MANITOBA – MINNESOTA TRANSMISSION PROJECT
Environmental Impact Statement

EFFECTS OF THE ENVIRONMENT ON THE PROJECT

CHAPTER 20
SEPTEMBER 2015

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ABBREVIATIONS AND ACRONYMS

AR5	IPCC's Fifth Assessment Report
CAPE	convectively available potential energy
CEAA 2012	*Canadian Environmental Assessment Act, 2012*
CEMP	Manitoba Hydro's Corporate Emergency Management Program
CO_2	carbon dioxide
CRCM	Canadian Regional Climate Model
CSA	Canadian Standards Association
GCM	global climate model
ha	hectares
IPCC	Intergovernmental Panel on Climate Change
MISO	Midcontent Independent System Operator
mm	millimetre
MMTP	Manitoba–Minnesota Transmission Project
MRO	Midwest Reliability Organization
NEB	National Energy Board
NERC	North American Electric Reliability Corporation
OPGW	optical protection ground wire
PDA	Project development area
RCP	representative concentration pathways
RBD	reliability based design
RM	rural municipality
ROW	right-of-way

GLOSSARY OF TECHNICAL TERMS

climate change	Refers to a change in the state of the climate that can be identified (*e.g.,* by using statistical tests) by changes in the mean or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use.
cold spells	Span of at least six consecutive days where the minimum daily temperature is below the historical 10th percentile (Klein Tank *et al.* 2009)
consecutive dry days	Maximum number of consecutive days where the daily precipitation accumulation is less than 1 mm (Klein Tank *et al.* 2009)
consecutive wet days	Maximum number of consecutive days where the daily precipitation accumulation exceeds 1 mm (Klein Tank *et al.* 2009)
convectively available potential energy	A measure of the amount of energy available for convection and is related to instability through the atmosphere. CAPE is directly related to maximum vertical wind speeds (National Weather Service n.d.).
diurnal temperature range	The mean difference between daily maximum and daily minimum temperature in a certain period (Klein Tank *et al*. 2009)
evapotranspiration	The combination of water moving from the earth’s surface into atmospheric water vapour, and includes evaporation of water and transpiration from plants (National Weather Service n.d.)
frost days	Days when the minimum daily temperature is below 0°C (Klein Tank *et al.* 2009)

Fujita scale (F-scale)	A system of rating the intensity of tornadoes (National Weather Service n.d.). A scale of tornado intensity in which wind speeds are inferred from an analysis of wind damage:

Rating	Wind, Damage
F0 (weak)	64-116 kph (40-72 mph), light damage
F1 (weak)	117-180 kph (73-112 mph), moderate damage
F2 (strong)	181-252 kph (113-157 mph), considerable damage
F3 (strong)	253-331 kph (158-206 mph), severe damage
F4 (violent)	331-414 kph (207-260 mph), devastating damage
F5 (violent)	415-511 kph (260-318 mph) (rare), incredible damage

heavy precipitation day	Days when total daily precipitation accumulation is greater than 10 mm (Klein Tank *et al.* 2009)
ice days	Days when maximum daily temperature is below 0°C (Klein Tank *et al.* 2009)
large fire	In Canada, large fires are those that cover more than 200 ha (de Groot *et al.* 2013).
simple precipitation intensity index	The mean accumulation of precipitation on a wet day (daily accumulation greater than 1 mm) (Klein Tank *et al.* 2009)
tropical nights	Nights when the minimum daily temperature is above 20°C (Klein Tank *et al.* 2009)
very heavy precipitation day	Days when total daily precipitation accumulation is greater than 20 mm (Klein Tank *et al*. 2009)
wet days	Days when total daily precipitation accumulation is greater than 1 mm (Klein Tank *et al.* 2009)

20 Effects of the Environment on the Project

20.1 Identification of Potential Effects of the Environment on the Project

This chapter provides a discussion of potential effects of the environment on the Project's design, construction and operation. It was written with consideration given to the following federal and provincial legislation and guidelines in the preparation of this environmental assessment:

- The Project Final Scoping Document, issued on June 24, 2015, by Manitoba Conservation and Water Stewardship's Environmental Approvals Branch, which represents the Guidelines for this EIS;
- The relevant filing requirements under the *National Energy Board Act* (R.S.C., 1985, c. N-7), and guidance for environmental and socio-economic elements contained in the National Energy Board (NEB) Electricity Filing Manual, Chapter 6; and
- *The Canadian Environmental Assessment Act, 2012* (S.C. 2012, c. 19, s. 52) and its applicable regulations and guidelines.

Projections are provided on how local conditions and natural hazards, such as severe or extreme weather conditions and external events, could adversely affect the Project and how this in turn could affect the environment. The local conditions and natural hazards are described in terms of how they could affect the Project development area (PDA), which is the area in southeastern Manitoba from the Dorsey Converter Station near Rosser, MB to the Manitoba–Minnesota border and the area in the vicinity of Glenboro South Station in the Rural Municipality (RM) of South Cypress south of the Village of Glenboro (Chapter 6, Map 6-2 – Glenboro Project Region).

For the purposes of this assessment, this section considers how the following environmental conditions and hazards could affect the Project:

- extreme weather or climate conditions, including winds, extreme temperatures, severe precipitation, ice storms, tornadoes and lightning, that are applicable to the Project region;
- extreme hydrological conditions, including droughts and flooding, that are applicable to the Project region;
- climate change and its potential effects on future average and extreme climate conditions;
- regional geotechnical and geophysical hazards, including ground instability, erosion and earthquakes; and
- vegetation growth and high fire hazards (grass fires and forest fires) along the Project sites and New Right-of-way.

Each of these is described in further detail below, including existing conditions, potential effects and proposed mitigation. The effects on the Project due to the physical environment include:

- temporary holds on construction or maintenance activities during extreme weather events
- interruption in service
- damage to infrastructure
- potential threats to Project personnel or the public

In some cases, these effects on the Project can induce subsequent effects on the receiving environment. Ultimately, mitigation of these effects requires planning, design and operation procedures that consider normal and extreme physical environmental conditions for the operational setting. There must also be monitoring and forecasting of physical environmental conditions, in particular for thresholds related to effects triggers, such that Project activities can be adaptively managed to maintain a safe working environment. For example, Manitoba Hydro's weather monitoring system and hydroelectric system management are tools that address conditions that could affect system reliability.

The primary mitigation tool is the implementation of sound planning. Engineering designs will adhere to industry standards and reflect Manitoba Hydro's experience with similar projects. The transmission line will be designed to resist route-specific normal and extreme physical environmental conditions, based on historical records. The standards consider physical environmental criteria, such as temperature, wind, snow and ice loading for historical climate conditions. Climatic loading used for the structural design of transmission lines is based on historical weather data. Historical data on climate change are considered only for the years in which the data were collected. For D604I, an updated weather study was conducted to incorporate the weather data from 1954 up until the summer of 2013. To account for unforeseen conditions and events such as extremes caused by future climate change, transmission lines are designed to resist or limit the effects of failure events. While there is uncertainty surrounding climate change effects on future extreme events, potential effects could include more frequent wind storms or increased ice loads, which could potentially result in failure. To limit the effect of failure events on the line, structural components are designed as part of a system, where failure of one component will not necessarily result in the failure of another. Through numerical modelling and industry experience, it has been recognized that the effects of failure of a component on a line can be limited by building containment into the system.

Design of the D604I 500 kV AC transmission line will be subject to two general design standards. The Canadian Standards Association (CSA) C22.3 No. 1-10 "Overhead Systems" standard will be applied to determine electrical and safety clearances and the CAN/CSA-C22.3 No. 60826-10 "Design criteria of overhead transmission lines" standard will be used for structural design. Structural design loads will be based on a 150 year return period, in accordance with the Reliability Based Design (RBD) method.

20.2 Significance Thresholds for Effects of the Environment on the Project

A significant[1] adverse residual effect of the environment on the Project is defined as one that results in one or more of the following:

- damage to Project infrastructure resulting in harm to Project workers or the public;
- a substantial effect on the Project schedule, delaying ongoing Project construction activities by one month or resulting in a shutdown of operations on one part of the line for more than two weeks; and
- damage to Project infrastructure resulting in the need for repairs that cannot be technically or economically implemented.

20.3 Effect of Extreme Weather and Climate Conditions on the Project

In the following assessment, the existing conditions related to weather and climate are based primarily on the Supplemental Study – Historic and Future Climate Study (Manitoba Hydro 2015). Potential Project infrastructure, the ecozones of the region and the locations of six Environment Canada climate stations used to study the region are shown in Figure 20-1.

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[1] Significant adverse residual effects are not to be confused with statistical significance. Statistical significance is used in trend analysis of climate variables.

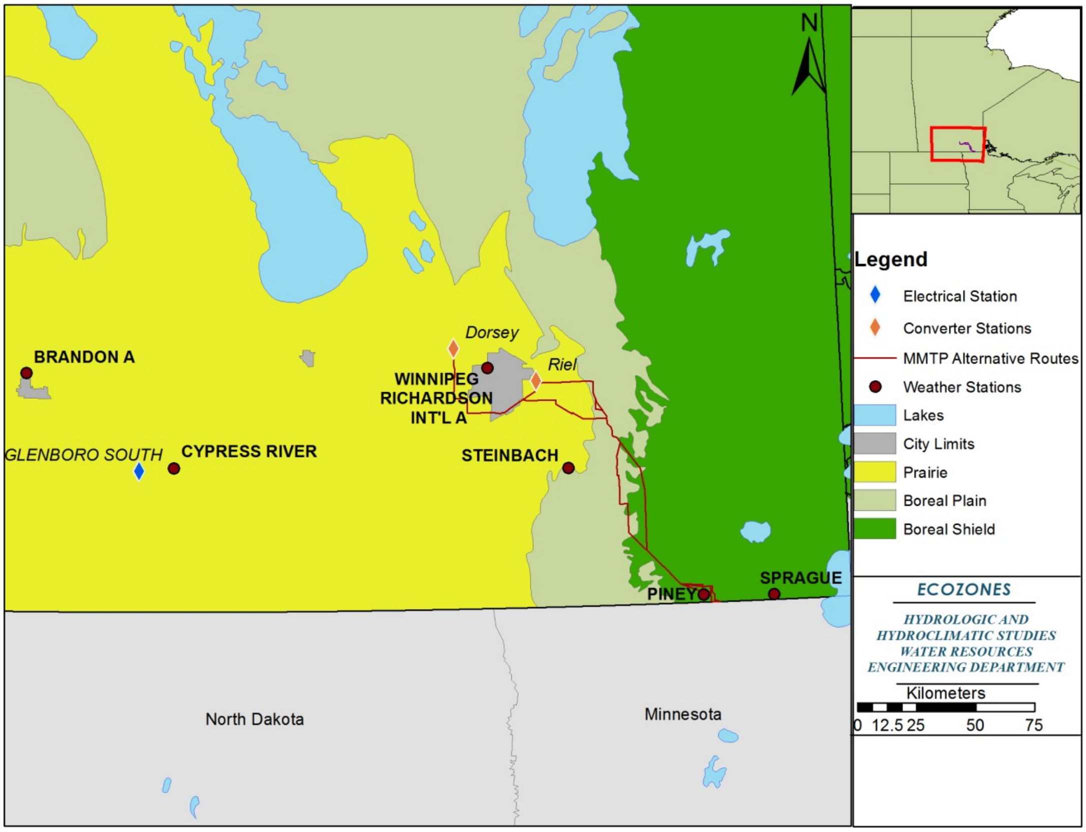


Figure 20-1 **Manitoba–Minnesota Transmission Project Infrastructure, Climate Stations and Ecozones**

20.3.1 Existing Conditions

A description of climate conditions along the Final Preferred Route is provided in Chapter 6, Section 6.2.1. The Project passes through three ecozones (Figure 20-1). The Prairies Ecozone in the west is characterized by short, warm summers, long, cold winters and low levels of precipitation. Winds are frequent and often strong in the Prairies Ecozone and precipitation in summer often occurs as localized, heavy storms (Smith *et al.* 1998).The Boreal Plain Ecozone is characterized by moderately warm summers and cold winters. The Boreal Shield Ecozone in the east has a strong continental climate, characterized by short, cool summers and long, cold winters. The Project could be influenced by localized storms, large-scale weather systems and the occurrence of tornadoes.

Based on temperature and precipitation data for the entire record period for Winnipeg, Steinbach, Piney, Sprague and Cypress River, extreme cold temperatures along the Final Preferred Route are below -40°C at all locations, and extreme high temperatures are above 35°C at all locations. The highest amounts of extreme daily precipitation at each station historically occurred in the months of June, July and August and ranged from 83.8 mm to 149.0 mm over the entire period of record. With respect to winds, maximum observed gust speed ranged from 129 km/h at Winnipeg to 139 km/h at Brandon.

Historically, mean temperature in the PDA has increased, while mean wind speed has decreased (Manitoba Hydro 2015). These results are consistent with other studies, including IPCC (2013) and Wan *et al*. (2009). Increasing precipitation trends have also been detected in the PDA. While these trends are statistically significant, there is less evidence and agreement regarding historic trends in precipitation.

With respect to extreme weather events, a trend analysis of 25 historic extreme indices based on climate data at Brandon, Winnipeg, Steinbach, Sprague and Cypress River shows statistically significant upwards trends for minimum and maximum temperature, growing season length and number of tropical nights (Manitoba Hydro 2015). Statistically significant downward trends were detected for diurnal temperature range, number of frost days, number of ice days and cold spells. For precipitation based indices, statistically significant upward trends were detected for total precipitation on wet days, very heavy precipitation days and consecutive wet days. Statistically significant downward trends were detected for the simple precipitation intensity index and consecutive dry days. For wind speed based indices, statistically significant downward trends were detected in maximum wind gusts above 90km/h and annual maximum of mean daily wind speed.

Southern Manitoba experiences on average less than 10 hours of freezing rain and 20–30 hours of freezing drizzle per year compared to up to 50 hours freezing rain and 80 to100 hours of freezing drizzle per year in eastern Newfoundland (Cortinas *et al.* 2004; Stuart and Isaac 2010). The term “freezing precipitation” includes freezing rain (> 0.5 mm droplets) and freezing drizzle (< 0.5 mm droplets). Freezing rain or drizzle generally occurs when frozen precipitation falls through a layer of the atmosphere that is above freezing. The frozen precipitation melts and subsequently falls into another layer that is below freezing where it becomes supercooled. The supercooled droplets then freeze upon contact with solid objects creating a layer of ice (Lambert and Hansen 2011).

Table 20-1 summarizes lightning activity in Manitoba cities closest to the Project. Based on these statistics, on average, 0.79 to 1.09 cloud to ground flashes per year, per square kilometre are predicted to occur in the PDA. Southern Manitoba and southern Saskatchewan have relatively high total flash densities relative to western Canada, which appears to be an extension of the active Great Plains area of the United States; however, some of the highest total lightning flash densities in the country occur in southwestern Ontario, with more than 3 flashes/km^2/yr. Other hot spots exist between Calgary and Edson, AB (1.40 flashes/km^2/yr), and areas of southeastern Saskatchewan and southwestern Manitoba (1.40 flashes/ km^2/yr) (Environment Canada 2014b).

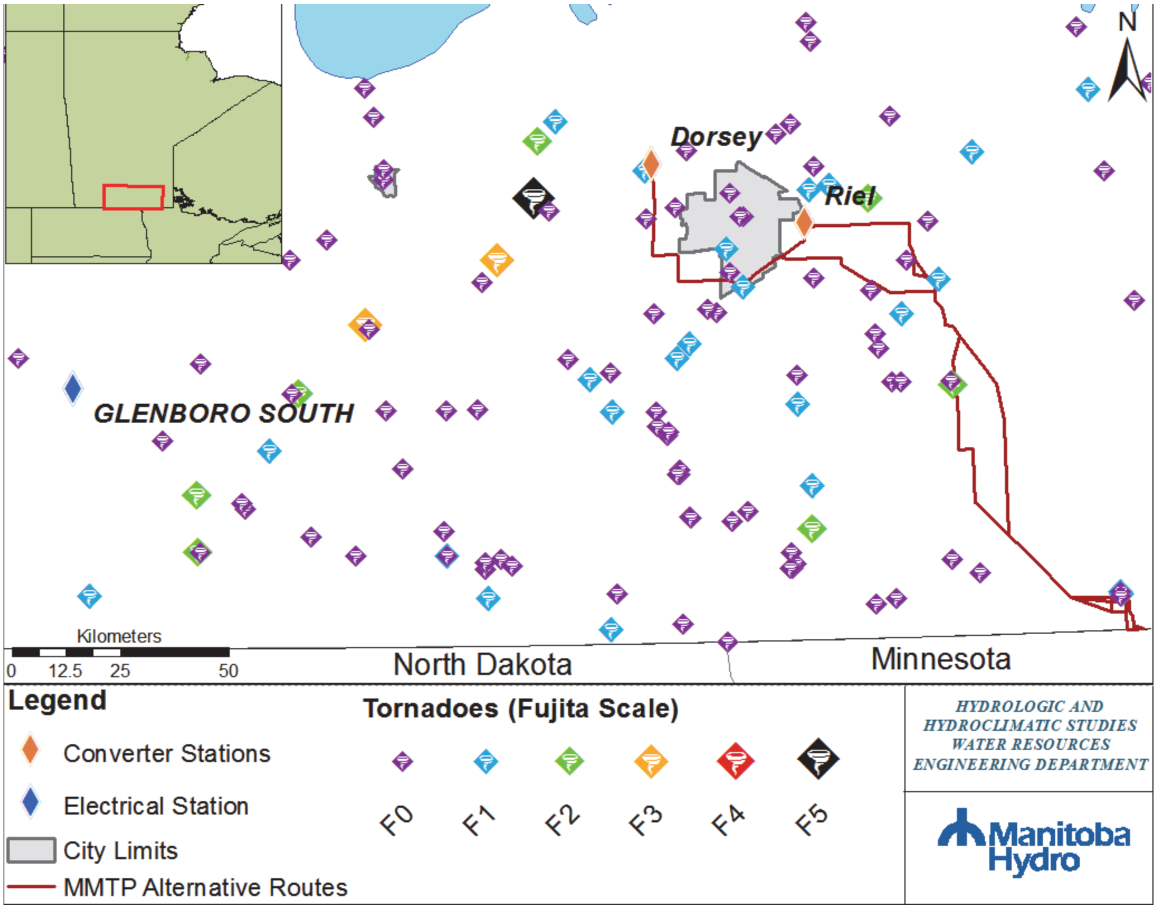
Table 20-1 Lightning Activity in Manitoba Cities

City	Area (km^2)	Total flashes (1999 to 2008)[1]	Total flashes per square kilometre per year	Cloud to ground flashes (1999 to 2008)	Cloud to ground flashes per square kilometre per year
Winnipeg	346.53	4526	1.31	3786	1.09
Brandon	30.05	360	1.20	255	0.85
Steinbach	6.96	70	1.01	55	0.79
Portage la Prairie	5.86	54	0.92	43	0.73

NOTE:
[1] Includes cloud-to-ground and cloud-to-cloud flashes; study period from January 1, 1999 to December 31, 2008.
SOURCE: (Environment Canada 2013)

Tornadoes are produced by thunderstorms and form suddenly, often preceded by warm, humid weather. Southern Ontario has the highest rate of tornado occurrence in Canada, followed by southern Manitoba (Newark 2008). Canada records an average of 80-100 tornadoes a year, but the actual number is probably higher, as some may occur in remote areas and are not recorded. Each year, the Prairies experience an average of 43 tornadoes (Environment Canada 2014). The peak of the season is June through August. The area damaged by the average tornado is 0.6 km^2 (Newark 2008). The majority of Canadian tornadoes have maximum wind speeds under 180 km/h (Environment Canada 2014). Figure 20-2 shows the distribution of confirmed and probable tornado events in Canada from 1980 to 2009 along with their Fujita (F)-scale designations.

Severe hail events are also known to occur in the Prairies, with large hail stones causing damage to property and infrastructure. While the majority of severe hail stone events occur in Alberta, they have also been recorded in southern Manitoba. According to the Canadian Disaster Database, several large-scale hail events have occurred in the past couple of decades in southern Manitoba, which have involved baseball-sized or tennis-ball sized hail stones (Government of Canada 2013).



SOURCE: Sills *et al.* (2012)

Figure 20-2 **Confirmed and Probable Tornadoes for 1980–2009 in the Project Region**

20.3.2 Effects Analysis and Mitigation

During construction, runoff from extreme precipitation or storm events may cause road blockages, may damage some erosion and sedimentation control measures, and may shut down Project activities until conditions return to normal. Extreme events can create difficult and unsafe working conditions and may result in work stoppages. Excessive rainfall/snowfall events can result in reduced visibility and hazardous conditions for construction operators. This in turn can increase the potential for accidental events, including spills, which can affect the environment.

During the operation and maintenance phase, extreme temperatures or precipitation events are not expected to affect the system, as it will be designed to operate within these parameters. Extreme wind and icing conditions, however, are a well-known concern for transmission systems, related infrastructure and supporting maintenance/repair activities. Such events can cause damage to wires and towers and result in loss of service to customers, exerting potentially large scale, sudden urgent need for line maintenance crews and, potentially, large economic consequences associated with equipment repair and loss of business operational time.

Proposed right-of-way (ROW) widths will help address potential safety concerns related to wind, by creating separation between Project infrastructure and environment features that could induce hazards to the Project under extreme events. To allow for the effects of wind on the conductors (*i.e.,* conductor swing-out), the ROW width will be sufficient, under severe wind conditions, to provide lateral separation between the conductors and objects located at the ROW edge. ROW widths will also be designed to avoid damage to adjacent property in the event of a structure failure (Chapter 21 – Accidents, Malfunctions and Unplanned Events, Section 21.2). Related design parameters are based on CSA standards, NERC/MRO/MISO reliability criteria and internal Manitoba Hydro policy.

Infrastructure could also be damaged by tornadoes, hail and lightning strikes. Lightning strikes can result in flashovers, a condition where electricity, especially at higher voltages, jumps across an air gap to create a conductive path. A flashover may occur between wires or from wires to the ground - this may be seen as a flash or heard as an explosion or loud “crack”. Flashovers are potentially life threatening to a person standing in the vicinity of the flashover; they can also damage nearby equipment and the power line, and cause possible interruptions in power supply.

Two skywires will be strung along the tops of the towers to provide lightning protection. One of the skywires will be equipped as an Optical Protection Ground Wire (OPGW). The OPGW is designed to provide system protection and communication links for the transmission line and terminating stations. Insulators are used between the conductor bundles and the steel lattice towers to prevent arcing or grounding. During construction, lightning could strike a tower, which could affect Project personnel in the area, but given the design measures described above, it is unlikely that lightning will affect Project operation.

Manitoba Hydro’s Corporate Emergency Management Program (Chapter 22 – Environmental Protection, Follow-up and Monitoring) have response procedures to address extreme weather and climate conditions.

20.3.3 Residual Effect Characterization

Despite mitigation efforts, residual effects of extreme weather and climate conditions may remain. During construction, the greatest potential for extreme weather and climate conditions to affect the Project and, in turn, the environment, stems from the creation of unsafe working conditions that could lead to increased chance of a spill (*e.g.,* snow and ice conditions leading to a vehicle collision, which leads to a spill of hazardous materials from a vehicle). While extreme conditions do increase the risk of such an event occurring, Manitoba Hydro has policies in place to encourage safe working conditions, including temporary shutdowns when conditions are unsafe and safe driving policies. Spill prevention and response procedures are prepared by the contractors and will be in place during Project phases.

During operation and maintenance, regardless of design loading parameters, there is a potential that an extreme icing event or wind conditions, tornado or hail event could damage equipment and cause temporary outages. This in turn could result in safety concerns for the general public (*e.g.,* from live wires) or again increased risk of spills or effects on worker health and safety if repair crews are required to work under harsh conditions.

Manitoba Hydro has policies in place to address worker health and safety and will work to inform the public of dangers in such an event through media communications and the Outages and Safety section of the Manitoba Hydro website (https://www.hydro.mb.ca/safety/index.shtml).

While extreme weather could result in interruptions in power and economic costs for repair, the frequency of the extreme weather events are such the effects of these scenarios are assessed as being not significant to the Project.

20.4 Effect of Extreme Hydrological Conditions on the Project

20.4.1 Existing Conditions

Both lack of water and too much water could affect the Project. Droughts can be characterized into three categories: hydrological drought (below normal streamflow, lake and groundwater levels), agricultural drought (lack of growing season precipitation), and meteorological drought (prolonged precipitation deficit) (Trenberth *et al.* 2014). Challenges in determining the frequency, duration and severity of historic and future droughts have been well documented in scientific literature (Trenberth *et al.* 2014; Sheffield *et al.* 2012; Dai 2013; IPCC SREX 2012; IPCC 2013). Challenges arise due to differences in drought characterization, methodologies for drought detection, complex and unknown atmospheric-land-ocean dynamics, natural climate variability and regional variability.

Following major flooding in 1950, southern Manitoba put extensive flood control measures in place, particularly in the Red River Valley, from Winnipeg south to the U.S. border (Government of Manitoba 2013). The Red River Floodway was completed in 1968 and additional flood control improvements, including an expansion of the floodway, were made after the 1997 flood. The 1997 flood was the most severe flood in Manitoba’s Red River Valley since 1852. While this flood was much larger than the 1950 flood, there was much less property damage due to the flood control measures already in place. There are also flood control measures along the Assiniboine River.

The Riel Converter Station is located east of the Red River Floodway and north of the City of Winnipeg Deacon Water Supply Reservoir in the Rural Municipality of Springfield. The site includes local drainage system additions for flood protection.

20.4.2 Effects Analysis and Mitigation

Periods of meteorological drought are not expected to affect Project construction and operation except where drought leads to higher risk of forest or grass fires. The effect of forest or grass fires on the Project is addressed in Section 20.6. Manitoba Hydro's Environmental Protection Plan for the Project will include fire prevention and response measures in the event of a fire.

Floods can damage transmission towers due to debris or ice movement in flood waters. Transmission towers and poles may become unstable, fall or cause overhead lines to sag. Sagging overheads lines that are still live can injure employees, members of the public and wildlife. These conditions can also result in electrical shock to persons, boats in flood waters, wildlife, and vehicles and machinery.

Increased incidence of flooding, arising from the prospect of higher precipitation, can be mitigated when required through consideration of flood protection in design of station facilities, and through provision of conductor to ground clearances that meet or exceed the applicable standards.

Site development at station locations will take into account existing drainage patterns surrounding the site and the need to protect the existing station from overland flooding during spring runoff or an extreme rainfall event. If additional localized drainage is required, it will be integrated with the existing site grading and drainage design.

20.4.3 Residual Effect Characterization

A flooding event could case a short-term interruption in services until flood waters recede and infrastructure can be repaired or replaced. Flooding of stations could result in an uncontrolled release of oil if the oil containment ponds were to be breached. The effect of an uncontrolled release of hydrocarbons is further assessed in Chapter 21– Accidents, Malfunctions and Unplanned Events.

Manitoba Hydro will implement a fire prevention protection program as outlined in the Fire Manual: Part 1 (2009) and will respond to fires affecting the Project based on the Corporate Emergency Management Program (CEMP) (2014). Therefore, residual effects from fires associated with drought conditions are expected to be localized.

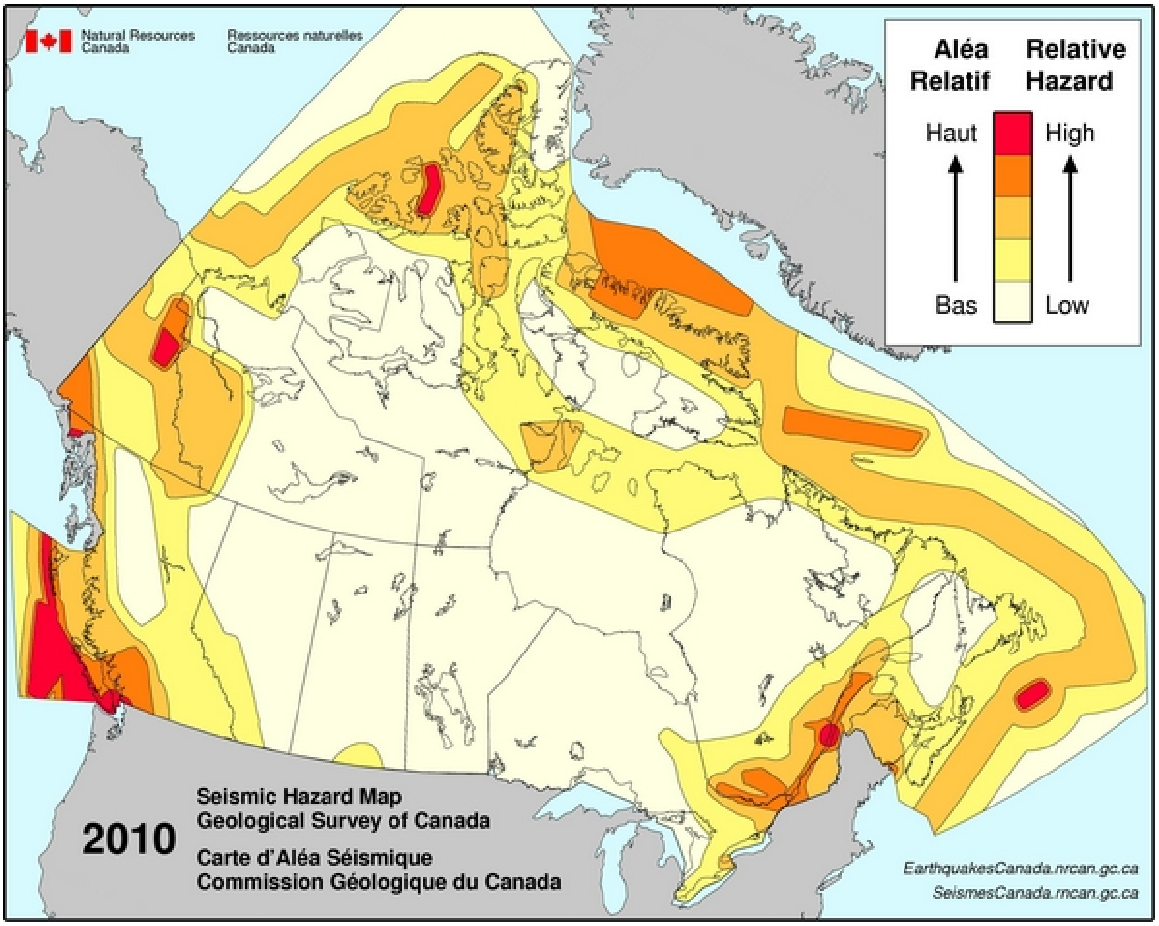
The development of site-specific drainage control measures, and the flooding response component of the CEMP will limit flooding effects on Project infrastructure and personnel. With mitigation in place, the residual effects of extreme hydrological conditions on the Project are predicted to be not significant.

20.5 Effect of Geophysical and Geotechnical Hazards on the Project

20.5.1 Existing Conditions

The Project Final Preferred Route is in an area of low seismic hazard (Figure 20-3). While Manitoba has experienced a few minor earthquakes, it is considered by Natural Resources Canada as the province in the country least likely to experience earthquakes.

The potential for geotechnical hazards associated with steep slopes along the Final Preferred Route are low because most of the area has slopes ranging from level to 5% (Chapter 6, Section 6.2.2) (Smith *et al.* 1998). Slopes around the Glenboro South Station range between level and 15% (Smith *et al.* 1998).



SOURCE: (Natural Resources Canada 2013)

Figure 20-3 Simplified Seismic Hazard Map for Canada

20.5.2 Effects Analysis and Mitigation

Seismic activity is not predicted to result in adverse residual effects on the Project during construction or operation and maintenance. The area is not anticipated to experience seismic activity and activity that could occur is expected to be minor and not result in damage.

A geotechnical investigation of the Final Preferred Route will be conducted as part of detailed planning for the Project and foundations for towers and infrastructure will be designed and constructed to address foundation or stability issues. Site-specific construction techniques will be developed where necessary for difficult terrain or steep slope conditions.

20.5.3 Residual Effect Characterization

With Manitoba Hydro's long-term experience with similar projects, the application of general design standards for the Project and site-specific design and mitigation where needed, the residual effects of geophysical and geotechnical hazards on the Project are predicted to be negligible and not significant.

20.6 Effect of Vegetation and Fire Hazards on the Project

20.6.1 Existing Conditions

Vegetation cover along the Project region varies from cultivated, pasture, native grasslands and shrubland to deciduous forests, mixedwood forests, coniferous forests and varying types of wetlands. Agriculture (pasture and cultivated) is the most common land cover class. Most of the forest cover is located in the southeastern portion of the Project region.

Fires that could affect the Project could result from uncontrolled grass fires, forest fires, burning of brush piles during construction and uncontrolled grass or stubble fires on agricultural lands.

Table 20-2 provides a summary of historic forest fire data for Manitoba. Fire activity is influenced by weather/climate, fuels, ignition agents and human activity (Flannigan *et al.* 2005b). Weather is the most important factor influencing fires because it drives other important parameters such as fuel moisture, soil moisture, lightning ignitions and wind (Flannigan *et al.* 2005b). Area burned is most directly linked to temperature (de Groot *et al.* 2013; Flannigan *et al.* 2005a), which is expected to increase into the future across the PDA. Historical analysis of fire regimes in Manitoba shows a link between drought cycles and area burned (Tardif 2004). Additionally, there is correlation between soil moisture and forest fires (Girardin and Mudelsee 2008). Fires spread rapidly when the available fuel is dry and weather conditions are warm, dry and windy. Over the past 150 years, the fire cycle in parts of Manitoba has lengthened from 55 to 200 years, which raises the risk of a large fire (Tardif 2004; Flannigan *et al.* 2005a). The lengthening of the fire cycle may be related to modern fire suppression strategies, which increases the time between fires but can also increase the risk of large fires (Tardif 2004).

Table 20-2 Manitoba Historic Forest Fire Data (2003 to 2013)

	Number of Fires					Area Burned (ha)				
Year	**Human-caused**	**%**	**Lightning-caused**	**%**	**Total**	**Human-caused**	**%**	**Lightning-caused**	**%**	**Total**
2003	685	56	529	44	1214	89,859	10	828,986	90	918,845
2004	110	47	123	53	233	937	4	25,066	96	26,003
2005	110	44	138	56	248	5,545	8	64,490	92	70,035
2006	266	39	416	61	682	5,907	4	151,486	96	157,393
2007	216	57	166	43	382	5,799	2	311,985	98	317,784
2008	259	65	137	35	396	74,403	49	77,463	51	151,866
2009	117	64	67	36	184	2,132	74	740	26	2,872
2010	273	47	302	53	575	22,853	12	171,549	88	194,402
2011	156	50	159	50	315	26,229	21	100,367	79	126,596
2012	204	41	293	59	497	21,027	10	195,861	90	216,888
2013	192	39	302	61	494	896	1	1,114,519	99	1,115,415

SOURCE: Manitoba Conservation (2013)

20.6.2 Effects Analysis and Mitigation

Fires can negatively affect the Project during construction and operation. During construction, fires can create safety issues for personnel, damage infrastructure and equipment and create delays in the schedule. During operation, a fire can cause damage to structures and interruption of service. Fires can cause damage to steel towers and conductors and if a fire is close enough, emergency shutdowns might be ordered to prevent thermal damage to the line, a line fault caused by smoke or particulate, or to meet the safety needs of firefighters. If the ambient temperature of the air surrounding the conductors rises above the line's operating parameters, it can create outages. Heavy smoke can also cause an outage as a result of a phase-to-phase, or phase-to-ground fault. Ionized air in the smoke can conduct electricity resulting in arcing between lines on a circuit or between a line and the ground.

The Manitoba Hydro Fire Manual (Manitoba Hydro 2009) provides general rules, guidelines and standards for fire prevention and protection. The primary objective is to prevent the loss of life and property resulting from fires. This manual and the Corporate Emergency Response Plan form the basis of a response to uncontrolled grass fires or forest fires. Further detail is provided in Chapter 21– Accidents, Malfunctions and Unplanned Events.

Trees within the ROW will be cleared to a maximum height of approximately 10 cm above the ground. Clearing requirements for the new transmission line ROW will require selective clearing of “danger trees” beyond the ROW (Manitoba Hydro n.d.1). Such trees could potentially affect the function of the transmission line or result in safety concerns, and are normally identified during initial ROW clearing activities and removed. In addition, vegetation management will be required on an ongoing basis to ensure that re-growth in the cleared ROW does not interfere with transmission line operations. Related management procedures extend to periodic review and removal of danger trees in the immediate vicinity of the ROW. Manitoba Hydro is also subject to NERC requirements that stipulate vegetation control be conducted along its ROWs to prevent situations from arising where trees can cause an outage on transmission lines 200 kV or greater or on voltages less than 200 kV that are identified as an element of an Interconnection Reliability Operating Limit.

During Project construction, brush piles will be burned during winter or under a Work Permit issued by Manitoba Conservation and Water Stewardship; they will also be located far enough away from the ROW edge to avoid damaging uncleared vegetation, and where feasible, will be located on mineral and bedrock sites. Fires will be completely extinguished after burning of slash, and burn piles will be monitored to ensure that no hot spots remain.

Manitoba Hydro provides information on safety precautions for planned burning of ditches or stubble on agricultural lands on their corporate website (Manitoba Hydro n.d.2). Recommendations include checking with local municipalities for permits and guidelines, cultivating a fire guard around hydro poles and fields that could be subject to planned burns, carefully considering wind direction and closely monitoring field fires at all times.

20.6.3 Residual Effect Characterization

The effects of fire that may be accidentally started as a result of Project activities is addressed in Chapter 21. As described above, a fire could result in damage to infrastructure and disruptions in service. Further environmental effects could occur if a fire caused damage at a station and resulted in an uncontrolled release of hydrocarbon products (refer to Chapter 21 for an assessment of accidental spills). Burning of equipment or infrastructure could also result in a short-term reduction in air quality in the immediate area. The effects of vegetation and fire hazards on the Project are assessed as not significant.

20.7 Effect of Long-Term Climate Change on the Project

Climate plays an important role in determining most of the effects of the environment on the Project. Consequently, long-term climate change could potentially alter many of these effects. A summary of the Supplemental Study Physical Environment: Historic and Future Climate Study is presented in this section to describe the potential changes in effects of the environment on the Project.

20.7.1 Climate Change Modelling

As described in the Supplemental Study Physical Environment: Historic and Future Climate Study an ensemble of 69 Global Climate Model (GCM) simulations from the Coupled Model Intercomparision Project Phase 5 were used to assess future climate projections in the PDA (Manitoba Hydro 2015). These GCMs were driven by four future representative concentration pathways (RCP), which prescribe different levels of greenhouse gas concentrations ranging from a mitigation scenario (RCP 2.6) to a business as usual scenario (RCP 8.5). The Canadian Regional Climate Model (CRCM 4.2.3) was also used to supplement GCM results. Three future horizons were modelled: 2010–2039 (2020s), 2040–2069 (2050s) and 2070–2099 (2080s). Future climate projections for the Winnipeg area are summarized in Table 20-3.

Table 20-3 Climate Change Modelling Results for Winnipeg Area

Parameter	Variable	Current	2020	Increase	2050	Increase	2080	Increase
Temperature (ºC)	Mean annual temperature	3.0	4.5	1.5	5.9	2.9	7.5	4.1
Precipitation (mm)	Total annual precipitation	521.1	539.3	18.2	543.0	21.9	556.0	34.9
Wind speed (km/h)	Mean annual surface wind speed	17.1	15.9	-1.2	14.7	-2.4	13.5	-3.6

SOURCE: Manitoba Hydro 2015

The overall trend is for increases in temperature and precipitation and a decrease in mean surface wind speed. Winter months are generally projected to experience greater changes in temperature and precipitation than summer months. The largest projected wind speeds occur in summer and are projected to decrease. The projected changes in wind speed in non-summer months are close to zero. There is little agreement on the projected direction of change in monthly wind speed, suggesting that there is considerable uncertainty in future wind speed projections. It is important to note, many sources of uncertainty exist in projecting future climate and should be considered when interpreting these results. Sources of uncertainty include future atmospheric forcing scenarios, GCM structure and internal variability within the GCM.

20.7.2 Projected Changes in Climatic Extremes

A review of the scientific literature was conducted for parameters that are not easily analyzed using readily available climate models data. This review was intended to find the range of possible future scenarios related to extreme climate indices such as freezing precipitation, wind gusts, tornado occurrence, lightning strikes, droughts and forest fires. A summary of the literature is as follows,

20.7.2.1 Freezing Precipitation

Cheng *et al.* (2011) and Lambert and Hansen (2011) project changes in freezing rain over eastern and central Canada. Cheng *et al.* (2011) projects an increase for southern Manitoba with the greatest increase in frequency to occur during December, January and February, a moderate/small increase in November, March and April and potentially no change or a slight decrease in October and May. The greatest increase is projected for the end of the 21st century. On an annual basis, Lambert and Hansen (2011) also projected an increase in freezing rain by the end of the century. It is important to note that the studies are not focused on Manitoba, and that they are based on relatively few GCMs. Manitoba Hydro (2015) concluded that robust conclusions on freezing precipitation should not be drawn from these studies.

20.7.2.2 Wind Gusts

Climate change simulation projects increasing temperature and decreasing pressure, which suggests that frequency and intensity of future wind gusts can be anticipated to increase based on evidence from the historical records (Cheng 2014). Cheng *et al.* (2014) used downscaled daily future wind speeds from GCMs to make projections for future wind gusts regimes over Canada. Southern Manitoba is projected to experience increases in annual mean frequency of gusts of 20–40% for 70 km/h gusts and increases of 100-200% in 90 km/h gusts by the end of the century. The large percentage of increase in the highest speed wind gusts is because of the relative rarity of these events. Increases in severe wind gusts of 20-40% are more likely (Cheng *et al.* 2014; Cheng 2014). Seasonality analysis shows that increase in frequency of wind gusts will be greater in winter than in summer (Cheng *et al.* 2014).

20.7.2.3 Tornado Occurrence

Brooks (2013) and Diffenbaugh *et al.* (2013) indicate that the increase in convectively available potential energy (CAPE) in future climate scenarios may lead to more favourable conditions for severe thunderstorms and tornadoes; however, there still remains a high degree of uncertainty in projections on conditions that favour tornado development. A weather-risk assessment (Teshmont 2006) states that as summer and spring temperatures increase as a result of climate change, there may be an increase in tornado frequency in southern Manitoba. A related weather study on transmission lines states that, despite a low probability of occurrence of tornadoes in Manitoba, there is a higher probability that tornadoes will cross transmission lines because the long tracks of the transmission lines run north–south, whereas tornadoes tend to move west to east (Etkin *et al*. 2001).

20.7.2.4 Lightning Strikes

Climate change projections show that there will be an increase in more explosive storms, with increasing occurrence of convective storms leading to the formation of lightning (Price 2009). A double CO_2 scenario (twice the existing CO_2 concentration in the atmosphere; projected to occur around 2050) shows a 10% increase in lightning for every 1˚C of warming, however this value is highly regionalized (Price 2013). The majority of the increase in lightning is projected to occur in the tropics. The Great Plains region of North America is also projected to experience increasing electrification, with the expectation that intense storms that lead to electrification, and therefore to lightning, will increase (Price 2009). The IPCC's Fifth Assessment Report (AR5) also indicates that heavy precipitation events are very likely to increase in frequency, intensity and amount (IPCC 2013). Lightning interactions with climate change have not been specifically studied in Manitoba.

20.7.2.5 Droughts and Floods

Challenges in determining the frequency, duration and severity of historic and future droughts and floods have been documented in scientific literature (Trenberth *et al.* 2014; Sheffield *et al.* 2012; Dai 2013; IPCC SREX 2012; IPCC 2013). For drought, challenges arise due to differences in event characterization, methodologies for drought detection, complex and unknown atmospheric-land-ocean dynamics, natural climate variability and regional variability. Similar challenges exist in characterizing historic and future floods due to different flood drivers (*e.g.,* snowmelt, precipitation, ice jamming), complex terrain (*e.g.,* non-contributing areas) and anthropogenic interaction (*e.g.,* river diversions, withdrawals and drainage improvements).

Historically, a lack of precipitation has been the root cause of droughts; an abundance has been the root cause of floods. For droughts, Dai (2011) suggested that the rate of drying has become increasingly more important since the 1980s. In addition, changes in available energy, wind speed and humidity affect the rate of evapotranspiration and therefore the rate of which moisture is removed from the surface (Dai 2011; Sheffield *et al.* 2014). So while precipitation is projected to increase on average within the Project region, this does not rule out periods of dryness. Similarly, while winter precipitation is projected to increase on average, warmer temperatures may lead to less snow accumulation, which could result in lower spring melts and lower spring flood peaks (Whitfield 2012).

On a global scale, the IPCC has overall low confidence in observed trends and projections of droughts and floods (IPCC 2013; IPCC SREX 2012). For central North America, the IPCC shows that there is medium confidence that future duration and intensity of droughts will increase (IPCC

SREX 2012). IPCC SREX (2012) also shows that there is medium confidence that floods driven by heavy rainfall could increase into the future in some regions and that earlier spring peak flows are likely in snowmelt fed rivers but there is low confidence on the projected magnitude of change.

20.7.2.6 Forest Fires

Although there is lack of agreement in the literature about future forest fire regimes, historic analyses show that areas burned by forest fires in North America’s boreal forest have been increasing over the past 50 years but are still within long-term historic variability (Bergeron *et al.* 2010). Predictions of forest fires and climate change are highly regionalized (Girardin and Mudelsee 2008). It is therefore difficult to make sweeping generalizations of fire regimes across Canada because of variability in forest distribution and tree composition (Tardif 2004). It is possible to piece together a picture of future forest fire regimes in Manitoba through studies that have been conducted in the area. Historical analysis of fire regimes in Manitoba shows a link between drought cycles and area burned (Tardif 2004). Temperature can be modeled using GCMs (Gillett *et al.* 2004), so links can be established between climate change and forest fire regimes.

Fire severity indices and area burned were shown to increase into the future under global climate change (de Groot et al. 2013). Severity of fire weather is expected to increase across large portions of Canada, and a lengthening of the fire season is predicted by climate change modelling, with the fire season starting earlier in the year (de Groot *et al.* 2013). In southern Manitoba, the ratio of area burned for a $3xCO_2$ scenario (three times the existing CO_2 concentration in the atmosphere) was modelled to be in the range of 1.5–2 (Flannigan *et al.* 2005b), indicating a potential doubling of area burned. Additionally, lightning ignitions of wildfires are expected to increase by 44% because of increased occurrence of cloud-to-ground lightning (Flannigan *et al.* 2005a; Flannigan *et al.* 2005b). Higher greenhouse gas scenarios predict more drought and more wildfires. The highest greenhouse gas scenario will lead to forest fire occurrence in the upper part of the historical range (before fire suppression was commonplace). Moderate greenhouse gas scenarios result in wildfire occurrence which falls within the range of the past 240 years (Girardin 2008).

20.7.3 Effects Analysis and Mitigation

Due to the timing of planned construction, the effects of long-term climate change on construction activities will likely be minor. In general, climate change signals in short-term projections (*i.e.,* pre-2050s) are often masked by natural climate variability and longer term projections show a more prominent climate change signal. Extreme weather events could result in delays in construction, as discussed above, but these events are not expected to be frequent enough to substantially affect the construction schedule.

Load effects on the transmission line due to long-term climate change is not considered specifically in engineering design. If long-term climate change increases the frequency of extreme weather but extremes are below the maximums designed for, climate change will have no effect on the line. If long-term climate change creates extremes beyond the maximums designed for, failure containment will be incorporated into the transmission line to limit the extent of failure. The Reliability Based Design Method will be used for designing the structural components following the CAN/CSA-C22.3 No. 60826-10 “Design Criteria of Overhead Transmission Lines” standard. Climatic design loads will be determined using a 150-year return period and statistical historical weather data.

20.7.4 Residual Effect Characterization

With sound engineering design to account for projected climate change, the residual effect is similar to the effect described for extreme weather events. While extreme weather and climate conditions could result in interruptions in power and economic costs for repair, the residual effect of these scenarios on the Project are assessed as not significant.

20.8 Summary of the Effects of the Environment on the Project

The most likely effect of the environment on the Project is a short-term disruption in service and the economic costs of repair. The Project will be designed to meet CSA standards. Design of the D604I 500 kV AC transmission line will be subject to two general design standards and the structural design loads will be based on a 150-year return period, in accordance with the RBD method. Despite these measures, it is likely that extreme weather events can still result in outages and the requirement for repair of lines, conductors or towers. While this can result in socio-economic effects and potential public safety hazards, potential effects on the biophysical environment would be limited and associated mainly with an increased risk of an accidental release of hydrocarbons at a station in the event of a flood or fire. Accidental releases are addressed in Chapter 21 – Accidents, Malfunctions and Unplanned Events.

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