

Hazard Identification, Risk and Vulnerability

Assessment Case Study

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HAZARD IDENTIFICATION, RISK AND VULNERABILITY ASSESSMENT (HIRVA) CASE STUDY



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Submitted to:

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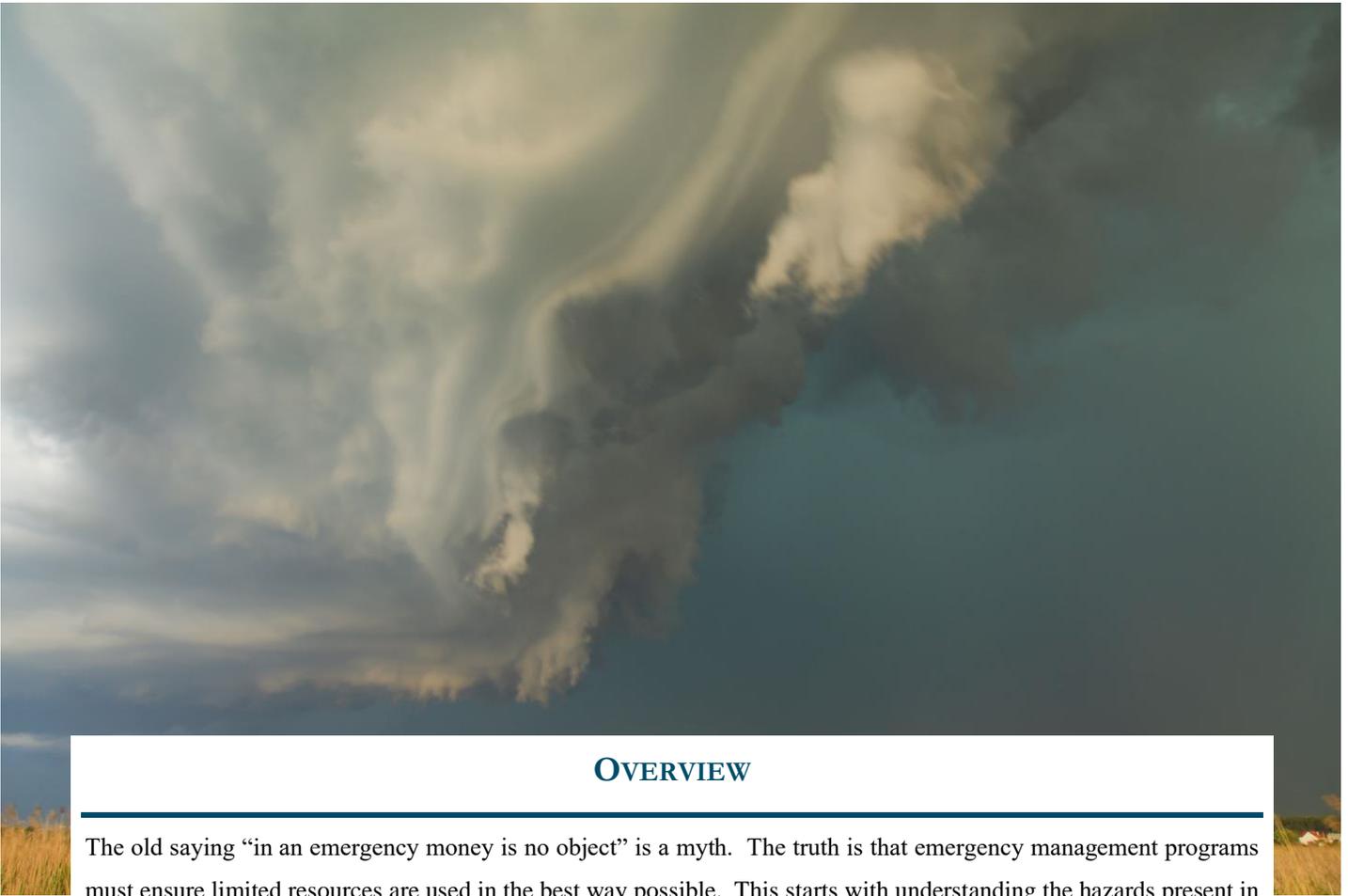
Siksika Nation Emergency Management would like to thank those who contributed to the development of the Emergency Management Program Framework. The project team provided guidance, research and support and consisted of:

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STATEMENT OF LIMITATIONS

The information contained in this document is the application of the Siksika Nation Emergency Management Department's professional expertise and where applicable professional opinion, subject to the accuracy and content of available information and the scope of work. The user of this information accepts full responsibility for any errors or omissions contained therein.



OVERVIEW

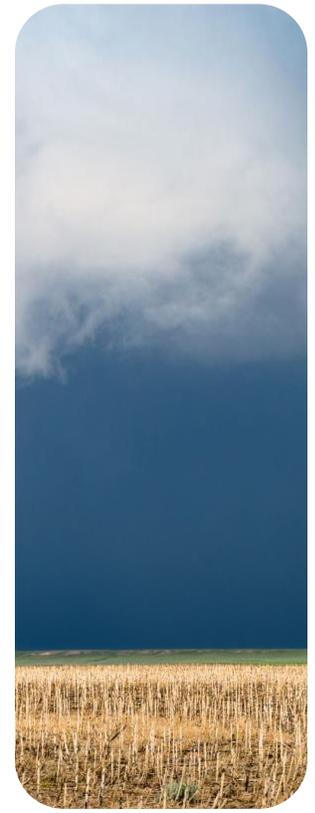
The old saying “in an emergency money is no object” is a myth. The truth is that emergency management programs must ensure limited resources are used in the best way possible. This starts with understanding the hazards present in a community’s environment, the risk of those hazards impacting the community, and how vulnerable the community is to the impact.

A Hazard Identification, Risk and Vulnerability Assessment (HIRVA) is the starting point and a critical part of an emergency management program. Simply put, hazards are things that can happen that have a negative outcome for the community, risk is the likelihood of it happening, and vulnerability describes how bad the impact would be for the community. This HIRVA was developed for the File Hills Qu’Appelle Tribal Council (FHQTC) as a case study to demonstrate how the HIRVA process identifies hazards and assesses risk and vulnerability. Informed by the HIRVA, communities can:

- Focus effort & resources on the hazards that present the greatest risk & vulnerability.
- Apply preventative & mitigative measures where possible.
- Develop emergency plans that ensure the appropriate preparedness, response, & recovery measures are in place for an identified hazard or effect that can’t be prevented.
- Ensure, based on evidence, the continued support for an effective emergency management program in the face of organizational change.
- Satisfy & meet legal, regulatory & moral obligations to identify hazards & manage risk & vulnerability.

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1. HAZARD ASSESSMENT OVERVIEW

1.1. Ranking Summary

A comprehensive and coordinated hazard and risk assessment can help increase understanding around the risk environment, facilitate information sharing, enable the identification of hazards that have the potential to cause an emergency or disaster, and provide emergency managers with a foundation to inform the development of emergency plans. Both natural and human hazards were analyzed for the File Hills Qu'Appelle Tribal Council (FHQTC) using publicly available historical data. General categories were made to better group certain hazards and some categories encompass multiple incident types while some were ranked separately as data stressed particular attention to this hazard. A rank was then assigned based on the perceived risk to the FHQTC Member Nations. Although the report does its best to highlight notable differences, given the geographical distribution of the communities, it must be noted that individual risk may differ.

Natural Class hazards received higher risk scores overall, with wildfire and convective storms topping this category due to their volatility of consequence. These events happen suddenly and move quickly and have high consequences even though the spatial distribution can be more concentrated. It should be noted that although wildfire is listed as natural it can be ignited by humans, therefore increasing the hazard susceptibility. Floods, although prominent and widespread, can be prepared for based on antecedent weather conditions and cyclical patterns. However, historically floods have been the costliest and most spatially dispersed natural hazard in the area. Flash surface flooding, usually the result of summer storm systems, can happen quickly and be damaging but lasts a shorter duration with more acute effects. Extreme winds not only applies to tornado and plough wind events which are extremely dangerous to human life and structure but acts as a multiplier to other natural hazards such as wildfire and winter storms. Therefore, although extreme winds was ranked individually it is discussed in multiple sections. Drought, depending on its severity can result in cumulative issues for an area and cause economic losses that involve directives beyond an emergency management division's span of control. However, it is important for the emergency management division to monitor drought as causative weather conditions can heighten more immediate risks such as wildfires. Dust storms have historically posed risk but require specific conditions and often only cause impacts to transportation safety and visibility.

Amongst the Human Class, health emergencies and railway accidents were ranked highest as they can have a large demand on emergency management resources, especially if evacuations are required. The impacts of railway accidents are limited by the lack of proximity to most of the FHQTC Member Nations, however, they can occur regularly with little forewarning. The majority of railway accidents result in few long-term consequences but pose the greatest emergency hazard when carrying dangerous goods close to a high-density populace and can cause lasting environmental impacts. Critical service failures are generally low impact, short-lived, and the result of a natural hazard event. Water quality emergencies complicate this ranking as they have been identified as a continuing issue in some areas, with long-term mitigation measures required. Furthermore, the current COVID-19 pandemic situation was not directly assessed in this report however, it impacted the

ranking of health emergencies as it demonstrates the many measures actively in place to mitigate the impacts of a pandemic. Public safety risks such as crime and missing persons were not highlighted within this report as they can be influenced by a large variety of factors and are primarily responded to by police and health services. However, missing person incidents can expand to include emergency management resources when an intensive ground search is required. Health emergencies are also primarily dealt with by health services however, emergency management can provide logistical, administrative and planning support as seen during the COVID-19 response.

Overall, it must be stressed that the rankings in this report provide a general overview and were limited by subjectivity. An examination of individual hazard assessments will create a more comprehensive picture of hazard potential for the FHQTC Member Nations. Lastly, given time limitations not all potential hazards (structural fire and earth movement events) were able to be adequately assessed and it is recommended that they be analyzed further.

		Severity	Minimal 1	Minor 2	Major 3	Hazardous 4	Catastrophic 5	
	Wildfire	Likelihood						
	Convective Summer Storms		Frequent 5			 		
	Flood		Probable 4					
	Extreme Winds		Remote 3		 	 		
	Drought		Extremely Remote 2					
	Winter Storms		Extremely Improbable 1					
	Dust Storms		High Risk					
	Railway Accident		Medium Risk					
	Health Emergency		Low Risk					
	Service Failure							
	Oil and Gas							

1.2. Hazard Ranking

HAZARD	FREQUENCY	LIKELIHOOD	CONSEQUENCE	VULNERABILITY	SCORE
Natural Class					
Wildfire	Yearly (Spring/Fall)	High 5	Mid 3	High 5	13
Convective Summer Storms	Yearly (Summer)	High 5	Mid 3	Mid-high 4	12
Flood	Yearly (Spring/Summer)	High 5	Mid 3	Mid 3	11

Extreme Winds	Yearly	Mid-high 4	Mid 3	Mid 3	10
Drought	Cyclical	Mid 3	Mid 3	Mid 3	9
Winter Storms	Yearly	Mid 3	Low-mid 2	Low 1	6
Dust Storms	Cyclical	Low-mid 2	Low-mid 2	Low 1	5
Human Class					
Heath Emergency	Ongoing/Occasional	Mid 3	Mid 3	Mid 2	8
Railway Accident	Regularly	Mid 3	Low-mid 2	Low-mid 2	7
Critical Service Failure	Occasional	Mid 3	Low 2	Low 2	7
Oil & Gas Emergency	Occasional	Mid 3	Low 1	Low 1	5

1.3. A Priori Information

Below is the geographical distribution of communities within the File Hills Qu’appelle Tribal Council (FHQTC) and the member First Nations. Within this assessment when the term FHQTC Member Nations is used it is referring to these First Nations as a whole.

Figure 1: File Hills Qu’Appelle Tribal Council (FHQTC) Geographic Area and First Nations

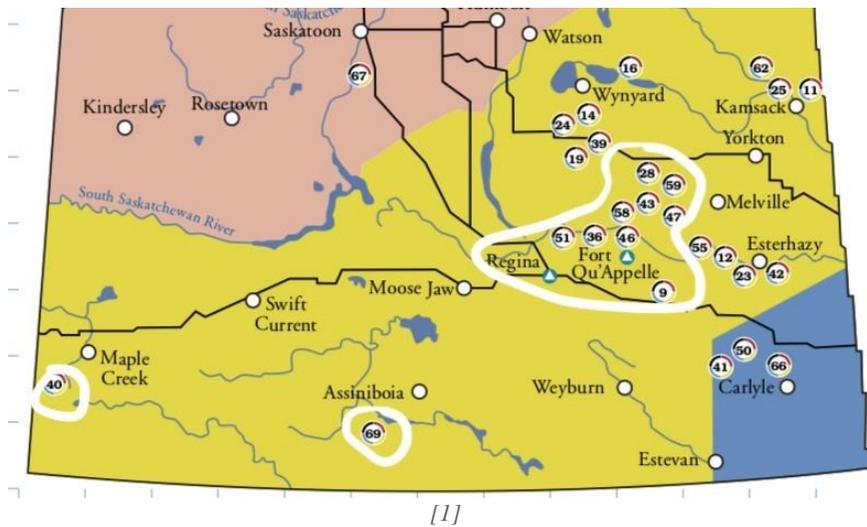


Table 1: FHQTC Member Nations

QU’APPELLE AGENCY	FILE HILLS AGENCY
Nekaneet First Nation (40)	Little Black Bear’s Band of Cree & Assiniboine Nations (28)
Wood Mountain Lakota First Nation (69)	Okanese First Nation (43)
Piapot First Nation (51)	Star Blanket Cree Nation (59)
Muscowpetung Saulteaux Nation (36)	Peepeekisis Cree Nation (47)
Standing Buffalo Dakota Nation (58)	Carry-The-Kettle Nakoda Nation (9)
Pasqua First Nation (46)	

Given the large spatial distribution of FHQTC Member Nations, when assessing regional climate history three stations were selected to provide the best representation of historical data, Lipton 2, Cypress Hills, and Woodrow Stations. Cypress Hills Station is in the southwest of the province, near Cypress Hills Provincial Park. Lipton 2 Station is in east central Saskatchewan, northeast of the town of Fort Qu’Appelle and in between the towns of Balcarres and Ituna. Woodrow Station is near the northeast corner of Wood Mountain Lakota First Nation in the southern central portion of province.

Table 2: Weather Stations Utilized to Assess Regional Climate History

STATION NAME	LATITUDE	LONGITUDE	ELEVATION
Cypress Hills Station	49°40'00.000" N	109°28'00.000" W	1196.0 m
Woodrow Station	49°34'00.000" N	106°47'00.000" W	730.0 m
Lipton 2 Station	51°09'08.008" N	103°53'22.001" W	640.0 m

1.4. Risk Schedule

Table 3 demonstrates the months when the assessed natural class events are most likely to occur and pose significant risks to the FHQTC Member Nations. Although the events listed below can occur outside of the highlighted months, the likelihood is lower. Human class events are not highly dependent upon seasonal variation and are therefore not represented in the table.

Table 3: Potential Critical Natural Class Events by Month (Alphabetical Order - Not Severity)

Critical Event	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Convective Summer Storms												
Critical Services Failure												
Drought												
Dust storms												
Extreme Winds												
Flooding												
Wildfire												
Winter Storm												

2. HAZARD: WILDFIRE

HAZARD: WILDFIRE

CLASS: Natural/Human

RISK SCORE: 13 FREQUENCY: Yearly LIKELIHOOD: 5 CONSEQUENCE: 3 VULNERABILITY: 5

WORST CASE SCENARIO: >500ha grass fire, in April/May, little snow cover, 100% cured grass, winds exceeding 20km/h, ISI value >13, Relative Humidity (RH) <40, near community or values

TYPE	DESCRIPTION
Forest/Prairie/Grass	Uncontrolled fire burning in wildland areas dominated by brush, forest, grasslands, or pasture
Wildland Urban Interface	Uncontrolled fire burning in a wildland area that encroaches populated areas

INDICATORS

Fuel Type & Condition	Seasonal Variation	Wildland Human Activity
Landscape Topography	Ignition Source	Urban Interface Extent
Fire Weather Indices	Burned Area & Frequency	Response

SELECT INCIDENT HISTORY

LOCATION	DATE (dd.mm.yyyy)	INCIDENT
Pasqua First Nation	05.11.2020	Grassfire: Human-caused fire, started west of the nation and within 4 hours went 12.8km through the area. Winds up to 78km/h, Temp ~20C, ISI>15
Biggar, SK	22.04.2019	Grassfire: ~1,500 human-caused, from people evacuated from 3 communities
Burstall, SK	17.10.2017 to 22.10.2017	Grassfire: Downed powerlines & rail from winds caused multiple interprovincial grassfires, leading to the evacuation of ~1,600 people from 6 communities within AB & SK, 10 structures lost, 750 cattle & one person died. Temp ~15-20C, Winds up to 110km/h, RH~20, ISI>15
Condie, SK	26.04.2016	Grassfire: 250ha early spring fire, human-caused, ISI 5-10, Temp ~15C, Avg Wind @10-15km/h
23km W of Nekaneet Cree Nation	10.09.2012	Grassfire: Human-caused, early fall fire along the highway, growing to 25ha. RH <20, ISI >15
Lethbridge, AB	10.09.2012	Grassfire: Human-caused grass fire that burned 5,336 ha, burning structures, farmland and caused an evacuation of 2,200 residents from Coalhurst. RH <20, ~ROS 15-25m/min

Milk River, AB	27.11.2011	Grassfire: Human-caused fire burning 6,958 ha in 8 hours, no structures lost. Avg Wind @ 64km/h, ISI 38, 100% dry-cured grass
Fontier, SK	25.08-31.08.2003	Grassfire: Human-caused fire burned 1,613 ha, in SW corner of the province, north of Hwy 18. Approximate ISI >15, Avg Wind @ 15-25km/h
Sandhills, SK	19.10-24.10.1988	Grassfire: Human-caused grass fire, burning 1,300ha
4.5km NW of Nekaneet Cree Nation	24.08.-27.08.1983	Grassfire: Human-caused grass fire, late summer, 1538 ha burned

2.1. Hazard Exposure

In Saskatchewan, there are on average 247 wildfires per year that burn 486,836 hectares annually. The southern portion (below 51.50° latitude) sees a much smaller portion of these wildfires and on average there are 10 per year that burn approximately 21 hectares. These fires are a combination of human and lightning ignition starts, and the extent of the area burned is dictated by anthropogenic, topographic, fuel, and weather factors. Most wildfires in Saskatchewan occur from June to August (Figure 2) respectively but the southern region can see a significantly longer wildfire season (~225 days) than the northern regions (~150 days) beginning in April and continuing until November (Figure 9 & Figure 10) [2]. In the southern portion of the province, the highest frequency of fire occurrence is during May, and there is a significant jump of starts from March to April, once the snow cover dissipates (Figure 2). The spatial severity in the regions differs greatly, and although southern regions can see frequent wildfires, they are often less than 1 hectare and burn a much smaller total area (Figure 4 & Figure 14).

In Saskatchewan, ignition from lightning strikes accounts for 47% of fire starts, slightly lower to human factors at 49% (the other 4% being undetermined). However, lightning-caused wildfires account for upwards of 93% of the area burned (Figure 3). Although lightning is common in southern Saskatchewan, it does not cause a significant proportion of wildfire starts, only 44 since 1981 [3]. In this region human-caused wildfires account for the significant majority of starts (362) and have burnt 9,114 hectares since 1981 (Figure 3 & Figure 13). Southern Saskatchewan is primarily dominated by agricultural, rangeland, industrial, and municipal development. Wildland vegetation in the region consists of forage crops, native grasslands, woody shrubs, parkland deciduous trees and coniferous species. Under the National Fire Behaviour Prediction System fuel classification structure this becomes classified as O1 (Grass), D1 (Leafless Aspen), and marginal C2/C3 (Boreal Spruce & Mature Pine) respectively (Figure 12) [4]. Closer to the Cypress Hills area, heavier fuel loads are observed, whereas elsewhere it is predominantly O1 and light D1 interspaced with Nonfuel classification.

The primary hazard that comes with grass fuels is their ability to dry out, ignite, and move quickly across uninterrupted terrain. The terrain is primarily flat open plain, deciduous tree stands, rolling river valleys, badlands, and wetland lowlands. Although the topographic change is generally minimal over the landscape, present river valleys can influence wind direction

and significantly increase behaviour on steep banks (>20% slope). These fuels are seasonally variable, with the highest index values (and subsequent wildfire risk) in the late spring and early fall. The southern region can also experience warm temperatures, dry air (relative humidity), lack of precipitation, and high winds which all contribute to wildland grassfire behaviour.

The Fire Weather Index System (FWI) provides an overview of predicted fire behaviour based on these conditions. The Initial Spread Index (ISI), part of FWI, is a numeric rating that represents expected fire spread, weighted toward fine fuel moisture content and wind speed. This region on average possesses some of the highest ISI values (5-15) during April and May in Canada (Figure 7). Historically, this is also reflected in the frequency of fires during May, and the significant jump of starts from March to April (Figure 2). This in combination with standing cured grass (>90%) could result in spread rates of 10-50 m/min, putting it on the threshold of suppression capabilities [5]. From 1978 to 2007 the southern portion of the province recorded an average of 5 to 10 days of wind speeds greater than 63km/h which can lead to incidents become increasingly complex if an ignition occurs during these conditions [6]. Furthermore, it should be noted that within the region many of the ignitions happen in proximity to recreational areas or along transportation corridors (Figure 13 & Figure 12). Proximity to infrastructure, such as roads, can act as an inhibitor to fire spread under less than extreme conditions by fragmenting the landscape and as such the majority of fires close in this zone appear to not exceed 1 hectare.

2.2. Hazard Outlook

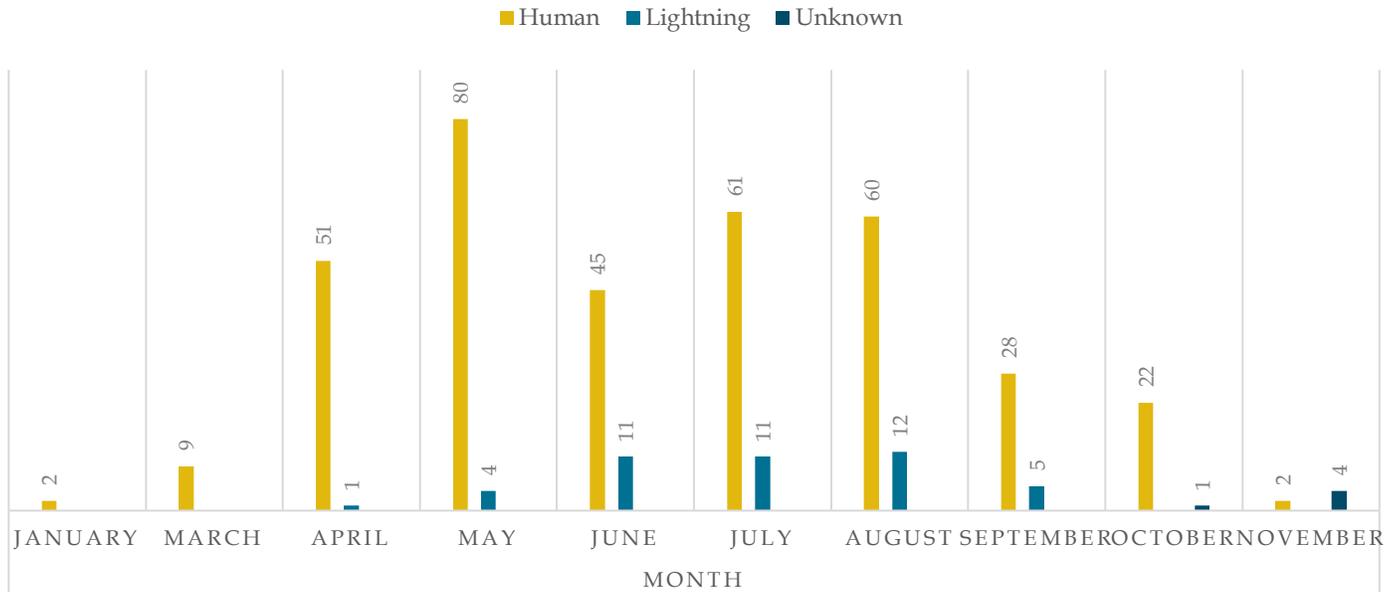
The FHQTC Member Nations face the risk of wildland grassfires under certain conditions, primarily in the spring and fall, when ISI values are at the highest. The combination of cured grasses or crops and strong prairie winds could result in a rapidly spreading grass fire. Climate change models depict the area's potential fire season increasing by up to 30 days, escalating the risk of beyond resource control wildfires into early spring and late fall (Figure 9 & Figure 10). Within the standard fire season most models depict a higher variability of precipitation as well as intense drying periods, making indices norms harder to predict, and extremes more likely. As observed provincially, a few larger incidents account for the greatest proportion of area burned, enforcing the idea that most fires remain small, but under certain indices can grow rapidly beyond the norm. This highlights the imperative to maintain readiness on days of extreme hazard and to respond as quickly as possible.

Since 1980 the number of wildfires per year has increased but the total annual hectares burned has decreased slightly (Figure 5). From these results it could be inferred that increased anthropogenic activity in the area has increased ignition likelihood but also impacted fire spread potential, due to man-made barriers or suppression response. Subsequently, the network of railroad, highways, powerlines, and recreation areas historically have the highest concentration of fire origin points and future ignitions will most likely be situated in these areas Proximity to these sources is imperative for gauging risk, as many FHQTC Member Nations live in rural areas in the wildland-urban interface. Priority zones around structures should include a 30m buffer of surface fuels (grasses) but could expand upwards of 70m based on slope, aspect, and vegetation load [7]. A

site-specific assessment can be undertaken by community members to score potential property hazards, as outlined by the *FireSmart* handbook [7].

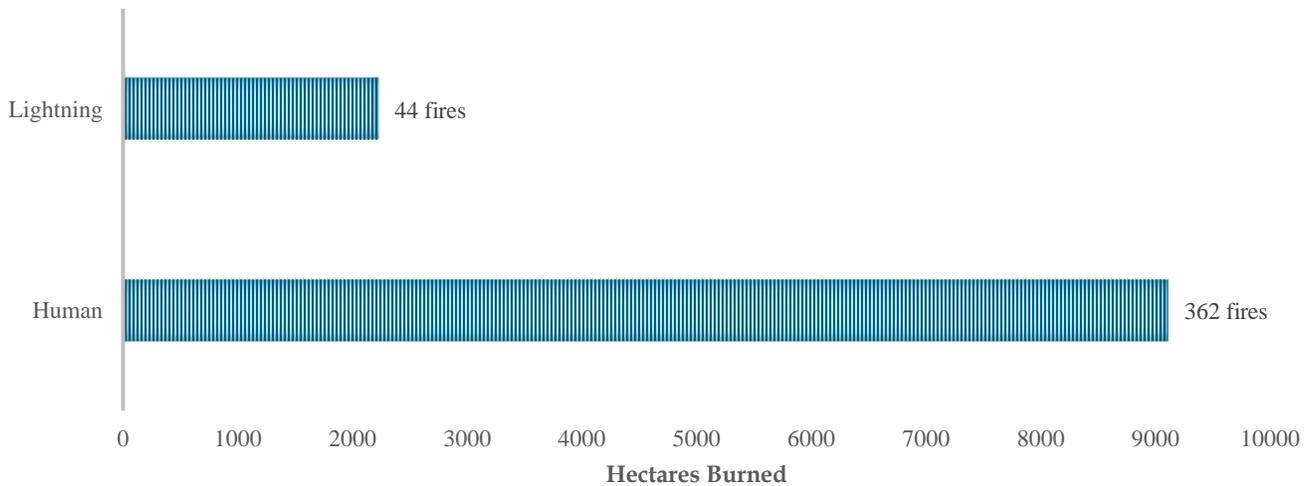
2.3. Figures & Tables

Figure 2: Saskatchewan (below 51.50 Degrees Latitude) Wildfire Frequency by Month (1980-2020)



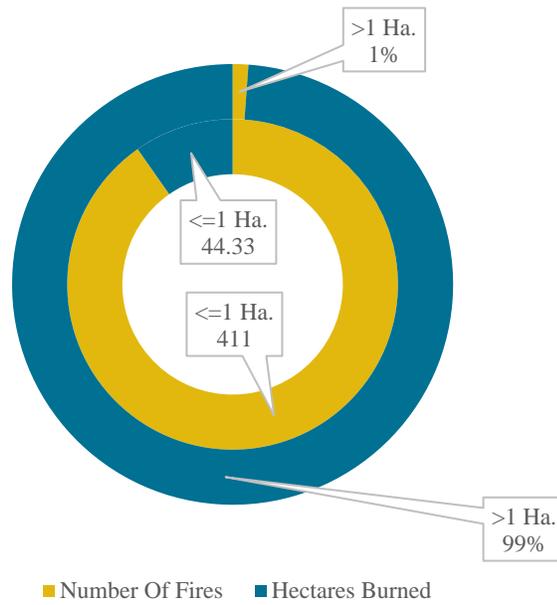
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Figure 3: Saskatchewan (below 51.50 Degrees Latitude) Wildfire Number and Hectares Burned by Cause



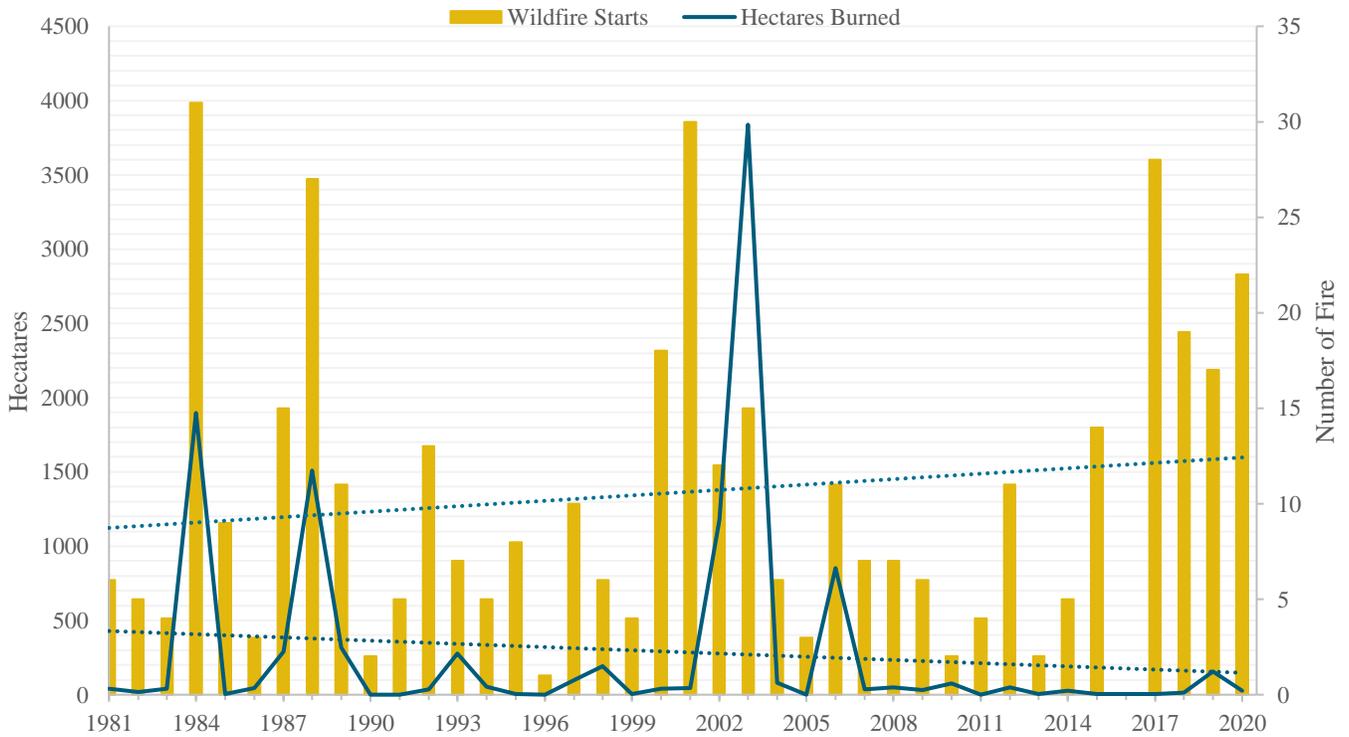
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Figure 4: Saskatchewan (below 51.50 Degrees Latitude) Proportion of Number and Hectares Burned by Size Class



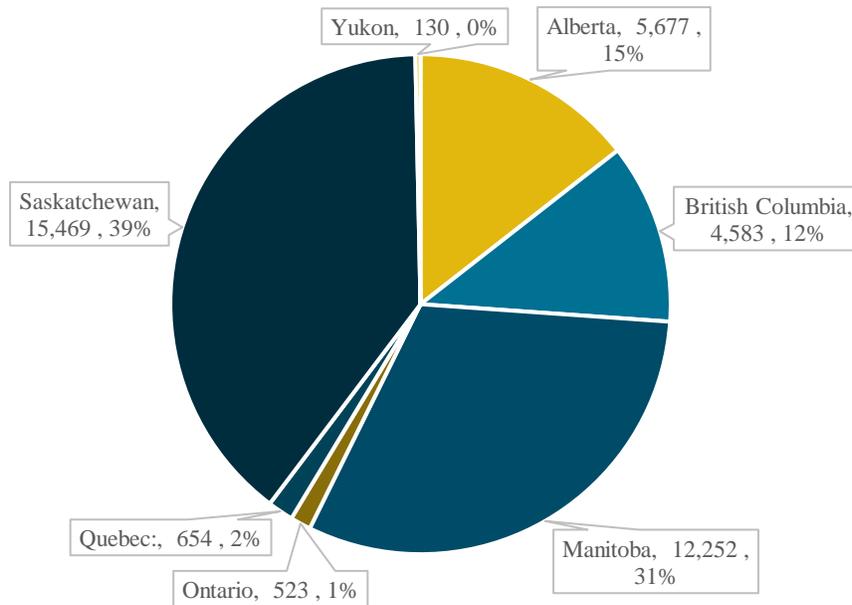
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Figure 5: Saskatchewan (below 51.50 Degrees Latitude) Wildfire Area Burned & Number by Year (1980-2020)



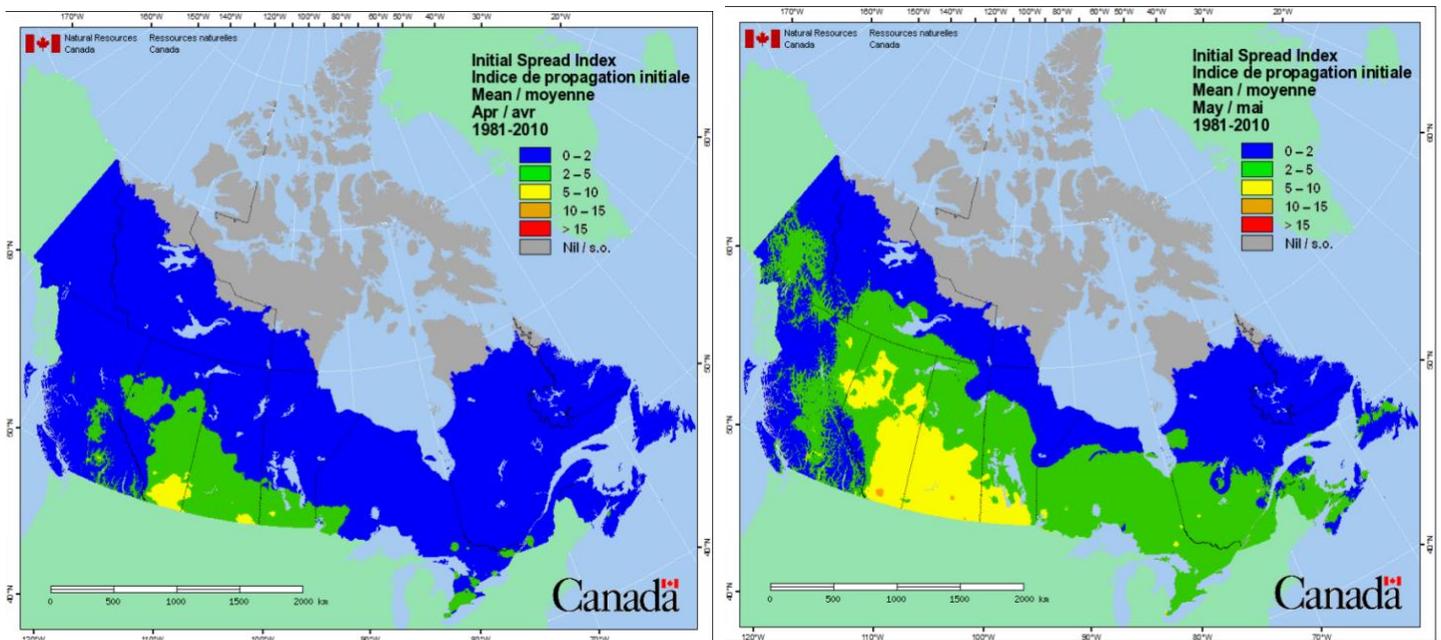
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Figure 6: Number of People in First Nations Communities Evacuated in Canada (2013-2019)



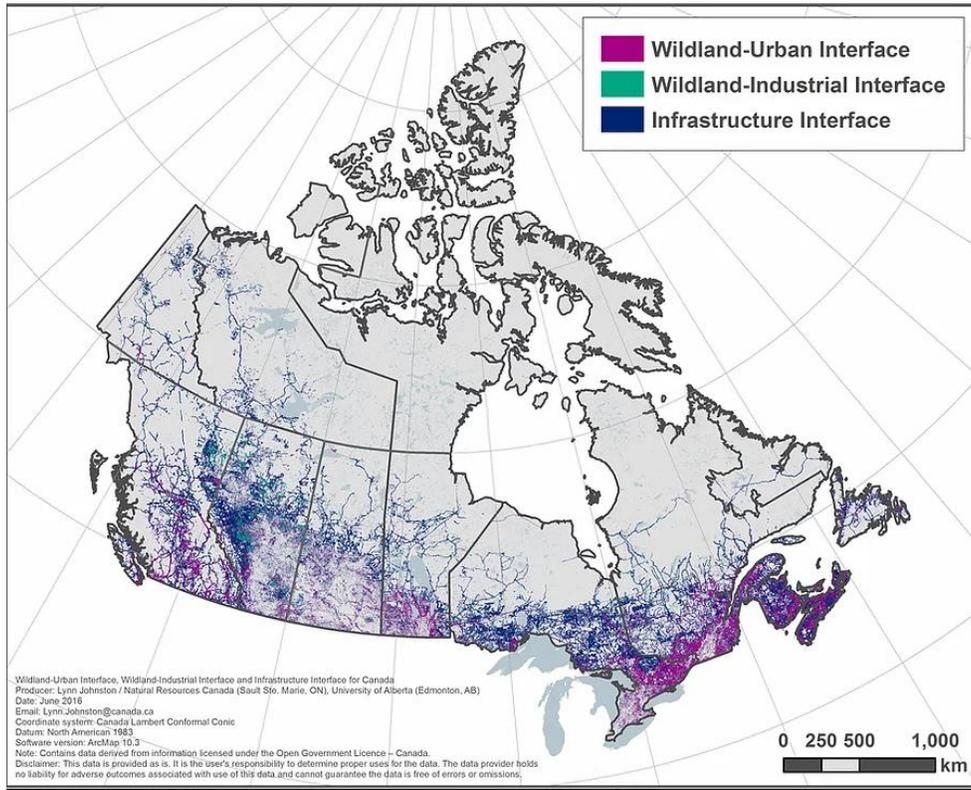
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Figure 7: Initial Spread Index Value Normals April & May (1981-2010)



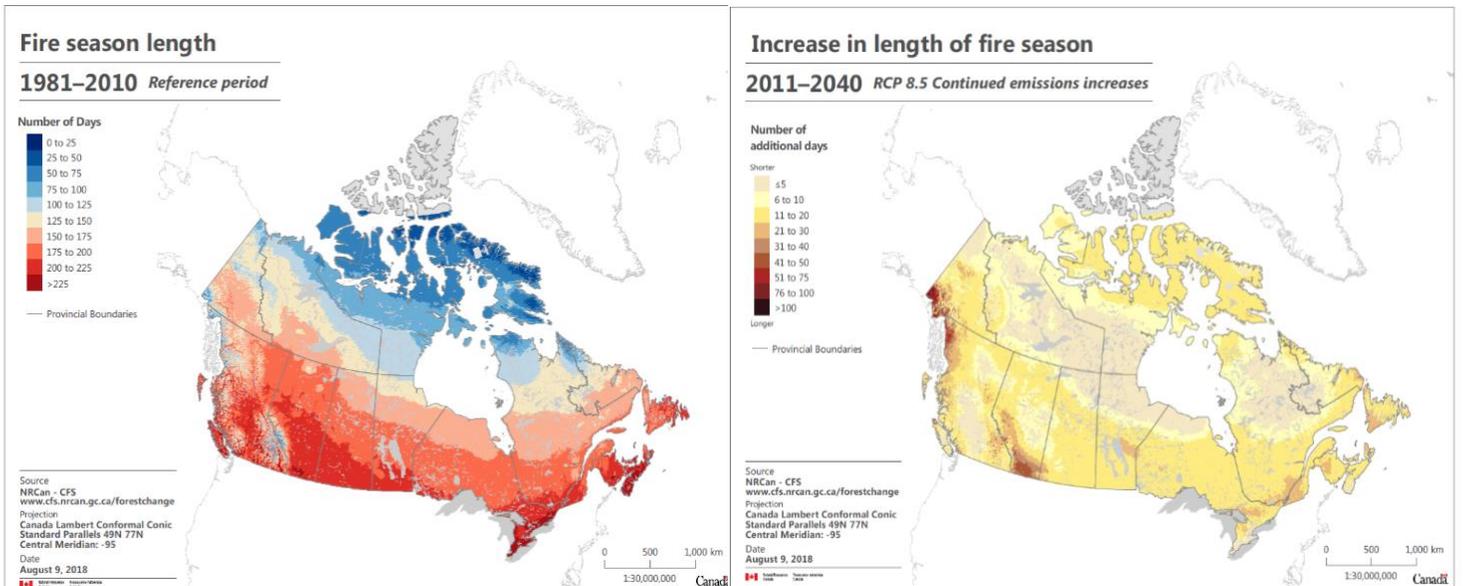
[9] [10]

Figure 8: Wildland Interface Map Canada



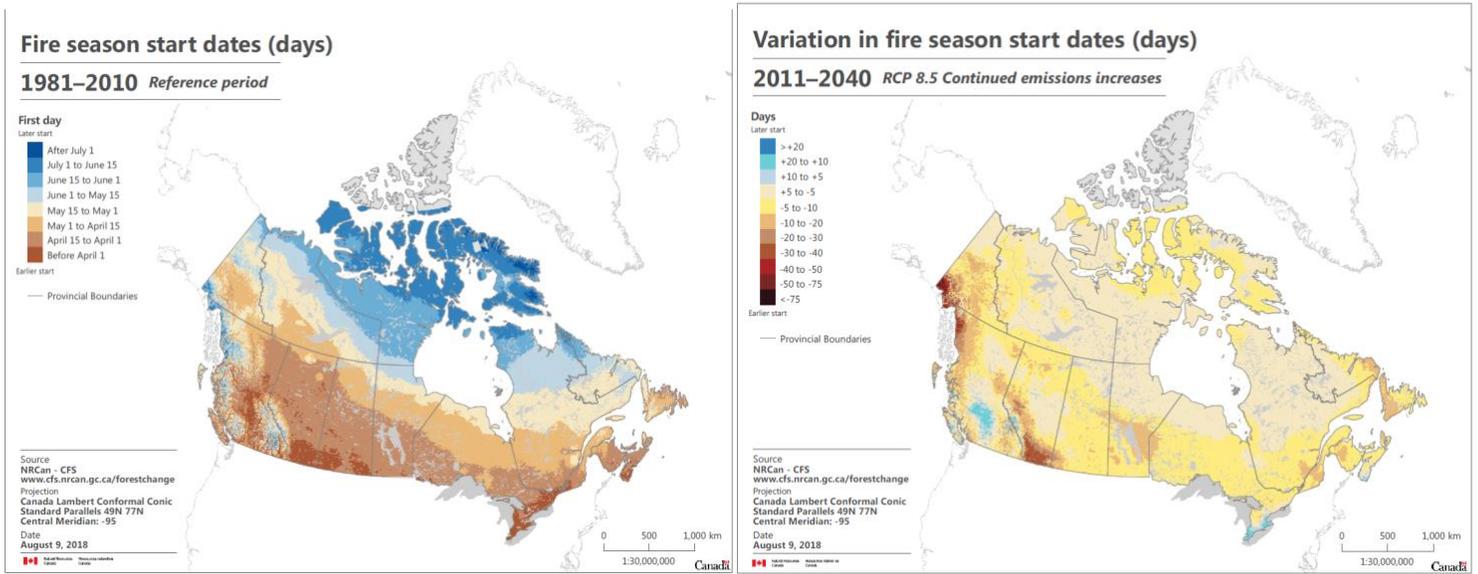
[11]

Figure 9: National Map of Modelled Historical & Projected Fire Season Lengths



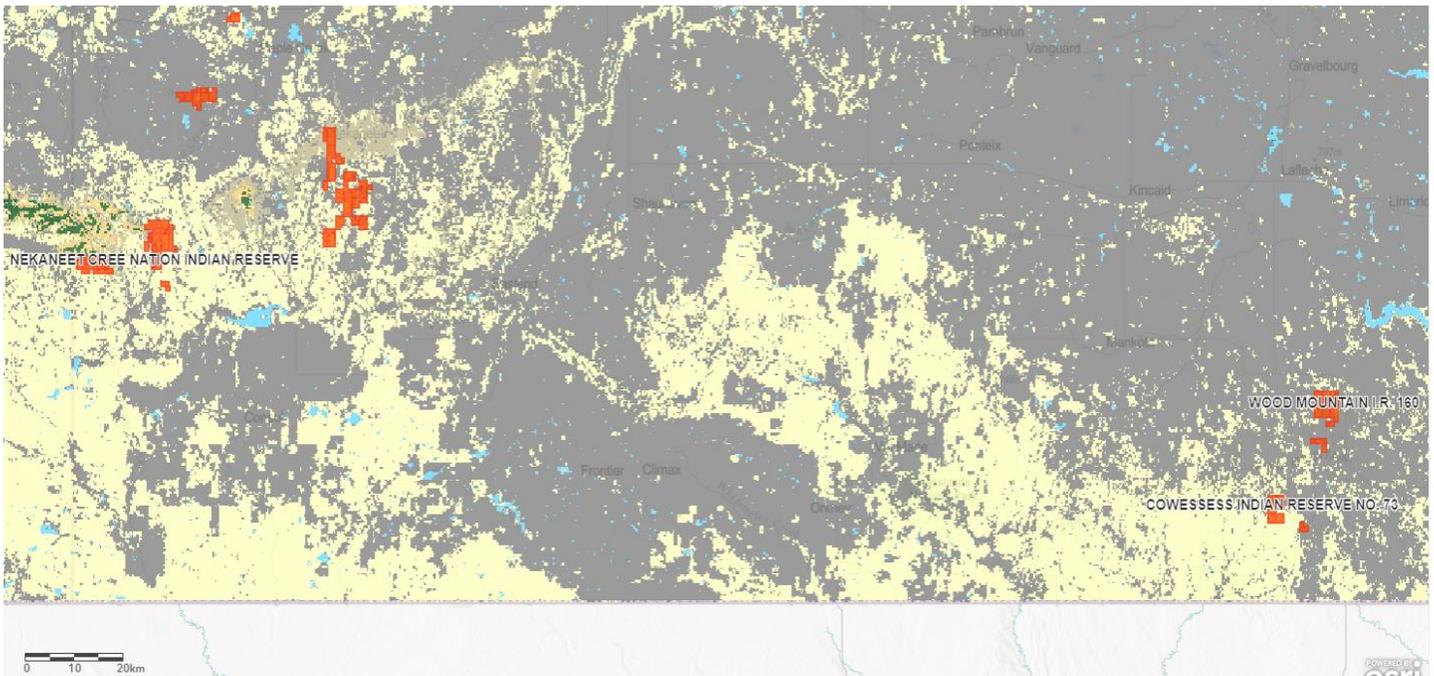
[12]

Figure 10: National Map of Modelled Historical & Projected Fire Season Start Dates



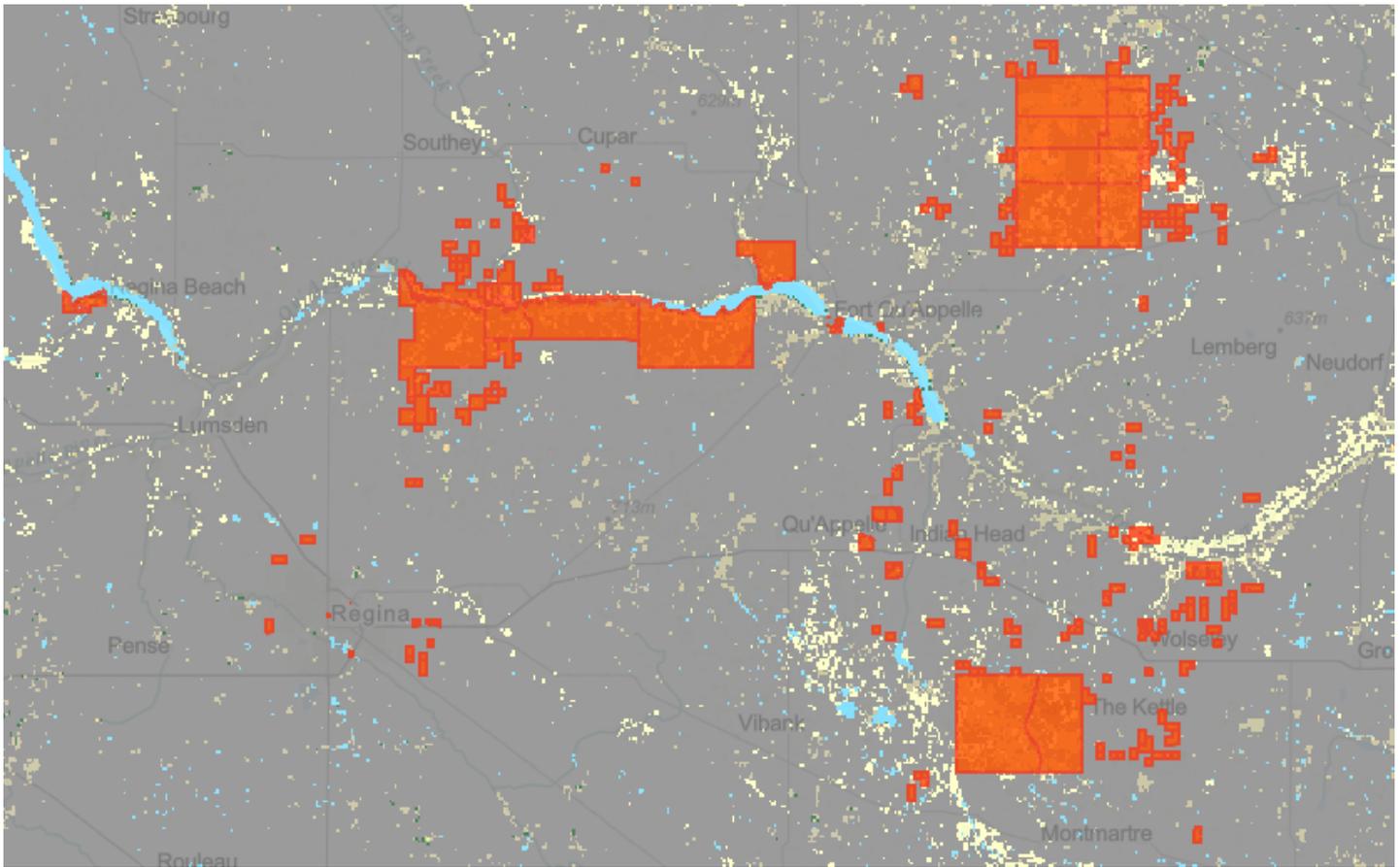
[12]

Figure 11: FBP Fuel Type Maps of FHQTC Member Nations & Surrounding Area



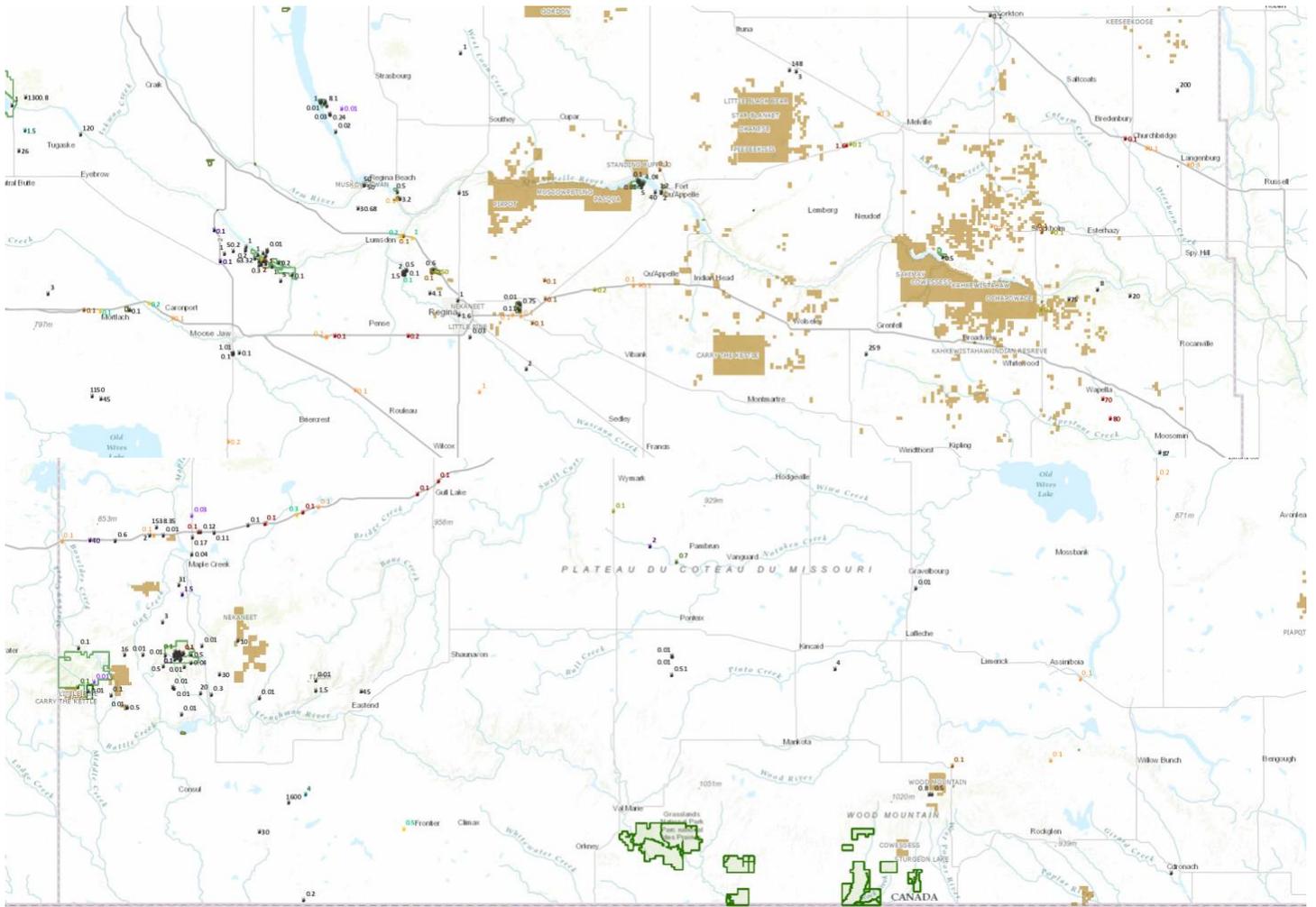
Yellow/white: 01a Matted Grass, Gold: 01b Standing Grass, Beige/Brown: D1 Aspen, Dark Green: C2 Boreal Spruce,
 Grey: Non-Fuel/Urban/Wetland/Veg Non-Fuel, Blue: Water, Orange: FHQTC & Area [13] [4]

Figure 12: FBP Fuel Type Maps of FHQTC Member Nations & Surrounding Area



Yellow/white: 01a Matted Grass, Gold: 01b Standing Grass, Beige/Brown: D1 Aspen, Dark Green: C2 Boreal Spruce,
Grey: Non-Fuel/Urban/Wetland/Veg Non-Fuel, Blue: Water, Orange: FHQTC & Area [13] [4]

Figure 14: Maps of Fire Size in the FHQTC Member Nations & Surrounding Area (1980-2019)



[8]

3. HAZARD: CONVECTIVE SUMMER STORM

HAZARD: CONVECTIVE SUMMER STORMS

CLASS: Natural

RISK SCORE: 12 FREQUENCY: Yearly LIKELIHOOD: 5 CONSEQUENCE: 3 VULNERABILITY: 4

WORST CASE SCENARIO: Thunderstorm event results in hail and F3 or greater tornado, moving through area incurring millions of damages to structures, power failures, and resident casualties. Prolonged damage to public infrastructure, displaced citizens, and community morale.

TYPE	DESCRIPTION
Thunderstorm	A weather event that involves heavy clouds, lightning, thunder, heavy rain, hail, and erratic winds. Due to the rising of warm unstable air mass to cooler regions of the atmosphere.
Tornado	A strong vortex of air and rotating wind reaching to the ground result of the mixing of warm humid air with cold air mass. Destructive force being determined by the wind speed of the rotating column.
Hail	Pellets of frozen and compacted ice and hard snow which fall in quantity from cumulonimbus clouds.
Cloud to Ground Lightning	A powerful electrical flash from thunderstorms due to the atmospheric separation of positive and negative charge.

INDICATORS

Storm Severity	Pressure System Pattern	Infrastructure Network
Precipitation Levels	Climate Change Impact	Municipality Proximity
Seasonal Occurrence	Cumulative Effect on Resources	Response Cost

SELECT INCIDENT HISTORY

LOCATION	DATE (dd.mm.yyyy)	INCIDENT
Southern Prairies	18-20.07.2016	Thunderstorm, Tornado & Hail: Storm system entered southern AB and expanded to Manitoba. Golf ball hail in Stewart Valley, SK and tornado warnings. Long Plain First Nation tornado caused damage. Est. Insurance Payments: \$102,739,000
Prairie Provinces	8-11.07.2016	Thunderstorms: Intense weather system moved across provinces, 130mm rain in Estevan, funnel cloud reports in SK, Battleford funnel cloud touched for 20 seconds, wind gusts greater than 100km/h. Est Insurance Payments: \$54,252,000
Southern Saskatchewan	25.06.2016	Thunderstorms: Hail and lighting, powerful winds uprooting trees and downing powerlines, some overland flooding Insurance Payments: \$35,523,000

Southern Saskatchewan	22.07.2015	Thunderstorm & Hail: Kerrobert, Anglin Lake, and Regina suffered strong winds, heavy rain, lightning, and golf ball size hail, damages to roofs, windows, and vehicles
Southern Prairies	12.06.2015	Thunderstorm: Moved west to east from High River to Manitoba. 900 people in Alberta lost power. In Maple Creek, winds >120km/h, hail and in Assiniboia hail damage was recorded. Est. Insurable Payments: \$98, 184,000
Kawacatoose First Nation, SK	02.07.2010	Tornado: F3 tornado, speeds >330km/h, 500m wide path, 45km long. Destroying 18 homes, and leaving 85 homeless. Federal DFAA Payments \$12,881,000
Regina, SK	22.07.2008	Thunderstorm: Wind gusts >92 km/h, 11.2mm rain, left 15,000 people without power
Pilot Butte, SK	26.08.1995	Severe Thunderstorm & Tornado: Winds gusting over 130km/h, golf ball-sized hail, prompted local state of emergency, 500 homes without power, 72 trailers destroyed, and 2400 trees marred. Est. \$30 million damages
Lebret & Kamsack SK	09.07.1944 to 09.08.1944	Tornado: Two tornado hit Lebret, four people died, “Kamsack Cyclone” in August, destroyed 400 homes, 100 businesses, and 3 fatalities
Southeastern Saskatchewan	22.07.1920	Tornado: Swept over large region including Estevan, SK, four fatalities, >12 injured, 42 families assisted by Red Cross and \$100,000 in damage reported (1920’s cost)
Regina, SK	30.06.1912	Tornado: Canada’s deadliest tornado, F4, 28 fatalities, 2,500 homeless, >100 injured and >400 buildings destroyed.

3.1. Hazard Exposure

Convective summer storms are intense weather events that can arise quickly over the prairies, can cause extensive infrastructure damage and can threaten human life over a short duration of time. These storms can occur anywhere across central and southern Saskatchewan outside and within the FHQTC Member Nations. On average there are more than 24 days per year that record severe thunderstorm events (Figure 15), typically anywhere from April to October, with most occurring in June, July, and August as warmer temperatures and humidity generating convective instability [14] [6]. Environment Canada issues severe thunderstorm warnings when systems can produce wind gusts exceeding 90km/h, hail > 2cm, or heavy rainfall >25mm per 24 hours.

Lightning strikes from thunderstorms can pose a risk to individuals and infrastructure within the vicinity of a positive strike through ground current, side flashes, contact, upward leaders, and direct strikes. Within Canada, there are on average 2.3 million flashes of lightning per year, with June (21%), July (39%), and August (25%) accounting for the majority of occurrences. In the southern half of Saskatchewan, the lightning season can begin as soon as March 26th and continue as

late as October 20th, with the average number of days with cloud-to-ground lightning strikes ranging from 10 to 30 [3]. This area also records some of the highest average frequency of flashes per km² in western Canada, ranging from .8 flashes in the Cypress Hills and Pasqua Lake areas, to 1.2 in the Wood Mountain area (Figure 17) [15].

Hail from thunderstorms can lead to significant damages in a short temporal period, potentially decimating agricultural production, and crop insurance payouts attributed to hail damage can exceed \$100 million in a year nationally and \$23.1 million provincially [6]. Between 1978 to 2007 the forecast regions that encompass the FHQTC experienced anywhere from 29 to 67 severe hail events, averaging .93 to 2.3 per year, respectively (Figure 19). However, one report demonstrated that Saskatchewan had a statistically significant decreasing trend in the average of hail frequencies per year from 1977 to 2007 in comparison to other provinces [16]. Hail in this area has reached softball size, which is 4 inches in diameter, enough to smash windshields, and put holes in homes and even car roofs [17].

Extreme winds, such as downbursts and plough winds, caused by the vacuum of rapidly rising hot air have also demonstrated destructive capabilities, with events exceeding 120km/h, demolishing structures, ripping roofs, flattening crops, and causing injuries [18]. These winds differ from tornados as they are fast, straight, and wide caused by the vacuum of rapidly rising hot air and plunging of cold, while tornadoes create a vortex. Southern Saskatchewan is susceptible to high-intensity winds throughout the year averaging 23-27km/h annually (50m wind speed) and an average of up to 8 days of extreme wind speeds per year, with gusts with the potential to reach nearly 160km/h. Strong wind gusts are defined as exceeding 90km/h or sustained wind surpassing the 70km/h threshold by Environment Canada.

These winds differ from tornados as they are fast, straight, and wide caused by the vacuum of rapidly rising hot air and plunging of cold, while tornadoes create a vortex. Southern Saskatchewan is susceptible to high-intensity winds throughout the year capable, averaging 23-27km/h annually (50m wind speed) and average up to 8 days of extreme wind speeds per year, with gusts possessing the potential to reach nearly 160km/h (Figure 20 & Figure 21) [14]. Strong wind gusts being defined as exceeding 90km/h or sustained wind surpassing the 70km/h threshold by Environment Canada. Southern Saskatchewan has one of the highest risks for tornadoes in Canada, and between 1880 to 2007 there was a total of 1,143 sightings [19]. This region averaged 17.6 tornadoes per year from 1980 to 2009, with most of these being F0 and F1 classifications [19] [6]. More specifically, FHQTC Member Nations in eastern and southeastern Saskatchewan can record on average 2.5 to 4.9 tornadoes per 10,000km², and in the southwest .5 to .9 [14]. From 1970 to 2009, the forecast zones of Cypress Hills reported a total of 23 tornados, Assiniboia 46, and Fort Qu'Appelle area the highest at 71 (Figure 16). From 1980 to 2009 most of these occurrences were Fujita Class (F) 0 or 1 events, predominately in the Qu'Appelle zone, F2 events were recorded in all zones, with one F3 being recorded in Assiniboia (Table 4). All verified tracks in the province indicate an eastward movement from the origin (Figure 18), average track distances of 8km for F0's and 4km for F1's (Table 5), and some F3 events have reached 70km. Tornado events in this region generally occur between May and August from 4 pm to 8 pm in the evening and the highest frequency occur during June, then July [20].

3.2. Hazard Outlook

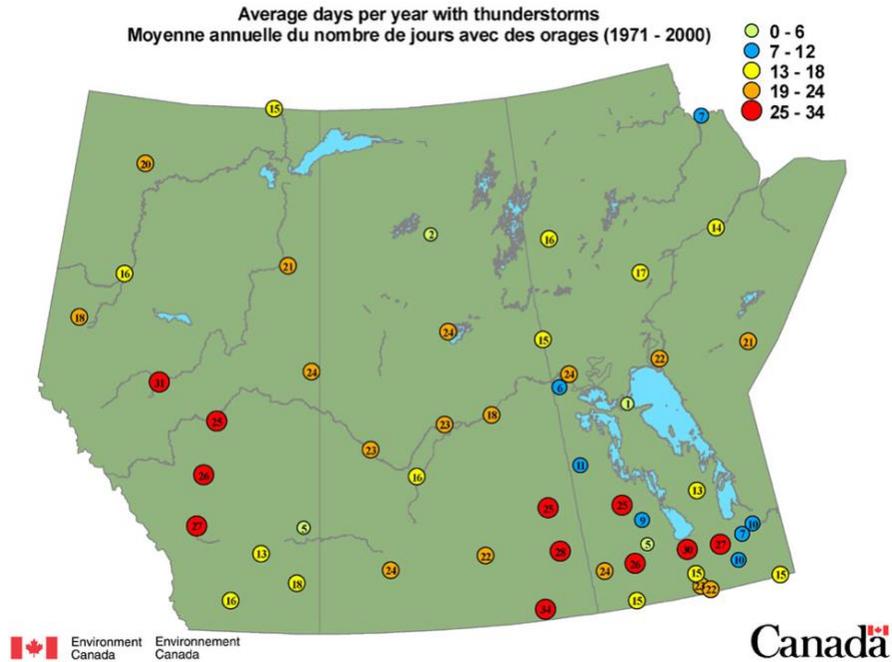
Climate change evaluations predict that the frequency and severity of weather extremes will increase in southern Saskatchewan in part since warmer temperatures allow for higher moisture-holding capacity. However, events such as isolated thunderstorms are of such small spatial and temporal scale, as well as being dependent on very specific atmospheric conditions, they are difficult to predict through climate modelling [6]. Convective events already incur a significant amount of insurance-related costs, in 2017 one hailstorm caused \$46 million provincially, with strong correlations existing between the presence of severe thunderstorms, hail, and tornadoes in the southern portion of the province [21] [22].

From these storm hazards, tornadoes possess the highest financial and human life risk to the FHQTC Member Nations. Although these events are typically lower on the Fujita scale, systems creating F3 or larger are historically possible. In 2007, Canada's first and only F5 tornado, was recorded in Elie Manitoba, less than 500km away from Fort Qu'Appelle. This shows that in the southern prairie provinces, events of catastrophic magnitude can occur. Although these events are rare, the predictive occurrence of tornadoes remains the highest over a large spatial area in the center of southern Saskatchewan, and subsequently encompassing some FHQTC Member Nations [23]. Lower severity wind events can still create excessive damages, with an F1 (winds reaching 170km/h) capable of peeling roof surfaces, breaking trees, blowing vehicles off the road, and overturning mobile homes [24]. Events of lower magnitude can pose risk to residents, and from 1980-2009, 139 injuries and 7 fatalities were reported during <F2 events. Greatest concern comes from events exceeding F3, and historically these events have accounted for 748 injuries and 53 casualties in Canada (Table 4). An F3 event is capable of tearing roofs off homes, throwing vehicles, demolishing mobile homes, and creating object missiles, as wind speeds reach 320km/h [24]. It has even been estimated that an event the same magnitude of Regina in 1912, today could exceed \$82 million and cause over 10,000 people to become homeless [6].

Furthermore, FHQTC Member Nations around Fort Qu'Appelle could expect the highest probability of tornado occurrence going forward. While lightning strikes appear highest closer to Wood Mountain Lakota First Nation, hail events occur less frequently to the eastern central portion of the province and are highest toward Nekaneet First Nation in Cypress Hills. Communities should be prepared during peak summer months and hours after 2pm for most convective events, as buildup occurs during the heat of the day, with many significant storm tracking from the west to the east [18]. Lastly, the FHQTC Member Nations can monitor regional weather warnings provided by Environment Canada, to stay up to date on projected conditions and to anticipate these occurrences. As well, increasing resident familiarity with the SaskAlert application, which provides information on extreme weather alerts, can help increase the preparedness of communities.

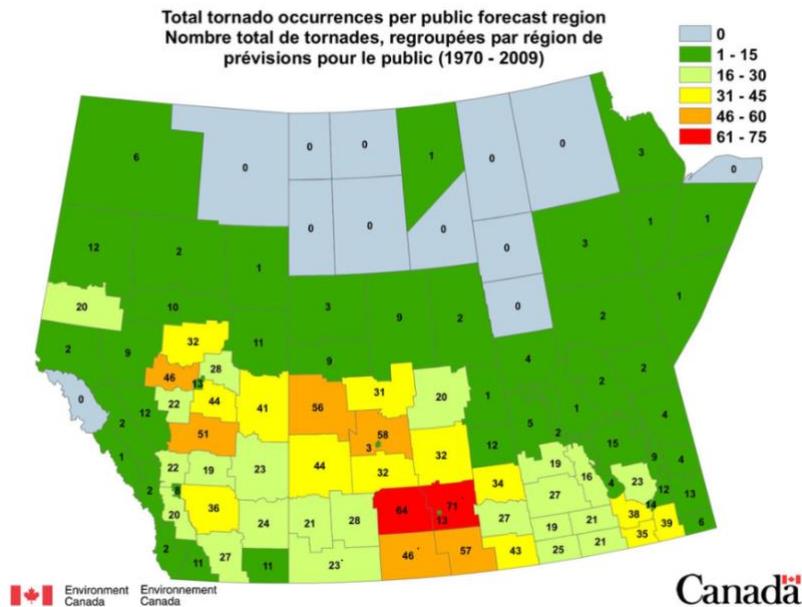
3.3. Figures & Tables

Figure 15: Average Days Per Year with Thunderstorms in the Prairies



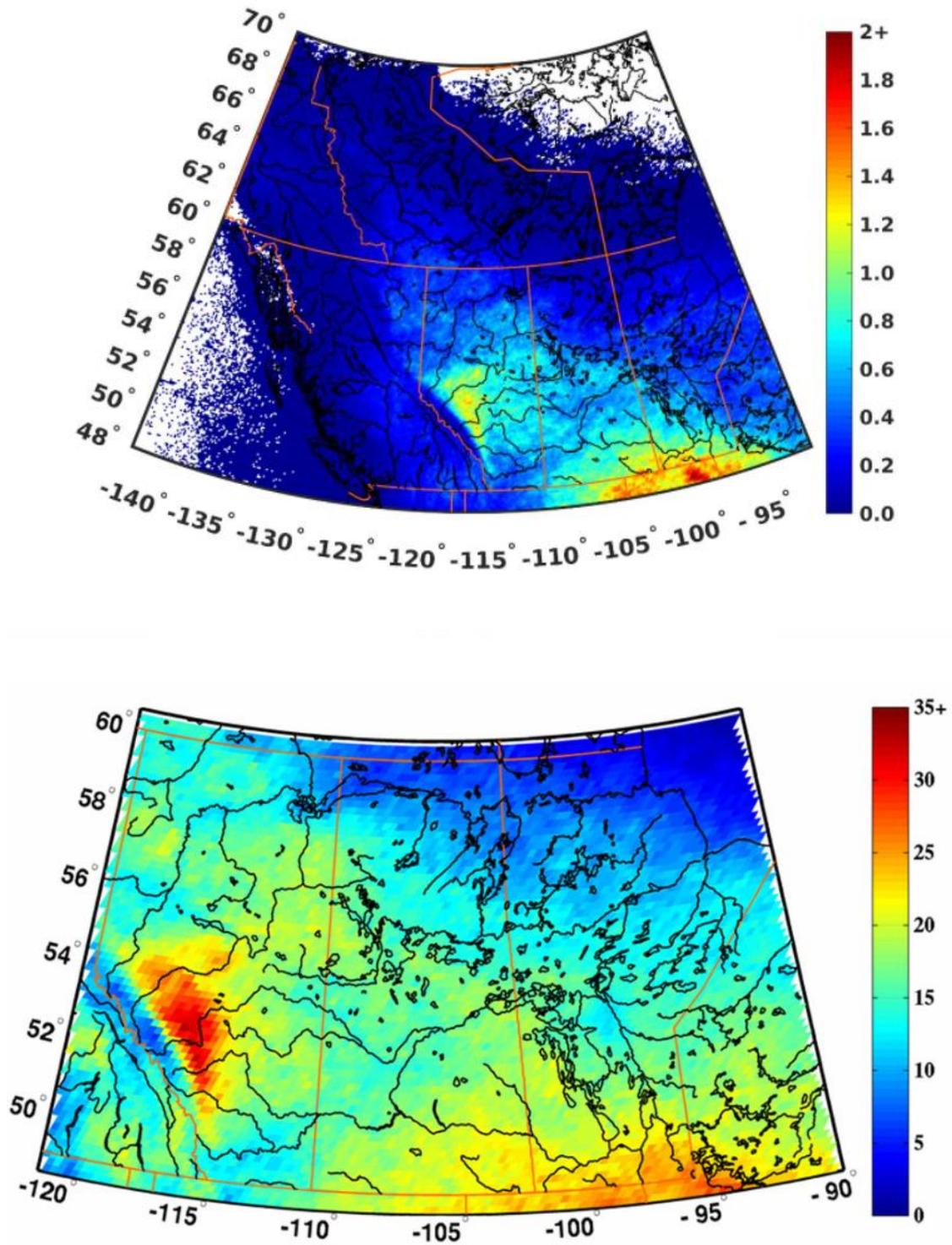
[14]

Figure 16: Tornado Occurrence Per Forecast Region (Prairies)



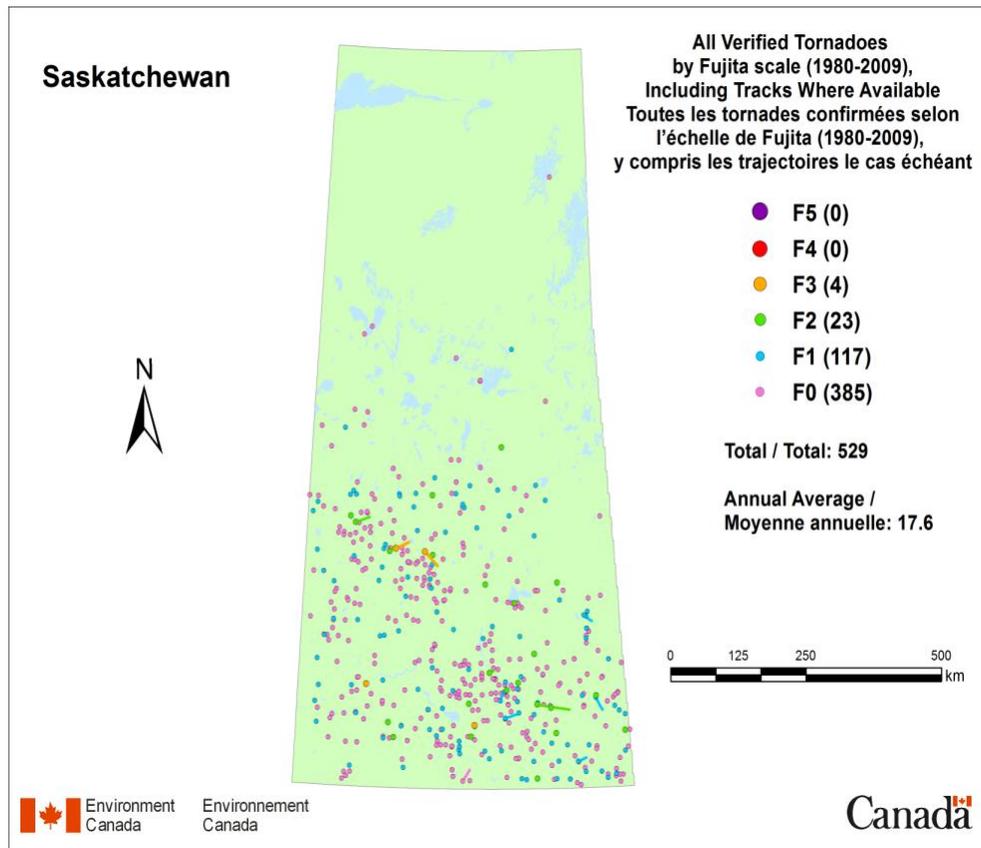
[14]

Figure 17: Average Lightning Flash Density (flashes/sq. km) & Annual Days with Cloud to Ground Strikes (Prairies 1999-2018)



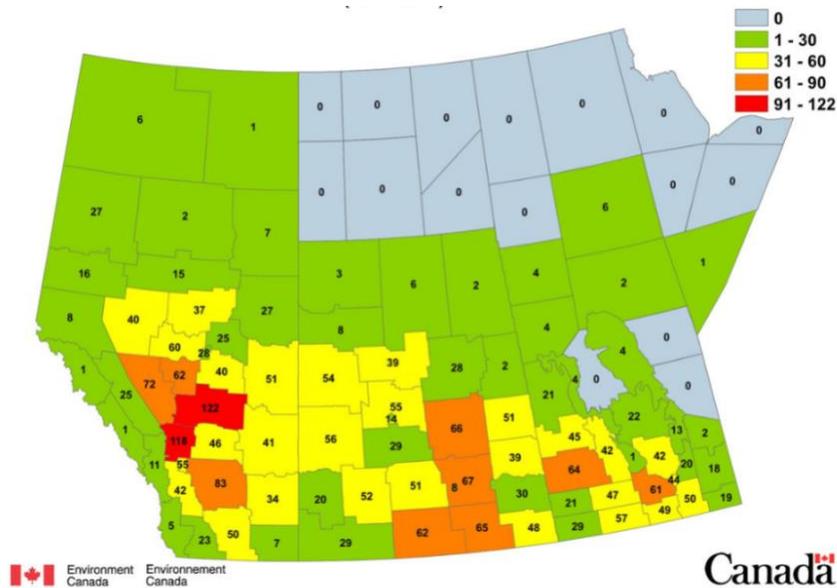
[15]

Figure 18: Locations of Verified Tornado Tracks in Saskatchewan



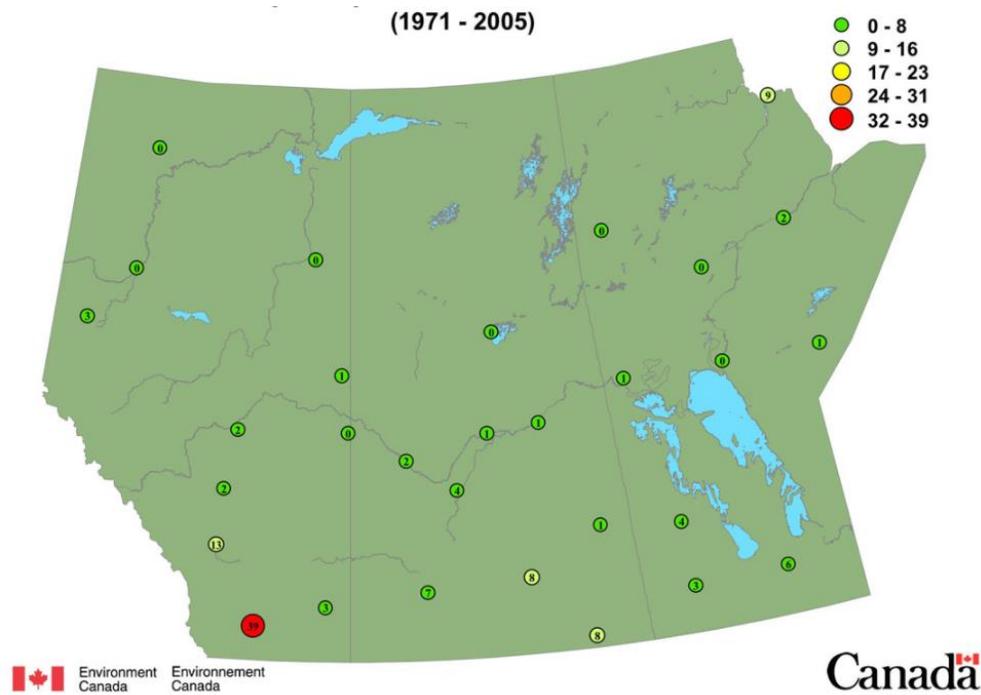
[6]

Figure 19: Total Severe Hail Events Per Public Forecast Region (Prairies 1978-2007)



[14]

Figure 20: Annual Average Days with Wind Speed over 63km/h in Prairie Provinces



[14]

Table 4: Tornado Frequency by F Class (1980-2009)

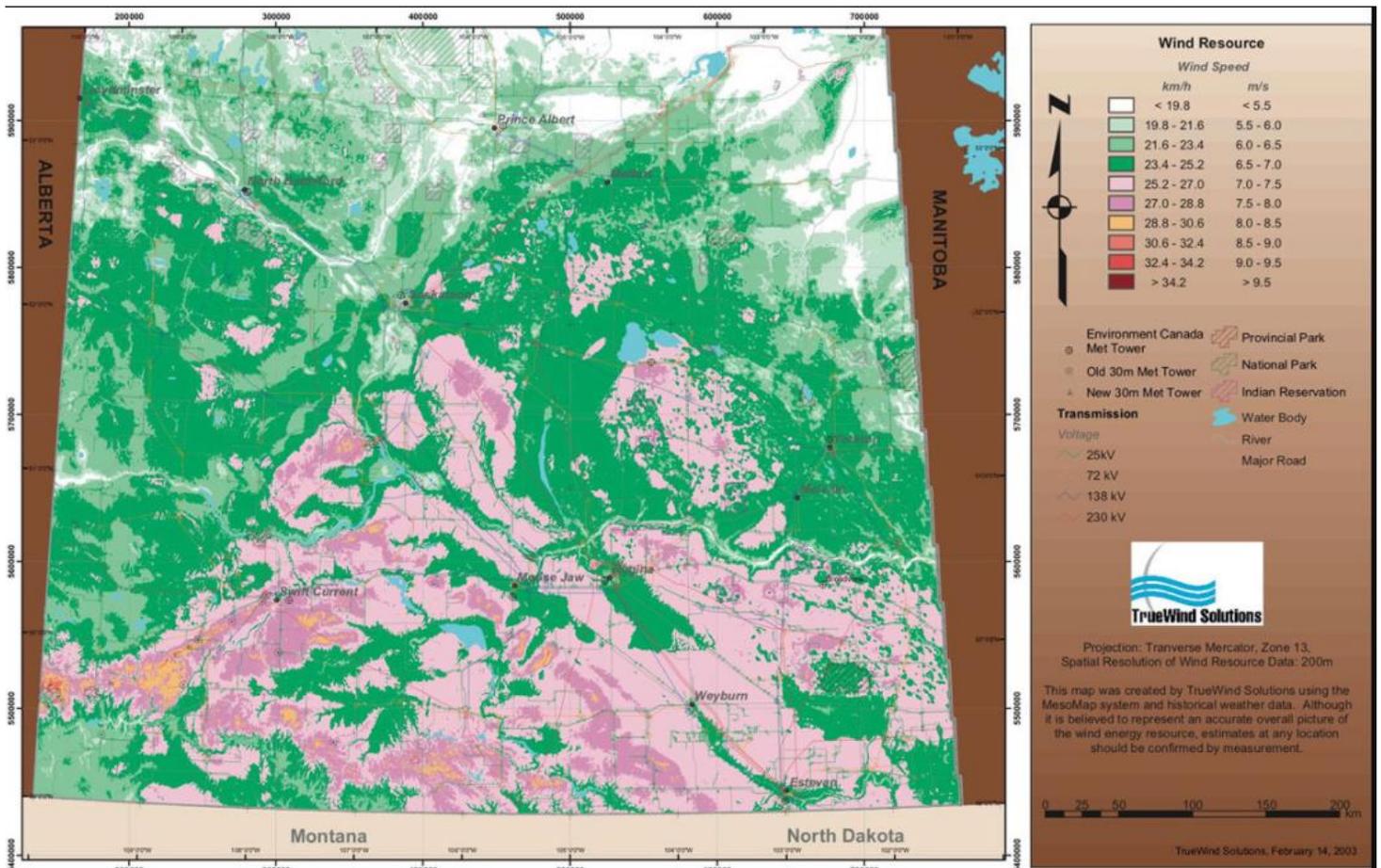
Reporting Forecast Region	0	1	2	3	Total
Assiniboia - Gravelbourg - Coronach	25	10	1	1	37
Fort Qu'Appelle - Indian Head - Lumsden - Pilot Butte	36	9	5		50
Shaunavon - Maple Creek - Val Marie - Cypress Hills	14	9	1		24
Total	75	28	7	1	111

Table 5: Recorded Track Data for Tornadoes in Regions (1980-2009)

Reporting Forecast Region	F Class 0			F Class 1			F Class 2		
	Count	Width (m)	Length (km)	Count	Width (m)	Length (km)	Count	Width (m)	Length (km)
Assiniboia - Gravelbourg - Coronach	2		16.2						
Fort Qu'Appelle - Indian Head - Lumsden - Pilot Butte	1		7.2	2	425	8.4	2	800	30
Shaunavon - Maple Creek - Val Marie - Cypress Hills	2		1.1						
Saskatchewan	7	463	8	5	282	4	4	450	25

[25] [26]

Figure 21: Average Annual Wind Speed Saskatchewan (2003)



[14]

Table 6: Tornado Injuries & Fatalities Provincially & Nationally (1980-2009)

Region	F Class 0,1,& 2		F Class, 3,4 5	
	Fatalities	Injuries	Fatalities	Injuries
Saskatchewan	0	11	0	0
Canada	7	139	53	748

Table 7: Recorded Tornadoes by Month in Region (1980-2009)

Reporting Forecast Region	May	June	July	August	Total
Assiniboia - Gravelbourg - Coronach	4	20	7	6	37
Fort Qu'Appelle - Indian Head - Lumsden - Pilot Butte	2	24	20	4	50
Shaunavon - Maple Creek - Val Marie - Cypress Hills	5	10	7	2	24
Total	11	54	34	12	111

[25] [26]

4. HAZARD: FLOOD

HAZARD: FLOOD

CLASS: Natural

RISK SCORE: 11 FREQUENCY: Yearly LIKELIHOOD: 5 CONSEQUENCE: 3 VULNERABILITY: 3

WORST CASE SCENARIO: Heavy winter snowfall, delayed spring runoff into late spring, sustained precipitation during spring, with one extreme early summer event (100mm) causing a 1:200-year flood event, that damaging community structures.

TYPE	DESCRIPTION
Seasonal Fluvial	Overbank river & lake flooding as a result of freshet or ice jams during spring or winter thaws.
Flash Fluvial	River and lake surge that happens within <6hours of an intense downpour.
Surface	Overland flooding due to intense or sustained rainfall cannot be adequately dispersed.
Urban	Includes basement, sewage, and stormwater backups. Typically, a result of other flooding events.

INDICATORS

Precipitation Patterns	Flow & Discharge Properties	Recurrence Intervals
Waterbody Location	Drainage Characteristics	Municipality Proximity
Landscape Topography	Infrastructure Capability	Response Cost

SELECT INCIDENT HISTORY

LOCATION	DATE (dd.mm.yyyy)	INCIDENT
Estevan, SK	10.07.2016 to 13.07.2016	Surface & Flash: 127mm in 24 hours, caused overland flooding, due to a slow low-pressure system. 400 people evacuated from the area.
Qu'Appelle Valley & Touchwood Hills	10.04-19.04.2015	Seasonal Fluvial: Freshet & rain caused localized overbank and overland flood damage for farmers and lakeside residents.
Souris, Lower Qu'Appelle & Assiniboine Basin, SK	25.06.-14.07.2014	Surface: Summer rainstorm, ~240mm in two days, 68 municipalities in southern SK enacted state of emergency, road washouts, highway closures, power, and rail outages. DFAA Request: \$ 147 million Est. damage cost at 48 million
Across Central & Southern SK	16.04.-3.07.2013	Seasonal Fluvial: Freshet, rainfall, high snowfall, delayed spring melt, overland flooding occurred in many areas south of Regina to the US Border. 15 communities and FHQTC declared a state of emergency, highways flooded. Peak flows at Lake Diefenbaker reached 6000 m ³ /s. Downstream it reached 200m ³ /s, rising by 2metres. Prov. DFAA Request: \$43 million
Across Southern, SK	17.06.-28.06.2011	Surface: Spring rainfall resulted in overland flooding, ~112mm, 19 municipalities enacted a state of emergency, 383 people evacuated,

		water treatment system at capacity. DFAA Request \$252 million. Est. total costs 360 million.
North Battleford, SK	22.07.2010	Surface: Rainstorm flood caused extensive flash flooding, 97 homes were flooded, and Red Cross accommodating the evacuated 45 people. Federal DFAA Payments: \$112,00
Blood Tribe Reserve & Medicine Hat AB, Maple Creek, SK	14.06.-18.06.2010	Fluvial Flash & Seasonal: Spring rainfall >100mm, overland and fluvial flooding, rail & highway routes shut down, 2065 evacuated. DFAA Request: \$42,000,000
Fishing Lake, SK	25.05.2007	Seasonal Fluvial: Freshet from high snowfall, ice melt runoff and 50-75mm, 300 homes/cottages damaged, and 600 individuals removed from the area
Vanguard, SK	18.07.2001	Surface: Flash overland flood, 375 mm of rain in 8 hours, washing out homes and roads in community with damage still appearing for residents into the following year
Carrot, Red Deer and Qu'Appelle River Basin, SK	.04.1974	Seasonal Fluvial: Freshet, record Snow Water Equivalent @152mm in March, 436 cubic m/s, evacuation of 1400 people, Est. total cost was \$6,611,800.
Qu'Appelle River Basin, SK	~.04.1969	Seasonal Fluvial: Freshet, high fall and winter precipitation with quick melt period, 12-14 thousand acres of agricultural land flooded.
Eastend, SK	1.04.1952	Seasonal fluvial: Freshet flood, high snowfall in Cypress Hills, low spring temperatures, caused the Frenchman River to overbank.

4.1. Hazard Exposure

Drainage basin properties are extremely influential in determining flood frequency and severity [27]. The FHQTC Member Nations span the Qu'Appelle, Old Wives, Cypress Hills North Slope, and Missouri (border) Watersheds. Within these catchments, there are contributing and non-contributing areas (Figure 22) [28]. The latter are extremely vulnerable to overland flooding as they lack external drainage routes, and once at capacity begin to overflow into adjacent low-lying lands and terminal lakes [29]. Consequentially, wetland draining activities can greatly increase the severity of flood and storm events in these zones [30]. The highest surrounding concentration of these areas amongst FHQTC Member Nations is northeast of Pasqua Lake, where even winters of less precipitation have reported spring agricultural and road flooding damage nearby [31]. Wood Mountain Lakota First Nation is completely in a non-contributing sub-basin but sustains lower overall discharge rates (Figure 22 & Figure 23). Whereas in high drainage areas, such as the Cypress Hills or tributaries to Pasqua Lake, contributing capabilities can result in severe runoff events for areas downstream (Figure 23) [32].

Freshet flooding is instigated by the thaw of snow and ice, therefore tracking accumulated precipitation during the winter months is critical in determining the potential of spring flooding [33]. Ground frost depth, melt rate, and spring precipitation coverage have also been factors during past freshet events [6]. Historically, within the region, March and April account for the majority of the peak flow occurrence (Table 7). What exacerbates the freshet problems is, as demonstrated in 2011, the

delayed thaw of snowmelt in combination with spring rains. In these instances, average flow rates of rivers in the region can climb past 900% of their norm and sustain flows well into the summer (Figure 23).

Additionally, periods of high summer rainfall and intense rainstorms (flash floods) have caused localized states of emergency. June typically accounts for approximately 24-30% of these regions' annual rainfall. But an extreme storm can account for 44% of the annual average rainfall in a single day (Table 9). In 2010, the region surrounding Nekaneet First Nation experienced an approximately 140mm downpour in three days which subsequently resulted in overland flooding, entrapping residents, and damaging structures [32]. In 1961, at Buffalo Gap, east of Wood Mountain Lakota First Nation, a flash flood resulted from 254mm in less than an hour [34]. However, there is extreme variability in the downstream effect of these events as they can be highly localized (Figure 23).

Many waterways have been altered by dam construction to mitigate peak occurrences, but nearby reservoirs and lakes are still susceptible to flooding, notably Pasqua, Echo, Mission, and Junction. Flood events have occurred when lake levels increased by more than a meter [35]. The Pasqua, Echo, and Mission Lake Flood Maps show numerous structures are susceptible to a 1:200-year event, like that of 2011 (Figure 24). In 2010, Junction Reservoir, north of Maple Creek, experienced a 1:250-year volume event, with discharges reaching 408m³/s, overflowing into highways [32]. The complication with reservoirs results from their need to also retain water accessibility through to fall, as drought can occur within the same season and drop lake levels by a meter [35] [29]. It becomes imperative to manage spring flows responsibly as they can cause cumulative downstream effects. The vulnerability of FHQTC Member Nations is dependent on the proximity to river flood plains (Pasqua & Piapot First Nations), upslope catchments (Nekaneet First Nation), and wetland depressions (Wood Mountain Lakota First Nation & File Hills Agency).

4.2. Hazard Outlook

In 2010, the southwest experienced a 1:3700-year localized flow event [32], a year later the southeast had a 1:200-year flood [29], and in 2014 initial reports stated costs exceeded that of 2011 [36]. From 2005 to 2014, Saskatchewan received \$812 million in disaster financial assistance, the highest amount per capita in Canada, primarily due to flooding events [37] [38]. Climate change is expected to further increase regional warming and the frequency and severity of precipitation events which subsequently increases the variability, seasonality, and availability of riverine flow [39]. Floods will continue to retain a cyclic presence within the region and events of historically lower probability are expected to occur more frequently. Areas of poor drainage and limited outflow should expect to experience surface flooding more often. One mitigation measure is the altering of stream flows by dams to control future flow events and conveyance structures are in place along the Qu'Appelle Valley. However, these structures have limitations, Craven to Ketepawa has only an additional 14m³/s, and the sudden release of channels can still result in downstream flooding extremes [33]. To better prepare communities, the Water Security Agency publishes a seasonal flow forecast each February that accounts for the antecedent precipitation and

projections in various regions. As seen in 2011, Nations can then access the *Emergency Flood Damage Program* in anticipation of major flood events, potentially decreasing overall damages and costs [29].

4.3. Figures & Tables

Figure 22: Maps of Contributing (green) and Non-Contributing (red) Zones within the FHQTC and Surrounding Area

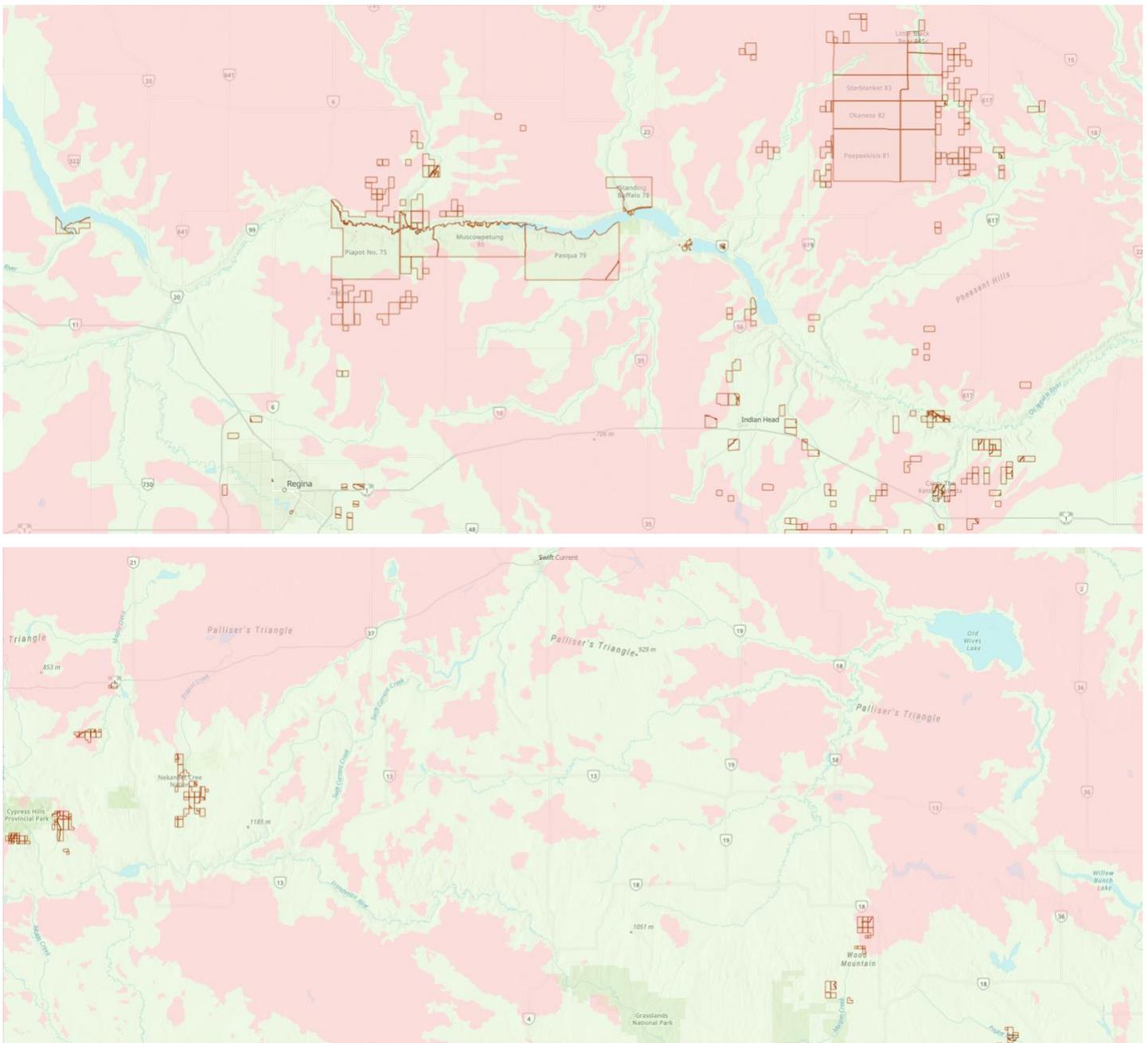
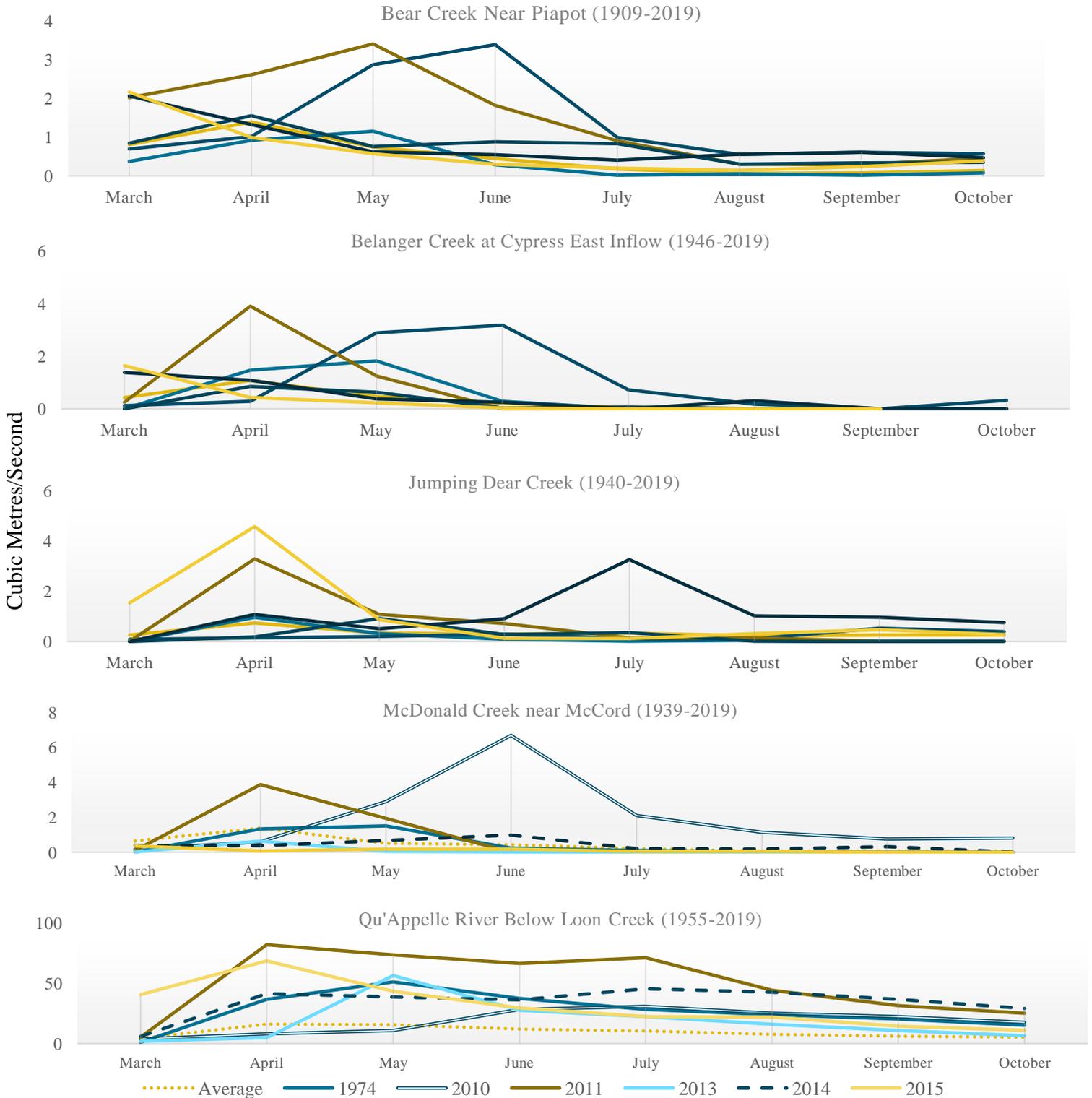


Figure 23: Average Monthly Flow Rates Between Flood Years and Average Flow from Reporting Hydrometric Stations



McDonald Creek is in the south, within the Old Wives Watershed. Belanger Creek flows into Cypress Lake from the east, is in the Missouri Watershed. Bear Creek is downstream of Cypress Hills within the Cypress Hills North Slope Watershed. Qu'Appelle River at Loon Creek is upstream of Pasqua Lake & Jumping Dear Creek is northeast of Lipton both are in Lower Qu'Appelle Watershed. [39]

Table 8: Average Monthly Lake Levels of Echo Lake Versus Flood Years

Echo Lake	March	April	May	June	July	August	September	October
Average (1973-2016)	478.51	478.87	479.11	479.1	479.11	479.06	478.97	478.83
1974	478.71	478.86	480.21	479.81	479.47	479.37	479.29	479.11
2010	478.52	478.68	478.6	479.14	479.5	479.47	479.31	479.12
2011	478.43	479.58	480.57	480.18	480.25	479.76	479.38	479.15
2013	478.36	478.26	479.5	479.32	479.03	478.92	478.87	478.7
2015	478.81	480.05	479.59	479.26	479.17	479.18	478.93	478.7
Metre Difference Between Max & Avg	0.3	1.18	1.46	1.08	1.14	0.7	0.41	0.33

Table 9: Reporting Regional Hydrometric Stations Peak Flow Monthly Distribution by Month

Station	March	April	May	June	July
Qu'Appelle River Below Loon Creek (1970-2016)	18.4%	42.9%	20.4%	8.2%	4.1%
McCord Creek (1990-2019)	26.1%	43.5%	8.7%	13.0%	4.3%
Bear Creek by Piapot (1990-2019)	51.4%	20.0%	14.3%	8.6%	0.0%

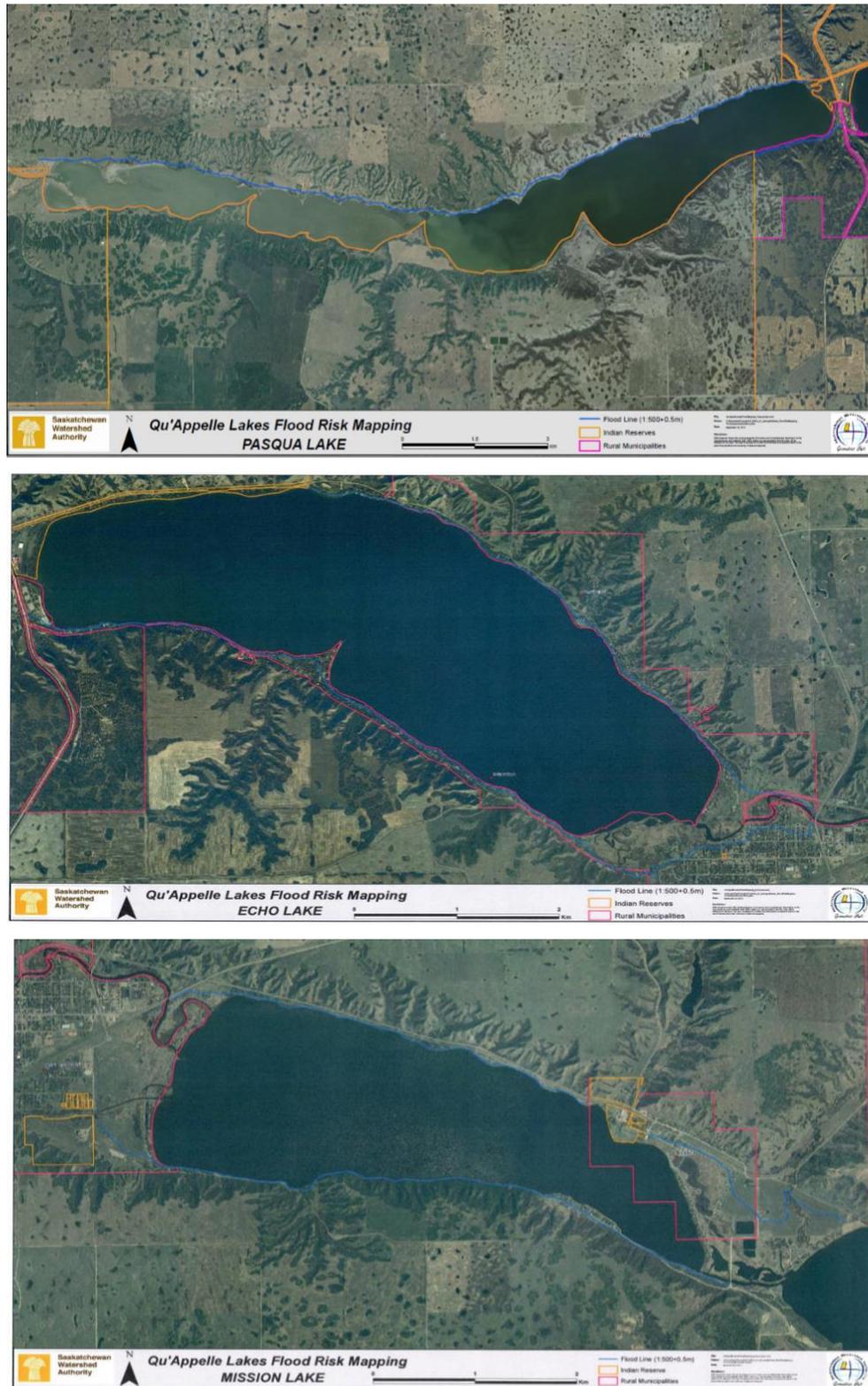
[39]

Table 10: Environment Canada Weather Stations Select Regional Normals Data (1981-2010)

Lipton 2 Station Rainfall/year - 349mm	April	May	June	July	August
Average Monthly Rainfall (mm)	17.8	49.8	85.3	66.9	64.8
% Monthly Average of Yearly Rainfall	5%	14%	24%	19%	19%
Extreme Daily Rainfall (mm)	30.8	52.6	65.8	54.2	64.2
% Daily Max of Avg Monthly Rainfall	173%	106%	77%	81%	99%
% Daily Max of Avg Yearly Rainfall	9%	15%	19%	16%	18%
Cypress Hills Park Station Rainfall/year - 345mm					
Average Monthly Rainfall (mm)	15.9	51.1	103	59.7	46.8
% Monthly Average of Yearly Rainfall	5%	15%	30%	17%	14%
Extreme Daily Rainfall (mm)	22	29.4	152	43.6	43.2
% Daily Max of Avg Monthly Rainfall	138%	58%	148%	73%	92%
% Daily Max of Avg Yearly Rainfall	6%	9%	44%	13%	13%
Woodrow Station Rainfall/year - 288mm					
Average Monthly Rainfall (mm)	13.1	51.4	77.1	56.1	34.5
% Average of Yearly Rainfall	5%	18%	27%	19%	12%
Extreme Daily Rainfall Event (mm)	45.2	49.6	114.3	69.9	40
% Daily Max of Avg Monthly Rainfall	345%	96%	148%	125%	116%
% Daily Max of Avg Yearly Rainfall	16%	17%	40%	24%	14%

[35]

Figure 24: Qu'Appelle Lakes (Pasqua, Echo, Mission) 1:200 Year Flood Maps



5. HAZARD: VOLATILE WEATHER - OTHER EXTREMES

HAZARD: OTHER EXTREMES

CLASS: Natural

RISK SCORE: 9 **FREQUENCY:** Cyclical **LIKELIHOOD:** 3 **CONSEQUENCE:** 3 **VULNERABILITY:** 3

WORST CASE SCENARIO: Multi-year regional drought, with several extreme heat days during summer, causing agriculture and socio-economic burdens. During this spring dust storms and smoke, events cause breathing difficulties and infrastructure stress.

TYPE	DESCRIPTION
Drought	A long period of abnormally dry weather that severely limits water availability for environmental and human purposes.
Extreme Heat	When two or more days exceed the maximum temperature of 32°C or humidex value of 38°C.
Smoke	Event which causes reduced visibility and air quality index alert, due to immediate or distant fire smoke.
Dust Storm	Where visibility is reduced to under 800m for over an hour from blowing dust.

INDICATORS

Climate Normals	Groundwater Availability	Cumulative Effect on Resources
Pressure System Pattern	Degree Day Frequency	Infrastructure Capabilities
Landscape Topography	Climate Change Impact	Response Cost

SELECT INCIDENT HISTORY

LOCATION	DATE (dd.mm.yyyy)	INCIDENT
Central & Southern SK	17.08.2020 to 20.08.2020	Heatwave: In late august due to larger upper ridge, which prompted warnings, broke records in Regina (35.9°C), and temperatures reached 37.4C in Maple Creek.
Southern SK	08.2020 to 09.2020	Smoke: From northwestern USA resulted in short term air quality alerts issued for the region.
Central & Southern SK	05.2015 to 08.2015	Wildfire Smoke: From northern AB & SK, BC, and northwestern USA resulted in multiple air quality alerts and severely reducing visibility.
Western SK & Central AB	03.2009 to 07.2009	Widespread Drought: Agricultural disaster, Palliser's Triangle 50-year rainfall low.
Central/Southern SK & Prairie Provinces	03.2001 to 10.2002	Severe Drought: 41,000 jobs lost, wheat decline of <40% in 2001, <25% in 2002 in Southern SK, 1.41billion crop insurance declared. Isolated dust storms, 386 related traffic incidents, 2 fatalities.

Prairie Provinces	03.1984 to 10.1986	Widespread m\Multi-year Drought: Insect infestation, dust storms, 10,000 farms affected. 1985 dust storms incidents recorded .
Saskatchewan	01.1961 to 12.1961	Part of multi-year Decrease: Little rain and snowfall, <60% precipitation than average, 48% drop in farm net income, causing dust storms, 668million in wheat production loss.
Southern SK to Ottawa Valley	05.07.1936 to 17.07.1936	Heatwave: >32°C, resulted in est. 1,180 people dead, during “Dirty Thirties (1931-38)” characterized by dust storms and dry conditions, est. 250,000 people left the prairie area.

5.1. Hazard Exposure

Drought susceptibility, whether it be meteorological, hydrological, agricultural, or socio-economic, varies based on both environmental and human-caused factors. However, atmospheric and geographical characteristics can provide an initial evaluation of overall susceptibility. Across the region, the climate is considered mid-continental, generally arid, offset by short-term rainfalls [14] [40]. However, the tendency of southern areas to have dry periods that stretch multiple months over a large spatial area is problematic, with 36 drought disasters being declared between 1909 and 2009, accounting for 43% of declared disasters [41]. Geographically, FHQTC Member Nations within the heart of Palliser’s Triangle (Figure 28), bordering the Missouri Coteau, may be more susceptible to drought events given that evapotranspiration generally exceeds annual precipitation [40].

Examining weather stations nearby it can be noted that annual precipitation is generally lowest at Woodrow station, close to Wood Mountain Lakota Nation and highest in the Cypress Hills, Nekaneet First Nation area, the latter due to the orographic effect, giving higher precipitation than the surrounding area (Table 11). Although precipitation amount does have an influence, it does not always indicate drought status which enforces the need to monitor drought indexes. The Standard Precipitation Evapotranspiration Index (SPEI) captures precipitation and temperature data, to determine evapotranspiration and water balance patterns over an extended period (Figure 25). This index highlights the frequency and severity of meteorological drought conditions. Increasingly negative values indicate increased drought intensity, where values beyond -1.0 are moderate, beyond -1.5 are severe and beyond -2.0 are extreme. This region has seen multiple instances of severe drought, reaching upwards of -2.6, and repeatedly lasting multiple years. Although the distribution of intensity can differ geographically, as in 1985-1990, extreme temporal variability is consistent across stations.

Drought impacts are further aggregated by extreme heat, dust storms, and atmospheric smoke events. The latter is a result of drier conditions which generally produce more extreme wildfires in the immediate area or distant locations. Smoke consists of fine organic matter and can be transported long distances dependent on the patterns of transboundary winds. On years of more significant wildfire activity, whether it be from British Columbia, Alberta, northern Saskatchewan, or western United States, the degree of smoke exposure and fine particulate matter (PM2.5) can increase within the FHQTC Member Nations air sheds (Figure 27). For instance, on May 5, 2016, the Grasslands area recorded 36 micrograms/cubic of PM2.5

in a 24hr period, greatly exceeding the standard of 27, while Great Plains remained at 24 under the same metric, attributed to wildland fire smoke from northern Alberta and Saskatchewan [42]. Heavy smoke events result in air quality index values that exceed 7, increasing breathing difficulty for the public, especially those with respiratory conditions [43].

Dust storms can further reduce air quality and visibility, while also increasing soil erosion, sandblasting, and crop burying. These events can create a drought positive feedback loop as they increase atmospheric subsidence and fine particulate matter [44]. Between 1977 to 1985, major regional drought years, there were on average approximately four dust storm days each year. In 1988, these events typically lasted three hours, but were recorded to upwards of 10. Some of the worst dust storms have been documented in April and May, with a second peak in August, during drought years [45]. Dust storm events are more likely in the spring when vegetation cover is sparse, and snow is depleted. Regional weather station data varies in reporting status, but generally indicate that snow cover cannot be expected through April and that there is the potential for regional dust storms during dry periods (Table 11). Land usage and management improvements have greatly decreased the scale of southern Saskatchewan dust storms from the 20th century but during the 2001 to 2002 drought, 36 incidents were recorded, leading to traffic accidents and two deaths [46].

Extreme heat events that generate Environment Canada warnings can happen within and outside of drought years and temperatures of 40°C have been recorded as early as May, with record heatwaves happening in 2020 [47] [48]. The rural location of the FHQTC Member Nations decreases the cumulative built environment impact of heatwaves as compared to urban centers but can also increase exposure to outdoor elements if adequate shelter is not present [49].

5.2. Hazard Outlook

As demonstrated historically, spatial patterns of drought vary. During the 1961 drought, precipitation levels in nearby Regina were 57% lower than the 30-year average and 36% lower in Swift Current [50]. Alternatively in 2002 they were only 8% lower than average in Regina but 35% in Swift Current [50]. These droughts placed stress on agricultural, industrial, and municipal water supplies which as of 2010 accounted for 70%, 12%, and 18% respectively [51]. Determining drought hazard going forward can be complex given the variety of inputs and demands that determine its severity. Some models suggest that by 2100 meteorological drought events will increase, interspaced by severe rainfall, and extreme heat, and increase in severity to the south [52]. Extreme heat events are also projected to increase in severity and frequency even outside of drought years. Smoke-induced air quality emergencies are dependent on prevailing wind and wildfire activity during the year, and hard to predict, although annual monitoring of regional airsheds may provide better predictive capacity for the FHQTC Member Nations. Snowfall amounts are projected to change, with snowmelt times being earlier which will increase the potential of dust storms in the spring. Dust events can be impacted by drought, and rural land and road conditions. Agricultural practices and monitoring have improved since the 1930s, reservoir infrastructure has expanded, and historically communities have demonstrated the capabilities to endure [46]. However, prolonged drought events can test these capabilities.

Under climate change scenarios river basins could see increases in total agricultural water demand of 301% in Qu’Appelle Basin, 21% in the Old Wives, and 28% in the Cypress Hills North Slope by 2060. Additionally, a 5% increase in lake evaporative loss is expected within the same time frame. Pasqua Lake could potentially lose 11,127 dam³ annually, Harris Reservoir is predicted to lose 844 dam³ (13% of current capacity), and Twelve Mile Lake 14,300 dam³. Notably under the same scenario, a 642% increase in water demand for First Nations communities within the Qu’Appelle Basin, Cypress Hills North Slope, and Old Wives was reported due to expected population growth. Nearby municipal demand is expected to increase at 5.9% and 88.3% respectively [51] [53]. Additionally, climate models suggest that by 2050, days exceeding 30°C in the region could be over 25 each year and growing exponentially under high emissions scenarios by 2100 (Figure 26). It is projected going forward, that the magnitude of drought scenarios will differ depending on the region. This makes it imperative for FHQTC Member Nations to monitor water availability, watershed management practices, and climate indices to prepare for drought and its cumulative impacts on communities.

5.3. Figures & Tables

Table 11: Environment Canada Weather Stations Select Regional Normals Data (1981-2010)

Lipton 2 Station Elev. 640m Precipitation/year - 464mm	March	April	May	June	July	August	Average
Snow Depth at Month-end (cm)	32	14	0	0	0	0	8
Extreme Snow Depth (cm)	57	41	16	0	0	0	19
Extreme Maximum (°C)	19	30.5	36.5	37.5	36.5	36.5	33
Precipitation (mm)	24.4	27	53.3	85.3	66.9	64.8	54
Days with Snowfall >= 0.2 cm	5.7	2.8	0.67	0	0	0	9
Days with Minimum Temp >0C	0.85	8.3	22.1	29	30.3	30.6	121
Days with Maximum Temp >30C	-	-	-	-	-	-	-
Cypress Hills Station Elev. 1196m Precipitation/year - 600mm							Average
Snow Depth at Month-end (cm)	17	0	0	0	0	0	3
Extreme Snow Depth (cm)	48	30	15	0	0	0	16
Extreme Maximum (°C)	19	26	40.5	34	34.5	34.5	31
Precipitation (mm)	43.3	41.4	74	103.3	59.7	47.8	62
Days with Snowfall >= 0.2 cm	10	6.4	2.8	0.07	0	0.11	19
Days with Minimum Temp >0C	2.3	7.2	19.7	28.3	30.9	30.1	119
Days with Maximum Temp >30C	0	0	0.04	0.23	1.7	1.7	4
Woodrow Station Elev. 730m Precipitation/year - 366mm							Average
Snow Depth at Month-end (cm)	3	0	0	0	0	0	1
Extreme Snow Depth (cm)	60	21	12	0	0	0	16
Extreme Maximum (°C)	23	22	29	31	43	36.5	31
Precipitation (mm)	18	18.9	56.3	77.1	56.1	34.5	43
Days with Snowfall >= 0.2 cm	3.6	1.4	0.62	0	0	0	6

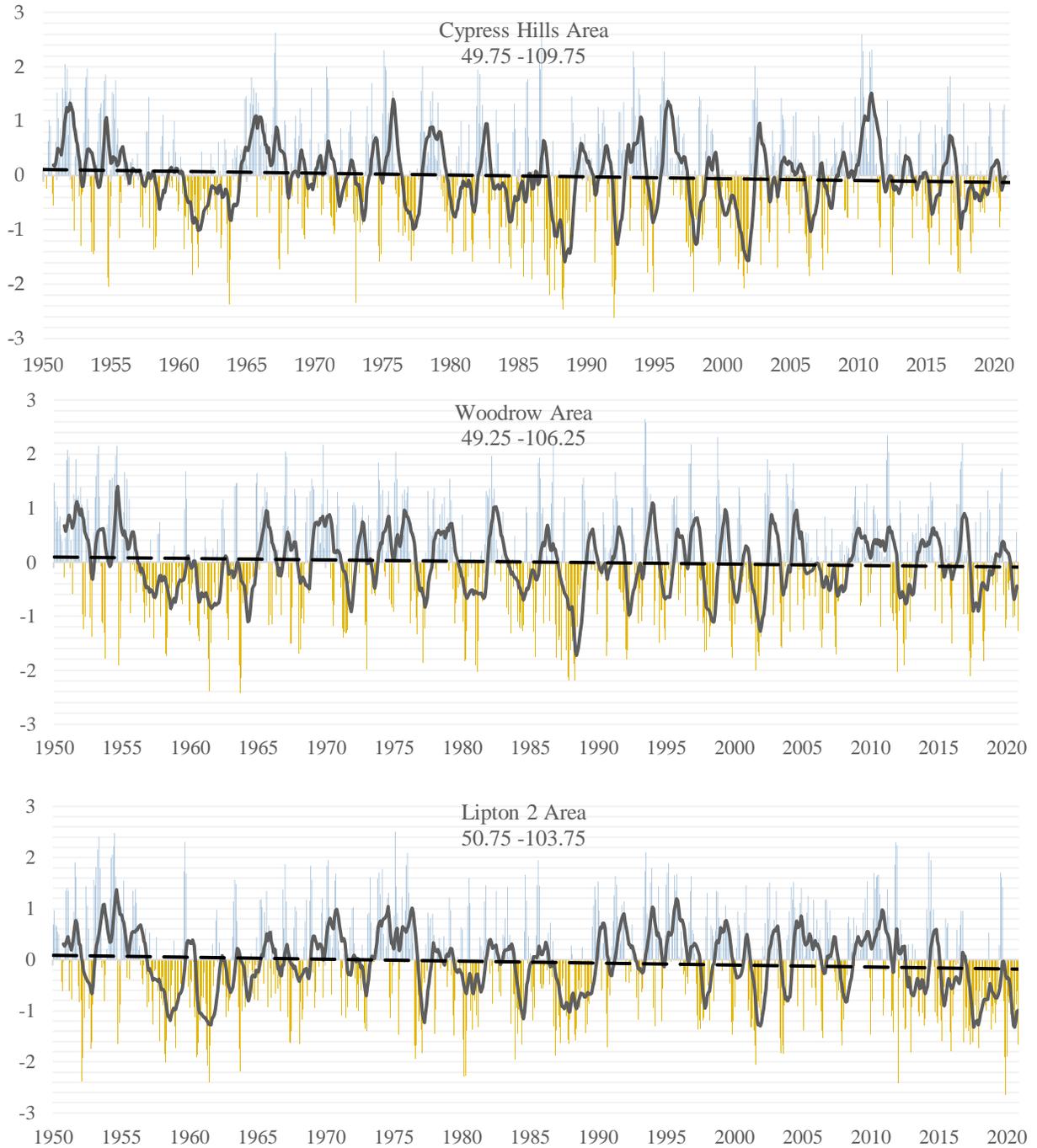
Days with Minimum Temp >0C
 Days with Maximum Temp >30C

-	-	24	-	-	-
-	-	-	-	-	9

24
 9

[35]

Figure 25: Standard Precipitation Evaporation Index Values for Areas Near Regional Weather Stations (1950-2021)



[54]

Figure 26: Climate Model Projections of Median Annual Days >30 °C based on Different Emission Scenarios

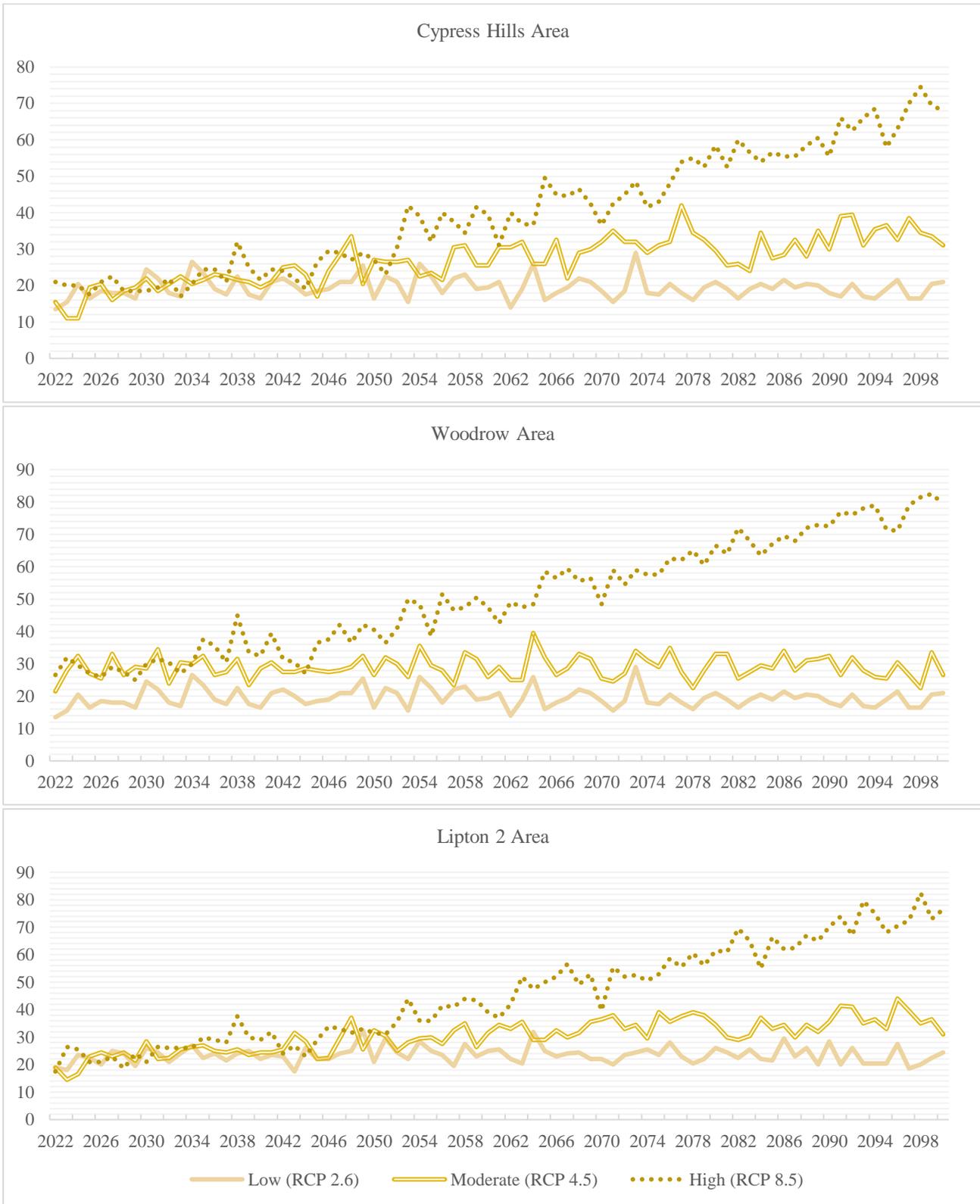


Figure 27: Air Shed Zone Particulate & Ozone Management Levels (2016-2018)

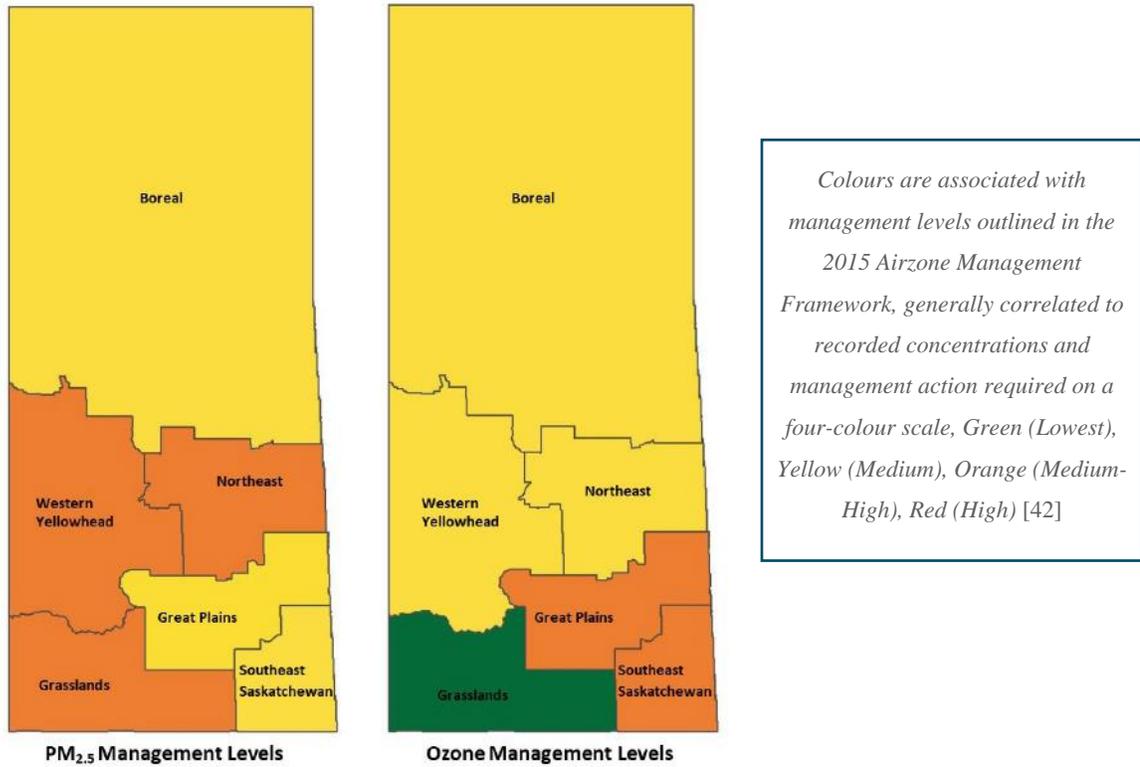


Figure 28: Map of Palliser's Triangle Zone



[40]

6. HAZARD: WINTER STORMS

HAZARD: WINTER STORMS

CLASS: Natural

RISK SCORE: 6 **FREQUENCY:** Yearly **LIKELIHOOD:** 3 **CONSEQUENCE:** 2 **VULNERABILITY:** 1

WORST CASE SCENARIO: Heavy Snowfall levels shutting down highways and roads and restricting the transportation of valuable goods and services to the community. Heavy snowfall endangering the power grid, as collapsing trees may down powerlines and place citizens in a position to face harsh winter temperatures without effective heating. Populace is in danger of freezing to death in exposure situations.

TYPE	DESCRIPTION
Blizzard & Blowing Snow	High winds accompanied with significant snow precipitation or transport of snow across landscape.
Freezing Rain	Precipitation that freezes upon contact with the ground and can cause highway closures and power failures.
Heavy Snowfall	Abnormal snowfall (>10cm) in 12-hour period-level events.
Extreme Cold	Period where wind chill temperatures are to reach -40C for at least two hours.

INDICATORS

Storm Severity	Pressure System Pattern	Infrastructure Network
Precipitation Levels	Climate Change Impact	Municipality Proximity
Seasonal Occurrence	Cumulative Effect on Resources	Response Cost

SELECT INCIDENT HISTORY

LOCATION	DATE (dd.mm.yyyy)	INCIDENT
Western Canadian Provinces	1.02.2021	Extreme Cold: Record low temperatures across SK, from polar vortex exceeding -40Cs in multiple locations. Winds exceed 143 km/hr causing multiple communities to lose power due to tree-damaged electrical lines.
Southern Saskatchewan	27.01.2021	Blowing Snow: Overnight winds from 90 to 126km/h, created zero visibility, closing highways, and stranding vehicles. 75 calls of tree-related damage in Regina, and 80,000 customers without power provincially
Saskatchewan & Prairies	08.11.2020 to 09.11.2020	Blizzard & Freezing Rain: Snow accumulating 30-50cm with high winds, closed highways, power outages, blocking buildings, cancelled classes in cities. Began with freezing rain and ice conditions.
Saskatchewan	.28.04.2007	Blizzard: 25 cm of snow accompanied by 70-90km/hr winds blocked highways. 2 people died walking from snow-stranded vehicles

Prairie Provinces	19-28.12.1989	Extreme Cold: Widespread cold event that resulted multiple infrastructures shut down; 3 farmers froze to death
Prairie Provinces	Spring/Summer 1992	Extreme Cold: Unseasonably cold temperatures across Ontario and Prairie provinces causes massive snow/frost damage to crops in excess of \$2 million.
Prairie Provinces	03.06.1983	Freezing Rain: Winter storm with freezing rain forced road closures and excessive damage. \Especially to electrical infrastructure causing widespread power outages.
Southern Prairies	12.02.1964	Blizzard: Strong blizzard produced heavy snow, -34 Celsius temperatures and 90 plus km/hr winds caused the death of three humans and thousands of cattle.
Saskatchewan	30.01 – 8.02.1947	Heavy Snowfall: Low temperatures and record snowfall up to 8 metres deep in locations. Trains stopped running, cutting off supplies to impacted communities.
Prairie Provinces	14.02.1941	Blizzard: Severe blizzard lasting seven hours produced winds in excess of 100 km/hr causing 76 deaths across parts of the Canadian prairies and into the Northern USA.
Saskatchewan	08.02.1906	Blizzard/Heavy Snowfall: Two-week long blizzard decimated southwest Saskatchewan, thousands of head of cattle perished, and communities shut down.

6.1. Hazard Exposure

As southern Saskatchewan has a continental climate it is susceptible to extreme weather events in winter. In Saskatchewan winter-like conditions can be expected to last approximately 6 to 7 months on average, although season variability exists, with snowfall being recorded into May and as early as September [6]. Winter weather in this area can bring events such as extreme cold from arctic air masses, freezing rain, blizzards, and even heavy snowfall outside of the normatively arid season. Depending on frontal passage and jet streams these events can vary in spatial and temporal severity but can halt transportation and power services while placing enhanced stress on heating infrastructure. Winter storms encompass blizzard, heavy snowfall, freezing rain, and blowing snow events and in combination, have left people stranded, cut power, caused accidents and made roads impassable, until either the storm ends, or infrastructure capability is restored [56].

Blizzards are classified when winds exceed 40km/h and reduce visibility to 400m or less from the falling of snow precipitation or snow transport across the landscape. From 1953 to 1997, the estimated average blizzard hours per year in the area surrounding the FHQTC Member Nations, was from 8 to over 25 hours. The areas that experienced the highest blizzard hours are closest to Regina, Swift Current, and towards the southern border (Figure 32). Furthermore, during this period the total number of blizzards for Regina and Swift Current were 98 and 92 respectively [6]. Areas with historically high snowfall amounts and depth indicate an increased susceptibility to blizzard and blowing snow events (Table 12). The

area where snowfall is the highest annually is in the Cypress Hills region, with snowfall being double the rate of areas to the east and south.

Furthermore, the average probability of days with snowfall exceeding 10cm is again highest at Cypress Hills Station (.70), followed by Woodrow Station (.33) then Lipton 2 Station (.26). Major events exceeding 20cm are exceedingly rare in this region occurring at .36, .16, and .12 days per year, respectively [6]. Although unlikely, the snowfall of extreme events can account for upwards of 45cm in a single day (Cypress Hills) averaging deposits of 22-32cm, with the potential to double the average month. Days exceeding 10cm are more common ranging from 1 to 4 annually. The frequencies of these events vary monthly as well, with heavy snowfall (days >10cm) appearing to occur more often in March and December than any other month for all stations within the region. These months also attain some of the highest snowfall averages with December seeing anywhere from 10 to 38cm and March seeing 13 to 40cm (Table 12). Furthermore, the shoulder seasons of March, April, October, and November have a higher combined average of daily snowfall maximums than December, January, and February across all stations. Conversely, months of December, January, and February retain higher average snow depths at months end.

Extreme snow depths have been recorded to reach 80cm deep (February) at Cypress, while the other two maximums approach 60cm (February & March). The average of all extreme snow depths recorded for respective months is highest for the regions surrounding Wood Mountain Lakota First Nation and Fort Qu'Appelle even though their snowfall levels are lesser. Across all stations, the depth outliers greatly exceed the month's end averages of 0 to 32cm. Therefore, it could be reasonable to assume that situations reducing visibility from strictly blowing snow (Figure 29) may be more likely during January and February as opposed to heavy snowfall, where October, November, March, and April are more likely from blizzard events, and December has a high susceptibility to both.

Freezing rain can also occur in the region and from 1971 to 2005 Environment Canada recorded an average of 4.0 to 10.7 days per year within the southern portions of Saskatchewan, occurring from September to May (Figure 30) Freezing rain is capable of damaging trees and infrastructure as well as powerlines due to additional weight, but also coats roadways making it very dangerous to travel. The maximum amount of freezing precipitation events recorded in a year, in city centers close to FHQTC Member Nations, was 16 in Swift Current and 26 in Regina, both occurring in 1983 [6]. Associated rime ice occurs in humid cold conditions between -4°C to -7°C, amongst low cloud and fog, creating a very heavy coating on objects. This type of event caused one of the worst power outages recorded in Saskatchewan in 2018.

Extreme cold events, as defined by Environment Canada, occur when temperatures exceed -40°C for more than two hours [56]. However, many issues can occur when temperatures dip below -30°C. Temperatures this low pose a danger to exposed individuals and can cause frostbite and potentially fatal hypothermia. It also stresses infrastructure, with heat demand increasing greatly during these periods and ice fog (below -30°C) can form and reduce visibility very quickly. Across the FHQTC geographical region, reporting weather stations record on average 12 to 15 days per year with temperatures below

-30°C. December and January are the coldest months with 2 to 6 days per month reaching extreme cold. Areas have recorded temperatures reaching -47°C, with Lipton 2 recording the coldest average minimums (-37°C) and Woodrow recording the warmest (-23°C). The months of December, January, and February more frequently have minimums below -20°C, and on average Lipton 2 station sees 46 days per year of these temperatures and Cypress sees 56.

Given the susceptibility of southern Saskatchewan to high winds, there is the capacity to reach Environment Canada blowing snow criteria of 30km/h and 40km/h for blizzards [56]. Blowing snow events where visibility is reduced to under 800m for more than 3 hours, is a direct result of these winds, and the region sees on average 16 to 24 days annually with these conditions (Figure 29) [56]. High winds can also intensify the severity of heavy snowfall, accumulated snow, freezing rain, and extreme cold hazards.

6.2. Hazard Outlook

Climate change implications will be the most significant determinant of the frequency and severity of this hazard going forward. Jet stream destabilization can significantly affect the probability of extreme events, such as polar vortex venturing south, but are very complex to model long term. Therefore, winter storm events may shift in distribution and frequency, as extreme weather event likelihood could increase with climate change [57]. Climatic models project an increase in average temperatures across all stations, with freezing degree days predicted to drop annually with certainty. Across the weather stations closest to the FHQTC Member Nations, it is predicted that there will be a drastic decline in temperatures reaching -25°C or lower and that by 2050 the current annual frequencies may be halved. Going forward, overall precipitation amounts can be expected to increase annually with warming temperatures, increasing anywhere from approximately 8 to 11% of average nationally [57]. Alternatively, there has been a steady decrease in the proportional amount of snowfall in the southern parts of Canada, with increasing temperatures resulting in falling rain instead, especially during the shoulder season months. However, increases have been observed for the highest single-day snowfall amounts, in some areas of the prairies [57]. As a result of increased snowfall, snow cover has increased in parts of southern Saskatchewan by 2 to 5% per decade. It is considered highly unlikely that this trend will continue, and it is predicted that annual snow cover will begin to decline as ambient air temperatures increase [58]. These predictions reinforce the complexity of determining winter storm probability in the area under climate change scenarios.

6.3. Figures & Tables

Figure 29: Average Days with Blowing Snow Prairies (1971-2005)

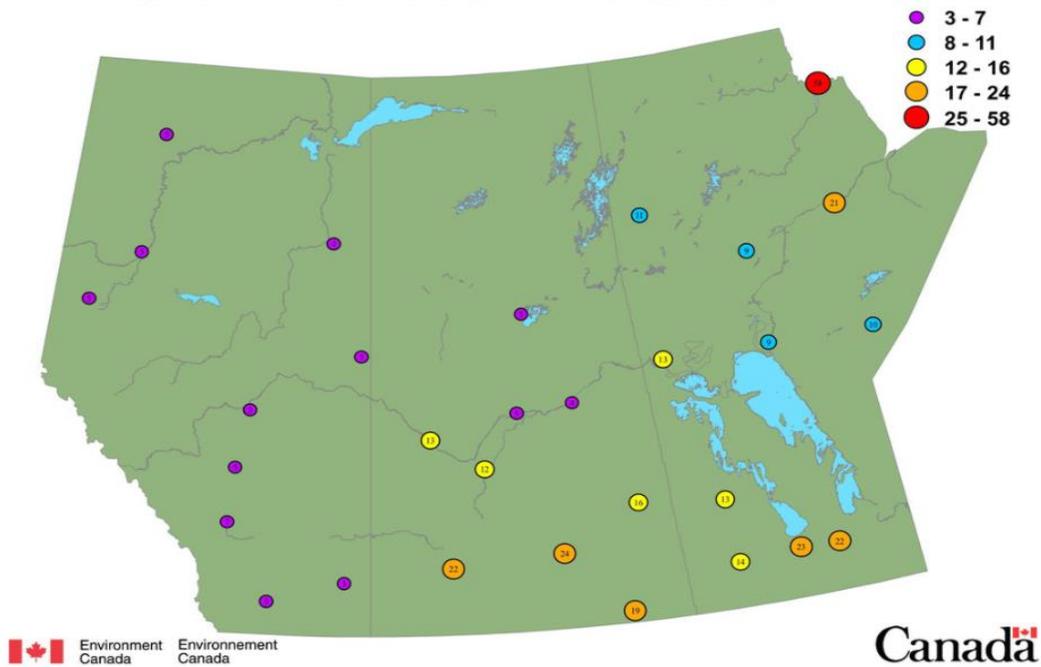


Figure 30: Average Days per Year with Freezing Precipitation (1971-2005)

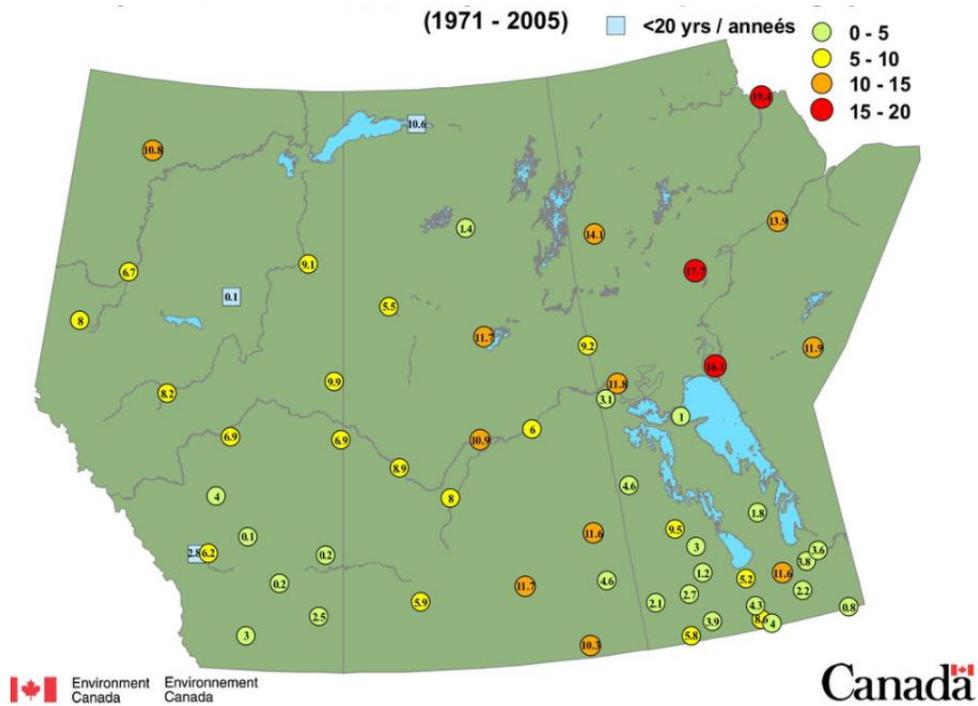
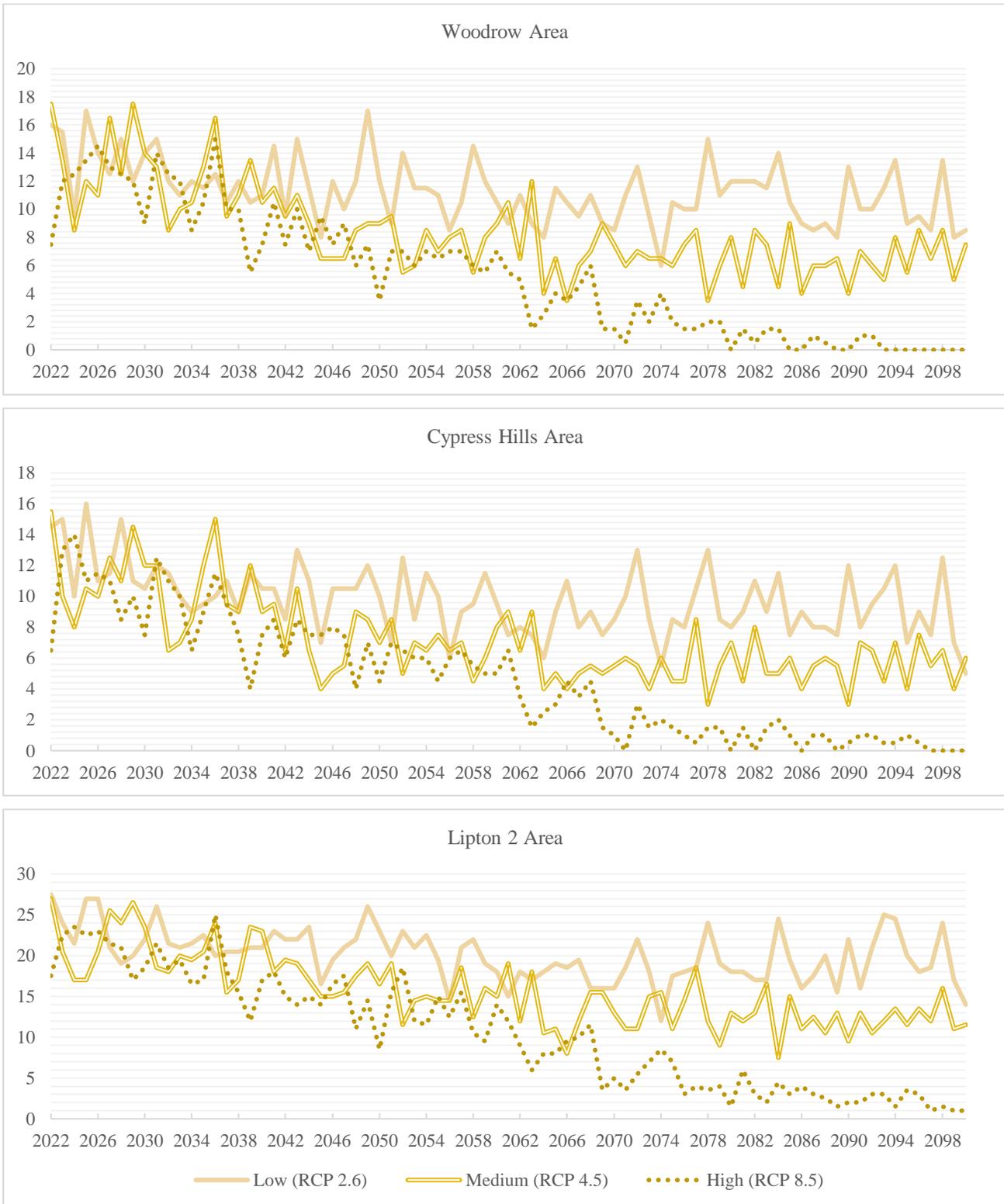


Table 12: Environment Canada Weather Stations Select Regional Normals Data (1981-2010)

Lipton 2 Station Elev. 640.0 m Snowfall/year - 115 cm	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Average
Extreme Snow Depth (cm)	52	60	57	41	30	30	53	46
Extreme Daily Snowfall (cm)	17	20	25	20	20	26	30	23
Extreme Minimum (°C)	-47	-43	-40	-24	-22.5	-37	-47	-37
Snowfall (cm)	19.9	11.4	20	9.2	8.8	15.6	24.9	16
Snow Depth at Month-end (cm)	29	32	14	0	2	8	21	15
								Total
Days with Snowfall >= 10 cm	0.19	0.16	0.44	0.19	0.22	0.26	0.42	1.88
Days with Snowfall >= 20 cm	0	0	0.04	0	0	0.04	0.04	0.12
Days with Minimum Temperature < -20 °C	15.2	10.4	5.2	0.19	0.08	3.5	12.1	46.67
Days with Minimum Temperature < -30 °C	6.4	3.7	1.3	0	0	0.27	4.3	15.97
Cypress Hills Station Elev. 1196.0 m Snowfall/year - 255 cm	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Average
Extreme Snow Depth (cm)	47	80	48	30	6	10	46	38
Extreme Daily Snowfall (cm)	24.4	23	35	45	37	33	31.4	33
Extreme Minimum (°C)	-43	-40	-36	-27	-29	-39	-42	-36
Snowfall (cm)	33.3	31	41.3	25.5	23.2	30.9	38.1	32
								Total
Days with Snowfall >= 10 cm	0.65	0.54	0.96	0.54	0.67	0.63	0.96	4.95
Days with Snowfall >= 20 cm	0	0	0.12	0.12	0.04	0.04	0.04	0.36
Days with Minimum Temperature < -20 °C	9.6	6.3	2.5	0.15	2.4	7.2	28.4	56.55
Days with Minimum Temperature < -30 °C	2.4	1.3	0.4	0	0.2	2	6.4	12.70
Woodrow Station Elev. 730.0 m Snowfall/year - 77 cm	Jan	Feb	Mar	Apr	Oct	Nov	Dec	Average
Extreme Snow Depth (cm)	55	55	60	21	15	46	46	43
Extreme Daily Snowfall (cm)	18	15.2	25	20.3	15	46	46	27
Extreme Minimum (°C)		-36	-23	-15	-13	-23	-29	-23
Snowfall (cm)	16.5	8.1	13.5	5.8	5.5	12.3	10.1	10
Snow Depth at Month-end (cm)	15	7	3	0	1	8	10	6
								Total
Days with Snowfall >= 10 cm	0.19	0.13	0.21	0.12	0.25	0.12	1.3	2.32
Days with Snowfall >= 20 cm	0	0	0.04	0	0	0.00	0.12	0.16
Days with Minimum Temperature < -20 °C		11						11
Days with Minimum Temperature < -30 °C		2						2

[35]

Figure 31: Climate Model Projections of Median Annual Days Reaching -25 °C or Lower based on Different Emission Scenarios



7. HAZARD: RAILWAY ACCIDENT

HAZARD: Railway Accident

CLASS: Human

RISK SCORE: 7 FREQUENCY: Regular LIKELIHOOD: 3 CONSEQUENCE: 2 VULNERABILITY: 2

WORST CASE SCENARIO: Derailment or collision results in releases of millions of litres of a dangerous good, causing immediate area fatalities, over 5. sq km radius evacuation, and long-term environmental damage.

TYPE	DESCRIPTION
Derailment	An instance where the running off/release of car wheels from rail resulting in a crash and potential exposure to dangerous goods in the vicinity of the incident
Collision	An instance where a train and another vehicle, pedestrian, or object collide resulting in damage to the immediate area and potential exposure to dangerous goods
Other	Event due to internal fire, explosion, terrorism, or issue that results in the train becoming a risk to area

INDICATORS

Network Usage Frequency	Hazardous Materials	Municipality Proximity
Infrastructure Type	History & Ownership	Resource Dependency
Extreme Weather Frequency	Sensitive Area Location	Response Cost

SELECT INCIDENT HISTORY

LOCATION	DATE (dd.mm.yyyy)	INCIDENT
Maple Creek, SK	9.11.2020 to 20.11.2020	Collision: CP Train(s), collide with over 100 pronghorns, no infrastructure damage, prompts public/media outcry and investigation
Guernsey, SK	6.02. 2020	Derailment: 31 CP tank cars derailed, 12 caught fire, 2.5km east of the town. Causing the evacuation of 100 people, highway closures, 1.6 million litres of product spilled
Balcarres, SK	24.01.2020	Collision: CN train and SUV collide at Hwy 10 crossing east of town, 4 injured
Guernsey, SK	9.12.2019	Derailment: 33 CP tank cars derailed, 20 caught fire, 1.5 million litres product spilled
Cypress County, AB	02.08.2019	Derailment: 22 CP cars, 5 dangerous goods, prompting 7 km ² area evacuation, small grass fire, and release of styrene monomer and residue methanol
Craven, SK	02.12.2016	Derailment: 23 CP Cars carrying potash derailed, only a small amount released

Lac-Megantic, QC	06.07.2013	Derailment/Runaway Train: Train rolled 7.2 miles reached 65km/h, 63 MMA Tank Cars, 6 million litres product spilled, Explosion destroyed 40 buildings, 53 vehicles, 47 fatalities, containment of adjacent lake and river
Pasqua First Nation, SK	05.03.2010	Collision: CN cars hit a vehicle at a crossing, resulting in 1 fatality
Spy Hill, SK	05.12.2009	Derailment: 36 CN cars, 22 tank cars, 34 cars burned for 6 days, residents within 1.6km were evacuated
Minot, ND	18.01.2002	Derailment: 30 CP cars, unknown anhydrous ammonia cars, released into the air, 1 fatality, 5 ICU, and another 90 injured, \$10 million in damages
Estevan, SK	10.08.2004	Derailment: 3 CP tank cars carrying anhydrous ammonia overturned, 150 people evacuated. No injuries
Regina, SK	18.10.1994	Collision: 4 CN locomotives, 2 empty cars collided, 4,000 litres of diesel spilt, no injuries

7.1. Hazard Exposure

In central and southern Saskatchewan, previous hazardous material incidents that have resulted in emergency response have been primarily caused by pipeline or railway infrastructure. The impact of railway events on surrounding communities largely depends on their proximity to existing infrastructure. Within the province there is an extensive rail network to move freight. Canadian Pacific (CP) operates 1,251 km of track, Canadian National (CN) operates 1,203 km of track, and there is 2,131 km of provincial short line track [59]. Multiple active mainline railways are operating near, but not always within the FHQTC Member Nations. Moving southwest to northeast, the Maple Creek Subdivision runs 147.4 miles between Swift Current and Medicine Hat, the Indian Head Subdivision runs 135 miles between Broadview and Moose Jaw, the Lanigan Subdivision runs 104 miles from Regina to Lanigan and north of Craven it meets the Bulyea Subdivision running 30 miles between Cupar and Bulyea and lastly the Qu'Appelle Subdivision is 93 miles and runs between Melville and Regina. The first four subdivisions are operated by CP and the last one by CN. There is a rail line that runs just north of Wood Mountain Nation, but it currently defunct and not actively used (Figure 33). The active mainline tracks in Saskatchewan move a variety of freight, including potash, grain, metals, consumer products and dangerous goods [59].

Although dangerous goods amounts differ by train and route, CN reports that 9% of its total shipments within the province are listed as dangerous goods. Petroleum crude oil, liquefied petroleum gases, and combustible liquid N.O.S comprise of 39%, 15%, and 8% of these dangerous goods, respectively. Notably, provincially transported crude oil petroleum is double the national percentage for CN [60]. CP reports that 13% of its shipments are regulated dangerous goods, and that crude oil contributes the largest percentage of these goods at 44%, followed by liquefied petroleum gas at 12.2%. Of note is anhydrous ammonia which is the sixth most common form of dangerous good (3.2%) [61]. Due to their combustibility and toxicity, all these substances are extremely dangerous in a major derailment incident and have the potential to cause

casualties, as seen in Quebec and Minot, or evacuations, as seen in Guernsey. However, accidents in Canada involving cars with hazardous material are uncommon, and between 2009 to 2019 there was an average of 127 per year with four resulting in a release [62].

Since 1983, there have been 1,063 reported rail accidents between all the subdivisions, with 155 of these involving dangerous goods cars (average 4 /year) and 6 resulting in a release that threatened public safety (Table 13 & Table 14). It should be noted that reportable accidents as defined by the Transportation Safety Board of Canada (TSB) are those in which an incident results in (1) the injury or death of a person or (2) rolling stock or contents sustain damage, fire, and cause a threat to the railway. The TSB further states that derailments and collisions on main tracks are considered the most severe events that can occur. From 1983 to 2019 a total of 191 of these events occurred (average 5/year) within the subdivisions and the provincial 10-year average is 11.9 [62]. Factors that have caused most main track derailments and collisions nationally include equipment failure, track geometry, rail issues and action failures.

Additionally, the provincial average from 2009 to 2019, for trespassing and railway crossings accidents was 3 and 26 respectively. These events account for the majority of reported casualties and serious injuries across Saskatchewan and Canada [62]. The annual average for the studied subdivisions is 1.35 for trespassing accidents and 8.5 for crossing accidents. Historically, collision accidents have the highest frequency of occurrence at crossings, whether it be publicly automated or passive (Figure 36). This highlights the need to increase awareness around crossing safety as they produce a high number of incidents. Non-mainline tracks within the subdivisions also account for a significant portion of accident derailment and collisions (about 72%), but most of these events present with minor damages. Although 40% of these incidents can involve dangerous goods, speeds are lower than 10mph within switching yards or sidings which can reduce potential impacts [62].

Within the subdivisions studied there have been accidents that have resulted in fire, explosions, injuries, and even evacuations, the latter occurring in 1996, 2016, and 2019, with 2019 being the most significant event when an area of 7km² was evacuated (Figure 35). Furthermore, most injuries from accidents in this area are reported as minor (182), but combined, fatal and serious are only slightly lower reaching 151 incidents. This indicates that incident severity can change drastically and immediately. As demonstrated earlier with crossing occurrences, most accidents that result in injury or death are related to motor vehicles. It should be considered that not all accidents listed have occurred on the FHQTC Member Nation lands, but the best estimate of hazard comes by assessing potential traffic along the entire subdivision. Notably, the distribution of accidents is higher closer to population centres and major yards, with Fort Qu'Appelle accounting for 10% of all accidents along the Qu'Appelle Subdivision (Figure 38). Maple Creek and Indian Head present the highest frequency of accidents which could be attributed to the quantity of traffic as these are a part of CP's major mainline between Alberta and Saskatchewan. Alternatively, Qu'Appelle and Lanigan subdivisions run on fewer interprovincial routes and Bulyea is exclusively local with only 36 miles of track (Figure 38).

7.2. Hazard Outlook

Exposure to hazardous rail accidents declines as proximity to the mainlines decrease. However, all rail lines present an acute risk within the immediate vicinity, with evacuation orders from an incident usually ranging from 300ft and 167 people to exceeding 2 sq km. and 2,000 people. The spatial severity of an event can be limited but it poses a high magnitude of threat within the affected area. Statistically, these events appear to be rare in the FHQTC Member Nations, but nearby Guernsey recently had two major events within two months, establishing the reality that incidents can occur at any time [63]. Since then, the TSB has enforced stricter rules for certain key trains, notably reducing the speeds to as low as 25 mph nearing census metropolitan areas and 30 mph outside of these areas under certain conditions [64]. These key trains carry dangerous goods of a certain type and quantity designating them as higher risk. Theoretically, this should reduce potential accidents and subsequent emergencies, especially in areas nearing larger municipalities. However, there is a need for continual inspection of tracks within these subdivisions by operating companies, as these areas are considered rural.

Nationally, track issues have been identified as the key factor for the majority of main track derailments, accounting for an average of 37% from 2009 to 2019. A further section of the new TSB rules attempts to remediate this issue by issuing special considerations when operating in colder temperatures and during certain months to negate the negative effects of cold weather on track performance [64]. An upward trend has been noticed in the average of main track accidents per million main track miles, averaging at 2.3 within Canada from 2009 to 2010, which can potentially be due to a yearly increase in traffic activities [62]. Alternately, the Railway Association of Canada (RAC) noted a decline in dangerous goods accidents, nationally during this same time period [65]. Both trends were not able to be identified for the subdivisions near the FHQTC Member Nations.

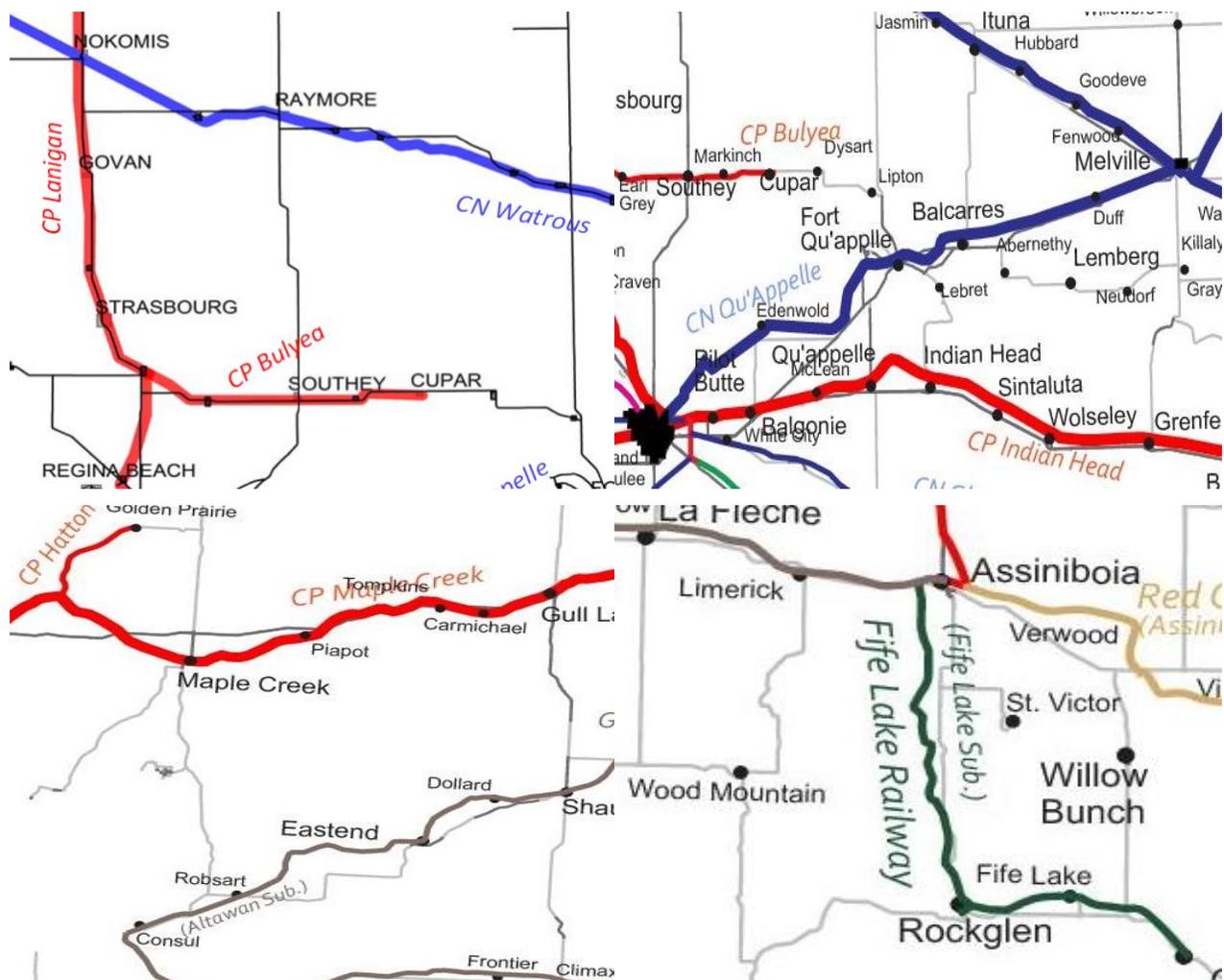
Mainline car traffic levels are expected to continue in all subdivisions as CP and CN rail are key movers of freight and contribute largely to the provincial economy. CN pledged in 2018 to invest a further \$210 million to expand provincial infrastructure capacity and CP already invests \$102 million annually [59] [66]. Although crude oil transport by rail draws public criticism, national events occur at a low rate of .0054 incidents per billion gallon-miles on Class I (mainline) railways, with 58.2% of spills since 2012 spilling less than 25 gallons [65]. This shows that although rail transport will continue, it does not guarantee a proportional higher hazard will be present. Areas of descending concern levels could be the Qu'Appelle, Indian Head, and Craven Subdivisions. Indian Head has the highest accident occurrences and is in proximity to primarily Carry the Kettle Nakoda Nation. Qu'Appelle has fewer accidents but is in proximity to more FHQTC Member Nations. Lastly, Craven has the potential to create downstream effects if a dangerous good event happens while crossing the valley.

Analyzing the accident distribution further within each subdivision (Figure 38) and understanding which geographical areas the miles coincide with will give a better understanding of high-risk areas, especially when it comes to crossings (Figure 33). Obtaining working knowledge of the actual frequency of dangerous goods freight and key trains in these subdivisions

will provide better foresight of occurrence and responses to a major train accident. CN and CP rail can provide yearly dangerous goods information for communities that meet their listed requirements, and FHQTC Member Nations should consider accessing these resources if they have not already. This is especially of concern when discussing key trains and acquiring data for this freight as it may prove useful to increase understanding around TSB key train rules. CP and CN Rail adhere to strict general operating instructions when it comes to tracking and operating with dangerous goods, which are laid out by Transport Canada [67]. Applications have also been built, such as CN's "Ask Rail", to inform first responders in the event of hazardous material emergencies and provide access to dangerous goods identification of the cars involved. Eligibility for first responder training and opportunities should be determined through contacting operators as training appears to be made available, but it is not discernible to which extent.

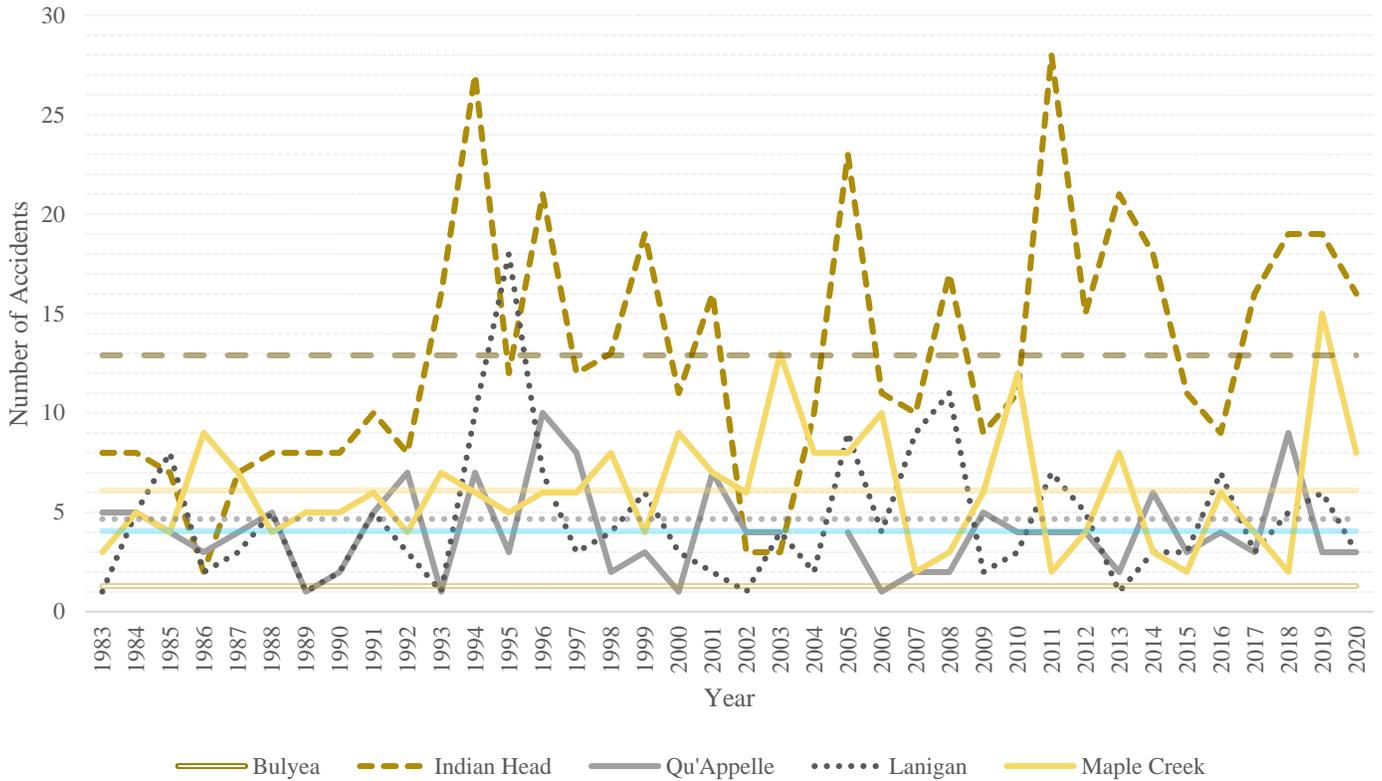
7.3. Figures & Tables

Figure 33: Maps of Railway Lines in Region & FHQTC Member Nation Area



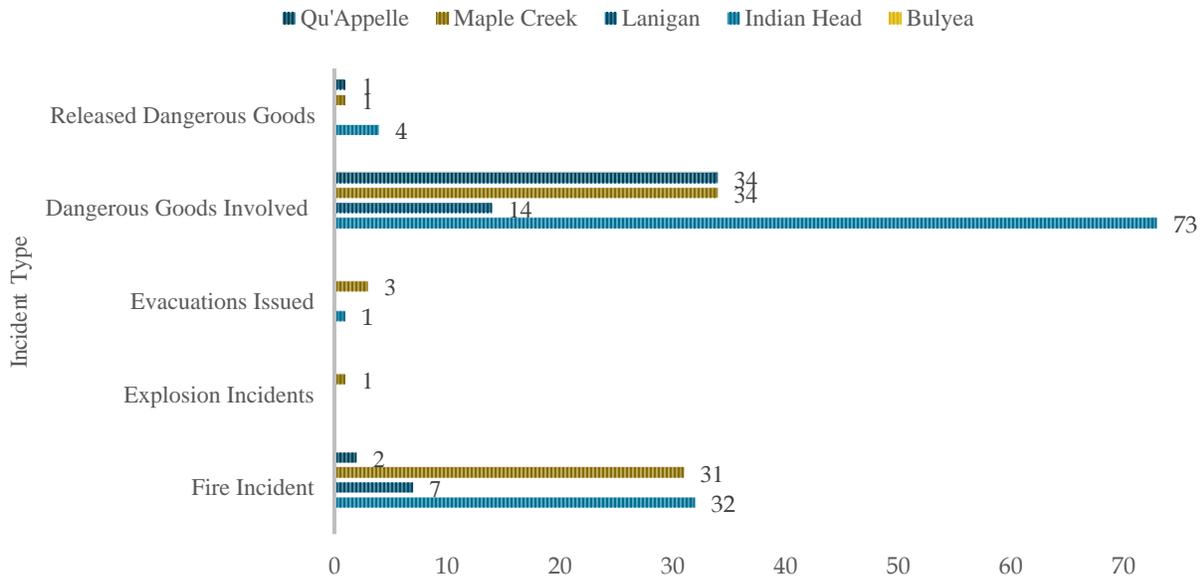
[68]

Figure 34: TSB Reported Train Accidents for FHQTC Regional Area Subdivisions (1983-2020)



[62]

Figure 35: Dangerous Good Related Incidents by Type on FHQTC Regional Area Subdivisions (1983-2020)



[62]

Table 13: Number of Train Cars Involved in TSB Reported Accidents on FHQTC Member Nations (1983-2020)

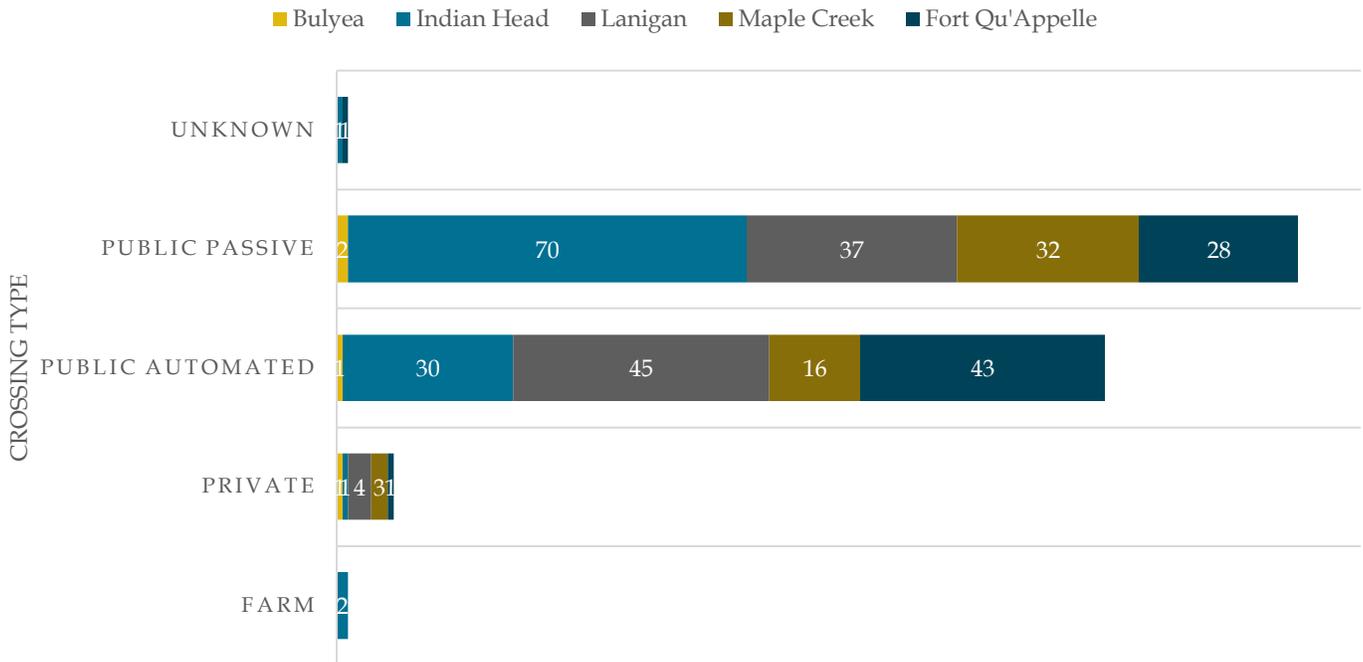
Accident type	Bulyea	Indian Head	Lanigan	Maple Creek	Qu'Appelle
Collision involving track unit	0	2	2	2	0
Crossing	2	33	11	7	3
Derailment involving track unit	0	1	0	1	0
Employee	0	1	0	0	0
Fire	0	4	1	2	1
Main-track train collision	0	6	2	6	8
Main-track train derailment	0	31	26	36	30
Non-main-track train collision	2	18	4	6	3
Non-main-track train derailment	2	13	10	10	5
Passenger	0	0	0	0	0
R/s coll. With abandoned vehicle	0	1	0	1	0
R/s coll. With object	0	1	0	1	1
R/s damage without derail./coll.	0	4	0	1	0
Trespasser	0	1	1	1	1
Total	2	33	26	36	30

Table 14: TSB Reported Train Accident Occurrence by Type on FHQTC Member Nations (1983-2020)

Accident Type	Bulyea	Indian Head	Lanigan	Maple Creek	Qu'Appelle	Total
Collision involving track unit	0	5	2	5	0	12
Crossing	4	104	86	51	73	318
Derailment involving track unit	0	1	0	4	0	5
Employee	0	4	0	3	0	7
Fire	0	22	7	29	2	60
Main-track train collision	0	3	3	6	5	17
Main-track train derailment	0	62	24	26	7	119
Non-main-track train collision	2	48	1	9	12	72
Non-main-track train derailment	3	200	52	86	41	382
Passenger	0	1	0	1	0	2
R/s coll. With abandoned vehicle	0	1	0	1	0	2
R/s coll. With object	0	3	0	2	1	6
R/s damage without derail./coll.	0	2	0	3	4	9
Trespasser	0	36	2	7	5	50
Total	9	492	177	233	150	1,061

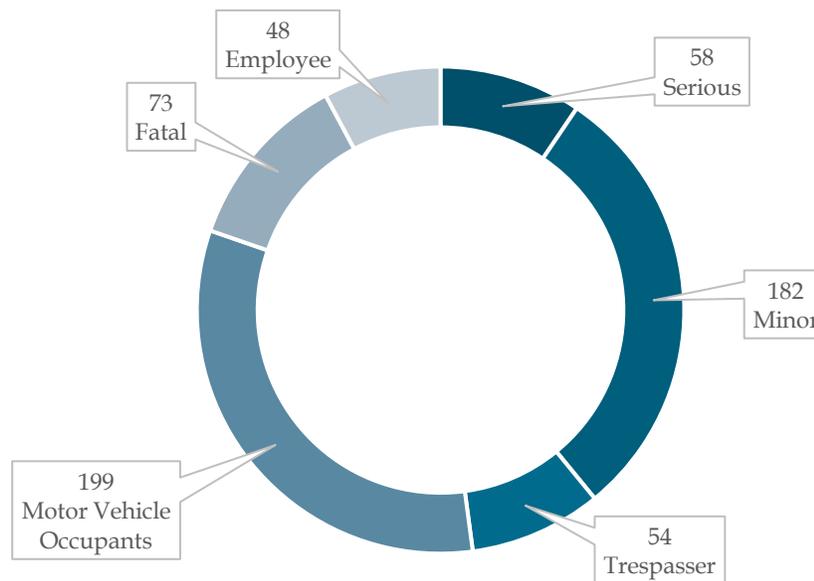
[62]

Figure 36: TSB Reported Crossing Incidents by Type on FHQTC Regional Area Subdivisions (1983-2020)



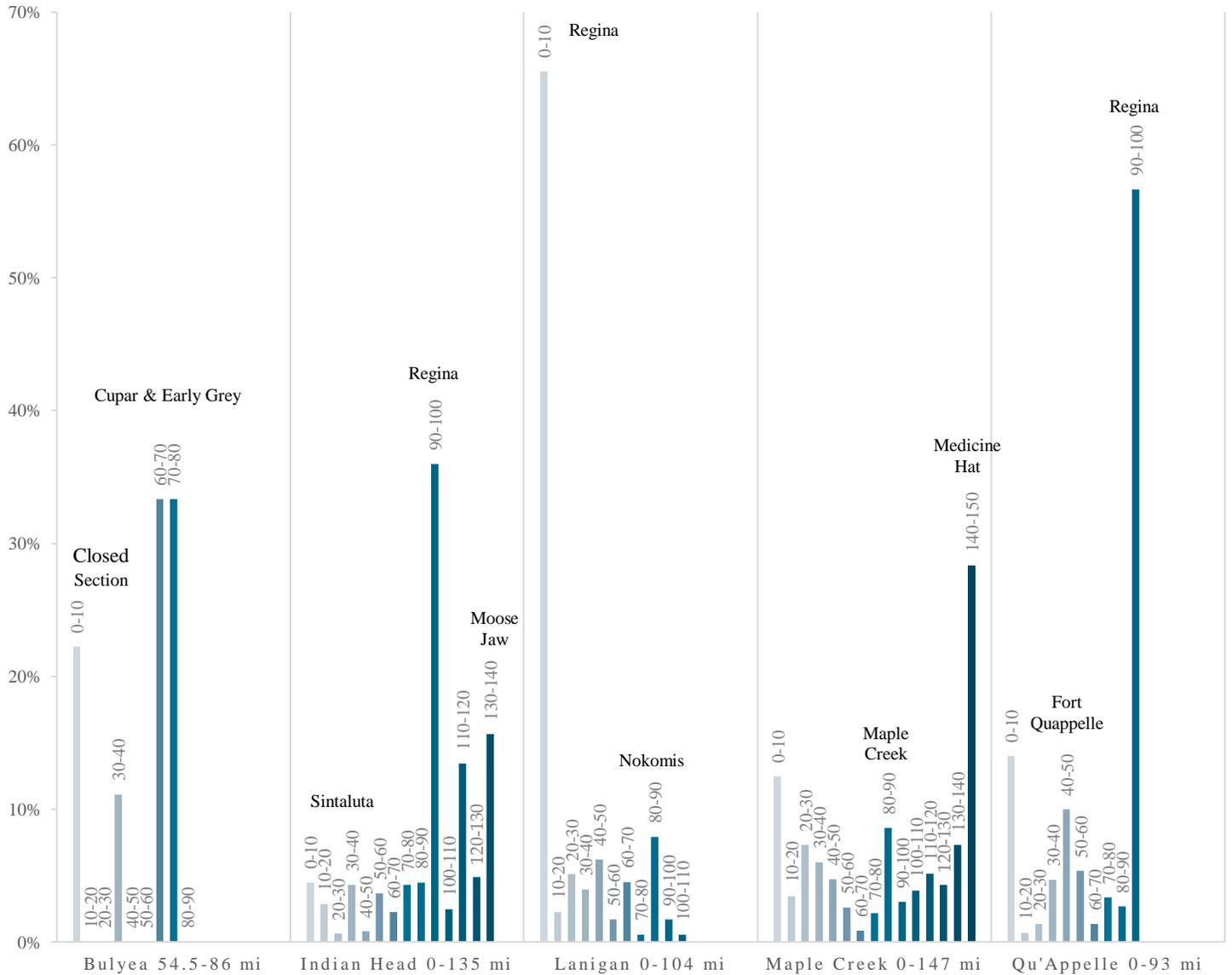
[62]

Figure 37: Injury and Fatalities by Type from TSB Reported Accidents on FHQTC Regional Area Subdivisions (1983-2020)



[62]

Figure 38: TSB Reported Train Accident Distribution by Mile of Track on FHQTC Regional Area Subdivisions (1983-2020)



[62]

8. HAZARD: CRITICAL SERVICE FAILURE

HAZARD: Service Failure

CLASS: Critical Infrastructure

RISK SCORE: 7 FREQUENCY: Occasional LIKELIHOOD: 3 CONSEQUENCE: 2 VULNERABILITY: 2

WORST CASE SCENARIO: A natural hazard (fire or winter storm) takes away essential power and water treatment services, during harsh winter or summer. Power & heat loss results in exposure to difficult conditions and lack of clean drinking water requires transportation in from outside sources, incurring scarcity of water and posing a potentially fatal health risk to community members.

TYPE	DESCRIPTION
Water Quality Emergency	Limitation on community drinking water access due to contamination of source water or inadequate infrastructure.
Powerline Outage	Loss of the electrical power network supply for an extended duration, due to unforeseen circumstance.
Heating Outage	Oil, refined fuel, or natural gas shortage that inhibits standard community heating and operations

INDICATORS

Network Usage Frequency	Hazardous Materials	Municipality Proximity
Infrastructure Type	History & Ownership	Resource Dependency
Extreme Weather Frequency	Sensitive Area Location	Response Cost

SELECT INCIDENT HISTORY

LOCATION	DATE (dd.mm.yyyy)	INCIDENT
Okanese First Nation, SK	28.08.2020 to Present	Boil Water Advisory: Water quality and treatment issue impacts 100-500 people.
Peepeekisis First Nation, SK	04.10.2013 to Present	Boil Water Advisory: Infrastructure is inadequate to achieve safe drinking water, affecting up to 150 homes, 90% are not hooked up to treatment system.
Star Blanket First Nation, SK	10.01.2007 to Present	Boil Water Advisory: Infrastructure inadequate to provide safe drinking water <500 people.
Various Areas Southern Saskatchewan	29.09.2019	Power Outage: Heavy snow and fallen trees caused an outage for communities including Moose Jaw, Wood Mountain, Lumsden overnight and the next day
Eston, Fort Qu'Appelle, Balcarres, Pasqua, and Lipton SK	14.07.2019	Power Outage: Summer storms caused overnight and day outages in communities, as well as in Eston a small emergency operations centre was set up.

Craik, SK	08.2010 to .02.05.2019	Boil Water Advisory: Inadequate infrastructure, BWA for 400 residents, received ~\$1.5 million federally and provincially for the new plant.
Carry the Kettle Nakoda Nation	26.02.2019 to 05.2019	Water Quality Emergency: Structure fire impacted water treatment facility, 250 homes, up to 1,500 people, affected, state of emergency declared, \$2million provided by ISC. 3 days to hook up untreated well water, boil water advisory through to April.
Nekaneet First Nation	10.26.2017 to 03.04.2019	Boil Water Advisory: Treatment System inadequate to provide safe drinking water <100 people
Piapot First Nation	29.10.2018 to 02.2019	Water Quality Emergency: Structure fire impacted water treatment facility, 240 homes affected, state of emergency declared, potable water truck in, ISC provided \$3 million, a temporary station was not complete until mid-February.
Southern Saskatchewan	05.12.2018	Power Outage: Due to frost and rime ice buildup, 200,000 people across communities from Humboldt to US Border. Dropping 1,400 megawatts. Power was restored in most areas by end of the day, but some went into the following days. Largest outage in 40 years.
Melfort, St. Brieux, Kinistino, SK	10.01.2018	Gas Outage: Line rupture in extreme cold resulted in the loss of heat to 4,500 customers for up to 48 hours.
Muskoday First Nation	27.07.2016	Water Quality Emergency: Oil spill resulted in ~800 people without water for, state of emergency declared
Fort Qu'Appelle, White City, Balgonie, and Indian Head	27.12.2015	Power Outage: Ice on powerlines resulted in communities being out of power for up to four hours.

8.1. Hazard Exposure

The loss of service infrastructure that communities rely on for daily operations, can be caused by severe weather events including flooding and winter storms, as well as the absence of connecting and adequate infrastructure. There is high variability in the magnitude of severity for these events as some are short in timespan but large in distribution, such as power outages, while others can last several days to years but be spatially specific, such as water quality emergencies. SaskPower is the major power provider in Saskatchewan with a generating capacity of 4,983 Megawatts (MW). Their average operating reserve in the province is 332 MW, which is provided through natural gas (45%), coal (31%), hydro (18%), and wind (5%) facilities [69]. The generating facilities nearest to the FHQTC Member Nations are Poplar River Coal (C1), Cypress (W1) and Western Lily (W6) Wind Power Facilities, and the NRGreen Estlin Heat Recovery Facility in Regina (Figure 39).

A vast network of 156,747 km of powerlines and transmission systems exist to distribute electricity, however, there are no 230kv or 138kv lines near the FHQTC Member Nations, and the distribution systems of lesser voltage systems in the surrounding areas was unable to be determined [70]. Although expansive, this network is prone to malfunction, so

SaskPower calculates annual averages per system/customer through an index evaluation to give an expected/observed duration and frequency marker for the province. Outages in Saskatchewan caused by weather, including summer storms, downed trees, ice/frost, and snow loading (although not reported on specifically), account for 25% of customer outages and for 61% of forced interruptions at bulk electric service delivery stations [70]. However, in 2019 to 2020 these events accounted for only 12% and 24% respectively [69]. From 2017 to 2020, there was an average of 2.4 outages per customer per year (6.6 hours per year) [69] [70].

Notably, there were major storms in June and December of 2018 that caused widespread outages across southern portions of the province. These major events accounted for 1.0 and 0.6 hours of the calculated annual index, although actual power loss during these times exceeded those time calculations. These major events account for a significant portion of downed bulk electric service centres in the year. For example, the rime ice storm in December 2018 disabled 292 transmission lines for up to 36 hours and tripped 3 coal-firing plants. This accounted for 164 minutes in the disruption index, while the summer storms of June into July accounted for 133 minutes. The total average disruption with other factors including equipment failure, was indexed at 464 minutes for 2018 which is double the target rate of 170 [71]. That year outage maintenance and repair accounted for an additional \$28 million in costs to SaskPower [69].

Loss of natural gas events appear to occur with less frequency in the province, as SaskEnergy the primary distributor of natural gas to communities, reported gas line body failures of .28 per 1000 km of gas in 2019, and zero in 2020. SaskEnergy further reports that gas systems are built to withstand 1 in 20 year severely cold winter events but that intense freeze-thaw cycles can increase valve failure frequency [72]. Although a seemingly stable and widespread source of heating in Saskatchewan, within the FHQTC Member Nations it is apparent that not all residents may have access to natural gas heating. For example, Pasqua First Nation reports some residents still use diesel and oil generators for heating.

Water quality emergencies on First Nation lands have long been a prominent issue in Canada, with 58 communities still under long term and 8 under short-term boil water advisories as of March 9, 2021 [73]. FHQTC Member Nations have also experienced and continue to experience these hazards, notably Peepeekisis Cree Nation and Star Blanket Cree Nation, who continue to have no access to piped clean drinking water to replace crumbling cistern infrastructure. The cost of replacing the Peepeekisis systems is estimated at over \$9 million, and residents currently rely on cisterns or the \$9,000 water bottling facility on site [74]. Furthermore, past emergencies in Piapot First Nation and Carry the Kettle First Nation resulted in the water treatment facilities being lost to a structure fire. These incidents resulted in multi-day to multi-month trucking of potable and bottled water into the communities from other regions, with new plant construction reportedly costing multiple millions. These events are not only financially costly but pose an extreme risk to human health as improperly treated water can result in severe illness. This was seen in North Battleford when an estimated 7,000 people fell ill from unsafe water quality.

From 1993 to 2007, 75% of water-borne illness outbreaks in Canadian communities occurred in areas with populations <5000 people [75]. Harmful substrates, bacteria, viruses, and parasites in untreated or improperly water include E.coli, giardia, nitrates, protozoans, lead, and arsenic, each having to be treated and assessed differently. For example, coliforms, (such as Escherichia coli) are an indicator of sewage or animal contamination. Boiling water for several minutes can mitigate the risk but 0/100ml needs to be attained to reach safe level. Alternatively, nitrates from agriculture fertilizer, sewage, decaying matter, or animal manure, must be treated with distillation or reverse osmosis filtration but is acceptable at levels up to 45mg/L [76]. Furthermore, from 1995 to 2008, there were elevated levels of natural arsenic, selenium, trihalomethane, and uranium recorded in drinking water in multiple areas across the province including areas near the FHQTC Member Nations (Figure 40). The immediate risk to individual water sources from these contaminants is unknown. The presence of water-borne illness is also influenced by weather events (spring thaw, heavy precipitation, drought and flooding), human activity (industrial, agricultural, and recreational) and lack of source water protection [77].

A 2011 provincial assessment divided risk into five categories (highlighting driving factors within each phase of the process (Table 15&Table 16). Provincially, *Source risk* was driven by the lack of source water protection plans at 93% of systems, followed by the insufficient capacity to meet future demand at 63%, and risk of contamination at 45%. *Design risk* was dominated by 69% of systems exceeding 75% capacity and a lack of design flexibility at 47%. For *Operations risk*, 60% of systems did not have emergency response plans. For *Operator risk*, 49% had no backup certified system operator, and for *Report risk*, 71% of systems kept poor records for key parameters [78]. During this assessment, 27 Saskatchewan First Nations water systems were categorized as high risk, 47 were medium, and 29 were low [78]. Amongst the FHQTC Member Nations risk levels differed, as well as water systems and delivery, and all but Star Blanket Cree Nation utilized groundwater as source water at the time (Table 15). Provincially groundwater sources had a mean risk level of 6.6/10, comparatively surface water had 8.8 and groundwater under the direct influence of surface water a 9.3. Additionally, it was noted there was no clear pattern provincially between small system, level I, and level II water treatment classifications and most wastewater systems/lagoons in First Nation Communities in southern Saskatchewan exhibited low risk with only a few reaching medium levels (Table 16). Lastly, the operator risk score was very low provincially due to the effective and aggressive certification of water and wastewater operators through the Circuit Rider Program [78].

8.2. Hazard Outlook

As of 2011, the projected cost to increase water system capabilities in First Nation communities in Saskatchewan in ten years was \$680 million. Since 2015 the federal government has committed \$3.5 billion nationally to fund projects to achieve clean drinking water [73]. Although progress has been made, projects have met unforeseen obstacles such as two water plant structure fires. The overall objective to achieve clean drinking water has not been fully achieved as two FHQTC Member Nations are still under long term water boil advisories, and one is currently under a short term advisory.

In 2011, 74% of First Nation water systems in the province were piped, 21% used truck delivery, 5% were serviced by individual wells, and <1% had no water services [78]. FHQTC Technical services reported in 2020 that 51% of houses were on cistern wells, 44% were piped and 1% utilize community wells [79]. Specifically, in the Peepeekisis Cree Nation, there are still ongoing concerns with cistern well safety, contamination through debris, and cost and logistical constraints limiting the attainment of piped water [74].

Additionally, sewer infrastructure varies with 25% of houses having holding tanks that need to be emptied regularly, 5% being piped to a hole in the ground on-site, and only 20% being hooked up to the community lagoons [79]. FHQTC Member Nations have council members who are circuit rider trainers in the *Healthy Water Working Group* and an internal *Drinking Water Safety Program* to develop drinkable water regulations and build source water protection plans in facilitation with the University of Saskatchewan. It is continually noted that First Nation groups in Saskatchewan are leaders in drinking water protection [80]. The 2011 assessment mentioned in this report is potentially outdated for many of these Nations but can provide an idea of historical risk and baseline of previous system limitations. Referencing the 2011 report can also increase awareness around component risk values (*Source, Design, Operations, Reporting, Operator*).

Given the limitations of research, the extent of risk within each FHQTC Member Nation could not be assessed and would be better undertaken internally or through an on-site assessment. These limitations are also applicable to understanding power and heating sources within communities. To better understand community-specific vulnerabilities, the layout and distribution of power and heating infrastructure should be assessed. SaskEnergy has stated that outages are unlikely for linked communities as they have an extensive network with 18 underground storage facilities in the province but determining the extent of this network within the FHQTC Member Nations requires a community-specific assessment [81]. SaskPower and SaskEnergy have both identified that the impact of severe weather events on system output will increase with projected climatic shifts. Lastly, FHQTC Member Nations can assess the feasibility of future energy security projects through partnerships with SaskPower and the First Nations Power Authority, as demonstrated through the active and prospective storage and solar projects developed with Star Blanket Cree Nation [82].

8.3. Figures & Tables

Figure 39: Map of Saskatchewan Transmission Lines & Power Stations 2020

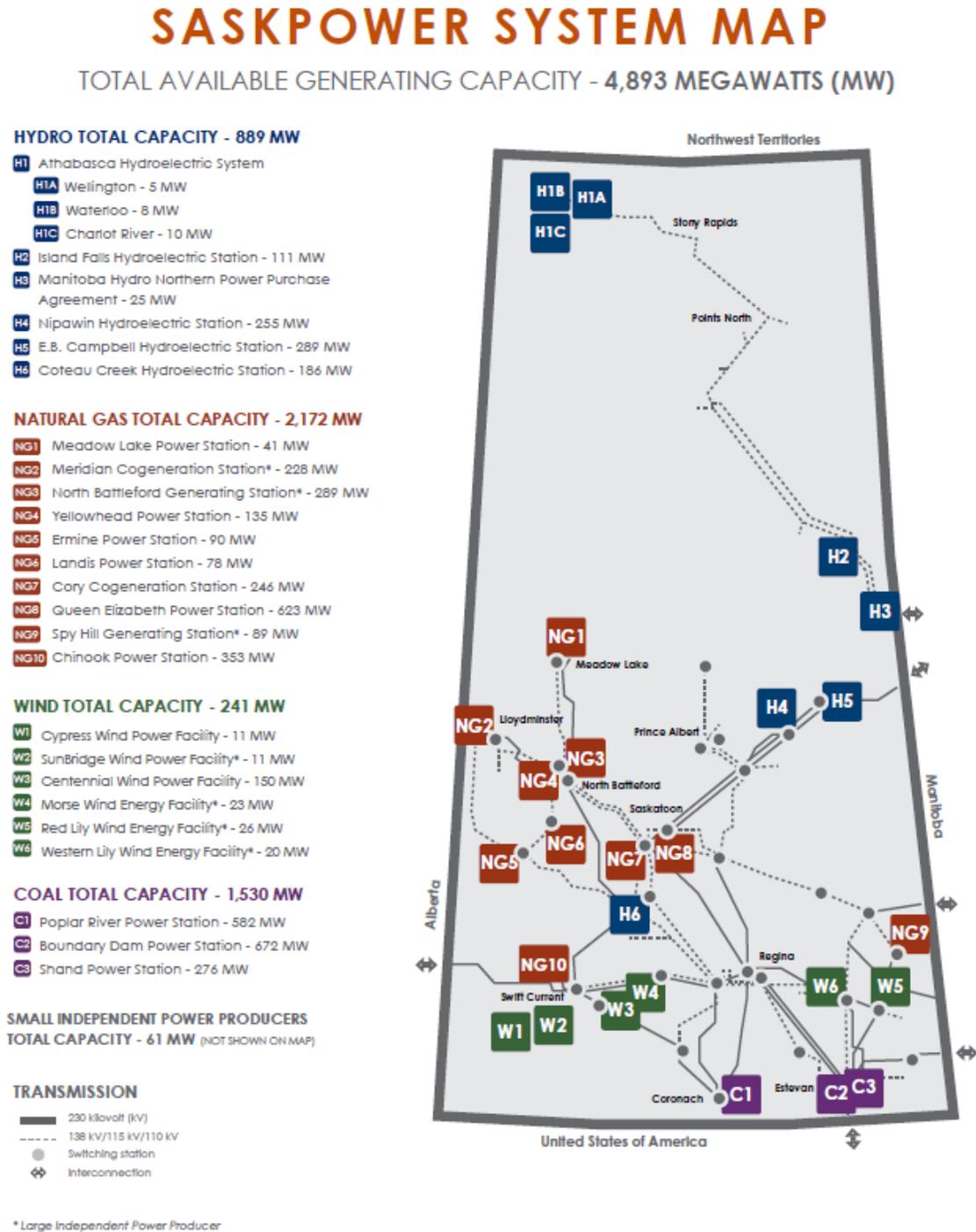


Figure 40: High Element Concentrations in Drinking Water Saskatchewan 1995-2008

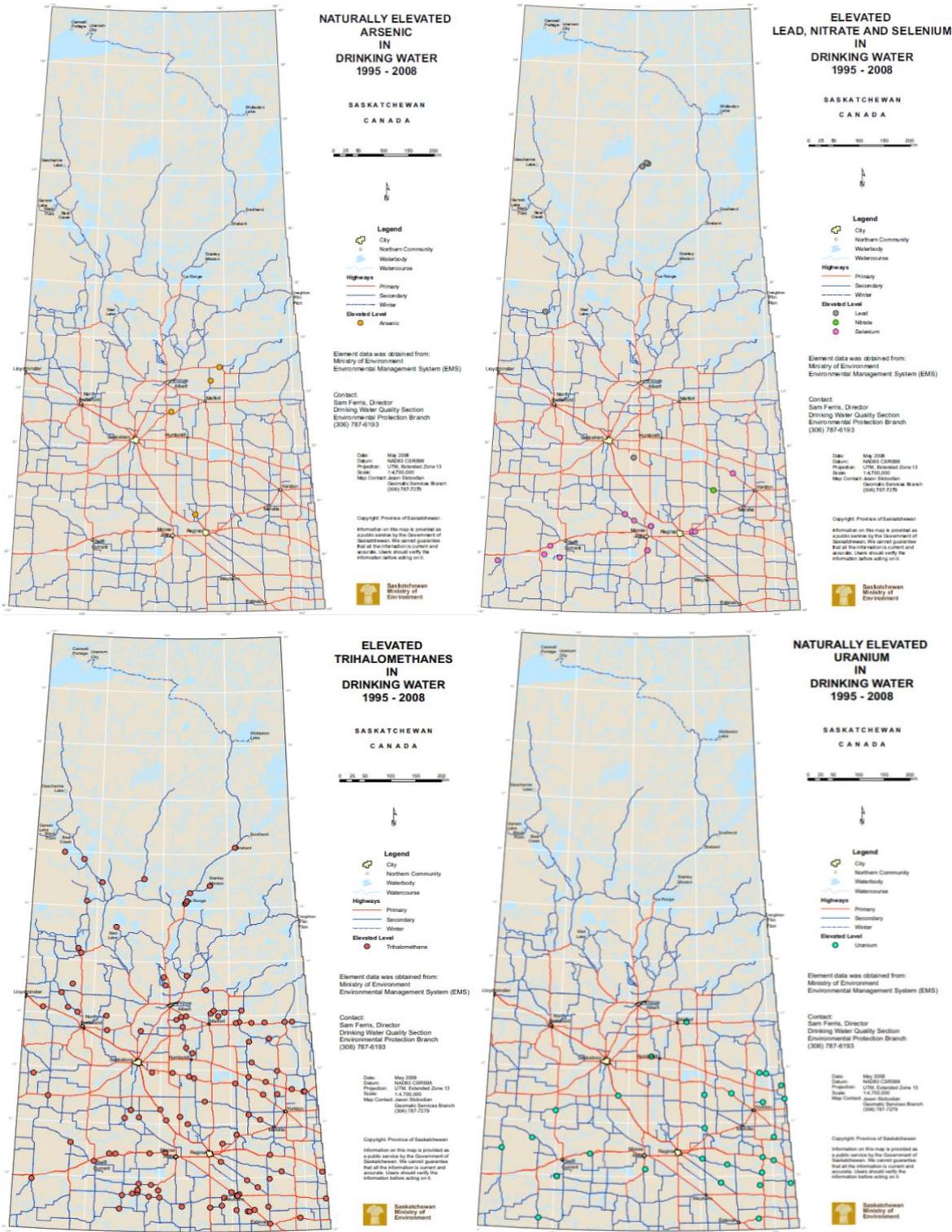


Table 15: 2011 FHQTC Drinking Water Treatment System Risk Assessment & Score

Band Name	System Name	Water Source	Treatment Class	Source	Design	Operation	Report	Operator	Total
Carry the Kettle	Assiniboine no. 76	Groundwater	Level I	6	5	8	8	1	5.5
Little Black Bear	Little Black Bear no. 84	Groundwater	Level II	5	5	1	7	6	4.2
Muscowpetung	Muscowpetung no. 80	Groundwater	Level I	5	1	8	10	1	8
Muscowpetung	Muscowpetung no. 80 - School	Groundwater	Level I Small	5	8	1	1	1	3.5
Nekaneet	Middle Camp Well	Groundwater	System Small	10	10	8	10	1	8
Nekaneet	Upper Camp Well	Groundwater	System	10	9	10	10	1	8
Nekaneet	Nekaneet no. 160a	Groundwater	Level I	5	8	7	7	1	8
Okanese	Okanese no. 82	Groundwater	Level II	5	3	8	7	1	8
Pasqua First Nation #79	Pasqua no. 79	Groundwater	Level II	4	5	1	1	1	2.5
Peepeekisis	Peepeekisis no. 81	Groundwater	Level II	9	4	8	3	1	5
Piapot	Piapot no. 75	Groundwater	Level II	7	3	4	1	1	3.1
Standing Buffalo	Standing Buffalo no. 78	Groundwater	Level II Municipal Transfer Agreement	6	5	2	8	2	3.9
Star Blanket	Wa-pii moos-toosis Indian Res. no. 83a	Municipal Transfer	Transfer Agreement	1	3	7	10	1	3.9
Wood Mountain	Wood mountain no. 160	Groundwater	Level I	5	6	8	10	1	8
Average				5.9	5.4	5.8	6.6	1.4	5.7

Table 16: 2011 FHQTC Wastewater System Risk Assessment

Band Name	System Name	Receiver Type	Treatment Class	Effluent	Design	Operations	Report	Operator	Total
Carry the Kettle	Assiniboine no. 76	Sub- surface/ Ground	Level I	1	2	7	10	1	3.6
Muscowpetung	Muscowpetung NO. 80	Evaporation	Level I	4	5	6	10	1	3.8
Nekaneet	Nekaneet no. 160a	Sub- surface/ Ground	Level I	1	8	7	1	1	4.2
Okanese	Okanese no. 82	Wetland	Level I	2	8	1	10	1	3.8
Pasqua First Nation #79	Pasqua no. 79	Evaporation	Level I	2	4	1	10	1	2.8
Peepeekisis	Peepeekisis no. 81	Evaporation	Level I	3	4	9	10	1	4.8
Piapot	Piapot no. 75	Sub- surface/ Ground	Level I	3	3	5	9	1	3.7
Standing Buffalo	Standing buffalo no. 78	Evaporation	Level I	2	5	3	10	1	3.6
Star Blanket	Star blanket no. 83	Wetland	Level I	2	3	6	10	1	3.8
Average				2.6	4.7	5.1	8.7	1.0	4.0

*Above tables & risk definition from source [78]

“**High Risk:** Major deficiencies in most of the components. Should a problem arise, the system and management as a whole is unlikely to be able to compensate, thus there is a high probability that any problem could result in unsafe water. **Medium Risk:** Minor deficiencies in several components, or major deficiencies in one or two components. Should a problem arise, the system and management can probably compensate for the problem, but the noted deficiencies makes this uncertain, thus there is a medium probability that any problem could result in unsafe water. **Low Risk:** Minor or no deficiencies with the system or management. Should a problem occur, it is likely that the system and management as a whole will be able to compensate and continue to provide safe water while the issue is being resolved.”

9. HAZARD: HEALTH EMERGENCY

HAZARD: Health Emergency

CLASS: Human

RISK SCORE: 8 **FREQUENCY:** Ongoing / Occasional **LIKELIHOOD: 3** **CONSEQUENCE: 3** **VULNERABILITY: 2**

WORST CASE SCENARIO: A community outbreak within a global pandemic that infects individuals of all demographics while exacerbating other health issues, including substance abuse, mental health, and chronic conditions leading to increased community stress, hospitalizations, and fatalities.

TYPE	DESCRIPTION
Infectious Disease Outbreak	Spread of disease caused by a pathogenic organism, resulting in epidemic or pandemic
Substance Use & Overdose	Public health emergency from problematic use of illicit and licit drugs
Chronic Disease & Wellness	Persistent medical conditions that are prolific within the community causing detrimental effects and compounding issues

INDICATORS

Population Demographics	Transport Corridors	Municipality Proximity
Infrastructure Type	Health Facility Proximity	Access to Support
Socioeconomic Conditions	Comorbidity Risk	Response Cost

SELECT INCIDENT HISTORY

LOCATION	DATE (dd.mm.yyyy)	INCIDENT
Global	11.03.2020 to Present	COVID 19-Pandemic: Infectious novel coronavirus strain that has spread worldwide, causing volatile economic uncertainty, major lockdowns, with 960,000 cases in Canada to date, with 22,615 fatalities.
Nationwide	12.2014 to Present	Opioid Crisis: Epidemic of the problematic overdose and usage of prescription and illegal opioids causing est. 21,824 hospitalizations, 17,602 related deaths, with 90% cases being in BC, AB, ON and Territories.
Piapot First Nation	08.02.2021	COVID 19 Outbreak: 70 cases since November, 36 active cases at the time of outbreak declared
Carry the Kettle First Nation	30.11.2020 to 14.12.2020	COVID 19 Lockdown/Outbreak: 8 cases in the community resulted in a 14-day lockdown and further restrictions
Alberta and Saskatchewan	26.10.2016 to 21.12.2016	Bovine Tuberculosis Epidemic: Infected herd, resulted in the quarantine of approximately 26,000 from 50 different properties across

		provinces, 10,000 cattle were destroyed to stop spread, federal government paid \$16.7 million for losses
Global	01.04.2009 to 01.02.2010	Swine Flu Pandemic: Strain of influenza, that spread globally, caused approximately 40,000 cases, 8,582 hospitalizations, 1,448 in ICU cases, and 452 deaths.
Saskatchewan	11.1951 to 02.1952	Foot and Mouth Disease Epidemic: Only one in Canadian history, 1,313 cattle, 294 pigs, 97 sheep, 1 goat, 2,372 fowl, and 15,828 eggs destroyed, eradication cost \$1 million at the time, and \$70 million spent to support fall of livestock value.
Global	1918-1920	Spanish Flu Pandemic: Influenza virus resulting in 20 million deaths worldwide, 50,000 in Canada and 5,000 in Saskatchewan.

9.1. Hazard Exposure

Health emergencies can be a multifaceted hazard depending on the type or condition. Infectious outbreaks can move quickly within a population requiring swift intervention, chronic conditions can persist prolifically but not be recognized or result in emergency status, and crises surrounding mental health and substance abuse involve a complexity of factors. Types of infectious disease all have different epidemiology and can include zoonotic/vector-borne, sexually transmitted, enteric, respiratory/droplet, and blood-borne infections [84]. Infections can spread via direct or indirect contact, airborne, droplet, or vector-borne transmission depending again on the characteristics of the disease [85].

Currently and most notably, the world is facing a global pandemic from the novel coronavirus COVID 19 which is spread by direct respiratory droplets from close contact. However, there is concern around aerosol transmission, where particles remain suspended in air and can occur in crowded conditions [86]. Since the outbreak, First Nation communities in Canada have reported 23,514 positive cases of COVID-19, 1,054 hospitalizations, and 266 deaths, with 1,174 active cases to date (March 2021), and 22,074 recovered [87]. Saskatchewan has reported a total of 6,071 cases on reserves, with the period of peak cases being 675 new cases between January 10th to 16th, 2021. There was a similar pattern viewed across other provinces during January 2021 [88].

It has been increasingly identified during this outbreak that some health issues already present within communities before the COVID-19 pandemic were magnified by the current situation. For example, FHQTC Technical Services reports identified the need for additional housing units as 8% are overcrowded, 35% have mold and not all homes are outfitted to accommodate the 18% of homes with elderly residents. These factors impact the ability of residents to isolate and may impact their overall health [79]. The prevalence of health emergencies can also further exacerbate substance usage and mental health concerns. In 2020 a substance abuse problem was identified across Saskatchewan as police and health authorities expressed extreme concern with increasing drug-related accidental overdoses and reported an average of 2.5 known overdoses per day in Regina [89]. Stimulants drugs are also a concern with 114 related hospitalizations annually during this period, averaging 9 to 13 per 100,000 people [90]. From 2009 to 2016 there was a 500% increase in demand for

harm reduction and treatment services [91] [92]. Mental health well-being has been identified as a concern among some Indigenous communities in Canada and rates of incidence can be high in remote and northern communities due to a multitude of factors including loss of culture, community disruption, discrimination and trauma [93].

9.2. Hazard Outlook

The COVID-19 pandemic is currently a major concern for FHQTC Member Nations as it not only presents as a dangerous infectious disease but can also exacerbate other health challenges. The FHQTC Member Nations have adopted comprehensive guidelines for community members to follow and the continued response to outbreaks will adjust as the situation changes. It is hoped going forward that the introduction of vaccination in communities will lessen the severity of the situation. As of March 2021, Indigenous Services Canada has estimated that the uptake of vaccination in Saskatchewan First Nation communities is around 75% or more [94].

Furthermore, the Saskatchewan Health Authority in August 2020 re-divided into 13 regional zones, and 32 sub-zones to better track caseloads [95]. As this impacts FHQTC Member Nations it is important for communities to understand the new health zones and how they may affect their members going forward. Additionally, accessing eHealth Saskatchewan communicable disease control manuals may provide a better idea of epidemiology and disease response [96]. The Saskatchewan provincial government has also recently allocated increases to historically under funded programs including an additional \$35 million in 2020 for addictions and mental health (totalling \$435 million), the building of a new methamphetamine specific hospital in Estevan and the introduction of a provincial suicide prevention plan *Pillars for Life* which aims to enhance available training and supports [97]. Furthermore, the increased commitment between the Federation of Sovereign Indigenous Nations, and the provincial and federal government aims to increase continued assistance [98].

The FHQTC has in place multiple programs to continue to address health concerns including a Youth Engagement Strategy to help empower youth and strengthen communities. It is hoped that the observed upward trend of health emergencies will decrease given the increased attention these risks are receiving provincially. It is understood that public health issues impact each community differently and many factors influence susceptibility including access to health services, trauma, and social inequalities [99]. Given the scope of research, specific projections are difficult to identify and FHQTC Member Nations have a much more comprehensive understanding of the individual needs of their communities going forward than this assessment can provide.

10. HAZARD: OIL & GAS INDUSTRIAL EMERGENCY

HAZARD: PIPELINE FAILURE

CLASS: Human

RISK SCORE: 5 **FREQUENCY:** Occasional **LIKELIHOOD:** 3 **CONSEQUENCE:** 1 **VULNERABILITY:** 1

WORST CASE SCENARIO: Incident causing pipeline rupture that releases hundreds of thousands of litres of crude oil into the surrounding area, creating sustained and costly environmental damage resulting in cumulative detriments to community well-being and function.

TYPE	DESCRIPTION
Pipeline Release	The unscheduled release of liquid or gaseous hydrocarbons from rupture or explosion, that result in contamination of municipal or natural areas
Facility Release	Industrial facility or station incident causing unsafe exposure or unscheduled release to a hazardous product or by-product

INDICATORS

Network Usage Frequency	Hazardous Materials	Municipality Proximity
Infrastructure Type	History & Ownership	Resource Dependency
Extreme Weather Frequency	Sensitive Area Location	Response Cost

SELECT INCIDENT HISTORY

LOCATION	DATE (dd.mm.yyyy)	INCIDENT
Maidstone, SK	21.07.2016 to 29.07.2016	Pipeline Rupture: Up to 250,000 litres spilt into North Saskatchewan River. Contaminated water >100km downstream, state of emergency declared in Muskoday First Nation, boil water advisory in Star City & Melfort. Leak fixed on July 29, spill only 40-50% contained. Husky fined \$3.8 million.
Prud'homme, SK	11.05.2014	Pipeline Rupture: SaskEnergy Subsidiary TransGas, steel pipe failure resulted in gas fire, burning 7 days, 75-metre flames, cost \$12 million.
Manor, SK	02.2013	Gas Leak: H ₂ S leak resulted in the death of 6 calves, launched investigation in well leakage, where sour gas >30,000ppm.
Indian Head, SK	13.03.2012	Well Spill: 400 litres of production water, 100 litres of oil.
Reno, SK	6.20.2010	Well Spill: 3,000 litres of oil, 1,000 litres of production water, impacting 1,340 sq. metres.
Fort Qu'Appelle	12.08.2008	Transformer Spill: 450 litres oil

Nipawin, SK	18.04.2008	Natural Gas Explosion: Workers digging too close to the active line, caused an explosion in a nearby butcher shop, causing 2 deaths and 3 buildings destroyed.
Antelope Lake, SK	01.09.2008	Pipeline Rupture: 1.4million litres of production water, 69,010 litres of oil, leaked for two weeks, none recovered, soil trucked into Gull Lake.
Glenavon, SK	15.04.2007	Pipeline Rupture: Line 3, leaked into adjacent wetland and farmland, 990m ³ crude oil released.
Waverley, SK	04.04.2002	Pipeline Rupture: 15,000 litres production water spilled, 6,000 oil, 5,600 litres recovered.

10.1. Hazard Exposure

Saskatchewan is one of the largest producers and distributors of crude oil in Canada. In 2018 the province produced approximately 489,000 barrels of crude oil per day and moved 82.5% of this by national and provincially regulated pipelines [100]. There is approximately 10,500 km of federally regulated pipelines that move product interprovincially through the south and central regions of Saskatchewan. These pipelines have terminals in Kerrobert, Regina, Milden, and Saskatoon [100]. In addition to the federally regulated pipelines there is over 102,400 km of provincially regulated pipelines in Saskatchewan [101]. Natural gas is also distributed by pipelines and SaskEnergy provides fuel to approximately 390,000 customers and 93% of the communities across the province [100]. There are major transmission gas pipelines that extend through and around the FHQTC Members Nations by Fort Qu’Appelle, in the south portion of Cypress Hills, and north of Wood Mountain Lakota Nation towards Mankota (Figure 43).

There are currently 6,832 operating and licensed pipelines in Saskatchewan, with 63% of these being for natural gas (20,011 km) and 8% for crude oil (2,479km) (Table 18). In addition to pipelines, there are 36,500 active wells, 24 compressor stations, and 8 gas storage sites [103] [104]. Given the extensive facility and pipeline infrastructure, spills are not uncommon in the province, with 28,798 occurrences being recorded since 2000. These occurrences reported in 18,315,663 m³ of natural gas and 57,806 m³ of oil being released. The severity of leakage events vary by size and substance type, with small gas leaks only visible if discoloured vegetation or frost appear along the pipeline while larger leaks can ignite immediately [105]. Large spill events that involve oil and saline product water, can have costly long-term environmental impacts on the surrounding area, and affect farmland productivity and well water safety [106]. Reports show that 1,916 hectares of land and 240 hectares of water in Saskatchewan have been impacted by spills since 2000. The majority of these spills were reported as production water and oil. Although recovery efforts are made, on average about 30% of spilled substance remains in the environment (Table 19).

Natural gas is also susceptible to unscheduled releases from provincial pipelines and facilities. It is reported that 18,315,663 m³ has been released into the atmosphere and that 14% of all product release concentrations are hydrogen sulphide gas (H₂S) (Table 19). H₂S is extremely toxic, and exposure can result in nausea, headaches, respiratory issues and death for

humans and animals. H₂S has been a major topic of concern for some residents in southern Saskatchewan that live close to sites of industrial production [108]. For example, in 2015 some facilities in southern Saskatchewan were emitting greater than 30 times the parts per million amount that could cause fatalities. This incident caused the death of six calves and over 60 registered complaints of nose, eye, lungs, and mouth irritation in the area [109]. Furthermore, the release of substances has accompanied 13 fire events and caused 6 explosions since 2000, but none of these incidents resulted in serious injuries being reported to the TSB (Table 18). Although spill events occur frequently in the province, reported data show that no recent incidents have occurred in immediate proximity to the FHQTC Member Nations (Figure 41). Oil production and movement is low in the area as most wells are abandoned, national pipelines are primarily distant, and industrial activity is concentrated elsewhere (Figure 44).

10.2. Hazard Outlook

Currently, FHQTC Member Nations have proportionally fewer active pipelines and wells in the vicinity in comparison to other Saskatchewan communities. Therefore, there have been significantly fewer pipeline spill accidents, with most being concentrated around areas of heavier activity at the central-western edge and southeastern corner of the province (Figure 41). Gas plant facilities are concentrated closer to Swift Current, Regina, Kindersley, and Estevan, all of which are greater than 75 km from any FHQTC Member Nation. Going forward, reports expect crude oil production to increase by 53% until 2030 [110]. As well, 60% of SaskEnergy natural gas lines rely on wells and demand for natural gas is predicted to continue to grow [72]. Currently, an additional 35,000 km of provincial pipeline is expected to be constructed (Table 17) and although spatial distribution of these licenses is unknown, the increase in activity could eventually affect FHQTC Member Nations.

The situation surrounding the Keystone XL pipeline bares uncertainty and although national pipelines have a low frequency of spills, if constructed, an incident would potentially impact the area surrounding Nekaneet First Nation. Crude oil incidents also have the ability to have downstream effects and impact a larger spatial area. Therefore, FHQTC Member Nations should be aware of any potential upwind, upstream, or nearby developments. Most historical incidents involving pipeline failure or crude oil spills have not impacted human life but have lasting effects on the surrounding environment. Clean-up can be costly, and critical infrastructure such as drinking water supply can be impacted. The biggest concern would be events that occur upstream or up slope of communities, causing a cascading effect to drinking water. This situation was seen in Muskoday First Nation as although the spill was comparatively small at 250m³, it largely impacted the drinking water supply and led to a state of local emergency being declared and boil water advisories. Furthermore, an incident can have lasting effects on ecologically sensitive and important land, and any expansion into the area should consider these factors. Notably, there appears to be a section of federally regulated Plains Midstream Pipeline that runs adjacent to and within a few kilometers of Piapot First Nation lands south of Regina (Figure 42).

Alternatively, natural gas pipeline failures can be of greater risk to human life as they can cause combustion or asphyxiation but have a smaller environmental impact. These incidents can potentially result in a flammable flume 600m downwind and

recommendations suggest an assumption of a 0.8 km unsafe zone until a spill is assessed [105]. Additionally, a natural gas incident that results in a lost line could cut off residential supply and create large impacts to a community in certain scenarios.

Community members that reside or work in areas near gas lines, pump jacks or tanks should be educated on prevention methods and safe work practices. This is important as 13 reported events were the result of a line strike and when reporting leakage emergencies, it is important to follow callout procedures. Saskatchewan has spill contingency groups that help respond to events within the province and engage communities for training and call-out preparedness activities. The FHQTC Member Nations are within the Area 3, 4, 5, and 6 response cooperatives and could investigate the potential for this mutual aid system for their respective areas [111]. Furthermore, TransGas offers the ability to contact staff to confirm area capacity as well as attain specific line locations. FHQTC Member Nations could also access cooperative training programs and industry mapping information to reduce risk and increase awareness around spill response measures.

10.3. Figures & Tables

Table 17: Operating Pipeline Infrastructure Saskatchewan 2021

Operating Pipeline Infrastructure Saskatchewan 2021	License Distribution	Current Operating Line (km)	Planned and Under Construction Line (km)
Natural Gas	62%	20,011	816
Oil Well Effluent	16%	720	1,371
Crude Oil	8%	2,479	27,336
Fuel Gas	5%	200	1,729
Sour Natural Gas	3%	1,131	1,881
Saltwater	3%	202	424
Fresh Water	2%	373	1,434
LVP Products	1%	539	1,259
Miscellaneous Gases	0%	117	369
HVP Products	0%	200	277
Miscellaneous Liquids	0%	15	136

[102]

Table 18: Incident Type and Spilled Substance Federal Pipelines Saskatchewan (2000-2019)

Fire	13
Crude Oil	1
Liquefied Petroleum Gas	1
Natural Gas	2
Natural Gas Liquids / LPG	9
Explosion	6
Crude Oil	1
Other	1
Unspecified	4
Line Strike	13
Crude Oil	1
Natural Gas Liquids / LPG	1
Unspecified	11
Significant Environmental Impact	

Crude Oil

3

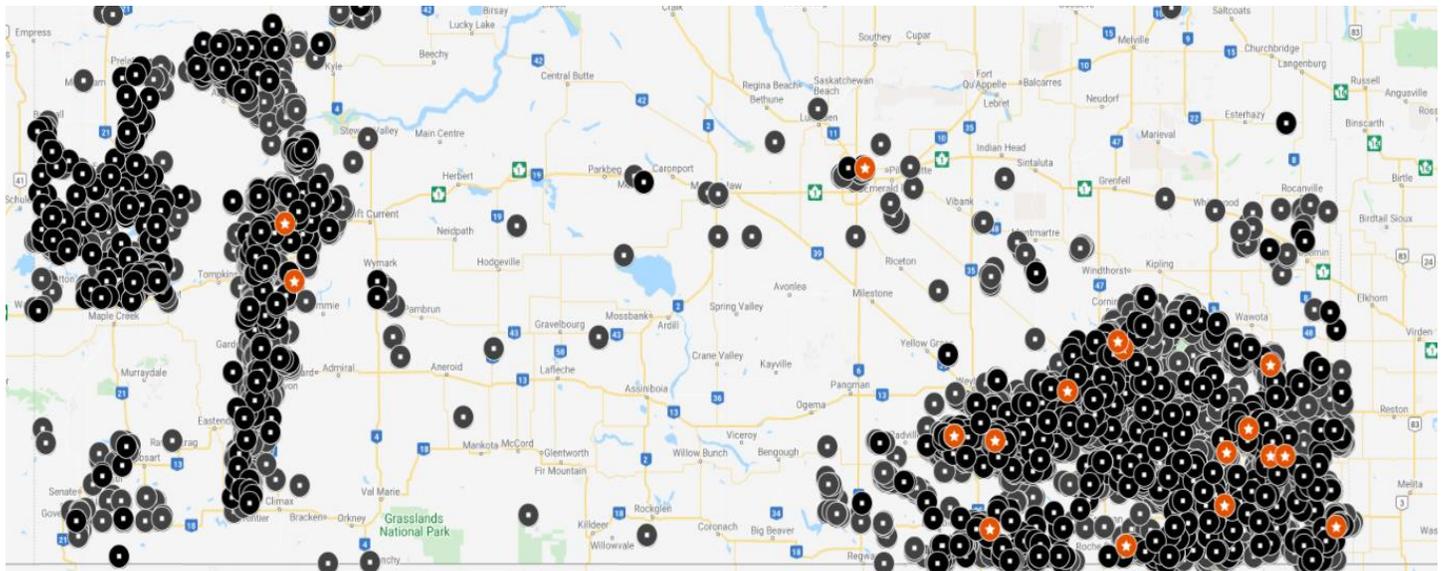
[107]

Table 19: Release of Product Incident Reports Saskatchewan (2000-2021)

Product Released	Released (m3)	% Recovered	Released Product in Waterbody (m3)	% Recovered in Waterbody
Oil	57,806	71%	5,759	51%
Water (Saline &/Or Fresh)	214,467	72%	53,095	70%
Natural Gas	18,315,663	0%	33,016	6%
Refined Product	496	-	0	-
Other	258,423	7%	3,104	69%
Total H ₂ S Concentration	2,623,878	0%	10,000	0%
Total Incidents in Waterbody	635			
Total Surface Area (ha) of Waterbody Impacted	240			
Total Incident Accounts	28,798			
Total Surface Area (ha) Impacted	1,916			
Total Oil and Product Water Not Recovered (m3)	76,765			

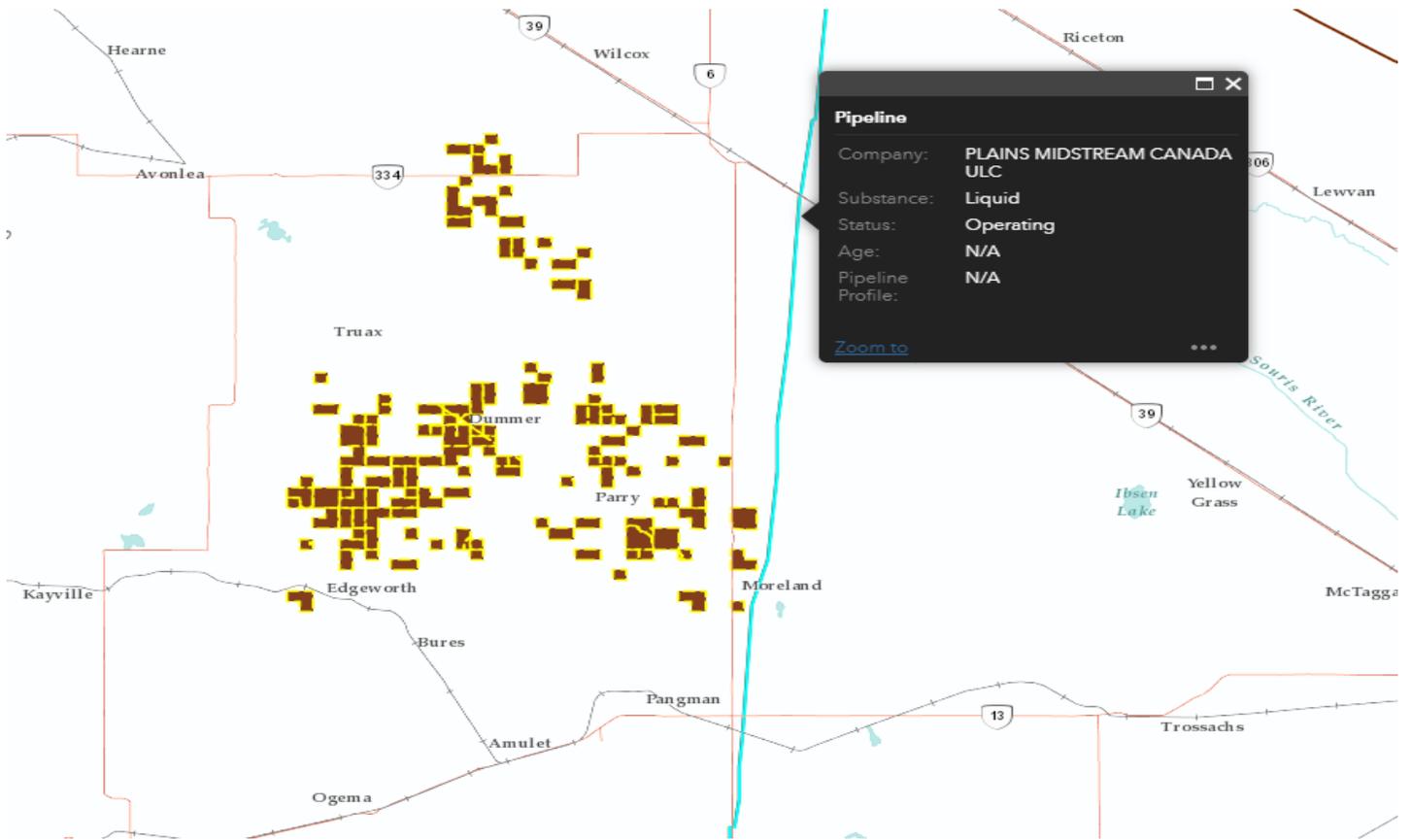
[102]

Figure 41: Reported Oil Spills Southern Saskatchewan 2000-2018



[112]

Figure 42: Piapot First Nation Lands and Plains Midstream Pipeline



[113]

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APPENDIX A: HAZARD ASSESSMENT RESOURCES

Resources to Development Hazard Assessments in Saskatchewan			
Section	Source	Description	Link
General Mapping	Government of Saskatchewan Geohub	Provides free online spatial mapping software from select management layers. With abilities to upload and download layer data, as well as export imagery	Link
	Government of Saskatchewan HABI Sask	Option within Geohub network focusing on environmental factors pertinent to outdoor pursuits. Contains pertinent vegetative, soil, hydrological, cadastral information that could provide useful to determine hazard/event	Link
General Data	Government of Canada Open Portal	Provides access to datasets and publications of spatial and non-spatial types prepared by most government jurisdictions	Link
	Canadian Disaster Database	Searchable geospatial and tabular database for reported disasters from 1900-Present day, includes cost, injury and affected services. Exportable .csv and .kml files	Link
	Government of Saskatchewan Publications Centre	Searchable Database with previous management frameworks, vegetative, geographic, and hydrologic data	Link
	Statistics Canada	Searchable database that provides publications, spatial maps, and complete tabular datasets on a variety of subjects	Link Link
General Weather & Climate	Climate Data Canada	An online portal by the Government of Canada & collaborators, high-resolution climate data, location-based summary, searchable queries, downloadable maps, and graph output. Includes concise training videos/materials for users to best utilize the application. Can be used for projection and custom variables and sorted by sector and emergency type	Link
	Climate Atlas of Canada	Online map database created by Prairie Climate Centre, used as an educational tool for climate change prediction throughout Canada. Has the ability to export data into graph and table format. Allows for specific location search, local data can be downloaded. Some comparison of historical data, on multiple future models	Link
	Government of Canada Climatic Normal Database (1981-2010)	Provides a historical database over the average from meteorological stations throughout the country. Online viewable & .csv exportable. Allows for assignment/station, for review based on area	Link
	Agroclimatic Maps Canada	Database documenting major weather trends that specifically deal with major agriculture inputs. Can be viewed on current year or historical record, parameters are dependent on the value of interest.	Link

Wildfire	Government of Saskatchewan Wildfire Management Map	Active online, printable & pdf exportable map showing current and historical wildfire statuses, wildfire risk, and management areas. Fire Weather Index indices are limited to current conditions & forecast (during fire season).	Link
	Canadian Wildfire Information System	Wildfire data center for Canada, run in partnership with Natural Resources Canada, Canadian Forest Service, and Canadian Space Agency. Uses background data from Canadian Forest Fire Danger Rating System, Forest Fire Behaviour Prediction System, Fuel Types, and Fire M3 hotspot satellite. Provides, historical, real-time, and some predictive analysis depending on the variables being investigated	Link
	National Forestry Database	Provides a national dataset from reporting jurisdictions and forest agencies in Canada. Streamlined site with graph, pdf, png, and table downloadable format. Provides historical context and trends at national & provincial levels	Link
	Canada Wildfire Smoke Prediction System	Portal providing information of air quality and smoke forecasts based on Canada and USA wildfires, using Blue Sky Canada System. Forecasting up to two days in advance	Link
	Forest Change Data Catalogue	An expansive empirical and spatial data set that shows predictive and historical trends on a national scale notably for fire weather, operations, and vegetation	Link
Flood	Government of Canada Hydrometric Station	Provides the central location for historical and real-time data collection from water gauges across the province, can search or use map feature by jurisdiction to find gauges. Has real-time and metadata indexes	Link Link
	Saskatchewan Water Security Agency	The primary provider of water information for the province. Provides mapping, testing and planning information for the major watersheds. Allows for previous case studies, examining of historical norms, investigation of documented watershed priorities and exportable water quality data	Link
	Water Quantity Canada	Provides general information & data to flood preparedness and water quality on a national scale. Highlights some provincial programs, as well as trends when it comes to rain, flow, and evapotranspiration. As well as data collection centres and strategies for focus regions	Link
Volatile Weather	Verified Tornado Database 1989-2009	From open source Canada these are verified tornado tracks and events from across Canada, there are	Link Link

		multiple file formats, can be exported to Google Earth (.kml), (.csv) Canada OpenMap, or ArcGIS Online	
	Government of Canada Lightning Data	Database showing the lightning education, hotspots, and statistics in map, graph, and tabular format	Link
	CoCORaHS Network	Citizen Science Network in North America that collects and maps severe weather data	Link
	Air Quality Canada	Source dedicated to tracking air quality and matters of related concern across regions in Canada. Data is viewable in an online map as well as exportable data in 3 formats.	Link
Seismic	Earthquake Canada	Provides seismic information & regulations on a national scale. Seismographs and hazard maps are included, as well as building code regulations based on these conditions. The main page has earthquake activity <30days	Link Link
Railway	Transportation Safety Board Canada- Railway	A section providing raw data(>1990), summary reports (>2015), and case studies of rail-related incidents nationally. Data can be viewed in summary or raw format for download to excel	Link
	Transportation Maps Saskatchewan	Central page of all transport maps for the province, with associated data. Available as pdf for download. Provides oversight of major transportation corridors type, usage, and capacity	Link
Oil & Gas	Transportation Safety Board Canada- Pipeline	A section providing raw data(>1990), summary reports (>2015), and case studies of pipeline-related incidents nationally. Data can be viewed in summary or raw format for download to excel	Link
	Provincial & Territorial Energy Profile Saskatchewan	Page providing a general overview of energy infrastructure and demand in the province. Providing maps on the spatial extent of pipeline and railway lines throughout the region and proximity to areas of study	Link
	Government of Saskatchewan Spill Search	Query-based database of spills that occurred within the province, data from 1998 onward. Can be exportable to .csv format for analysis.	Link
	Federal Government Interactive Pipeline Map	GIS web platform showing the different pipelines in Canada, different layers can be added, and incident data can be reviewed. This can be done within the application or downloaded to a CSV format	Link
	Mining & Petroleum GeoAtlas	Online GIS tool providing data and physical reference of oil well sites, geological features, tenures, and assets	Link

Critical Service	Canadian Drinking Water Advisories	Database keeping track of current and historical First Nation Communities water advisories that extended short & long duration. Also lists infrastructure developments and improvements being performed. Data is on a national database and can be viewed by province	Link Link Link
	Saskatchewan H2O- Water Quality	Water quality data for stations across the province. This data can range over extended periods, can be filtered for certain quality markers and is exportable to excel for graph and chart marking. A station can be selected via the map, can provide a background of continuous/discontinuous quality issues, markers, and timing for planning. Some stations only have data from >2017	Link
	SaskPower Outage Map	Website showing current outages in the province, with details and updates on statuses	Link
	Trans Gas Facility & System Map	An online interactive map providing spatial data of transmission gas lines. Not to be used for line locates by high-level mapping.	Link
Public Safety	National Centre for Missing Persons and Unidentified Remains	The national center that publishes missing person data for Canadian provinces as provided by authorities	Link
	Statistics Canada- Crime	Database providing the crime statistics by violation as reported by police service in Saskatchewan	Link
	Saskatchewan Association of Chiefs of Police	Website providing information on missing persons within the province from 1935-Present and information services in respect to missing person cases	Link
Health	Saskatchewan COVID 19 & Health & Wellness Dashboard	Information for the province on COVID-19 pandemic. Provides risk outlook as well as current caseloads, historical case trends. All data is exportable to .csv & .xlsx format	Link Link
	Saskatchewan Communicable Disease Control Manual	Database of all manuals for specific communicable disease control. Documents cover pertinent information to control such as signs, symptoms, virology, and response while providing pertinent documentation	Link
	Public Health Infobase	National tracking of public health information, general and disease, data can be organized on regional levels as well viewed spatially. Could be used to determined historical or future trends/risks	Link

APPENDIX B: EXAMPLE HIRVA

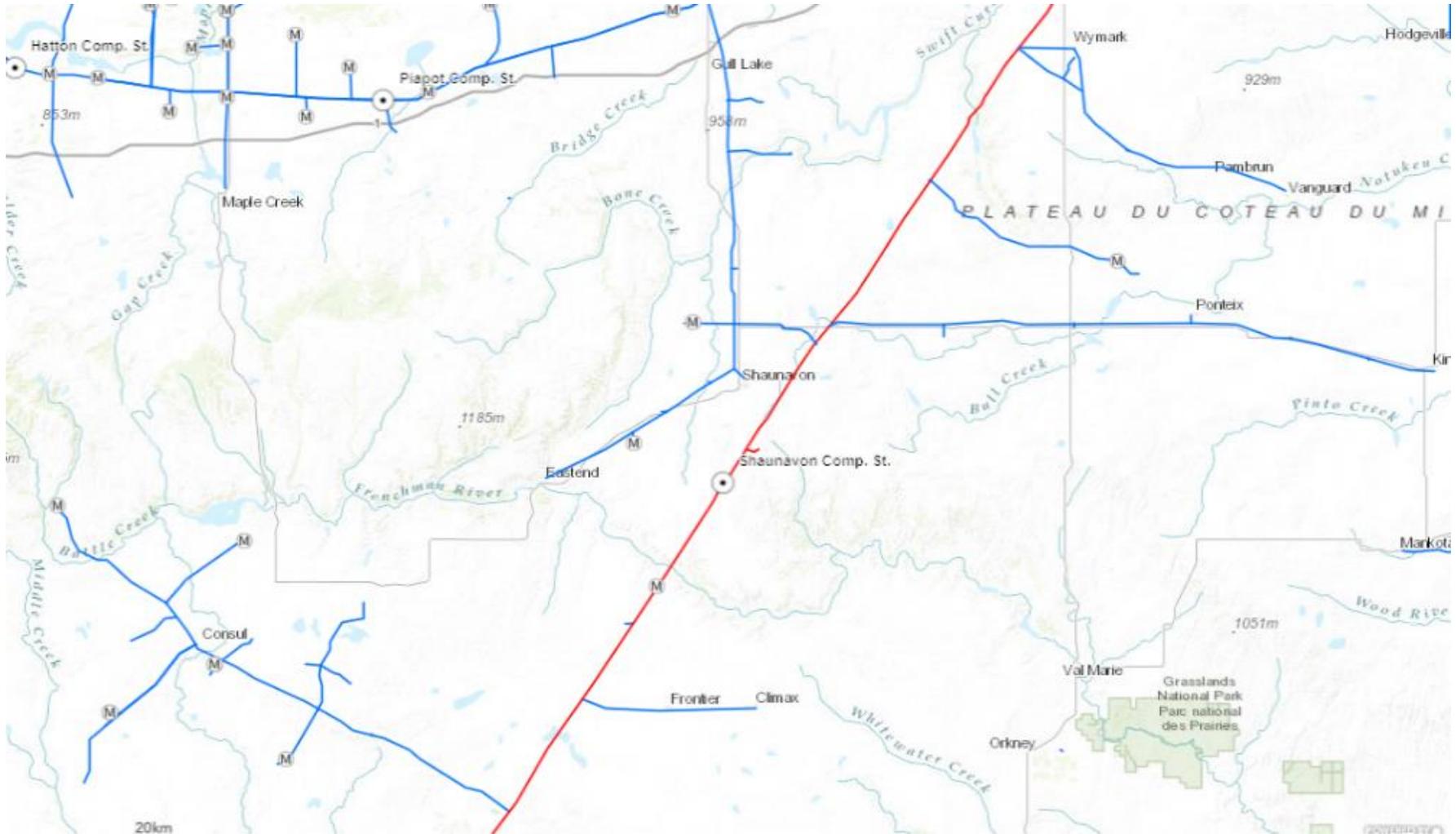
Risk Assessment Matrix								
		Likelihood of Failure	Risk Classification					
Likelihood Class	E	Happens several times in a year	Minor	Routine	Moderate	Critical	Take Action: Measures must be implemented to reduce risk to as low a reasonably possible level.	
	D	Happens every 1- 2 years						
	C	Happen every 2 – 10 years	Risk is tolerable and should be managed by application of existing control, and continual improvement				Serious	Plan and schedule risk reduction measures to reduce risk to as low a <u>reasonable possible</u> level.
	B	Happens every 10 – 20 years						
	A	Almost never happens						
Vulnerability Category	People	No illness or injuries	Mild illness / minor injuries first aid treatable	Minor illness/ injury resulting in lost time	Serious illness / injury requiring treatment extending weeks or months	Serious illness / injury/ death affecting a limited number of people	Mass casualty / fatality incident	
	Environment	No effect	Short term local impact	Local effect	Prolonged local / regional effect	Prolonged regional effect	Long term effect, loss of land use	
	Assets	No damage	Minimal damage, easily repaired, <\$20k	Minor damage, more complex repair, <\$100k	Serious localized damage, loss of equipment / utility structures/ homes <\$1m	Major damage, longer timeline / complexity to repair, <\$10m	Catastrophic loss, Repair timeline may extend to years, >\$10m	
	Reputation	No impact	Minor impact (local)	Limited impact (regional and short term)	Considerable impact (regional, longer term)	Significant, (national exposure, prolonged term)	Major (international exposure, irreparable harm)	
Severity		0	1	2	3	4	5	

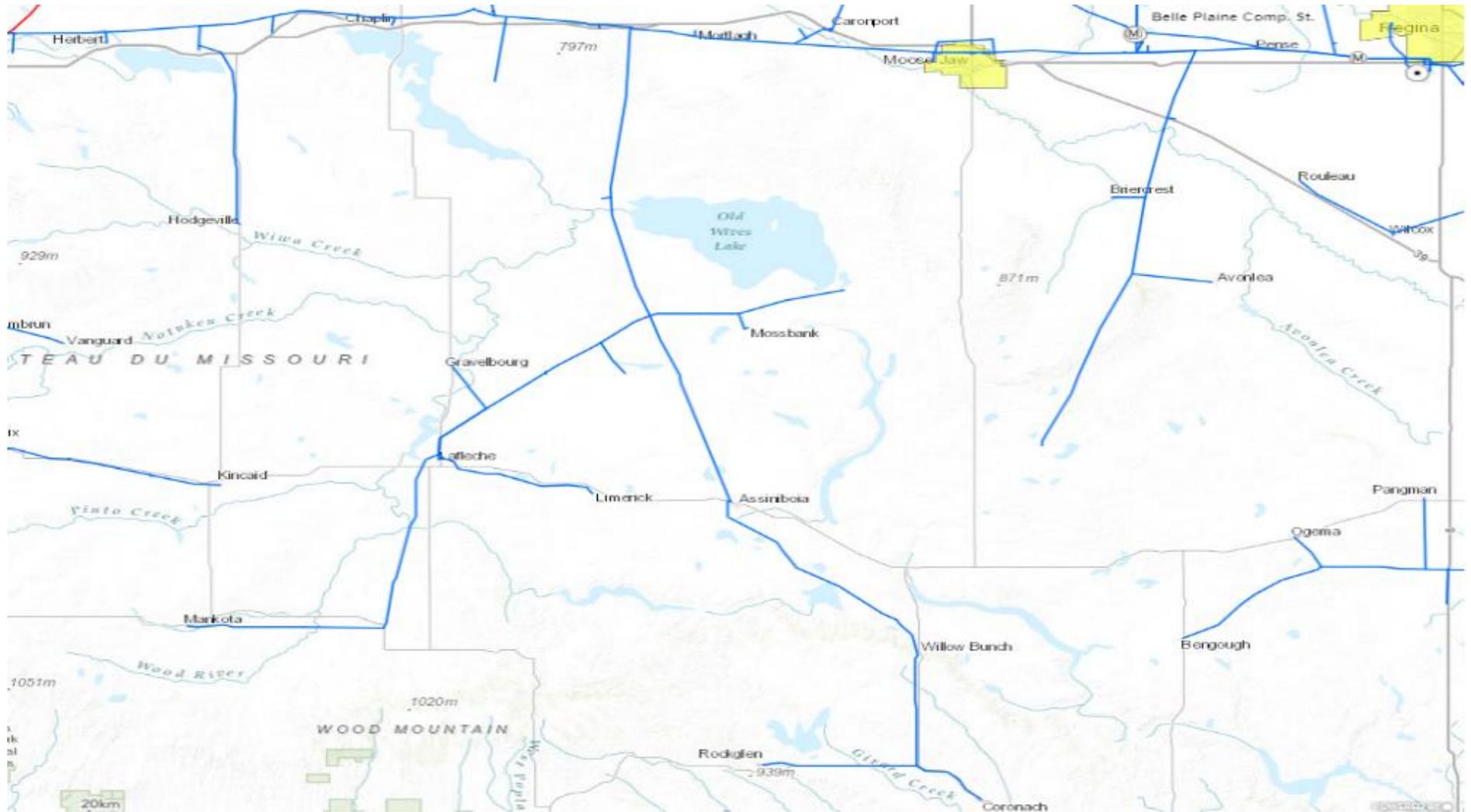
APPENDIX C: VULNERABILITY

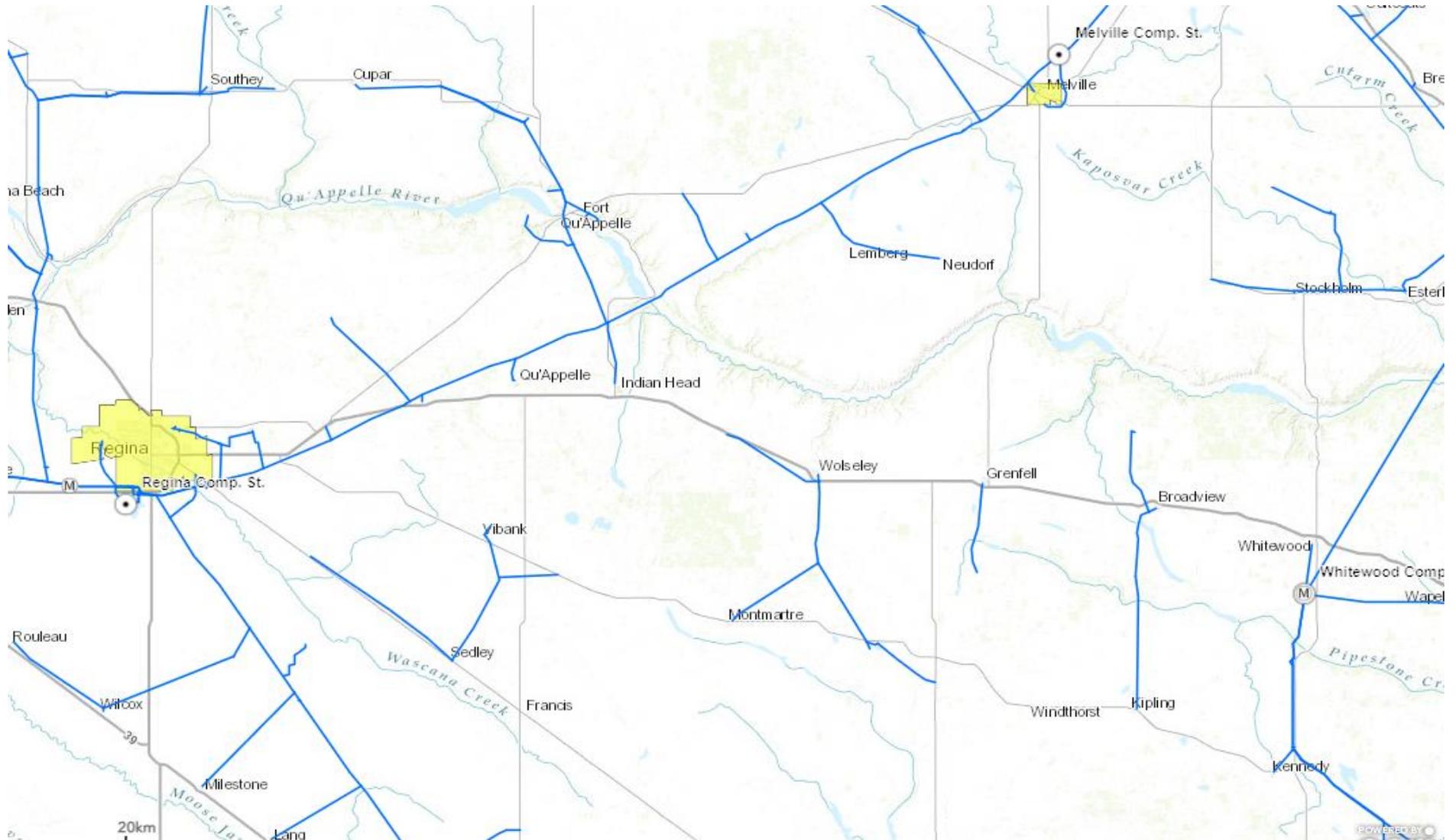
Consequences to People	
Rating	Description
0	No illness or injuries
1	Mild illness or minor injuries that are first aid treatable and do not require a hospital visit
2	Minor illness or injuries that may require a hospital visit, and result in a short recovery period (days)
3	Serious illness or injuries that may require hospital admission and extended recovery (weeks to months)
4	Serious illness/injury/death affecting a limited number of people
5	Mass casualty/fatality incident. Numerous serious injuries requiring activation of EMS /Hospital mass casualty ERP
Consequences to Environment	
Rating	Description
0	No effect on the environment gasses may be slow to dissipate.
1	Short term local impact: spill easily contained and cleaned up, gasses will dissipate quickly
2	Localized effect, spill containment may be challenging, clean-up may extend into more than one operating period,
3	Prolonged local/regional effect. There may be longer-term cleanup and remediation efforts that demand extra resources and extends over several days, and a larger land area. Affected residents may be displaced for an extended period.
4	Prolonged regional effect. Clean-up & remediation may extend into weeks/months. Residents may face longer displacement.
5	Long-term effect. Clean up and remediation may take months, years, or may not be possible. Affected people/operations may be permanently displaced
Consequence to Assets	
Rating	Description
0	No damage or loss
1	Minimal damage, easily repaired or replaced for less than \$20,000
2	Minor damage that may require a more complex repair plan or up to \$100,000 in costs
3	Serious localized damage, loss of equipment/utility structures or homes up to \$1,000,000.
4	Major damage demanding longer-term planning or increased complexity to effect repairs, with costs up to \$10,000,000
5	Catastrophic loss may include major infrastructure, requiring years to repair, and costs beyond \$10,000,000.
Consequence to Reputation	
Rating	Description
0	No impact
1	Minor impact to local perception of organization that can be repaired
2	Limited impact that may extend beyond local, but will be short term
3	Considerable impact that will extend regionally and may be longer term
4	Significant exposure with national-level interest, that may be prolonged
5	Major exposure, drawing international interest, or that may cause irreparable harm.

APPENDIX D: HIGH PRESSURE TRANSMISSION NATURAL GAS PIPELINES & OIL WELLS

Figure 43: High Pressure Transmission Natural Gas Pipelines by FHQTC Member Nations

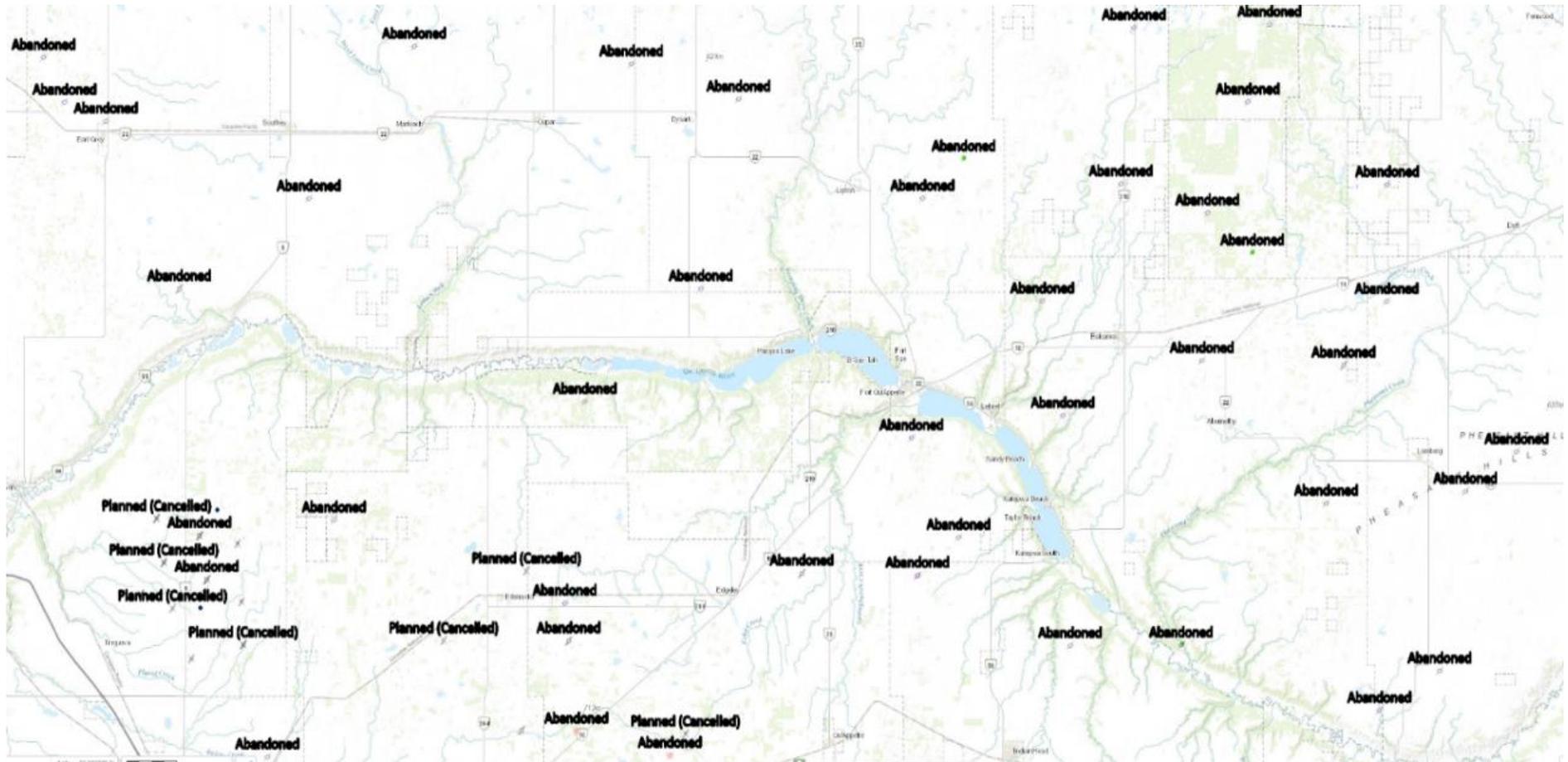


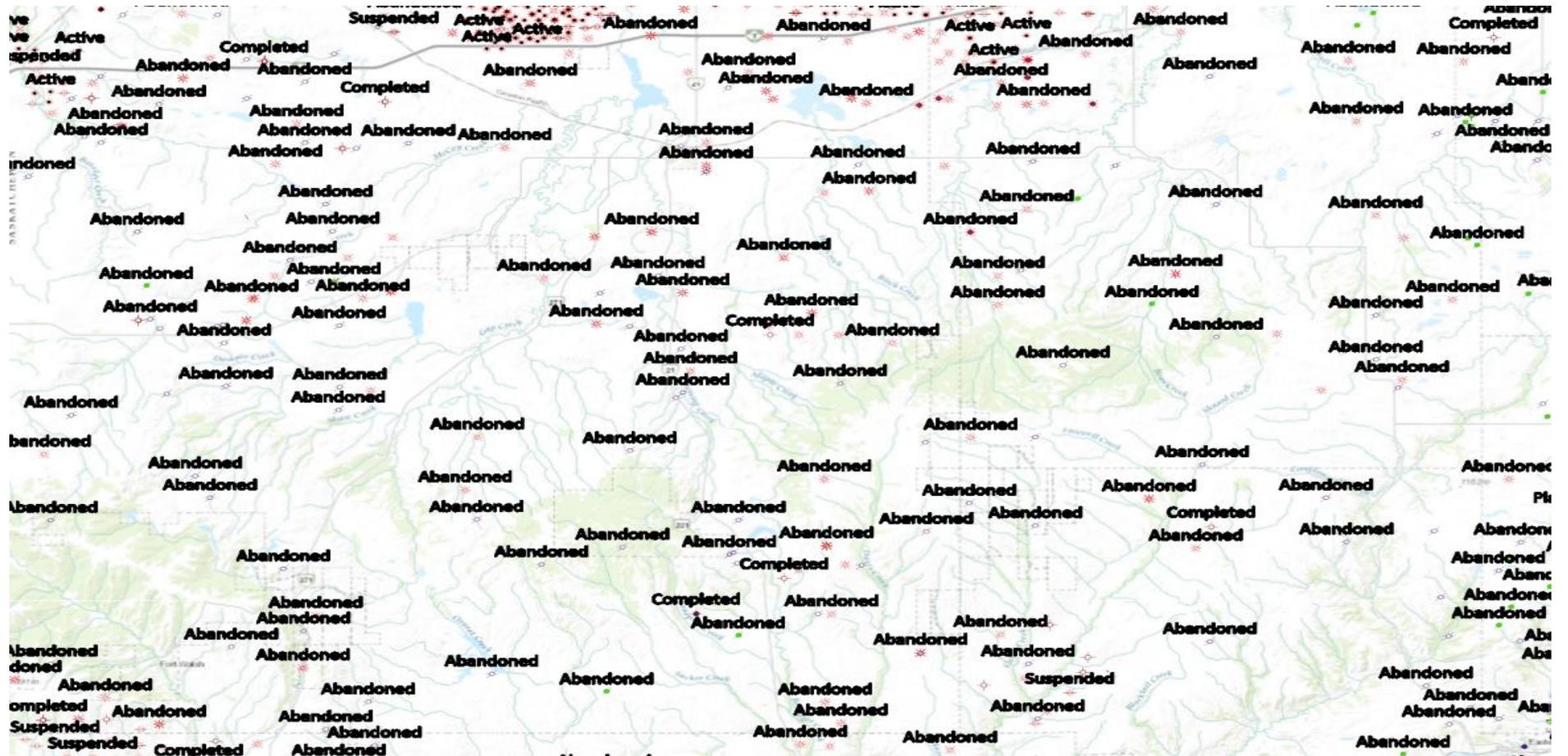


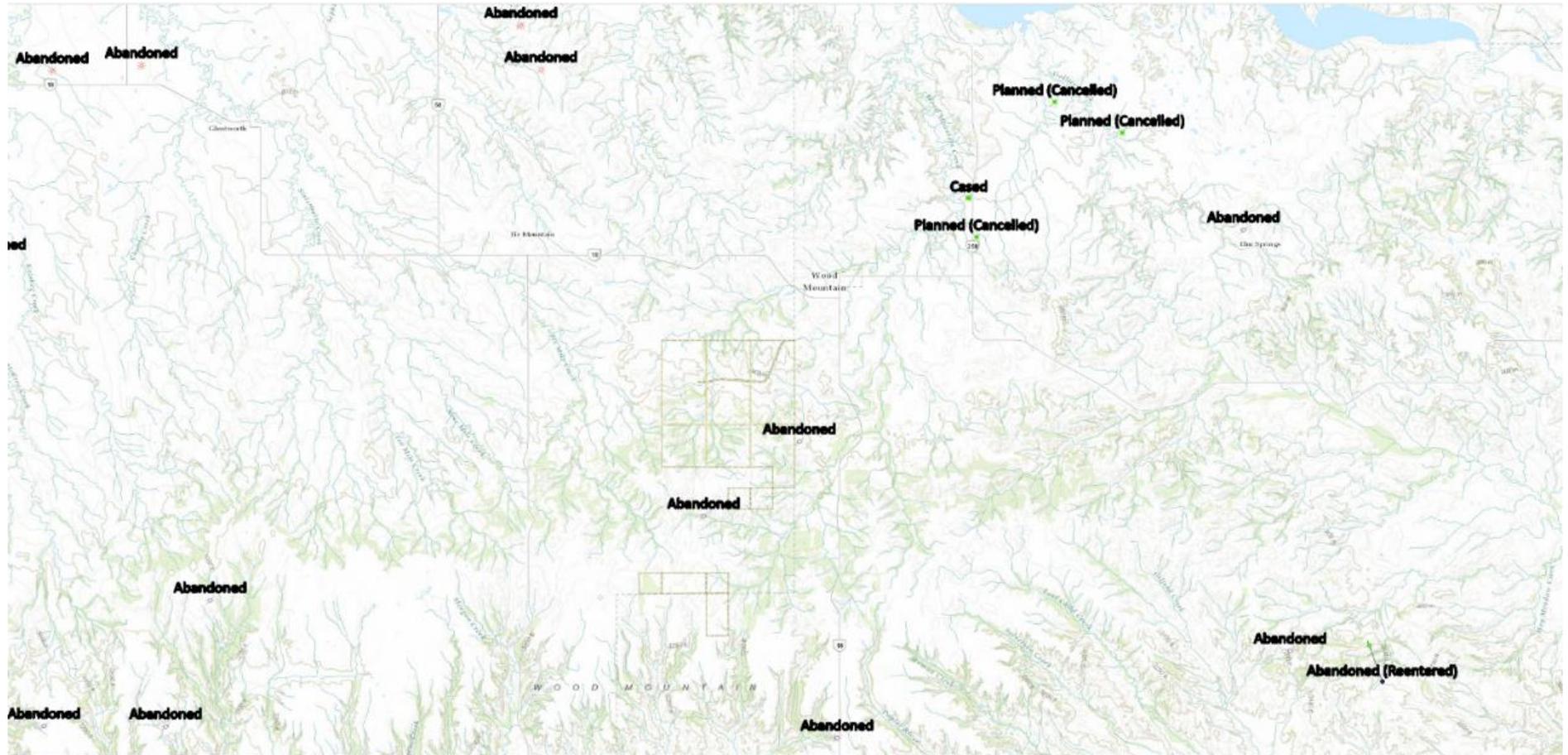


Blue Lines- TransGas, Red Lines- Many Islands Pipelines, Circle with Dot- Compressor Station [104]

Figure 44: Oil Well Status within and by the FHQTC Member Nations







[114]

