0																Y	4	4	4	8	8	8	Y	2	1	1	6	3	3	Y	2	1	1	6	3	3														
Structure																								Y	4	4	4	8	8	8																						Y	2			4	0	0
Exterior Cover																								Y	4	4	4	8	8	8																												
Foundation																																														Y	3		1	9	0	3							
Grounds																																																											
HVAC System							2												Y			3	0	0	9																																			
Electrical System																																																											
Water and Sewer				Y	4			16	0	0																																																	
Unserviced Housing																																																											
Roof																								Y	4	4	4	8	8	8	Y	2	1	1	6	3	3	Y	2	1	1	6	3	3														
Structure																								Y	4	4	4	8	8	8																						Y	2			4	0	0
Exterior Cover																								Y	4	4	4	8	8	8																												
Foundation																																														Y	3		1	9	0	3							
Grounds																																																											
HVAC System							2				Y			2	0	0	10																																										
Electrical System																																																											
Cisterns						3																		Y		3	3	0	6	6															Y	3		4	9	0	12							
Septic Tank and Bed																																																											
ROADS AND DRAINAGE																																																											
Asphalt																																																											
Gravel																																																											
Ditches																																																											
Culverts																																														Y	3	3	3	9	9	9							
Lighting	4100	1993	7																					Y	4	2	4	8	4	8	Y	2	3	3	6	9	9	Y	2	3	3	6	9	9														
Guard Rails																																																											
Third Party Services																																																											
Power/Hydro																								Y			5	0	0	10	Y	3	4	4	9	12	12	Y	3	4	4	9	12	12														
Gas																																																											
Telecommunications (Sasktel)																								Y			4	0	0	8	Y	3	4	5	9	12	15	Y	3	4	4	9	12	12								Y	3		4	6	0	8
Notation: S_s / R_s = Structural | S_o / R_o = Operational | S_f / R_f = Functional																																																											
					TOTALS																																																							
	Extreme (>= 20)				0			0	0	0					0	0	0					0	0	0					0	0	0					0	0	0					0	0	0					0	0	0					0	0	0
	High (10 - 16)				33			3	5	3					1	1	3					0	0	0					0	0	0					1	4	3					1	4	3					0	0	1					0	0	0
	Moderate (8 - 9)				132			0	0	0					0	0	0					0	0	5					33	32	33					8	1	2					8	1	2					4	1	1					0	0	1
	Low (3 - 6)				101			5	5	3					1	1	3					0	0	0					0	2	1					5	12	11					5	12	11					4	3	9					7	1	0
	Negligible (< 3)				0			0	0	0					0	0	0					0	0	0					0	0	0					0	0	0					0	0	0					0	0	0					0	0	0

First Nation Infrastrcuture Resilience Toolkit

Yellow Quill First Nation Worksheet

Asset/Infrastructure Elements	ACRS/ICMS Information			Climate 1							Climate 2							Climate 3							Climate 4							Climate 5							Climate 6							Climate 7							Climate 8						
				Temperature							Temperature							Temperature							Wind							Wind							Wind							Precipitation							Precipitation						
				Winter Storm							Extreme Cold							Heat Wave							Tornado							High Winds							Summer Wind Storm							Summer Storms - 1							Summer Storms - 2						
CLIMATE ASSESSMENT Select: Current ☐ Future 🟥	Asset Number	Year Constructed	Genearl Condition	Windchill, snowfall combined with high winds, strong winds, possible freezing rain							Cold Temperatures <-30C							Temp >30C and >18C Overnight							F0 to F2							Wind Gusts >80km/h							Microburst or Straight Line Winds							25-50mm Rain in 2 Hours							Golf Ball Sized Hail						
				Probability:					4		Probability:					4		Probability:					5		Probability:					4		Probability:					3		Probability:					4		Probability:					4		Probability:					3	
	(Entre)	(Auto Fill)	(Auto Fill)	Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk			Y/N	Severity			Risk		
					S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f		S_s	S_o	S_f	R_s	R_o	R_f
COMMUNITY BUILDINGS																																																											
School	60	1999	6																																																								
Roof	60	1999	6	Y	1			4	0	0															Y	4	4	4	16	16	16	Y	3	4	4	9	12	12	Y	3	4	4	12	16	16														
Structure	60	1999	6																						Y	4	4	4	16	16	16																						Y	3			9	0	0
Exterior Cover	60	1999	6																						Y	4	4	4	16	16	16																												
Foundation	60	1999	6																																											Y	2			8	0	0							
Grounds	60	1999	6																													Y	3	4	4	9	12	12	Y	3	4	4	12	16	16														
HVAC System	60	1999	6	Y		4	3	0	16	12	Y			3	0	0	12	Y			3	0	0	15																																			
Electrical System	60	1999	6	Y	4			16	0	0																																																	
Water and Sewer	60	1999	6																																											Y		2	2	0	8	8							
Safe House																																																											
Roof																									Y	4	4	4	16	16	16	Y	2	1	1	6	3	3	Y	2	1	1	8	4	4														
Structure																									Y	4	4	4	16	16	16																						Y	2			6	0	0
Exterior Cover																									Y	4	4	4	16	16	16																												
Foundation																																														Y	2		1	8	0	4							
Grounds																																Y	3	2	2	9	6	6	Y	3	2	2	12	8	8	Y		1		0	4	0							
HVAC System				Y		4	3	0	16	12								Y			3	0	0	15																																			
Electrical System																																																											
Water and Sewer				Y		3		0	12	0																																				Y			1	0	0	4							
Firehall	140	1989	5																																																								
Roof	140	1989	5																						Y	4	4	4	16	16	16	Y	3	2	2	9	6	6	Y	3	2	2	12	8	8														
Structure	140	1989	5																						Y	4	4	4	16	16	16																												
Exterior Cover	140	1989	5																						Y	4	4	4	16	16	16																												
Foundation	140	1989	5																																																								
Grounds	140	1989	5																																																								
HVAC System	140	1989	5																																																								
Electrical System	140	1989	5																																																								
Water and Sewer	140	1989	5																																																							
Health Centre	0		6																																																								
Roof	0		6																						Y	4	4	4	16	16	16	Y	3	4	4	9	12	12	Y	3	4	4	12	16	16														
Structure	0		6																						Y	4	4	4	16	16	16																						Y	2			6	0	0
Exterior Cover	0		6																						Y	4	4	4	16	16	16																												
Foundation	0		6																																											Y	2		1	8	0	4							
Grounds	0		6																																																								
HVAC System	0		6														Y			3	0	0	15																																				
Electrical System	0		6																																																								
Water and Sewer	0		6																																																								
Staffing																																																											
Head Start Building																																																											
Roof																									Y	4	4	4	16	16	16	Y	3	2	2	9	6	6	Y	3	2	2	12	8	8														
Structure																									Y	4	4	4	16	16	16																						Y	2			6	0	0
Exterior Cover																									Y	4	4	4	16	16	16																												
Foundation																																														Y	2		1	8	0	4							
Grounds																																																											
HVAC System																	Y			3	0	0	15																																				
Electrical System																																																											
Water and Sewer																																																											
WATER AND WASTE WATER TREATMENT SYSTEMS																																																											
WTP Building/Booster Station	130	2011	9																																																								
Roof	130	2011	9																						Y	4	4	4	16	16	16	Y	3	2	2	9	6	6	Y	3	2	2	12	8	8														
Structure	130	2011	9																						Y	4	4	4	16	16	16																												
Exterior Cover	130	2011	9																						Y	4	4	4	16	16	16																												

First Nation Infrastrcuture Resilience Toolkit

Yellow Quill First Nation Worksheet

Foundation	130	2011	9																																																						
Grounds	130	2011	9																																																						
HVAC System	130	2011	9																																																						
Treatment Equipment	130	2011	9																																																						
Pipes and Valves (Booster Station)	130	2011	9	Y	3	3	3	12	12	12	Y	3	3	3	12	12	12																																								
Electrical System	130	2011	9																																																						
RW Pump House	130	2011	9																																																						
Pump Building	130	2011	9																					Y	4	4	4	16	16	16	Y	3	2	2	9	6	6	Y	3	2	2	12	8	8														
Drilled Wells	130	2011	9																																																						
Communication/SCADA System	130	2011	9																					Y	4	4	4	16	16	16	Y	4	4	3	12	12	9	Y	4	4	3	16	16	12	Y		1	1	0	4	4	Y	3	3	4	9	9	12
Waste Water Treatment System	4070	1988	8																																																						
Pipes and Valves	4070	1988	8	Y		3		0	12	0																																															
Electrical System	4070	1988	8																																																						
Outfall	4960	-	-																																																						
Public Works Garage	40	1985	4																																																						
Roof	40	1985	4																					Y	4	4	4	16	16	16																													
Structure	40	1985	4																					Y	4	4	4	16	16	16																													
Exterior Cover	40	1985	4																					Y	4	4	4	16	16	16																													
Foundation	40	1985	4																																																						
Grounds	40	1985	4																																																						
HVAC System	40	1985	4																																																						
Electrical System	40	1985	4																																																						
Shop	150	1980	4																																																						
Roof	150	1980	4																					Y	4	4	4	16	16	16																													
Structure	150	1980	4																					Y	4	4	4	16	16	16																													
Exterior Cover	150	1980	4																					Y	4	4	4	16	16	16																													
Foundation	150	1980	4																																																						
HVAC System	150	1980	4																																																						
Electrical System	150	1980	4																																																						
HOUSING																																																											
Serviced Housing																																																											
Roof				Y	1			4	0	0														Y	4	4	4	16	16	16	Y	2	1	1	6	3	3	Y	2	1	1	8	4	4														
Structure																								Y	4	4	4	16	16	16																						Y	2			6	0	0
Exterior Cover																								Y	4	4	4	16	16	16																													
Foundation																																													Y	3		1	12	0	4							
Grounds																																																										
HVAC System							2												Y			3	0	0	15																																		
Electrical System																																																											
Water and Sewer				Y	4			16	0	0																																																	
Unserviced Housing																																																											
Roof																								Y	4	4	4	16	16	16	Y	2	1	1	6	3	3	Y	2	1	1	8	4	4														
Structure																								Y	4	4	4	16	16	16																						Y	2			6	0	0
Exterior Cover																								Y	4	4	4	16	16	16																													
Foundation																																													Y	3		1	12	0	4							
Grounds																																																										
HVAC System							2				Y			2	0	0	8																																									
Electrical System																																																											
Cisterns						3																		Y		3	3	0	12	12															Y	3		4	12	0	16							
Septic Tank and Bed																																																											
ROADS AND DRAINAGE																																																											
Asphalt																																																											
Gravel																																																											
Ditches																																																											
Culverts																																													Y	3	3	3	12	12	12							
Lighting	4100	1993	7																					Y	4	2	4	16	8	16	Y	2	3	3	6	9	9	Y	2	3	3	8	12	12														
Guard Rails																																																											
Third Party Services																																																											
Power/Hydro																								Y			5	0	0	20	Y	3	4	4	9	12	12	Y	3	4	4	12	16	16														
Gas																																																											
Telecommunications (Sasktel)																								Y			4	0	0	16	Y	3	4	5	9	12	15	Y	3	4	4	12	16	16								Y	3		4	9	0	12
Notation: S_s / R_s = Structural | S_o / R_o = Operational | S_f / R_f = Functional																																																											
				TOTALS																																																					
	Extreme (>= 20)				1			0	0	0					0	0	0					0	0	0					0	0	1					0	0	0					0	0	0					0	0	0					0	0	0
	High (10 - 16)				167			3	5	3					1	1	2					0	0	5					33	33	35					1	6	5					11	7	7					4	1	2					0	0	2
	Moderate (8 - 9)				40			0	0	0					0	0	1					0	0	0					0	1	1					10	1	2					4	5	5					4	1	1					3	1	0
	Low (3 - 6)				209			5	5	3					1	1	2					0	0	5					33	33	35					5	14	13					11	10	10					4	3	9					5	0	2
	Negligible (< 3)				0			0	0	0					0	0	0					0	0	0					0	0	0					0	0	0					0	0	0					0	0	0					0	0	0

APPENDIX F

YELLOW QUILL FIRST NATION CLIMATE PROFILE REPORT

Yellow Quill First Nation Climate Profile

November 12, 2019

Project No. 163401530

Prepared by:

Stantec

Developed in partnership with:

Ontario First Nations Technical Services Corporation

Table of Contents

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The first step in developing a profile of the historic climate and future climate projections for an area, is selecting nearby weather stations that can provide accurate temperature, precipitation, wind and other relevant meteorological data.

Using an area centered on the Yellow Quill Band Hall, there are a number of historical weather monitoring stations (no nearby active stations) in the vicinity of the Yellow Quill First Nation lands. The weather stations ID, approximate distance from the area centre, and the range and availability of data at each station are provided in Table 1. Data availability is represented as the percent to which the dataset from each station is complete for both temperature and precipitation.

Table 1: Summary of weather monitoring stations in the vicinity of the site location

Weather Monitoring Station	Station ID	Distance from approximate Site Location (centered on the YQ Band Hall)	Data Range	Data Availability	
				Temperature	Precipitation
Archerwill	4080200	21 km	1951-1982	6%	96%
Kelvington	4083720	24 km	1953-1967	92%	91%
Mckague	4085050	31 km	1971-2001	13%	67%
McKague 2	4085052	32 km	1985-2015	89%	91%
Paswegin (1)	4015960	35 km	1921-1963	14%	18%
Paswegin (2)	4015960	35 km	1964-2003	99%	99%
CanGrd[1]	-	-	1950-2013	100%	100%

Four of the stations presented in Table 1 have either undesirable data ranges or data availabilities. Three of these stations (as highlighted) will be compared as candidate weather monitoring stations to represent the approximate climate of the Yellow Quill area.

To help determine the best proxy for the site, Figure 1 and Figure 2 illustrate the mean temperature and total annual precipitation accumulation data for each of these stations for comparative purposes. These plots show that the more complete CanGrd data tends to align with Mckague 2 weather station. For the purposes of this assessment, CanGrd data was selected to represent the climate in the vicinity of the Yellow Quill land area due to its completeness and distance from the area of interest (i.e. the Mckague 2 station is located further away).

It is important to note that any differences between the CanGrd and observed data in the area are likely to be less than the uncertainties associated with projection modelling and downscaling processes.

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[1] CanGrd is a gridded network of data produced through data interpolation from nearby weather stations.

Furthermore, mean annual temperature projections for 2020 (Table 2) follow in line with the average global climate model projections (Allen et al., 2018), which helps validate the local projection data presented below. Data presented throughout this report are not affected by annual historical data, but rather are based on projections from the 1981-2010 climate normal.

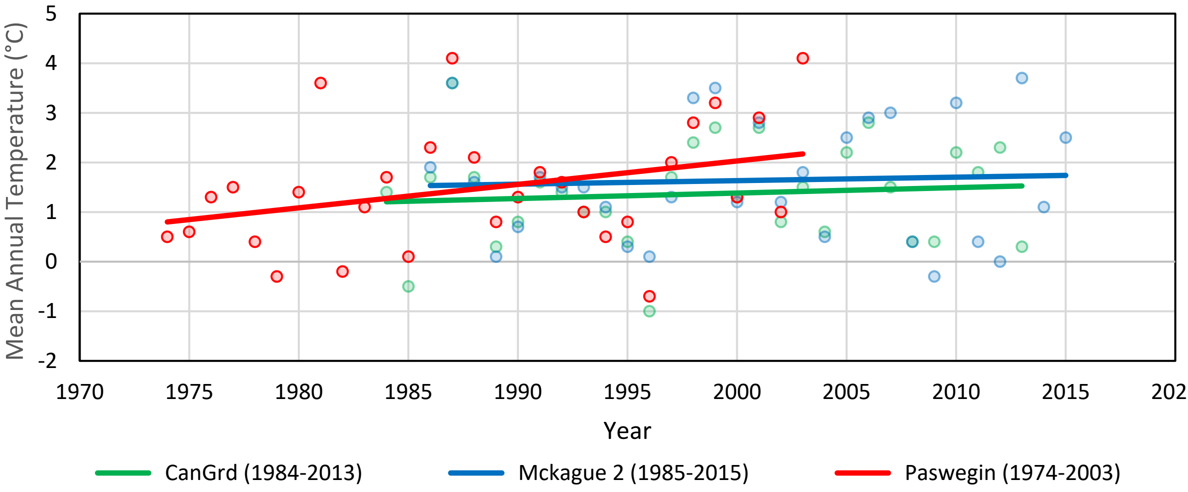

Figure 1: Comparison of historical mean annual temperature trends for the Mckague 2 (ID: 4085052) and Paswegin (ID: 4015960) weather stations and CANGRD data.

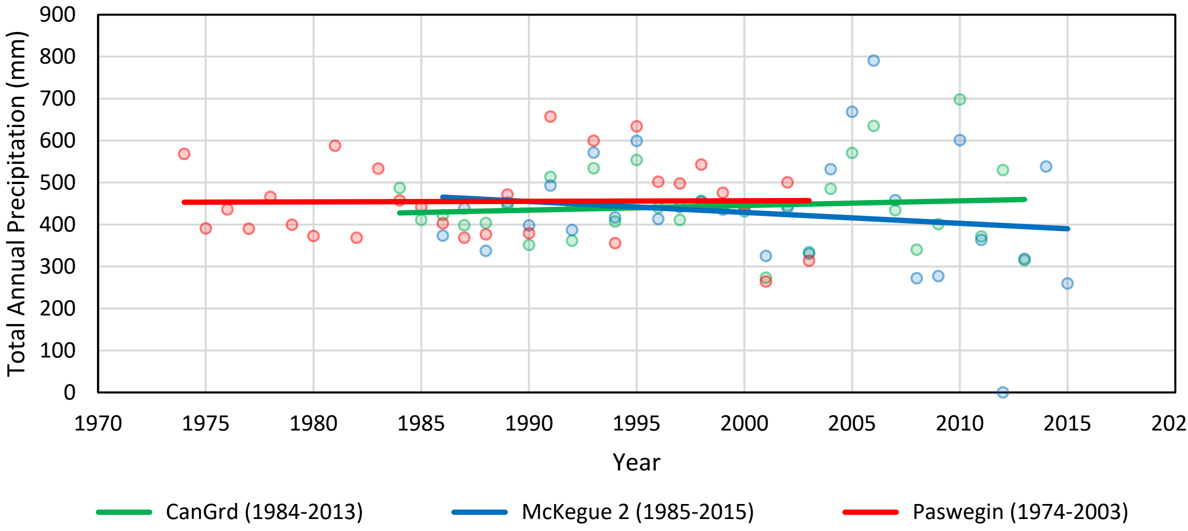

Figure 2: Comparison of historical total annual precipitation trends for the Mckague 2 (ID: 4085052) and Paswegin (ID: 4015960) weather stations and CANGRD data.

The IPCC is the international body for assessing the science related to climate change. The IPCC was set up in 1988 by the World Meteorological Organization (WMO) and United Nations Environment Programme (UNEP) to provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation.

IPCC assessments provide a scientific basis for governments at all levels to develop climate related policies, and they underlie negotiations at the UN Climate Conference – the United Nations Framework Convention on Climate Change (UNFCCC). The assessments are policy-relevant but not policy-prescriptive: they may present projections of future climate change based on different scenarios and the risks that climate change poses and discuss the implications of response options, but they do not tell policymakers what actions to take.

“Current climate” at a location is typically defined as the average weather for the last 30 years, although viewing the data over a longer period can be useful in understanding long-term trends. In addition to providing a profile of the “current climate” this document outlines the projected future climate for the Yellow Quill area,

A large source of uncertainty in future climate projections is a result of measuring global progress towards meeting greenhouse gas (GHG) emissions targets. There are four Representative Concentration Pathways (RCP)[2] scenarios adopted by the Intergovernmental Panel on Climate Change (IPCC) based on various future greenhouse gas concentration scenarios. Currently, global GHG concentrations are closer to following the “business as usual” greenhouse gas concentrations scenario, RCP 8.5 pathway, despite global agreements/targets for GHG emissions reductions. **Error! Reference source not found.** demonstrates that measured global emission rates continue to track along the RCP 8.5 pathway, which is the current standpoint of the IPCC as established in their 2018 special report on the impacts of global warming of 1.5°C above pre-industrial levels (Allen 2018). Future climate profiles will only present projection data for the RCP 8.5 scenario.

The current or baseline time horizons for the study is based on 1981-2010 Climate Normals. The climate for the 2020s (time horizon of 2011 to 2040) is presented to evaluate how recent trends correlate with projections in the near future. The 2050s (2041 to 2070) and 2080s (2071 to 2100) time horizons are presented as longer-term climate projections, which will highlight the variation between the various future GHG scenarios.

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[2] RCP: Representative Concentration Pathways – a greenhouse gas concentration (not emissions) trajectories adopted by the Intergovernmental Panel on Climate Change (IPCC) for its fifth Assessment Report (AR5) in 2014.

Climate is usually defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of meteorological variables such as temperature, precipitation and wind over a period of time, typically 30 years.[3] The "2050s" projected climate is therefore the projected average over the 30-year period from 2041 to 2070. The "baseline" current climate will be based on the 1984 to 2013 Climate Normals, as this information is widely available.

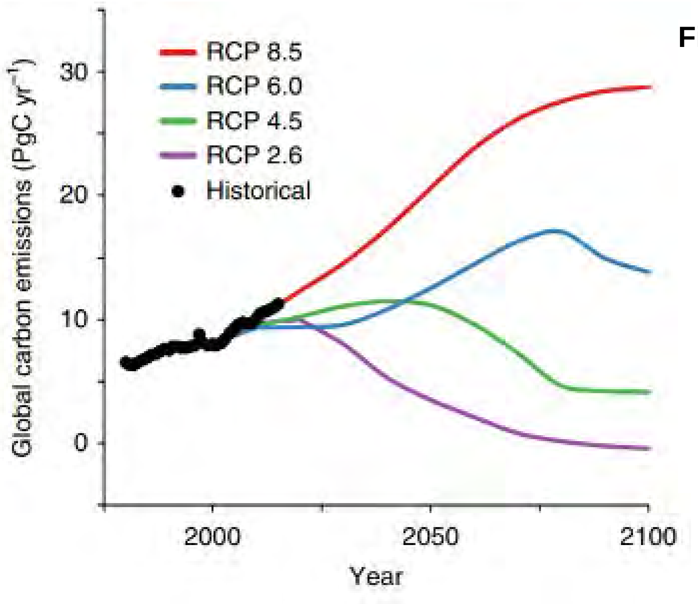

Figure 3: Historical CO_2 emissions for 1980-2017 and projected emissions trajectories to 2100 for the four Representative Concentration Pathway (RCP) scenarios. Current global emission trends have very closely followed the "business-as-usual" RCP8.5 scenario trajectory. Figure from Smith and Myers, 2018.

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[3] World Meteorological Organization, 2017: Commission for Climatology: Frequently Asked Questions. http://www.wmo.int/pages/prog/wcp/ccl/faqs.php (accessed Sept.28,2018)

2.0 TEMPERATURE

Baseline temperature data from CanGrd are presented in following subsections for the last climate normal period from 1981 to 2010. In addition to the baseline data, temperature projections are provided for three time periods to 2100. Projected changes provided here are generated using downscaled CMIP5 ensemble projections, containing 40 global climate models, through Risk Sciences International's Climate Change Hazards Information Portal (CCHIP). Temperature parameters are among the most accurately projected by global climate models and therefore hold a relatively high level of confidence in comparison to other parameters.

The Canadian prairies have experienced average annual mean temperature changes of 1.9°C and seasonal mean changes ranging from 1.1°C in the autumn to 3.1°C in the winter between 1948 and 2016 (Bush and Lemmen, 2019). Regional projections under RCP 8.5 anticipate a further increase in annual mean temperature of 2.3 and 6.5°C from 2031-2050 and 2081-2100 for the Canadian Prairies (Bush and Lemmen, 2019). It is noted that climate changes in the region are expected to be more exaggerated during the winter months than through the summer (Bush and Lemmen, 2019). These climate changes are generally reflected in the projection information presented in the following subsections which are more specific to the Yellow Quill area.

Note: Within the past 30-year climate period, historical data is not always aligned with mean, maximum and minimum temperature projections. In these cases, historical data from the past 60 years are used to gain a longer period of the temperature trends.

2.1 MEAN TEMPERATURE

2.1.1 Annual and Seasonal Average

Table 2: Average Change in Average Daily Mean Temperature from 1981-2010 Baseline, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Season	1981-2010 (°C)	Average Change in Mean Temperature from 1981-2010 Baseline (°C)		
		RCP 8.5		
		2020s	2050s	2080s
Annual	1.3	1.5	3.5	5.9
Winter	-15.4	1.8	4.3	7.3
Spring	1.9	1.3	3.0	5.1
Summer	16.3	1.3	3.2	5.6
Autumn	2.4	1.4	3.4	5.7

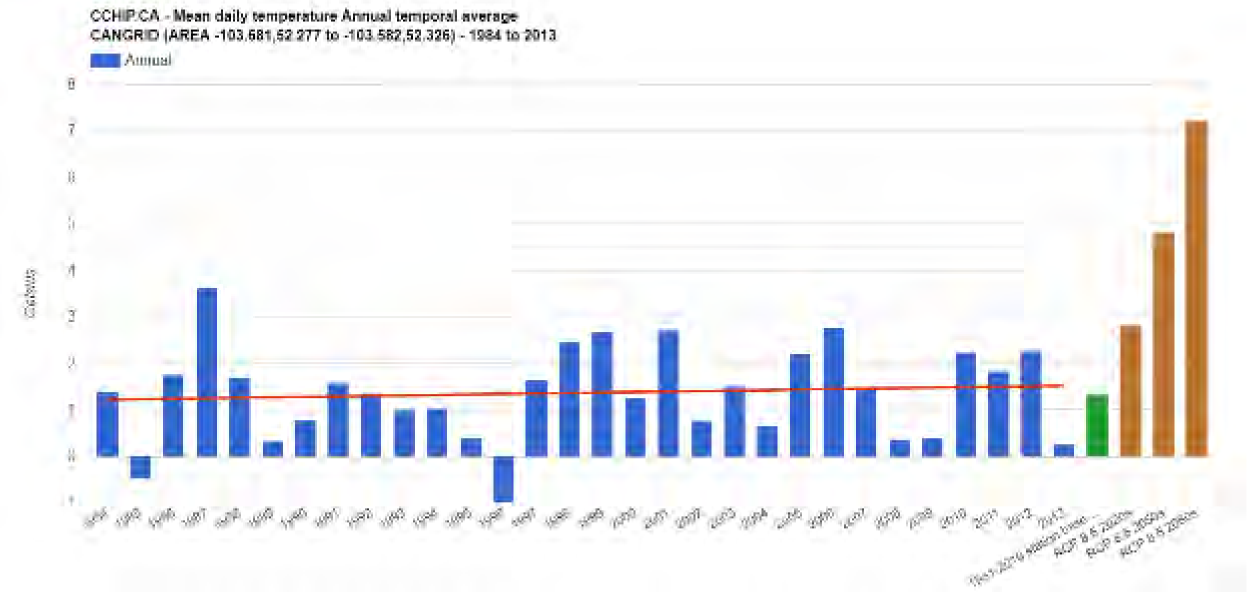

Figure 4: Annual Temporal Average – Mean Daily Temperature (30 years)

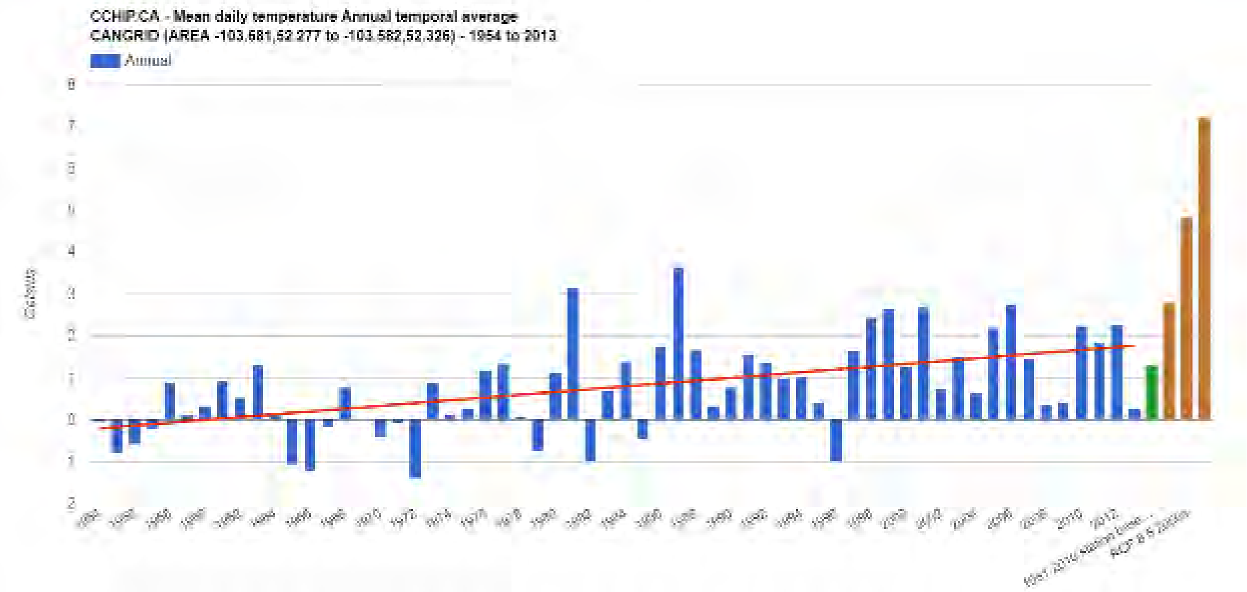

Figure 5: Annual Temporal Average – Mean Daily Temperature (60 years)

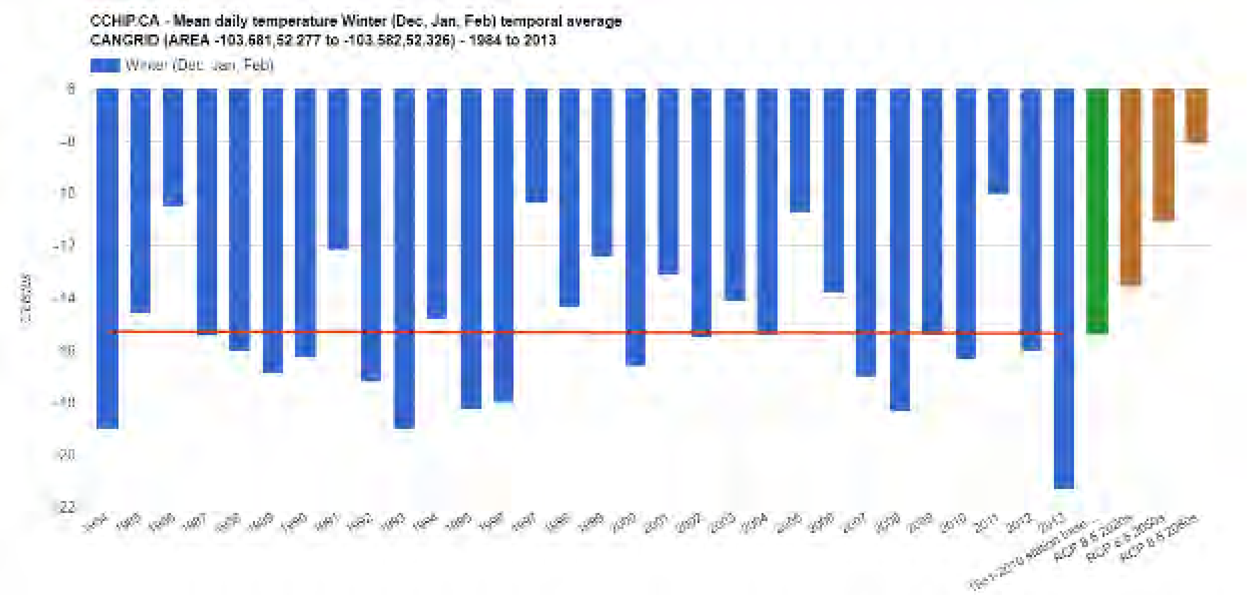

Figure 6: Winter Temporal Average – Mean Daily Temperature (30 years)

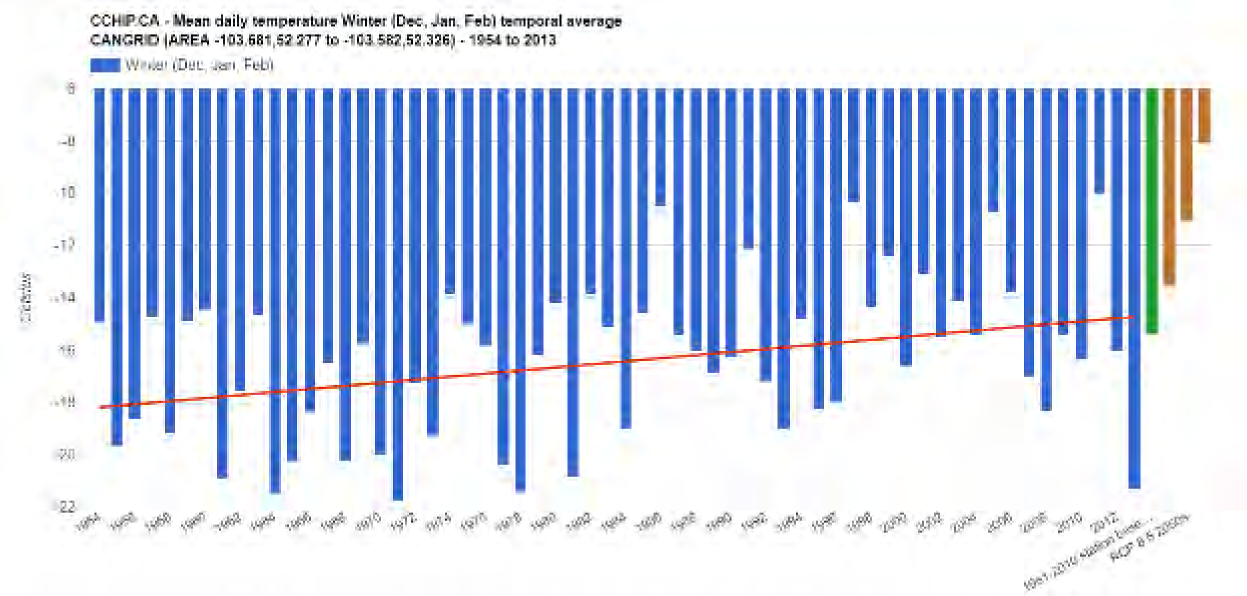

Figure 7: Winter Temporal Average – Mean Daily Temperature (60 years)

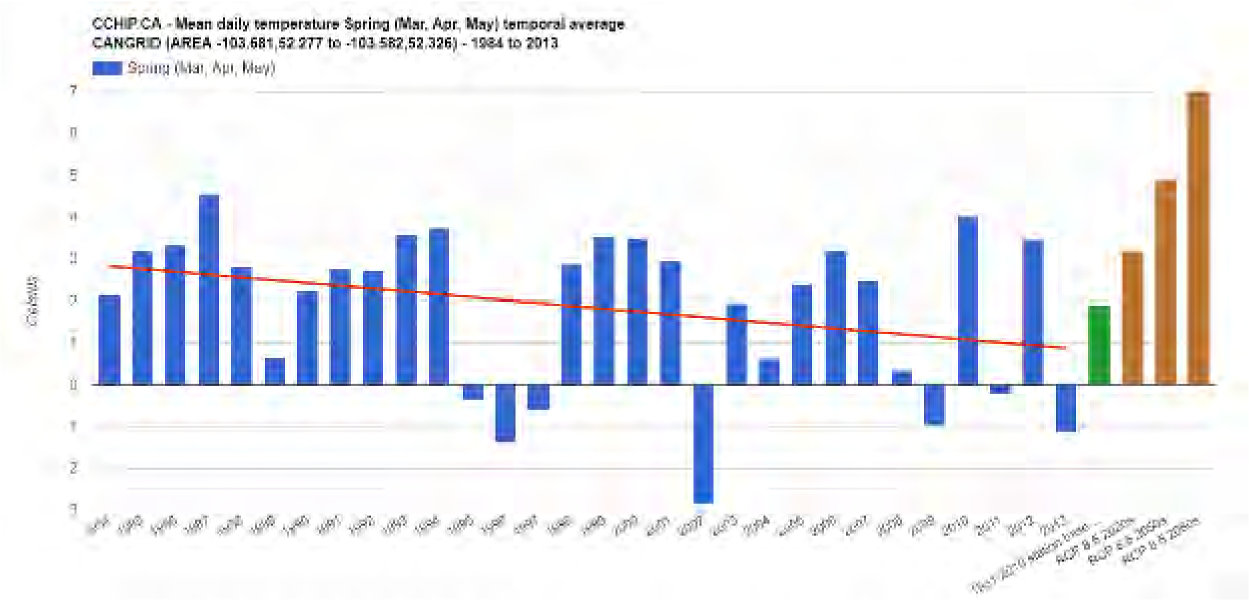

Figure 8: Spring Temporal Average – Mean Daily Temperature (30 years)

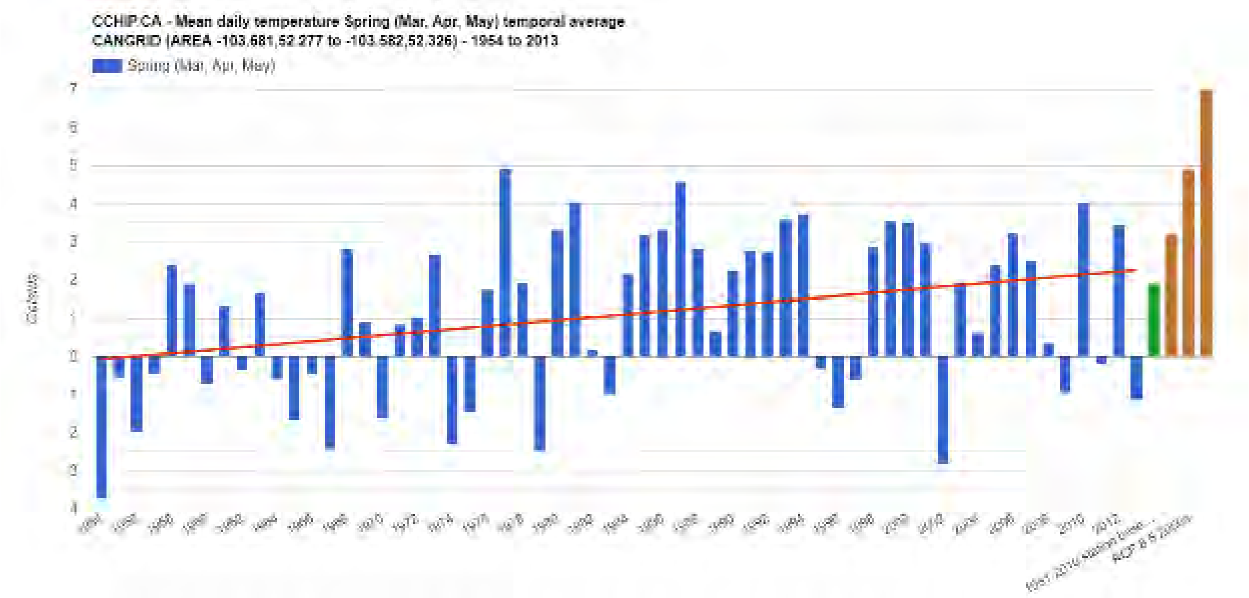

Figure 9: Spring Temporal Average – Mean Daily Temperature (60 years)

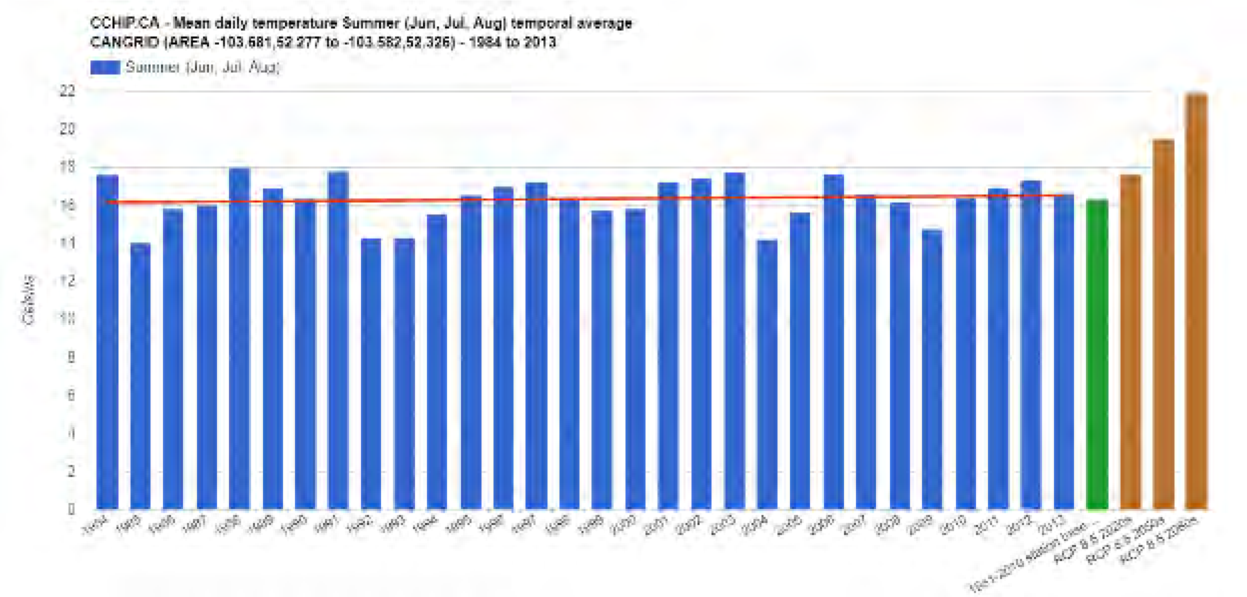

Figure 10: Summer Temporal Average – Mean Daily Temperature (30 years)

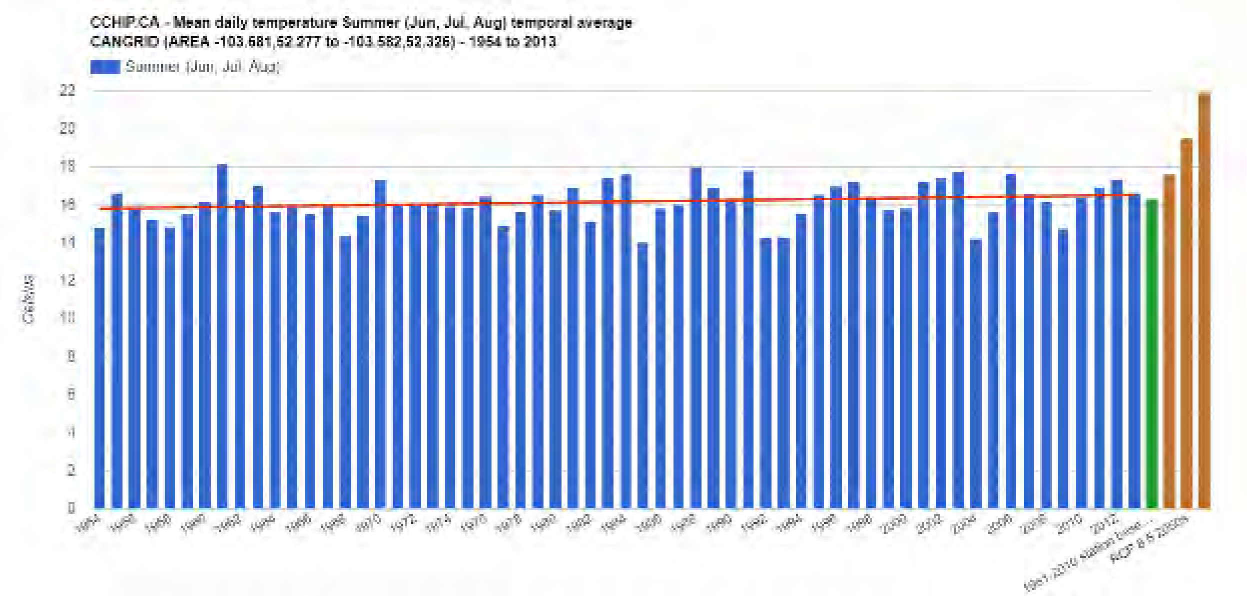

Figure 11: Summer Temporal Average – Mean Daily Temperature (60 years)

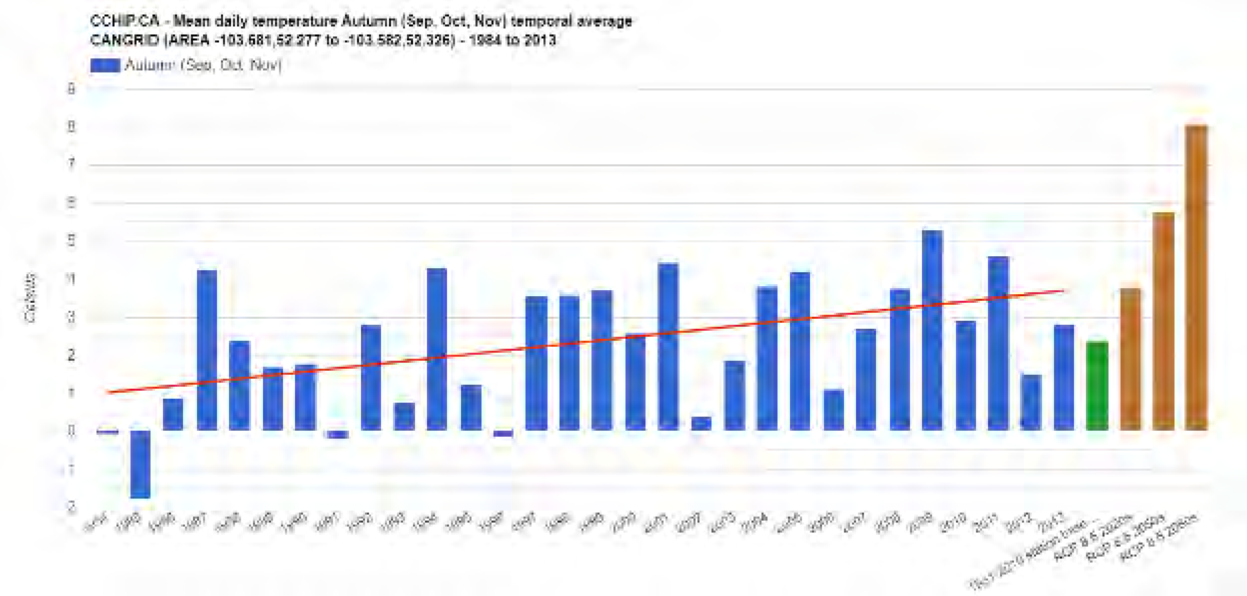

Figure 12: Autumn Temporal Average – Mean Daily Temperature (30 years)

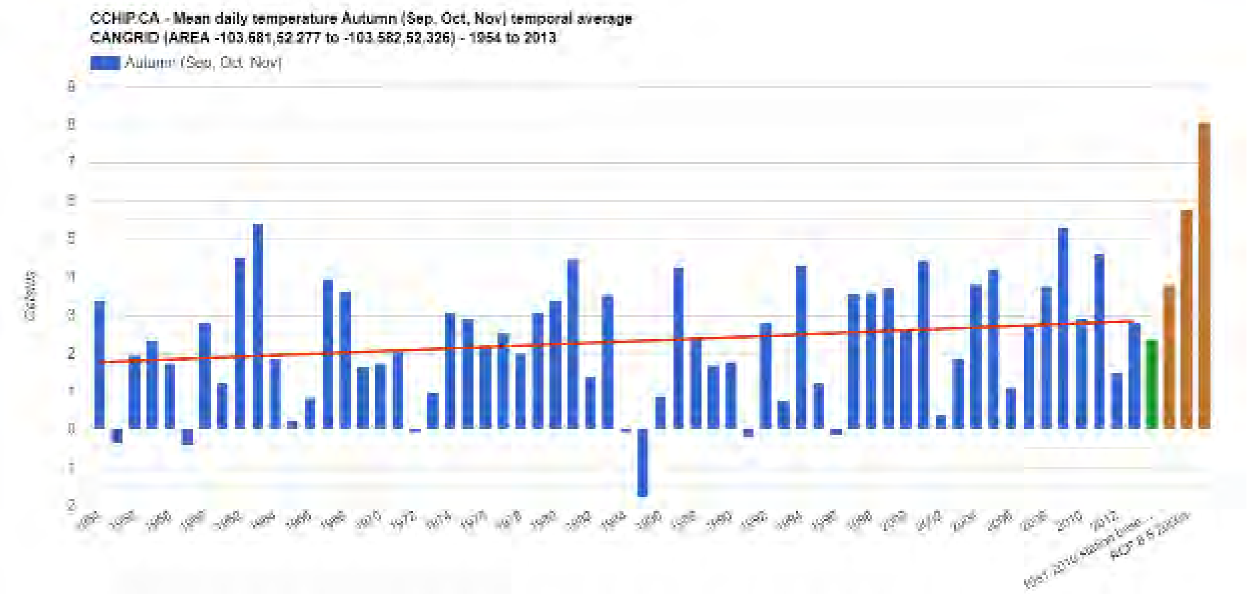

Figure 13: Autumn Temporal Average – Mean Daily Temperature (60 years)

2.2 MAXIMUM TEMPERATURE

2.2.1 Annual and Seasonal Average

Table 3: Average Change in Average Maximum Daily Temperature from 1981-2010 Baseline, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Season	1981-2010 (°C)	Average Change in Maximum Temperature from 1981-2010 Baseline (°C)		
		RCP 8.5		
		2020s	2050s	2080s
Annual	6.9	1.4	3.3	5.6
Winter	-10.5	1.6	3.7	6.2
Spring	7.8	1.2	3.0	5.0
Summer	22.6	1.3	3.2	5.7
Autumn	7.5	1.4	3.4	5.7

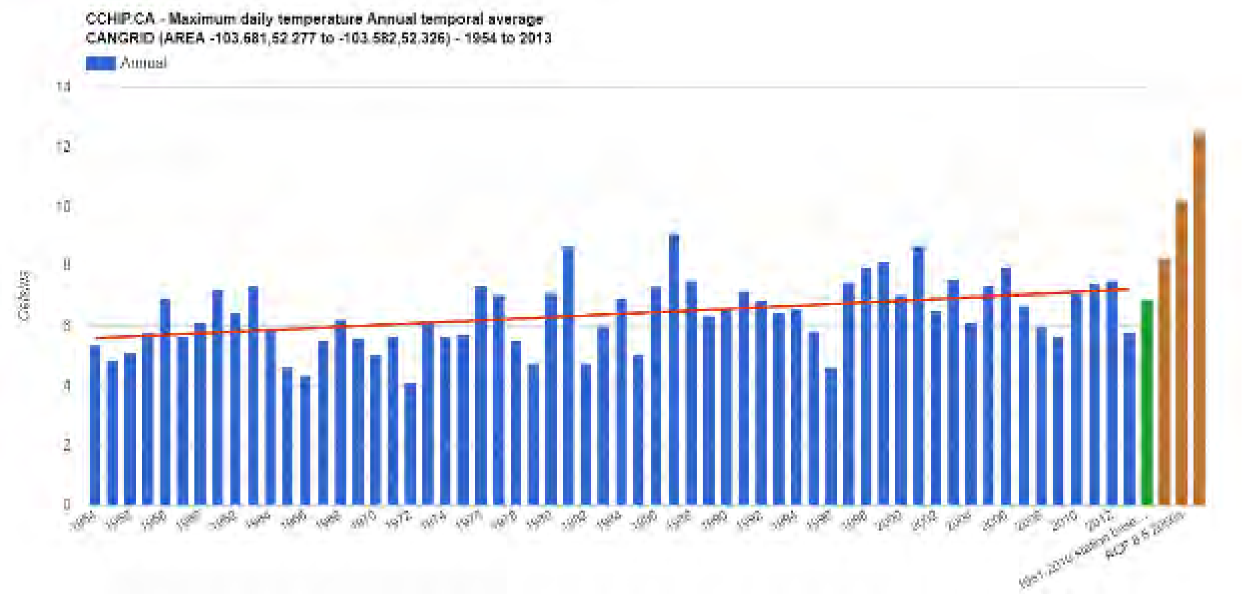

Figure 14: Annual Temporal Average – Maximum Daily Temperature (60 years)

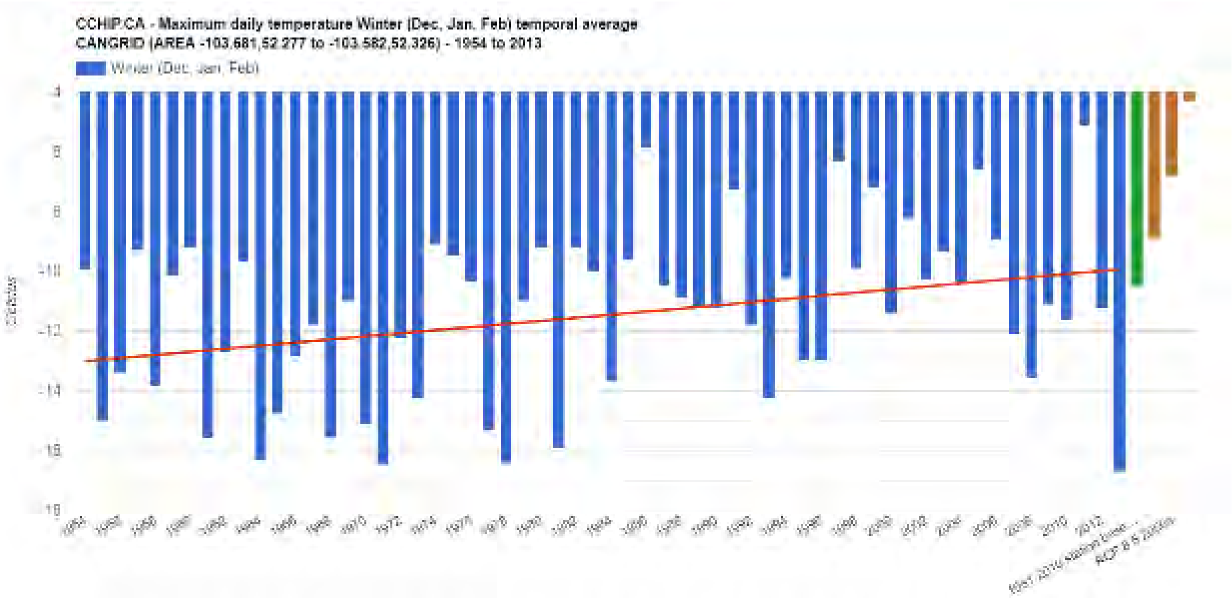

Figure 15: Winter Temporal Average – Maximum Daily Temperature (60 years)

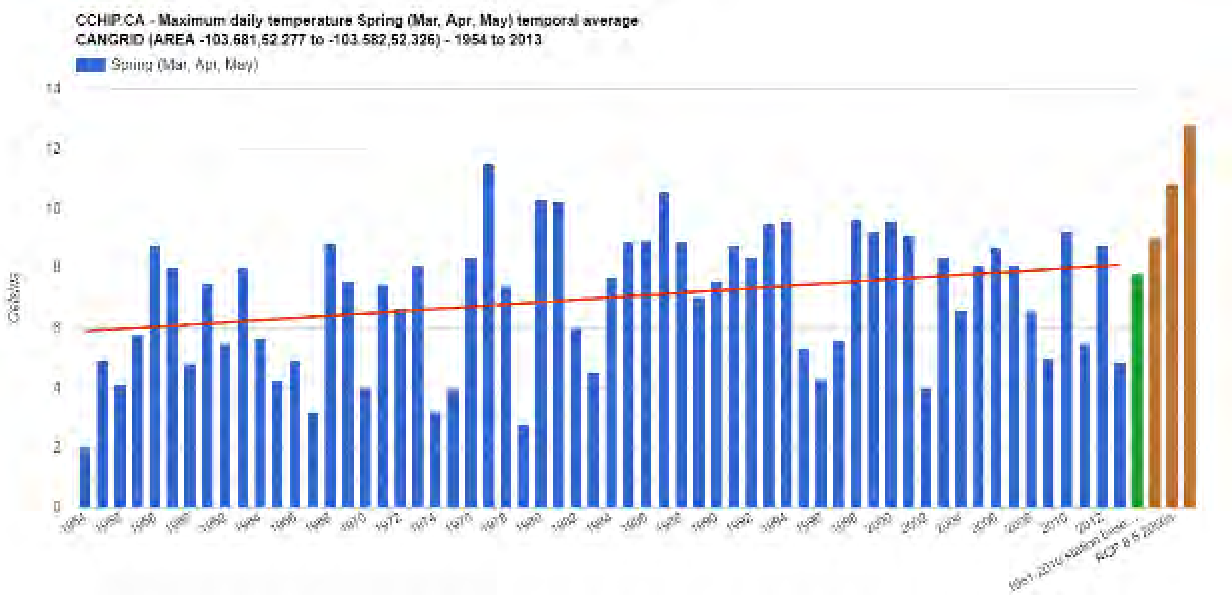

Figure 16: Spring Temporal Average – Maximum Daily Temperature (60 years)

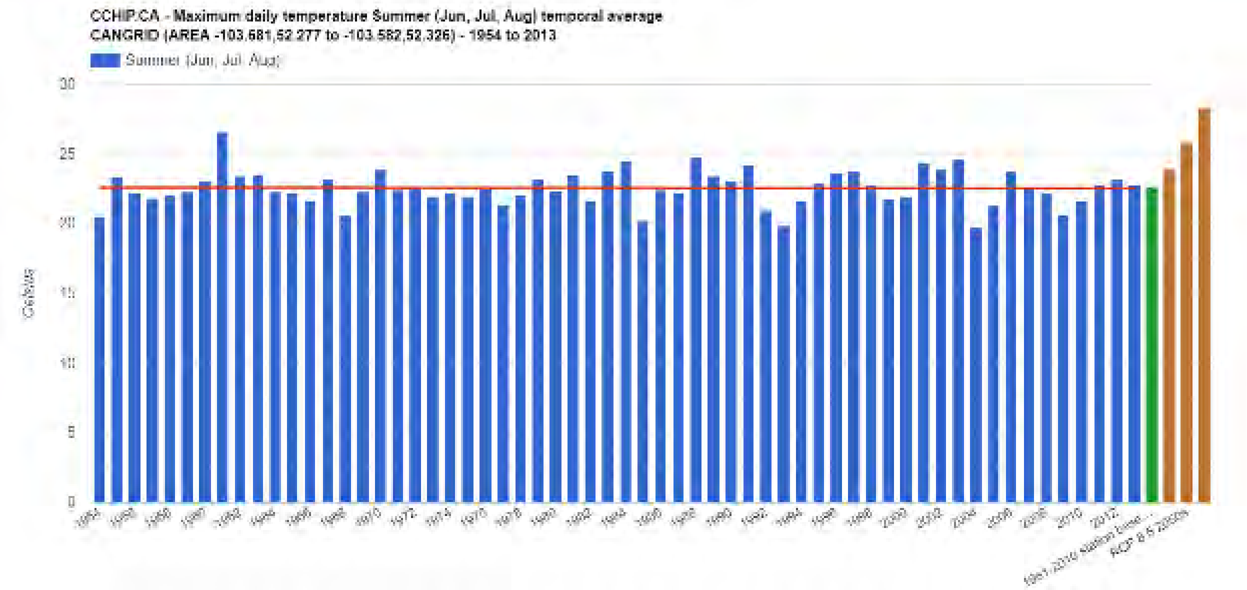

Figure 17: Summer Temporal Average – Maximum Daily Temperature (60 years)

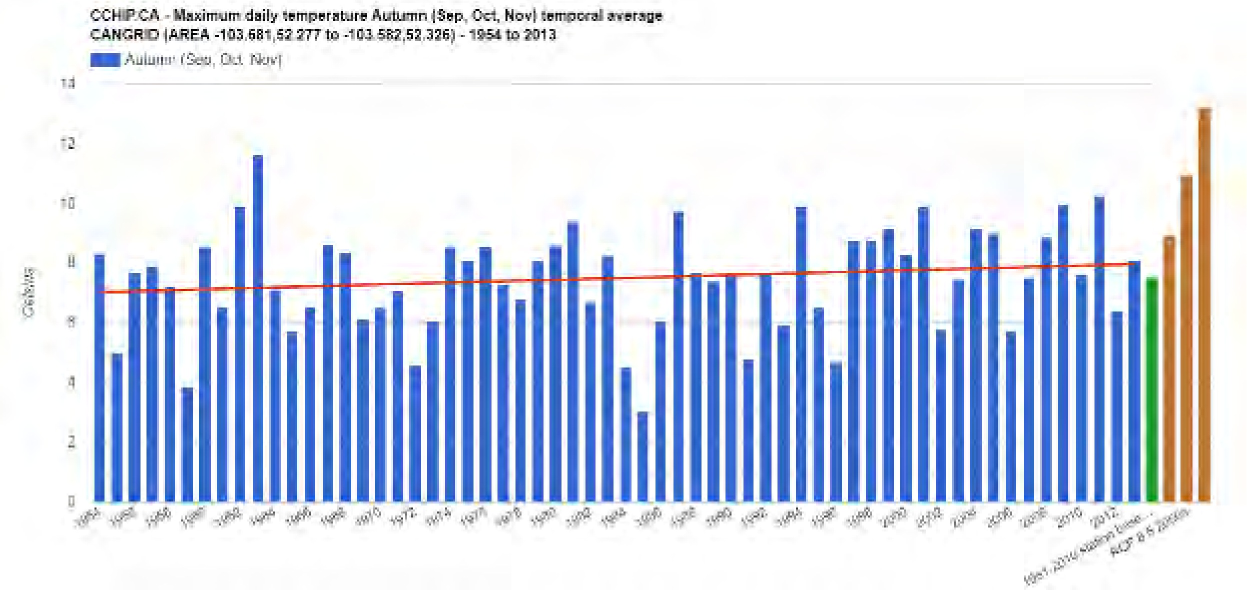

Figure 18: Autumn Temporal Average – Maximum Daily Temperature (60 years)

2.2.2 Extreme Maximum Temperature Frequency

It can be useful to view projected increases in temperatures as the change in the occurrence of days with a temperature higher than a certain extreme heat threshold. Table 4 presents the climate projection for the occurrence of days with temperatures greater than 25, 30, and 35°C.

Table 4: Occurrence of Maximum Temperatures, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Maximum Temperature Threshold	Annual Occurrence of Days above Max. Temp (Days/year)			
	Historical 1981-2010	RCP 8.5		
		2020s	2050s	2080s
25°C	34.59	49.11	68.69	95.18
30°C	5.41	10.06	20.80	43.08
35°C	0.19	0.71	2.37	8.51

2.3 MINIMUM TEMPERATURE

2.3.1 Annual and Seasonal Average

Table 5 shows projected future changes for average minimum annual and seasonal temperatures for the Yellow Quill area.

Table 5: Average Change in Average Minimum Daily Temperature from 1981-2010 Baseline, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Season	1981-2010 (°C)	Average Change in Minimum Temperature from 1981-2010 Baseline (°C)		
		RCP 8.5		
		2020s	2050s	2080s
Annual	-4.2	1.6	3.7	6.2
Winter	-20.3	2.1	5.0	8.3
Spring	-4.0	1.4	3.2	5.4
Summer	10.0	1.3	3.1	5.4
Autumn	-2.8	1.4	3.5	5.8

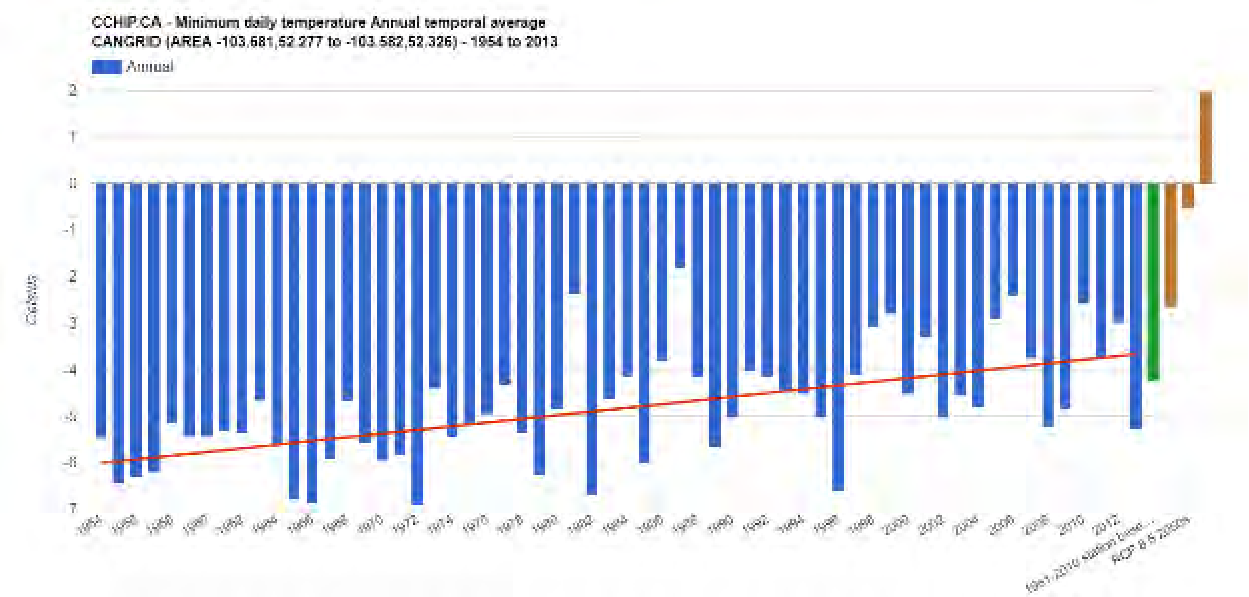

Figure 19: Annual Temporal Average – Minimum Daily Temperature (60 years)

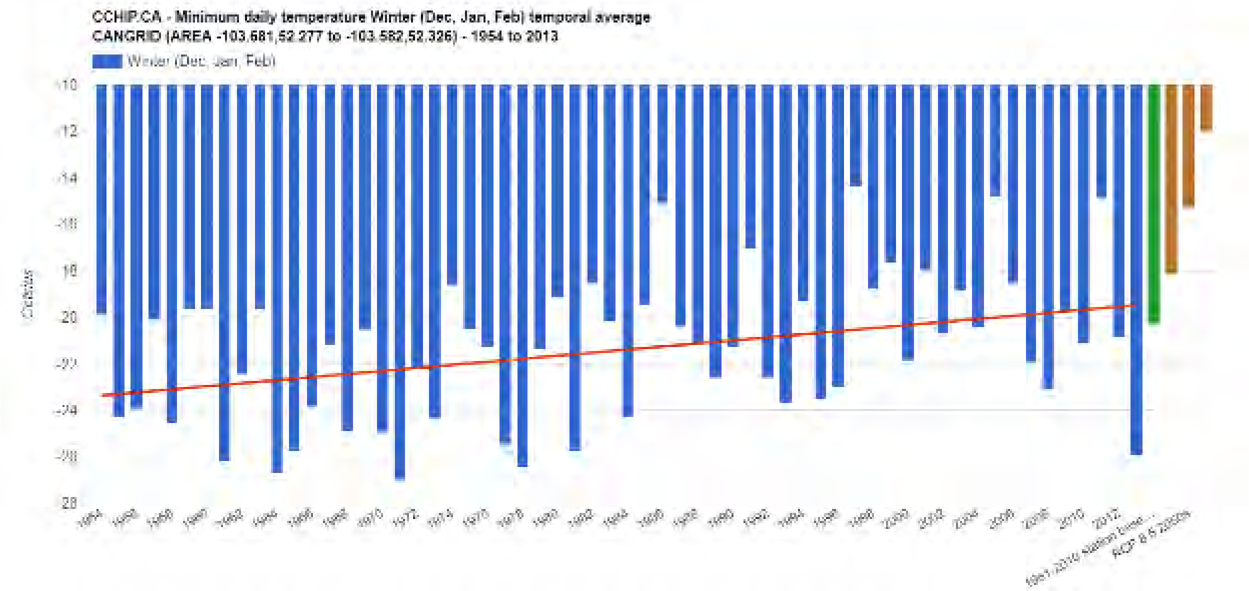

Figure 20: Winter Temporal Average – Minimum Daily Temperature (60 years)

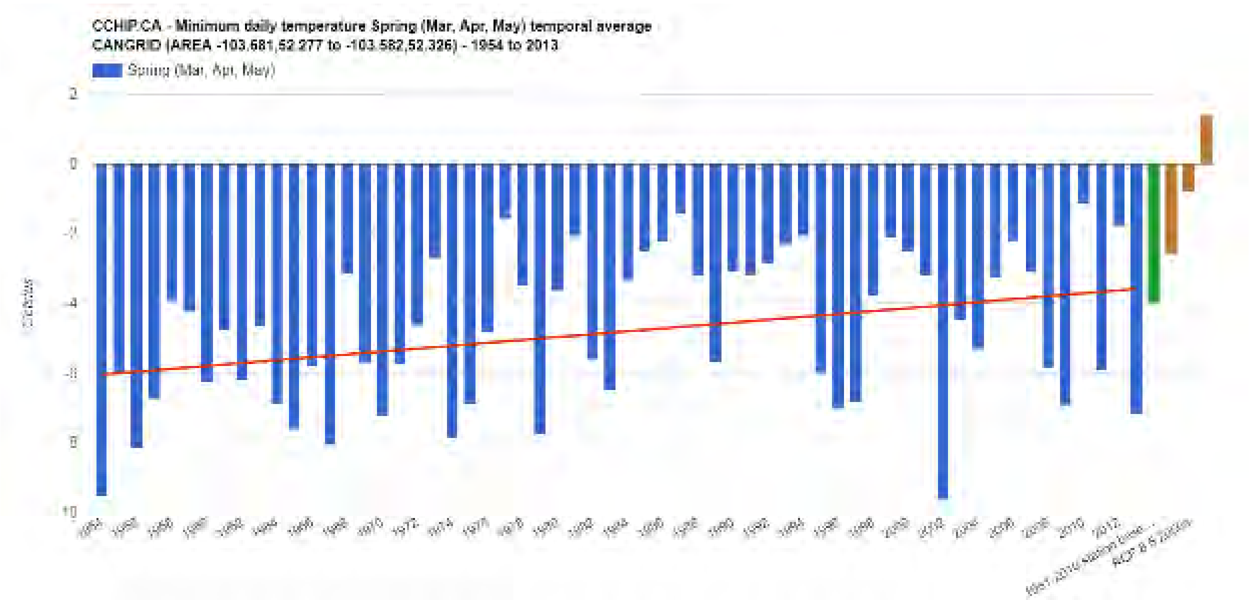

Figure 21: Spring Temporal Average – Minimum Daily Temperature (60 years)

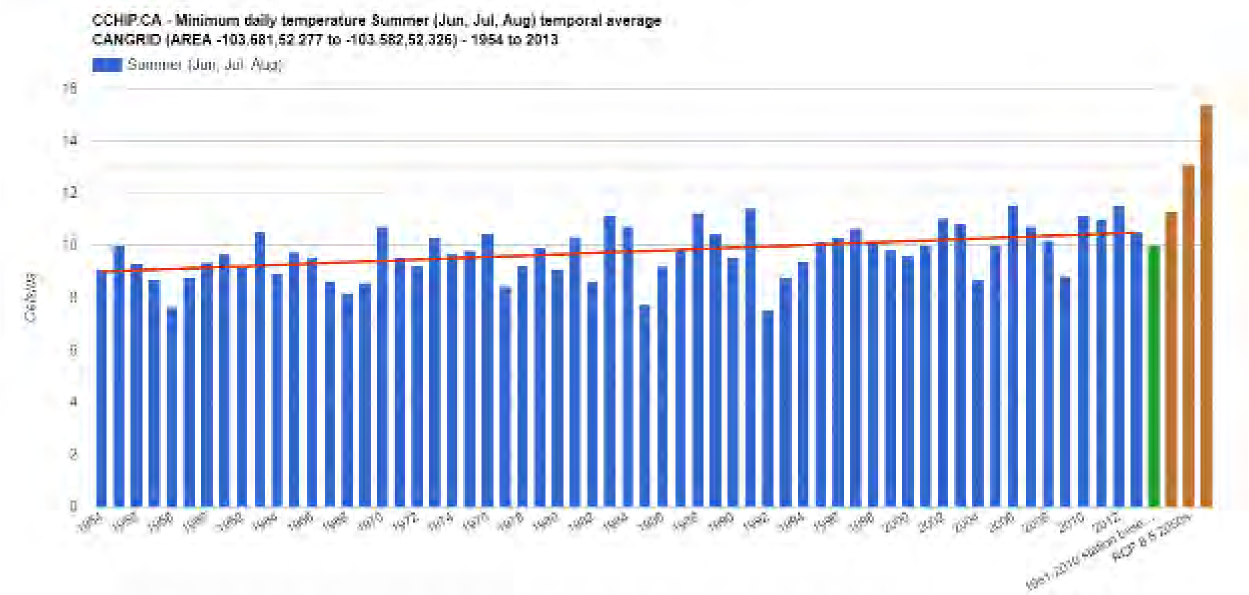

Figure 22: Summer Temporal Average – Minimum Daily Temperature (60 years)

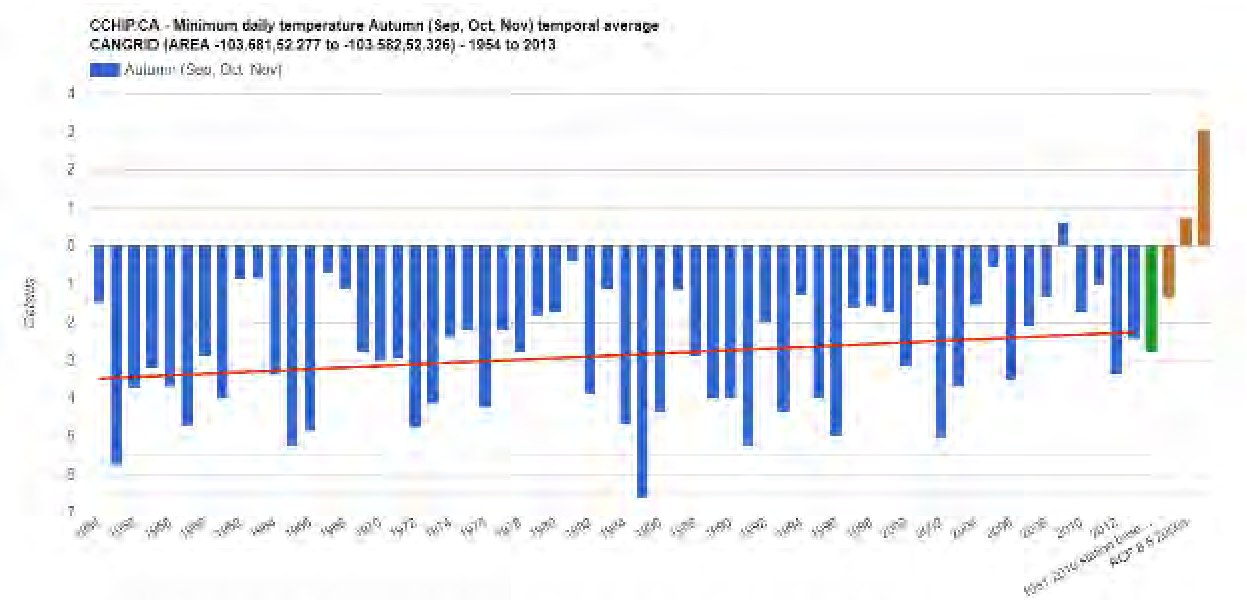

Figure 23: Autumn Temporal Average – Minimum Daily Temperature (60 years)

2.3.2 Extreme Minimum Temperature Frequency

It can be useful to view projected decreases in temperatures as the change in the occurrence of days with a temperature lower than a certain extreme cold threshold. Table 6 presents the climate projection for the occurrence of days with temperatures less than -30, -35, and -40°C.

Table 6: Occurrence of Minimum Temperatures, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Minimum Temperature Threshold	Annual Occurrence of Days below Min. Temp (Days/year)			
	Historical 1981-2010	RCP 8.5		
		2020s	2050s	2080s
-30°C	16.50	11.57	6.03	1.56
-35°C	5.53	2.47	0.89	0.02
-40°C	0.78	0.14	0.00	0.00

2.4 HEATING AND COOLING DEGREE DAYS

2.4.1 Heating Degree Days

Heating degree days (HDD) are the accumulated departures of temperature below the threshold value of 18°C, represented as number of degrees per day below the threshold. This measure is related to the heating capacity required from month to month. For the Yellow Quill area, Figure 24 illustrates a decrease in heating needs in the future.

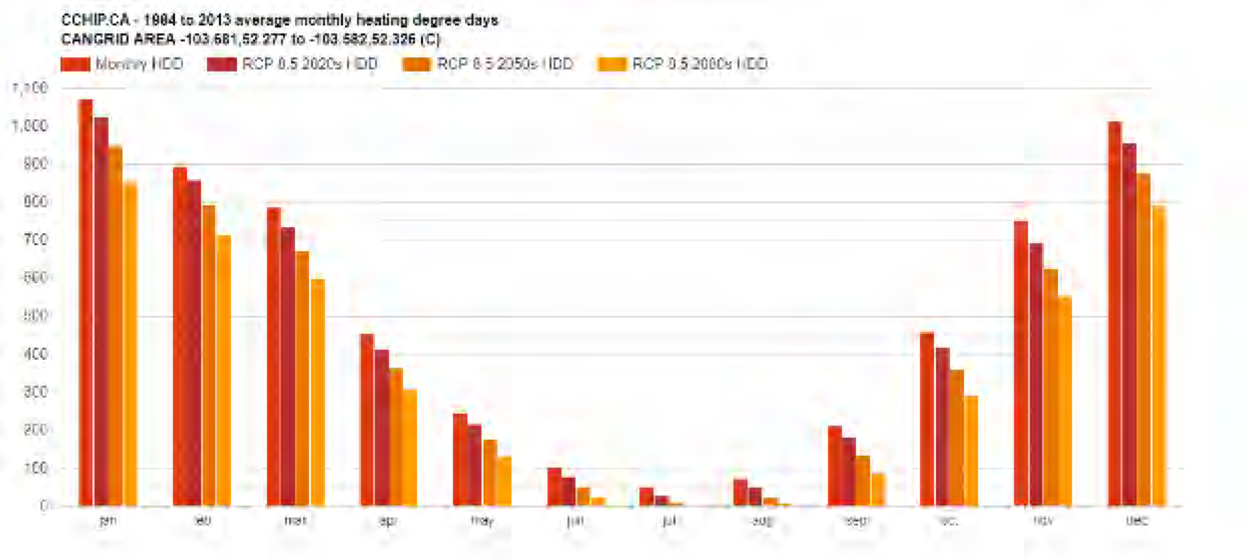

Figure 24: Average Monthly Heating Degree Days based on an 18°C threshold (RCP 8.5)

2.4.2 Cooling Degree Days

Similar to HDD, cooling degree days (CDD) are the accumulated departures of temperature above the threshold value of 18°C, represented as number of degrees per day above the threshold. This measure is related to the cooling capacity required from month to month. Figure 25 illustrates an increase in cooling needs in the future for the Yellow Quill area.

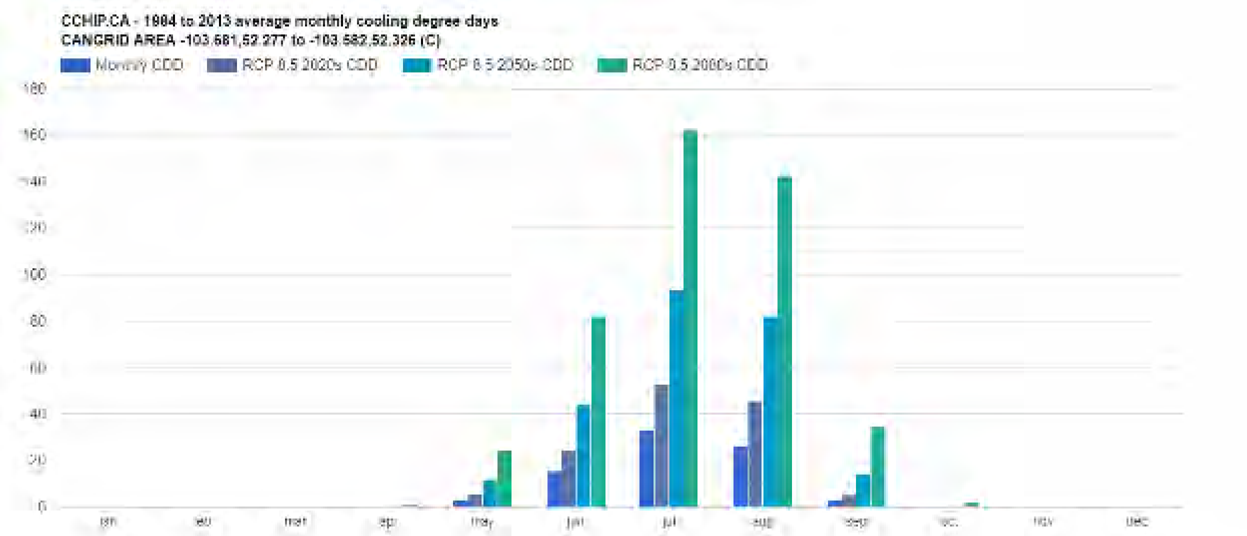

Figure 25: Average Monthly Cooling Degree Days based on an 18°C threshold (RCP 8.5)

3.0 PRECIPITATION

3.1 TOTAL ANNUAL & SEASONAL ACCUMULATION

Baseline total accumulated precipitation values are presented as 1981-2010 climate normals both annually and seasonally in Table 7. Average percent changes in total accumulated precipitation for 2020s, 2050s, and 2080s time periods are also shown. Projected changes provided here are generated using downscaled CMIP5 ensemble projections, containing 40 global climate models, using Risk Sciences International's Climate Change Hazards Information Portal. Unlike for temperature, the projection of precipitation-related parameters is more complex, making precipitation projections of moderate to moderate-high certainty. This is particularly the case in northern Canada where gaps in precipitation data are common and published literature on the precipitation is often lacking.

Based on available literature, total annual accumulated precipitation in the Canadian prairie region has been found to increase over the past several decades. In the Canadian prairies, the annual average precipitation was found to have increased by 7% between 1948 and 2012 (Bush and Lemmen, 2019, Vincent et al., 2015). Seasonally however, some variability is noted, ranging from -5.9% in the winter (decrease) to 13.6 in the spring (increase) within the same timeframe (Bush and Lemmen, 2019, Johnson et al., 2005, Vincent et al., 2015).

Precipitation in the prairie region is highly variable due to influences from the El Niño-Southern Oscillation (ENSO) and the Pacific-North American (PNA) circulation which can cause variable rainfall from one year to the next and intermittent droughts (Gan, 2005). This unstable precipitation pattern is reflected in the historical data presented in the following subsections. It should be noted that the uncertainty in the historical precipitation data in the area does not affect the projected climate trends, which rely on global climate model results relative to the climate normal values for the station.

Table 7: Average Percent Change in Total Annual and Seasonal Precipitation from 1981-2010 Baseline, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Season	1981-2010 (mm)	Average Percent Change in Total Precipitation from 1981-2010 Baseline (%)		
		RCP 8.5		
		2020s	2050s	2080s
Annual	449.8	2.9	7.3	9.7
Winter	59.3	4.7	12.2	20.1
Spring	89.6	5.4	15.1	23.4
Summer	206.2	-0.1	0.5	-3.7
Autumn	95.5	3.9	7.5	11.0

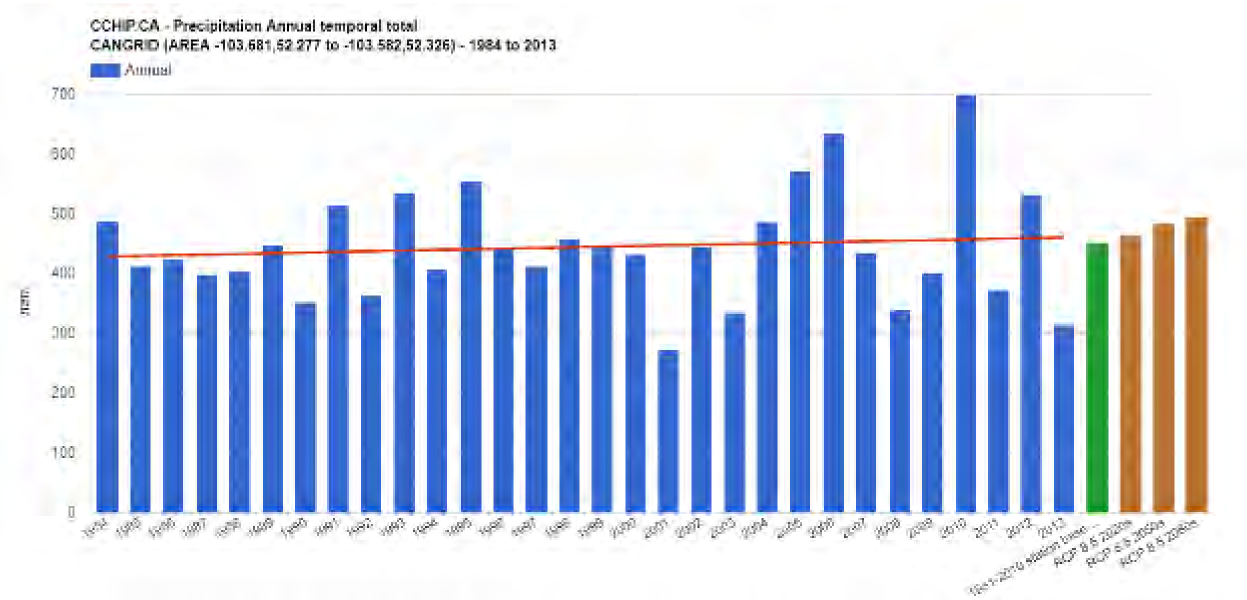

Figure 26: Annual Precipitation – Temporal Total (30 years)

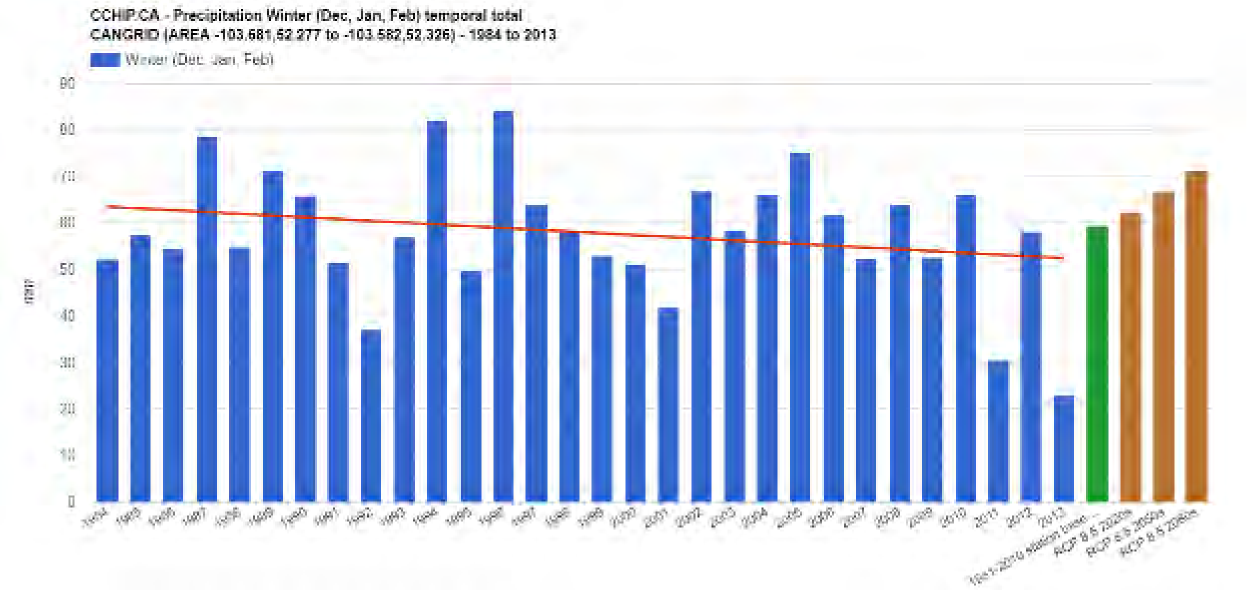

Figure 27: Winter Precipitation – Temporal Total (30 years)

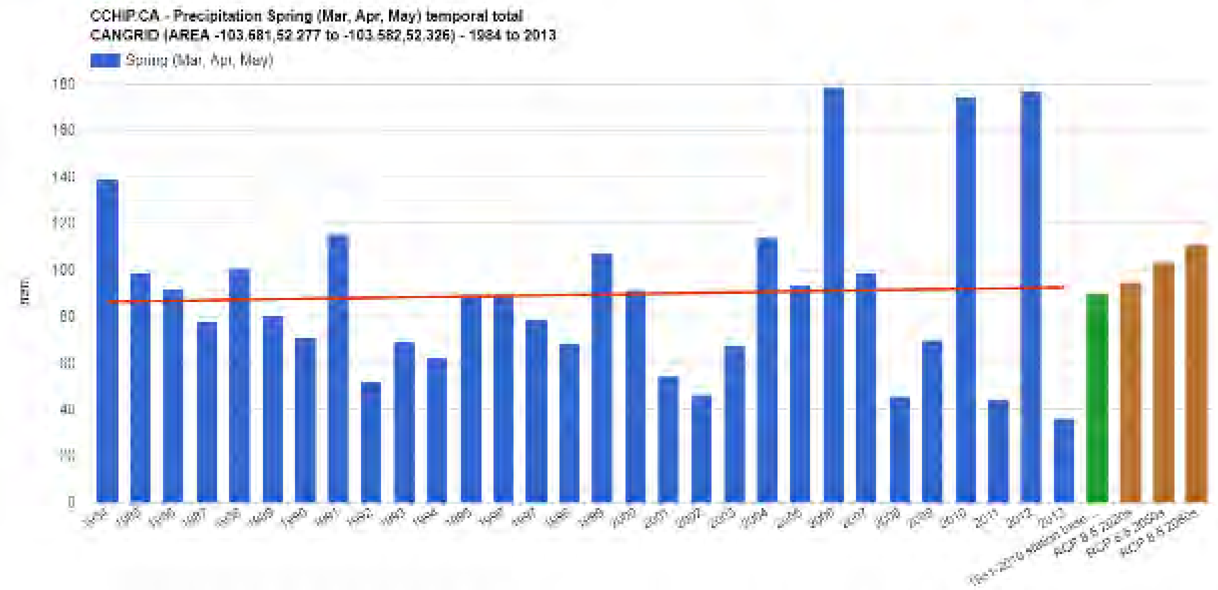

Figure 28: Spring Precipitation – Temporal Total (30 years)

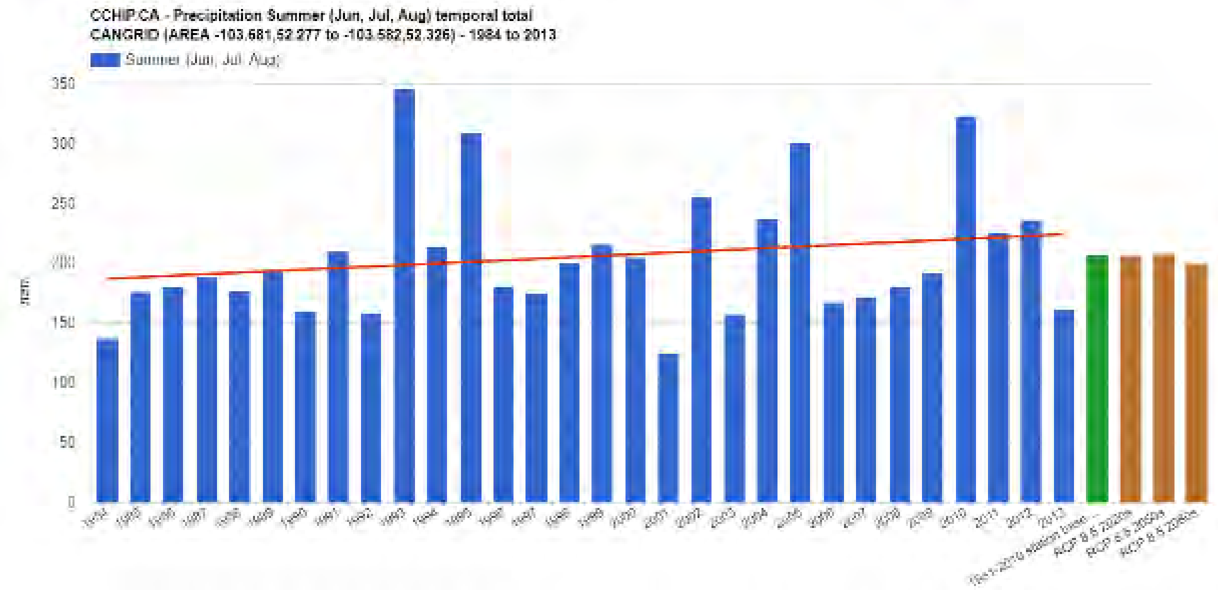

Figure 29: Summer Precipitation – Temporal Total (30 years)

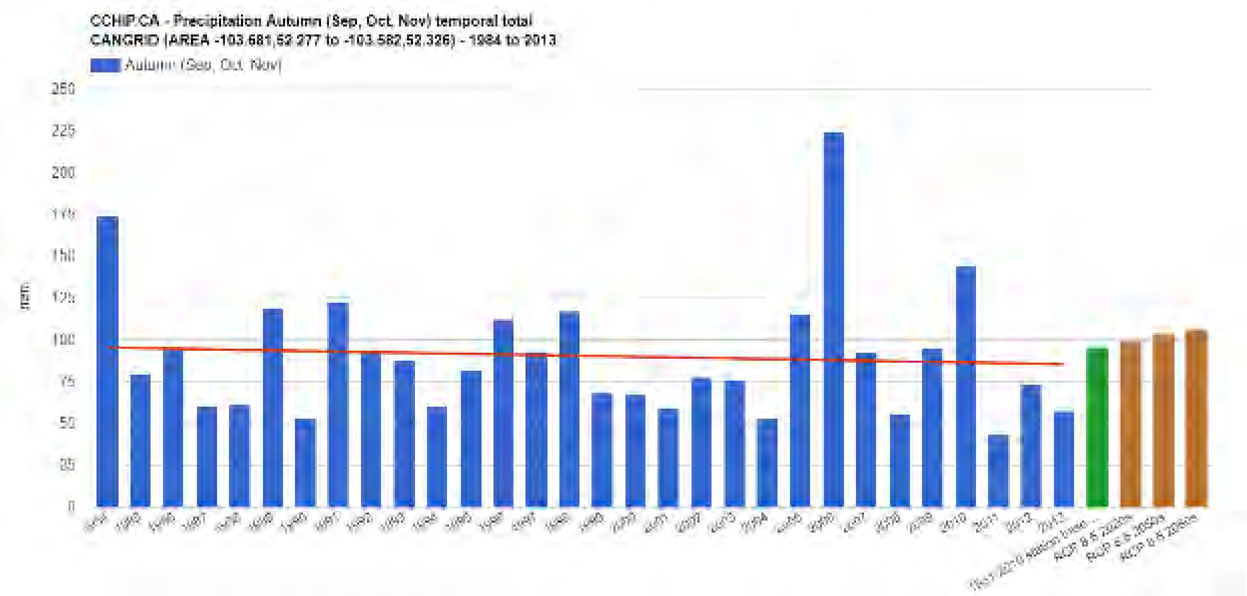

Figure 30: Autumn Precipitation – Temporal Total (30 years)

3.2 INTENSITY-DURATION-FREQUENCY (IDF)

The projection of rainfall intensity, duration, and frequency are presented as IDF relationships, is challenging produce. The scientific community is not settled on an appropriate method that can make these predictions with a high level of certainty.

Projections for future climate IDF are based on bias-corrected results from nine Global Circulation Models from the Pacific Climate Impacts Consortium that simulate future climate conditions for all of Canada and published by the Institute for Catastrophic Loss Reduction (ICLR), at Western University, London, Ontario. IDF information is from an ungagged location (52.304°, -103.625°) (the approximate location of the Yellow Quill Band Hall) and based on interpolated historical data.

3.2.1 Precipitation Event Accumulation

Total precipitation amount (mm) in specific time interval (5 minutes to 24 hours) for various return periods (2 years to 100 years) are shown in Tables 8 and 9.

Table 8: Historical Precipitation Event Accumulation, Ungauged Location (Lat: 52.304º, Lon: -103.625º)

T (years)	2	5	10	20	25	50	100
5 min	5.97	8.43	10.15	11.92	12.44	14.24	16.11
10 min	8.68	12.57	15.28	18.04	18.86	21.66	24.58
15 min	10.45	15.30	18.71	22.23	23.28	26.88	30.67
30 min	12.86	19.40	24.43	30.01	31.77	38.06	45.17
1 h	15.76	23.26	28.99	35.33	37.31	44.46	52.56
2 h	19.27	27.06	33.06	39.95	42.07	50.15	59.74
6 h	27.30	35.06	40.61	47.04	48.90	56.50	65.79
12 h	32.79	44.36	52.32	60.69	63.11	71.89	81.47
24 h	39.96	54.68	64.58	74.57	77.44	87.32	97.51

Table 9: Projected Precipitation Event Accumulation, Ungauged Location (Lat: 52.304º, Lon: -103.625º), RCP 8.5, 2041-2100

T (years)	2	5	10	20	25	50	100
5 min	6.62	9.69	12.13	14.77	15.52	17.86	20.45
10 min	9.62	14.44	18.25	22.36	23.53	27.18	31.20
15 min	11.58	17.58	22.36	27.56	29.04	33.73	38.92
30 min	14.25	22.28	29.19	37.20	39.63	47.75	57.32
1 h	17.46	26.72	34.64	43.80	46.55	55.77	66.70
2 h	21.35	31.07	39.51	49.52	52.49	62.92	75.82
6 h	30.24	40.26	48.53	58.31	61.01	70.89	83.49
12 h	36.33	50.95	62.52	75.22	78.74	90.19	103.40
24 h	44.27	62.80	77.17	92.43	96.61	109.55	123.74

The results presented in Table 8 and Table 9 indicate an increase in precipitation accumulation can be expected for all rainfall events. The projected percentage increase from the historical data to the period of 2041 - 2100 for precipitation events under RCP 8.5 range from 10.8% to 26.9%, as shown in Table 10. Due to statistical limitations when developing IDF models, the ICLR only provides data for a 50-year climate window; which is longer than the 30-year window for the projections obtained through CCHIP. The window selected (2041-2100) for this climate profile is a combination of the 30-year windows previously described in this report (the 2050s and 2080s, i.e. 2041-2070, and 2071-2100). When considering annual precipitation, it should be noted that snowfall depth equates to a liquid depth of precipitation by a factor of about 10mm snow to 1mm precipitation.

Table 10: Projected Percentage Precipitation Event Accumulation Increase, Ungauged Location (Lat: 52.304º, Lon: -103.625º), 8.5, 2041-2100

T (years)	2	5	10	20	25	50	100
5 min	10.9%	14.9%	19.5%	23.9%	24.8%	25.4%	26.9%
10 min	10.8%	14.9%	19.4%	23.9%	24.8%	25.5%	26.9%
15 min	10.8%	14.9%	19.5%	24.0%	24.7%	25.5%	26.9%
30 min	10.8%	14.8%	19.5%	24.0%	24.7%	25.5%	26.9%
1 h	10.8%	14.9%	19.5%	24.0%	24.8%	25.4%	26.9%
2 h	10.8%	14.8%	19.5%	24.0%	24.8%	25.5%	26.9%
6 h	10.8%	14.8%	19.5%	24.0%	24.8%	25.5%	26.9%
12 h	10.8%	14.9%	19.5%	23.9%	24.8%	25.5%	26.9%
24 h	10.8%	14.9%	19.5%	24.0%	24.8%	25.5%	26.9%

3.2.2 Precipitation Event Intensity

The increase in precipitation event accumulation discussed in the previous section correlates to increased precipitation event intensity (mm/hr) as indicated in Tables 11 and 12.

Table 11: Historical Precipitation Event Intensity, Ungauged Location (Lat: 52.304º, Lon: -103.625º)

T (years)	2	5	10	20	25	50	100
5 min	71.66	101.20	121.82	143.00	149.29	170.85	193.37
10 min	52.10	75.44	91.65	108.25	113.16	129.97	147.49
15 min	41.80	61.21	74.85	88.92	93.12	107.54	122.67
30 min	25.72	38.80	48.86	60.03	63.53	76.12	90.33
1 h	15.76	23.26	28.99	35.33	37.31	44.46	52.56
2 h	9.63	13.53	16.53	19.97	21.04	25.08	29.87
6 h	4.55	5.84	6.77	7.84	8.15	9.42	10.96
12 h	2.73	3.70	4.36	5.06	5.26	5.99	6.79
24 h	1.66	2.28	2.69	3.11	3.23	3.64	4.06

Table 12: Projected Precipitation Event Intensity, Ungauged Location (Lat: 52.304º, Lon: -103.625º), RCP 8.5, 2041-2100

T (years)	2	5	10	20	25	50	100
5 min	79.39	116.23	145.57	177.26	186.26	214.34	245.40
10 min	57.72	86.64	109.52	134.18	141.18	163.06	187.17
15 min	46.30	70.30	89.44	110.22	116.18	134.91	155.68
30 min	28.50	44.56	58.38	74.41	79.27	95.50	114.64
1 h	17.46	26.72	34.64	43.80	46.55	55.77	66.70
2 h	10.67	15.54	19.75	24.76	26.25	31.46	37.91
6 h	5.04	6.71	8.09	9.72	10.17	11.81	13.91
12 h	3.03	4.25	5.21	6.27	6.56	7.52	8.62
24 h	1.84	2.62	3.22	3.85	4.03	4.56	5.16

Correlating with the projected increases in precipitation event accumulation; the above results indicate an increase in the intensity of the events for each return period. The projected percentage increase from the historical data to the period of 2041 - 2100 for precipitation event intensities under RCP 8.5 range from 10.8% to 27.1%, as shown in Table 13.

Table 13: Projected Percentage Precipitation Event Intensity Increase, Ungauged Location (Lat: 52.304º, Lon: -103.625º), RCP 8.5, 2041-2100

T (years)	2	5	10	20	25	50	100
5 min	10.8%	14.9%	19.5%	24.0%	24.8%	25.5%	26.9%
10 min	10.8%	14.8%	19.5%	24.0%	24.8%	25.5%	26.9%
15 min	10.8%	14.9%	19.5%	24.0%	24.8%	25.5%	26.9%
30 min	10.8%	14.8%	19.5%	24.0%	24.8%	25.5%	26.9%
1 h	10.8%	14.9%	19.5%	24.0%	24.8%	25.4%	26.9%
2 h	10.8%	14.9%	19.5%	24.0%	24.8%	25.4%	26.9%
6 h	10.8%	14.9%	19.5%	24.0%	24.8%	25.4%	26.9%
12 h	11.0%	14.9%	19.5%	23.9%	24.7%	25.5%	27.0%
24 h	10.8%	14.9%	19.7%	23.8%	24.8%	25.3%	27.1%

3.3 3-5-7 DAY ACCUMULATION

Projection data for 3-5-7-day accumulation was not available. Based on the projected increase in precipitation accumulation for all events less than 24 hours duration (Section 3.2), it is highly probable the 3-5-7 day accumulations will also increase.

Table 14: Record Maximum 3/5/7 Days Precipitation Accumulation, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

	Record Maximum Precipitation Accumulation (1950-2013)		
	3 day	5 day	7 day
Precipitation (mm)	92.7	104.5	109.6
Date Ended	05-Jul-1993	17-Sep-2006	05-Jul-1993

3.4 DRY SPELLS

Dry spells are a measure of the number of consecutive days where daily precipitation is less than 1 mm (Peterson et al., 2001). The historic data for longest annual dry spell duration for the Yellow Quill area is summarized in Figure 31 below. It should be noted that there may be more than one dry spell of significant length in a given year but Figure 31 only shows the longest annual dry spell.

The length of the maximum annual dry spell in the Yellow Quill area has increased from 1950 to 2013. Projected dry spell durations under the future effects of climate change were unavailable, but the trend shown in Figure 31 could be extrapolated to the future to suggest the length of dry spells may stay relatively consistent to increase slightly on average in the coming decades. This observation may be supported by the projected decrease in future summer precipitation in the Yellow Quill Area (See Table 7 and Figure 29). This projection is not made with the same level of confidence as other climate variables in this report.

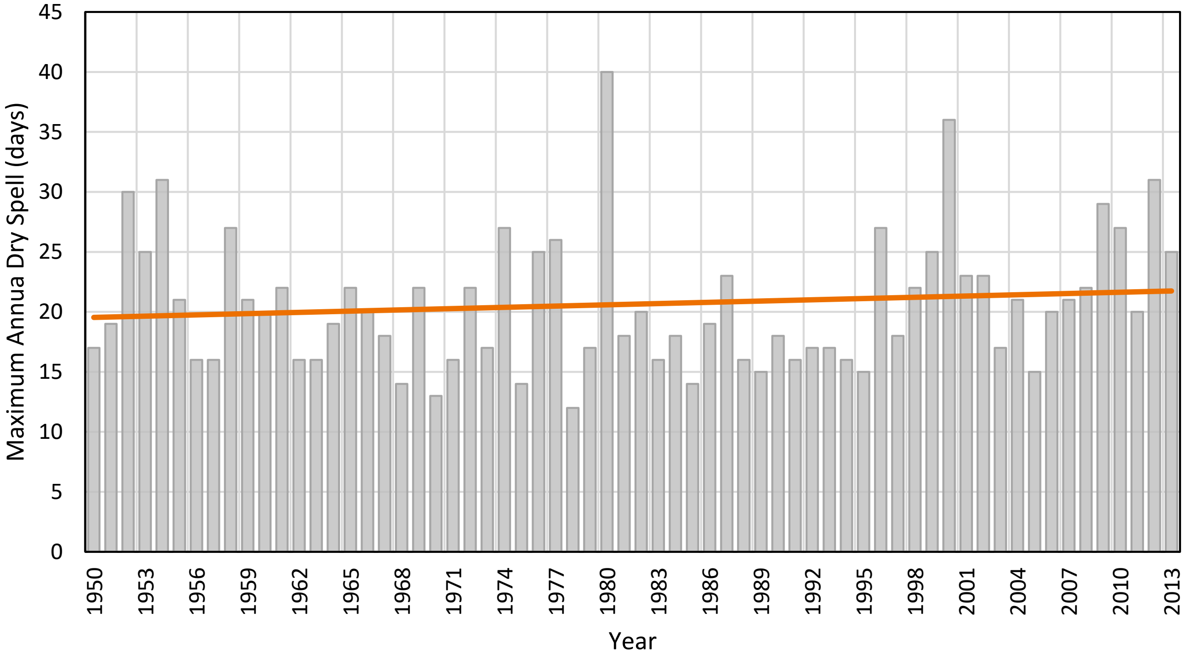

Figure 31: Maximum Annual Dry Spells, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326), 1943-2012

4.0 DAILY FROST

The number of frost-free days is projected to continually increase under future climate conditions as shown in Table 15. The daily frost profile shown in Figure 32 presents the historic and projected probability of frost on a given day of the year. This is illustrated on the 100th day of the year (April 10th in non-leap years), where historically there has been about a 77.3% chance there is frost on that day. Whereas under RCP 8.5 conditions, there is only a 33.3% chance of a frost on April 10 by the 2080s.

Table 15: Average Frost-Free Days, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Number of Frost-Free Days	
Period	**RCP 8.5**
Baseline (Historical 1982-2011)	161
2020s	177
2050s	199
2080s	225

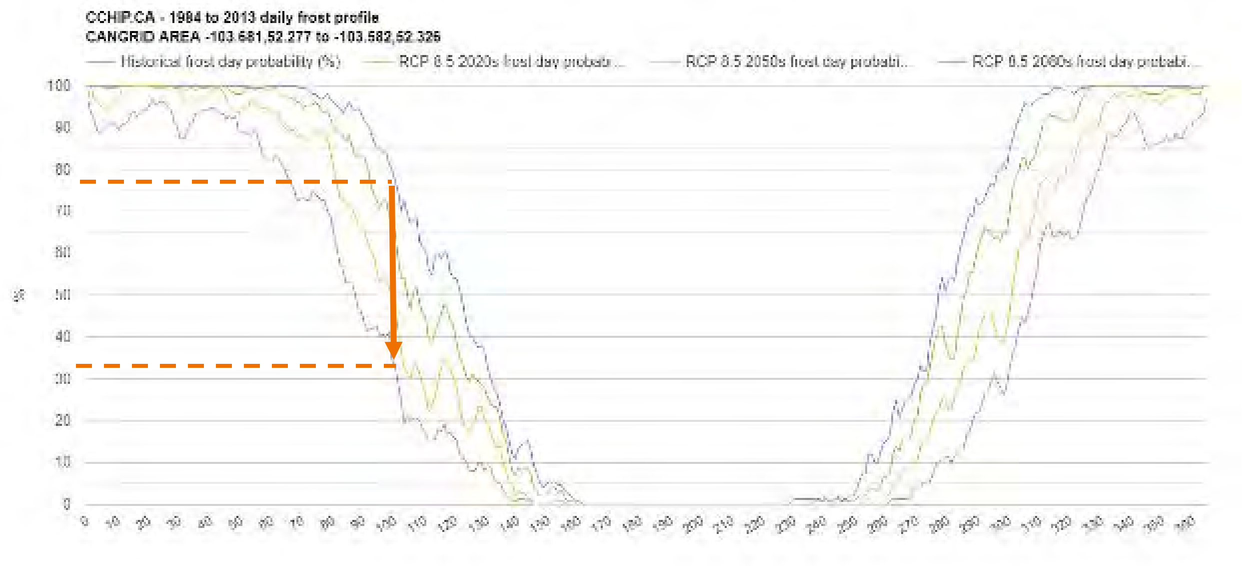

Figure 32: Daily Frost Probability Profile, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326), RCP 8.5

5.0 FREEZE-THAWS

As temperatures in the Yellow Quill area are expected to generally increase in the future, the number of freeze-thaw events is projected to decrease under the effects of climate change. The decrease is modest because most freeze-thaw events typically happen in months with temperatures fluctuating around 0°C. Figure 33 shows how the common freeze thaw events in April, May, September, and October are projected to decrease, while there is an increase is projected in December, January, and February. This change reflects the shift in typical times of year that temperatures are expected to fluctuate around 0°C – i.e. temperature fluctuations around 0°C are projected to be more common through the winter months.

Table 16: Average Annual Freeze-Thaw Cycles (Day with Max. Temp >0°C & Min. Temp <0°C), CANGRD (Location: -103.681, 52.277 to -103.582, 52.326)

Average Number of Freeze-Thaw Cycles	
Period	**RCP 8.5**
Baseline (Historical 1982-2011)	81.8
2020s	78.2
2050s	70.6
2080s	61.7

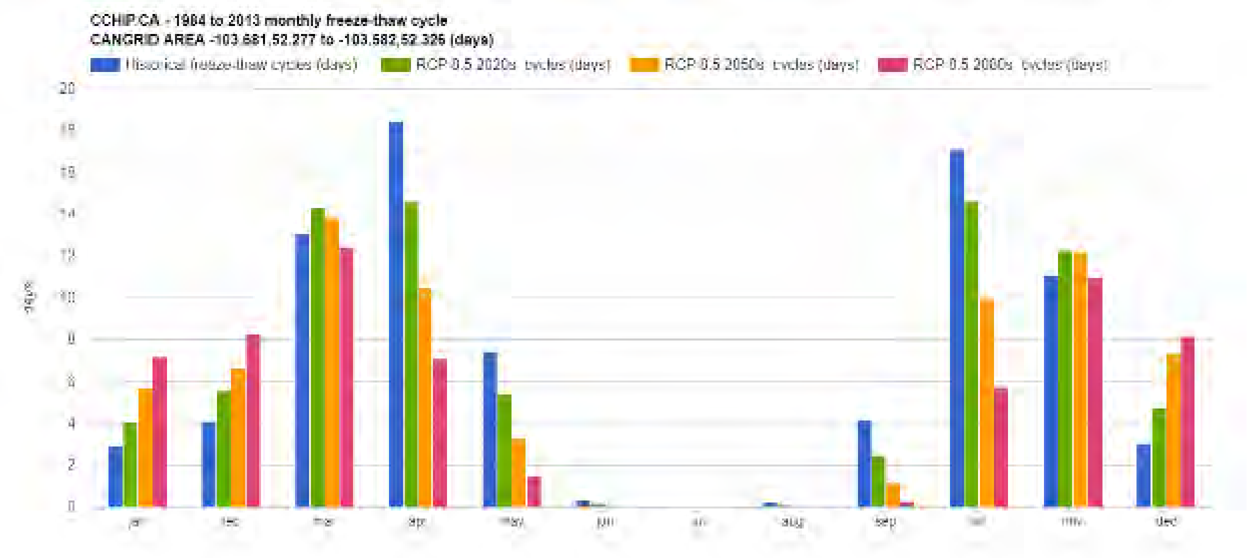

Figure 33: Monthly Freeze-Thaw Cycles, CANGRD (Location: -103.681, 52.277 to -103.582, 52.326), RCP 8.5

6.0 WIND

Due to the lack of data in the immediate vicinity of the Yellow Quill land area, the closest weather monitoring station with published wind data is the Wynyard weather monitoring station (ID: 4019035), located approximately 70km away from the Yellow Quill Band Hall. Table 17 below shows the historical wind data for the Wynyard weather station.

Table 17: 1981 to 2010 Canadian Climate Normals, Wind, Wynyard weather station (ID: 4019035) (source: Government of Canada – Environment and Natural Resource)

Month	Maximum Hourly Speed[4] (km/h)	Date (yyyy/dd)	Direction of Maximum Hourly Speed[3]	Maximum Gust Speed[5] (km/h)	Date (yyyy/dd)	Direction of Maximum Gust[4]
Jan	70	1986/ 11	W	102	1986/ 11	W
Feb	66	1965/ 20	NW	74	1978/ 06	SE
Mar	68	1967/ 30	N	85	1986/ 31	W
Apr	71	1968/ 11	W	93	1985/ 20	S
May	79	1965/ 17	SW	91	1984/ 17	W
Jun	72	1985/ 08	W	111	1989/ 19	W
Jul	69	1973/ 12	W	89	1988/ 05	W
Aug	59	1984/ 29	W	100	1984/ 25	SW
Sep	65	1988/ 08	W	87	1988/ 08	W
Oct	74	1971/ 07	NW	89	1980/ 09	NW
Nov	66	1974/ 25	S	81	1978/ 04	NW
Dec	66	1968/ 14	SE	87	1985/ 25	NW

The projected impacts of climate change with respect to wind patterns are not as well understood as variables such as temperature and precipitation. However, measured historic windspeeds from the Wynyard weather station can be used to establish trends that can be correlated with the climate changes to date, providing a basis for extrapolating wind trends under future climate conditions. Figure 34 below shows a historical decreasing trend in the measured hourly windspeeds between 1964 and 1991 and

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[4] Hourly windspeed is defined by Environment and Climate Change Canada as the average wind speed during one-, two- or ten-minute periods ending at the time of observation at 10 metres above the ground (ECCC 2019).

[5] Gusts are sudden, rapid and brief changes in the wind speed. They are characterized by more or less continual fluctuations between the high (peak) and low (lull) speed. The extreme gust speed is the instantaneous peak wind observed from the anemometer dials, abstracted from a continuous chart recording, or from a data logger (ECCC 2019).

1994 and 2016 from high resolution data at the Wynyard (ID: 4019035) and Wynyard (AUT) (ID: 40190LN) weather stations.

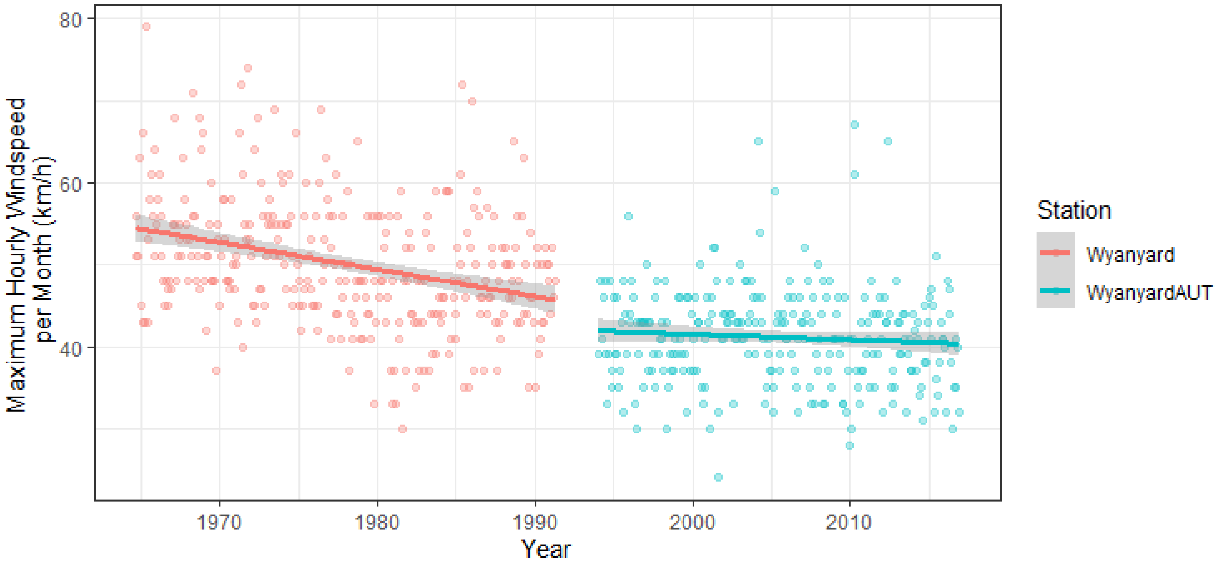

Figure 34: Maximum Hourly Windspeed measured in each month for the Wynyard (ID: 4019035, range: 1964-1991) and Wynyard (AUT) (ID: 40190LN, range: 1994-2016) weather stations. Linear regression shown as trendline and standard error indicated by grey highlights.

Extrapolating historic climate change trends to the future does not provide projections as reliable as those based on detailed climate modeling, however in the absence of climate models it can be considered a reasonable approach. Historical wind data at the Wynyard and Wynyard (AUT) weather stations show a trend of slightly decreasing windspeeds. Since windspeeds have reduced slightly in recent decades, while the climate in the Yellow Quill area has warmed (see Section 2.0) and varying precipitation impacts (see Section 3.0), it is assumed there will be no change or a slight decrease in windspeeds as the Yellow Quill area continues to experience these climate changes. This projection is not made with the same level of confidence as other climate variables in this report.

7.0 TORNADOS

A review of the Canadian National Tornado Database (1980-2009) was completed and a total of five tornados were found to have occurred historically within a 50km radius of the Yellow Quill Band Hall during that timeframe. Additionally, one tornado was found to have occurred immediately outside of this radius. Figure 35 shows the historical tornado occurrences in the Yellow Quill area. Future projection data is not available for tornados due to their meteorological complexity.

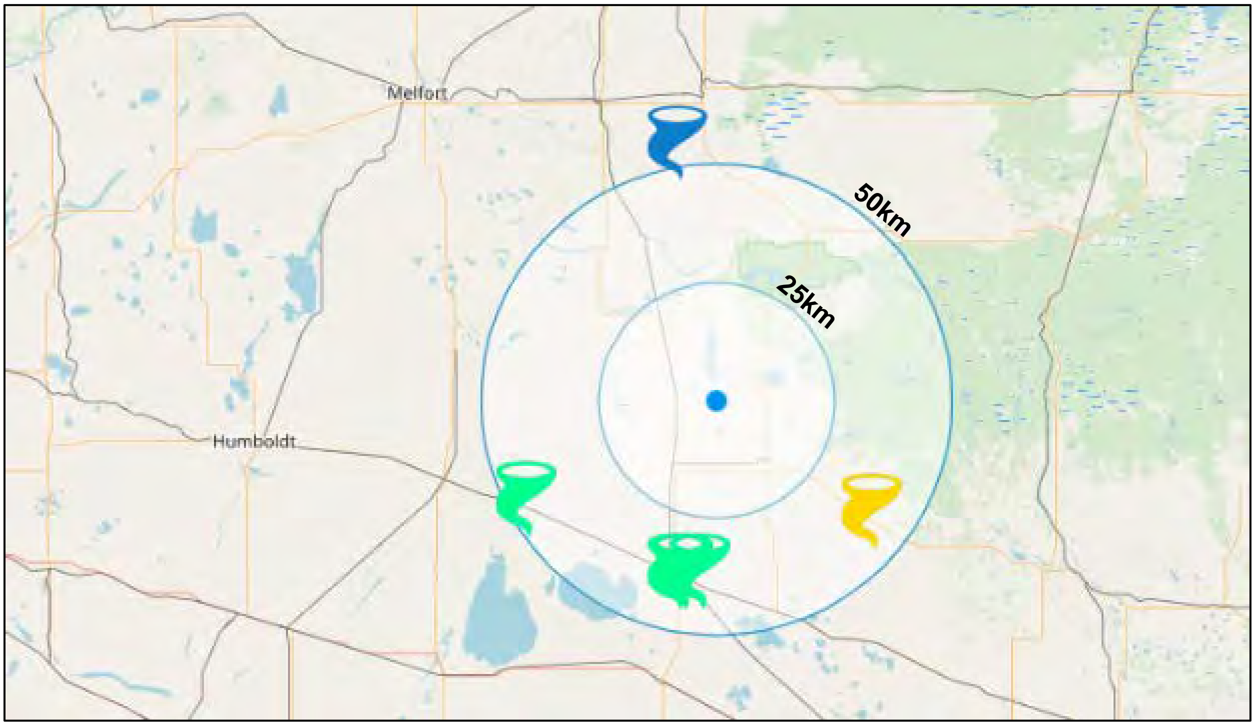

Figure 35: Map of Tornado Occurrences in the Vicinity of the Yellow Quill Lands.

The following is a summary of Tornado and their ranking that have occurred in the vicinity of the Yellow Quill lands.

Tornado occurrences within a 25km radius:
- No recorded tornados

Tornado occurrences between 25-50km radius:
- F0 – August 13, 2008
- F0 – July 5, 2000
- F2 – August 30, 1985
- F0 – August 22, 1981
- F0 – Unknown date

Tornadoes occurrences beyond 50km radius:
- F1 – August 17, 1982

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