ATTACHMENT 26

LTWP Preliminary Design Report – Appendix M – Climate Lens Assessment

City of Iqaluit

Climate Lens Assessment

Long Term Water Program – Supply and Storage

Iqaluit, Nunavut

April 2024

Photo of Qikiqtalik Lake

Climate Lens Assessment

Long Term Water Program – Supply and Storage

April 2024

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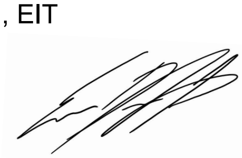

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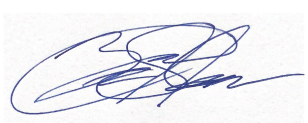

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Statement of Limitations

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Executive Summary

As an emergency measure to augment the over-winter storage requirements for the City, the City of Iqaluit has pumped water from the Niaqunnguk (Apex) River to Lake Geraldine. In 2021, the City also used as Lake Qikiqtalik (also now known as Unnamed Lake (UNL)) for emergency supply. Given the variability of flows within the Niaqunnguk (Apex) River and water-taking license constraints, seasonal pumping from the Niaqunnguk (Apex) River was considered a temporary interim solution until a long-term water supply and storage solution was implemented. A new long term water supply project is under development to replace the interim solution. It will pump water from Lake Qikiqtalik to fill a New Reservoir which will be constructed adjacent to Lake Geraldine, to augment storage in Lake Geraldine.

Lake Qikiqtalik has a larger water catchment basin than Lake Geraldine and has an estimated storage capacity of approximately 5,500,000 m^3 of freshwater. Preliminary studies (by others) on Lake Qikiqtalik have indicated that seasonal pumping from Lake Qikiqtalik is viable to supply Lake Geraldine and the New Reservoir. The planned approach is to begin water pumping in time to take advantage of water available during the Spring freshet followed by continuous pumping for an additional period to fill the new reservoir in preparation for winter. Water pipes would be empty during winter months.

Arcadis is currently completing professional engineering and environmental services for the City's Long Term Water Program Raw Water Supply and Storage (LTWP – Supply and Storage). The project scope includes a new raw water intake and pumping station, water conveyance pipeline and reservoir/dam embankment.

This document is the Climate Lens Assessment, as part of an application for funding under the Investing in Canada Infrastructure Program (ICIP) of Infrastructure Canada (INFC). The climate change impacts described in this report are a direct reflection of the parameters of the Climate Lens and INFC funding requirements and prepared according to the Annex A form provided by the Infrastructure Canada (INFC) Climate Lens Program. This report assesses the climate impacts of infrastructure from both a greenhouse gas and resilience perspective. However, this project is not a GHG mitigation project and is not implementing GHG mitigation measures. Accordingly, the majority of this report aims to consider risks from climate change and increase resilience.

1 Project Overview

Arcadis Canada Inc. (Arcadis) was retained by the City of Iqaluit (City) to prepare a Climate Lens Assessment for the planned Long Term Water Program - Raw Water Supply and Storage Project (LTWP) in Iqaluit, Nunavut (NU). This assessment has been completed in accordance with Infrastructure Canada's Investing in Canada Infrastructure Program (ICIP) Climate Lens Version 2.1[1]. The following sections summarize the required information in Annex A – Climate Lens Form[2].

1.1 Project Title

City of Iqaluit - Long Term Water Program – Supply and Storage

1.2 Ultimate Recipient

The full legal identification of the primary entity that is undertaking the project is:

City of Iqaluit
1085 Mivvik Street, P.O. Box 460
Iqaluit, Nunavut X0A 0H0
Canada
Phone: 867-979-5600

1.3 Project Description: Location, Activities Timeline

The Long Term Water Program (LTWP) consists of developing a permanent water conveyance system from Lake Qikiqtalik to Lake Geraldine, via a New Reservoir, and other associated structural requirements. The primary objectives of the LTWP are to:

- Establish a new long-term water source and the necessary infrastructure to address the City's present and future water demands, ensuring that the water supply system supports economic growth; and,
- Construct a new reservoir to secure sufficient year-round water storage capacity by adding a minimum 1.5-fold increase in the over-winter storage capacity and meeting the current and projected needs of the City.

Location

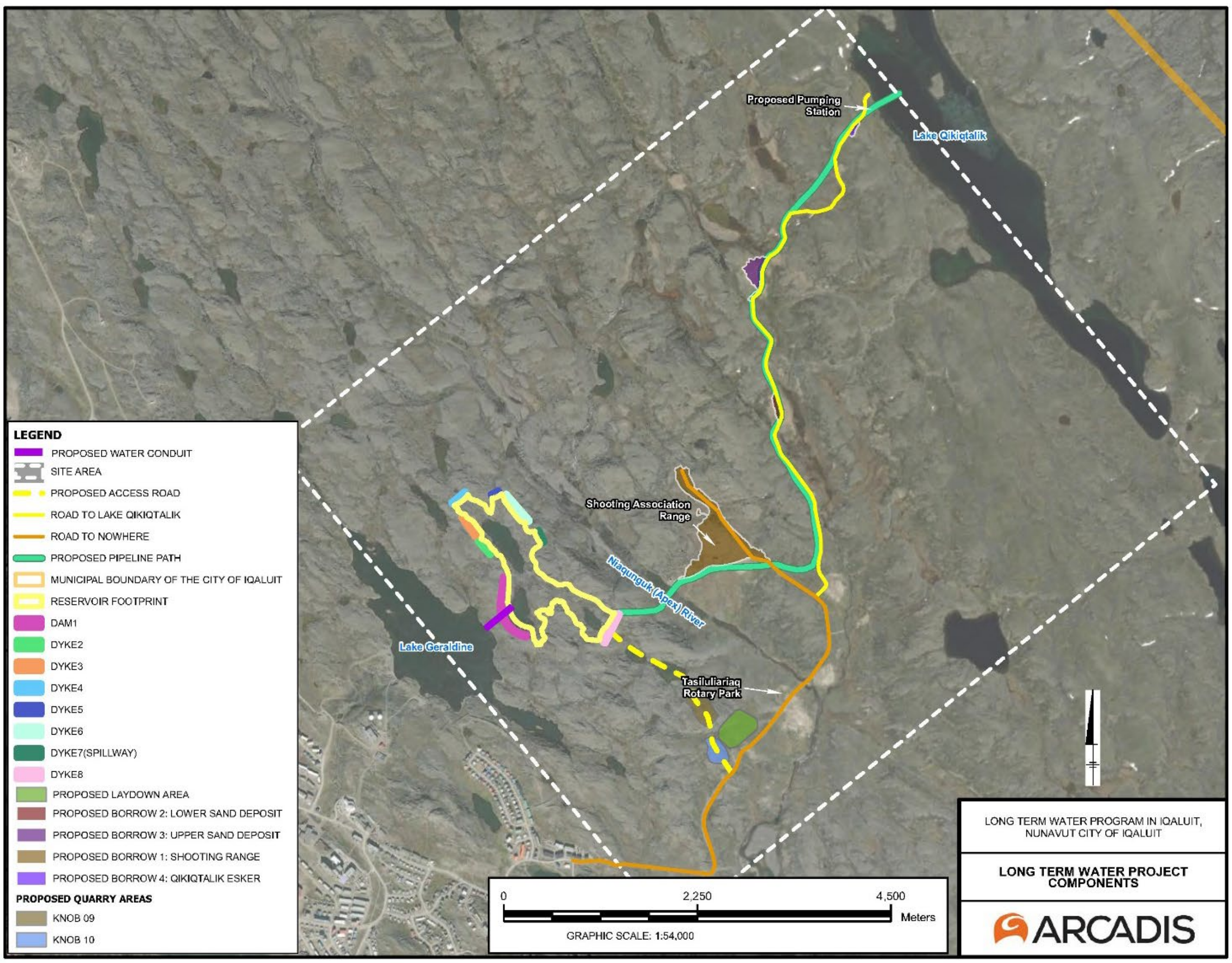
The location of the project is between Iqaluit, the city being serviced, and Qikiqtalik Lake, which is the source being considered to provide additional water to the city.

[1] https://www.infrastructure.gc.ca/alt-format/pdf/other-autre/cl-occ-eng.pdf
[2] https://www.infrastructure.gc.ca/pub/other-autre/cl-occ-eng.html#ANNEX_A

Iqaluit is situated at the southern tip of Baffin Island in Frobisher Bay (63°45'N latitude and 68°31'W longitude). The Site begins approximately 150 m northeast of the developed portion of the City of Iqaluit, is roughly square, and ends at Qikiqtalik Lake approximately 6 km northeast of Iqaluit, with aerial coverage of approximately 1,150 ha. The northeast half of Lake Geraldine is included in the LTWP, as is the southwest half of Qikiqtalik (Unnamed) Lake.

See Figure 1-1 for details.

Figure 1-1 Long-Term Water Project Components



The area is primarily bedrock/permafrost, with sparse vegetation. The terrain comprises rolling hills with rocky outcrops and tundra valleys, with finger lakes oriented northwest-southeast. Niaqunnguk (Apex) River traverses the Site from its northwest boundary to its southern corner. The Site has a tundra climate and is in a zone of continuous permafrost. The surficial soils are often shallow, with some areas having a thin layer of organic material on top of the rocky terrain. The soils are generally poorly drained, as the frozen ground restricts water movement.

The LTWP consists predominantly of undeveloped land used for hunting, foraging, and recreational purposes, including temporary camping, picnicking, and swimming, primarily along the Niaqunnguk River. Two unpaved roads traverse the LTWP.

Access to Iqaluit is facilitated by scheduled commercial flights throughout the year. In winter, snowmobile trails connect the city with other communities on Baffin Island, while in summer, sealift services from the ports of Montreal and Valleyfield in Quebec provide additional transportation options.

Description of Activities

In order to provide a long-term water source to meet Iqaluit's growing drinking water needs, the following components will be developed:

Water Conveyance Pipeline

A permanent water conveyance pipeline will be installed, consisting of a 65 m section of 600 mm diameter pipe, and a 4.2 km section of two parallel 400 mm diameter pipelines. The twin 400 mm diameter pipes will run between Lake Qikiqtalik and the New Reservoir, following the route of existing roads where feasible to minimize disturbance. They will be laid on the existing ground that will be slightly sub-excavated following clearing and grubbing (if applicable), bedded, and covered/backfilled with selected material to construct a berm of soil over the pipes for protection, with approximately 1.0 m layer on top and 750 mm on either side of the twin pipelines.

Pumphouse

A pumphouse will be constructed at Lake Qikiqtalik, which will require ground clearing and levelling, and reinforcement of the existing road to allow heavy construction equipment to pass. It will also necessitate an intake to be constructed at Lake Qikiqtalik, connected to the pumphouse.

New Reservoir

A new reservoir, adjacent to the current water source, Lake Geraldine, will be constructed. This will consist of eight dams and dykes, which will be made of quarries dug nearby. The new reservoir will require dewatering, excavation, blasting, installation of a liner, and flooding (using Lake Qikiqtalik as a water source). This will require a new access road to be built for the machinery. The reservoir will also require the construction of a control building and electrical distribution between the control building and the pumphouse at Lake Qikiqtalik. A conveyance pipeline will be installed between the New Reservoir and Lake Geraldine.

Other

Temporary work camps will need to be constructed, and a temporary concrete plant.

Timeline

The major LTWP timelines are in Table 1-1 below as follows.

Table 1-1 LTWP Timeline

Phase	Start Date- DD/MM/YYYY	End Date- DD/MM/YYYY
Construction	01/11/2025	31/10/2028
Operation	01/11/2028	01/11/2128
Any major maintenance/repairs	N/A	

The construction phase will operate on an annual cycle, to accommodate pauses during the winter months of November to April, when construction will proceed with difficulty, and to ensure environmental protection for sensitive times such as migration / spawning times of local birds, fish, caribou, and vegetation.

Expected Lifetime:

The expected lifetime of the infrastructure is 100 years.

Description of any maintenance, repairs, or refurbishments expected:

Throughout the lifetime of the project, the water conveyance pipeline will be regularly inspected and maintained, and at the decommissioning phase, the pipeline should be recovered and the ground re-levelled.

The pumphouse and its pumping / electrical components will be operated and maintained throughout the lifetime of the project. Water sampling and reporting will also be conducted. At the end of the project's lifetime, the intake structures should be dismantled, and the site equipment reused or disposed of.

The earthen dams surrounding the New Reservoir will be regularly inspected. At the end of the project lifecycle, the reservoir may be drained into Lake Geraldine or the Niaqunnguk (Apex) River. The dams can then be demolished if necessary or retained at the discretion of the City of Iqaluit.

2 GHG EMISSIONS & MITIGATION

2.1 *Is your project a GHG mitigation project OR are you implementing any GHG mitigation measures or best practices, such as clean technologies, renewable energy or LEED standards in the design of your project?*

No. This project does not meet Infrastructure Canada's definition of a GHG mitigation project and is not implementing GHG mitigation measures. A hydroelectric generation project is being considered. If it is included, this assessment will be updated accordingly. Solar energy generation was not deemed effective and cost-effective based on the far-northern location of the project.

2.2 *If your project is a GHG mitigation project or you are implementing GHG mitigation measures, what are the annual GHG emission reductions (tonnes CO2e/year) expected in 2030 from the operation of the project?*

N/A. This project is not a GHG mitigation project and is not implementing GHG mitigation measures.

2.3 *Which international GHG quantification standards or GHG guidance were consulted to understand the GHG impact of the project?*

N/A. This project is not a GHG mitigation project and is not implementing GHG mitigation measures.

3 CLIMATE RESILIENCY

3.1 *Identify all current and projected climate-related hazards given the project's location such as flooding, wildfire risk, permafrost thaw or coastal erosion. Assess high or medium risks (in likelihood and severity) to the project and the services it is to provide over its lifespan.*

The climate in Iqaluit is classified as a tundra climate, characterized by consistently low temperatures throughout the year. According to the Köppen and Geiger classification, this climate is designated as an "ET" polar tundra climate. In Iqaluit, the average temperature is -9.3 °C, with peak temperatures reaching around 8.2 °C in July and dropping to a typical low of -27.5 °C in February (EC 2023). Based on the nature of the infrastructure, the following climate hazards were deemed relevant by the project's Subject Matter Experts and Climate Risk Assessment team:

- Extreme Heat;
- Extreme Cold;
- Extreme Precipitation;
- Short Duration High-Intensity Precipitation;
- Drought;
- Frost Season;
- Frost Free Season;
- Permafrost Depth;
- Freeze Thaw Cycles;
- Wind;
- Tundra Fires.

To assess climate risk, a risk assessment was completed leveraging the PIEVC Level High-Level Screening Guide (HLSG). The steps of the PIEVC High-Level Screening Guide are listed below, and explained in more detail in the relevant sections:

- Determine Climate Hazard Indicators.
- Gather Climate Hazard Indicator Data.
- Determine Likelihood scores for each climate hazard shown on a scale from 1-5 using the PIEVC HLSG "middle baseline method".
- Divide the project into unique groups of infrastructure elements.
- Determine Consequence Scores.
- Determine the Risk Profile.
- Determine mitigation measures which are applicable throughout the lifetime of the project.

Climate Hazards are defined with Climate Hazard Indicator Data, gathered and compiled in Table 1-2. Climate Hazard Indicator projection data is provided for three 30-year periods namely, the Historic Values (ie. the baseline) from 1971-2000, Medium Term projections from 2041-2070 (also referred to as the 2050s) and Long-Term projections from 2071-2100 (also referred to as the 2080s). Definitions of the Climate Hazard Indicators can be found in Appendix A: Definitions of Climate Hazard Indicators.

The table below provides both the actual values of projection data, as well as the percent change. Climate data is based on Shared Socioeconomic Pathway 5-8.5 (SSP 5-8.5) which represents radiative forcing level increase of 8.5 watts per meter squared (W/m2) between 1750 and 2100; this is often referred to as the "worst case scenario" for climate emissions and is the emissions pathway typically used in climate risk assessments in Canada. The data for SSP 2-4.5 was also gathered and can be found in Appendix B: SSP 2-4.5 Data and Likelihood Scores. Climate projection data for SSP 2-4.5 was gathered to disclose any important differences with SSP 5-8.5 that might influence the results of the climate risk assessment. However, the differences between SSP 2-4.5 and SSP 5-8.5 were found to be negligible for the purposes of this high-level assessment and only the climate scenario for SSP 5-8.5 is used in this report.

Likelihood scores for each Climate Hazard are shown on a scale from 1-5 using the PIEVC HLSG "middle baseline method," wherein 3 represents the baseline score for historic climate conditions (1971-2000), scores of 2 and 1 indicate reduced frequency or intensity of climate events over future periods (the 2050s and 2080's), and scores 4 and 5 indicate increased frequency or intensity over the future periods. Each Climate Hazard Indicator is provided an "Interim Score". The indicator interim scores and the confidence in the indicators were used together to establish the overall "Likelihood Score" for each Climate Hazard.

The data sources used for climate projections are indicated. Where data sources were unavailable, proxies were used to establish likelihood scores. For example, no data was available for Permafrost Depths increasing, but Mean Air Temperature was used as a proxy to indicate that permafrost depths are increasing. Projections for the Climate Hazard "Wind" were found to be inconclusive. However, a conservative approach was taken, and the climate risk assessment assumes wind intensity and frequency will increase in likelihood over time. No reliable data could be found regarding the Climate Hazard for "Tundra Fires." However, a conservative approach was taken, and the climate risk assessment assumes the likelihood for Tundra Fires will increase over time.

The Climate Hazards and Indicators considered are shown in Table 1-2 below.

Table 1-2 *SSP5 - 8.5*

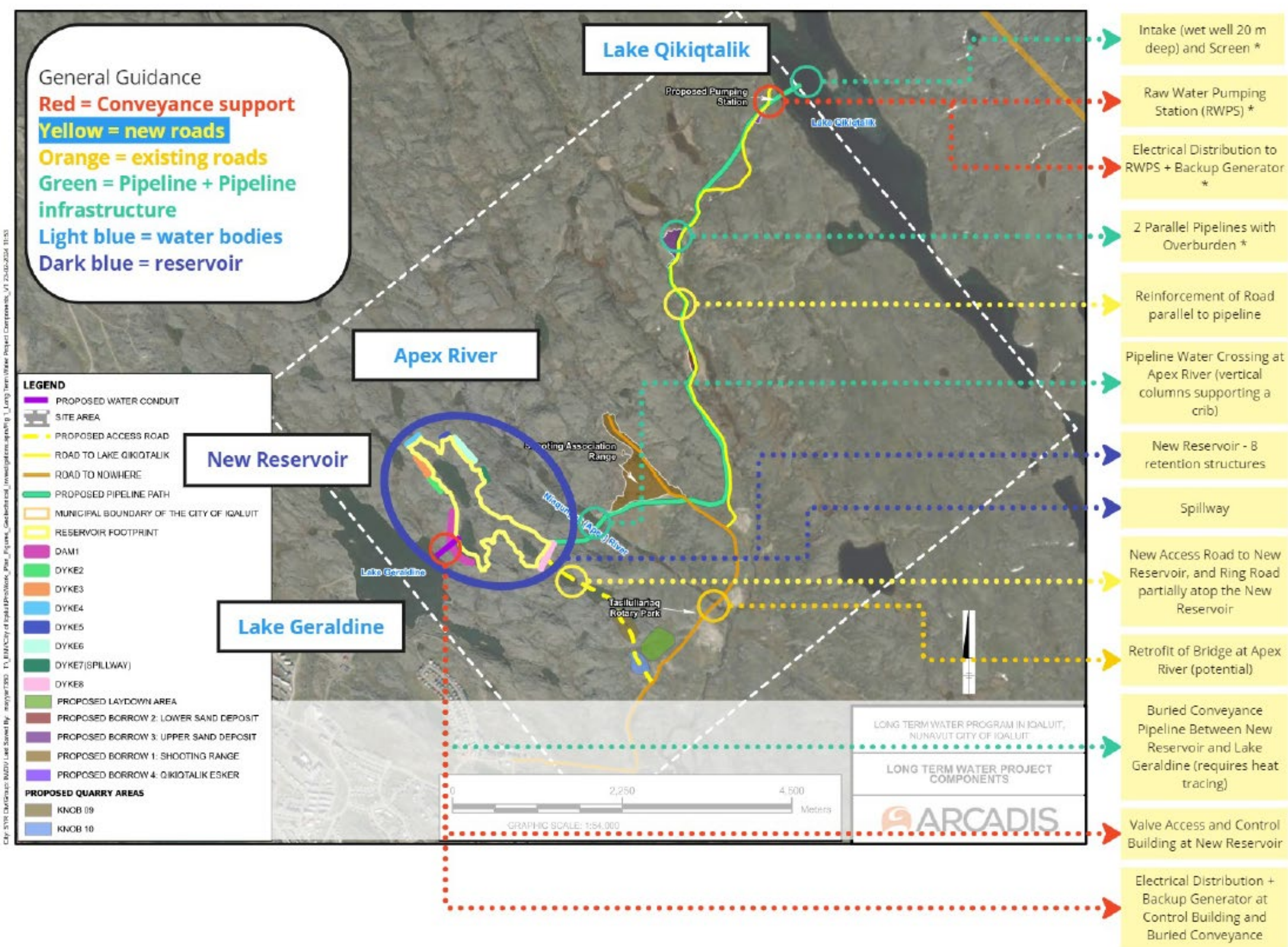
Climate Hazards	Climate Hazard Indicator	Historic value (1971-2000)	Medium-term projection (2041-2070)	% Change	Interim Score	Likelihood Score	Long-term projection (2071-2100)	% Change	Interim Score	Likelihood Score	Data source
Extreme Heat	Hottest day, (degrees C)	19.4	22.9	+18.0%	4	5	25.9	+33.5%	4	5	Climatedata.ca
	Mean temperature (degrees C)	-9.8	-4.3	+56.1%	5		-0.7	+92.8%	5		Climatedata.ca
	Maximum temperature in a day (degrees C)	-6.4	-1.1	+82.8%	5		2.5	139.1%	5		Climatedata.ca
Extreme Cold	Coldest Day (degrees C)	-41.5	-33.6	+19.0%	2	2	-27.3	+34.2%	2	1	Climatedata.ca
	Days Tmin < -25C (days)	100	40	-60%	1		6	-94%	1		Climatedata.ca
	Minimum temperature in a day (degrees C)	-13.2	-7.5	+43.2%	2		-3.8	+71.2%	1		Climatedata.ca
Extreme Precipitation	Max 1 day (mm)	24	29	+20.8%	4	4	32	+33.3%	4	4	Climatedata.ca
	Max 5 days (mm)	43	49	+14.0%	4		55	+27.9%	4		Climatedata.ca
	Total Precipitation (mm)	441	480	+8.8%	3		563	+27.7%	4		Climatedata.ca
	Wet days >10 mm (days)	7 days	9	+28.6%	4		12	+71.4%	5		Climatedata.ca
Short Duration High-	100 year 1-hour storm (mm)	13.5*	19	+40.7%	4	4	24	+77.8%	5	5	Climatedata.ca

Climate Hazards	Climate Hazard Indicator	Historic value (1971-2000)	Medium-term projection (2041-2070)	% Change	Interim Score	Likelihood Score	Long-term projection (2071-2100)	% Change	Interim Score	Likelihood Score	Data source
Intensity Precipitation*	50 year 1 hour storm (mm)	12.2*	17	+39.3%	4		21	+72.1%	5		Climatedata.ca
	25 year 1 hour storm (mm)	11*	15	+36.8%	4		19	+72.7%	5		Climatedata.ca
Drought	# dry periods > 5 days	17	15	-11.8%	3	3	13	-23.5%	2	2	Climatedata.ca
Frost Season	First Fall Frost (time of year)	Aug 29	Sept 26	n/a	2	2	Oct 14	n/a	1	1	Climatedata.ca
	Last Spring Frost (time of year)	June 22	June 3	n/a	2		May 23	n/a	1		Climatedata.ca
	Frost days (days)	274	234	-14.6%	2		202	-26.3%	1		Climatedata.ca
	Ice days (days)	221	187	-15.4%	2		159	-28.0%	1		Climatedata.ca
Frost Free Season	Frost Free Season (days)	67 days	116	+73.1%	5	5	142	+111.9%	5	5	Climatedata.ca
Permafrost Depth	Mean Air Temperature as Proxy	3				4				5	Climatedata.ca
Wind	Wind Gusts	3				4				4	Literature review
Freeze-Thaw Cycles	FT Cycles (days)	39 days	35	-10.3%		3	33	-15.4%		2	Climatedata.ca
Tundra Fires	Tundra Fires	3				4				4	SME advice

*For short-duration high-intensity precipitation, the historical value is based on a range of 1976-2005, as opposed to 1971-2000.

Next, the project was divided into 13 infrastructure elements. The elements are generally ordered from Lake Qikiqtalik to Lake Geraldine via the New Reservoir. This list only includes permanent infrastructure/retrofits, and not temporary elements such as work camps, as those will not need to be designed for resiliency in the same extended time frame as the permanent elements. They can be seen in the figure below.

Figure 1-2 Infrastructure Elements



Consequence scores were assessed in a PIEVC High-Level Screening Guide (HLSG) spreadsheet during a climate risk assessment workshop. Each score represents the vulnerability and expected consequences from each interaction with each Climate Hazard. The climate risk assessment workshop was facilitated by an Infrastructure Resilience Professional (IRP) trained and practiced in PIEVC climate risk assessment methodologies and general civil infrastructure. Workshop participants included five Subject Matter Experts (SMEs) in engineering fields for geotechnical engineering, water conveyance, pipeline design, water intake and pumphouse design, and environment and permitting. Consequence scores were assigned on a scale from 1-5. The consequence scores can also be seen in Table 1-3 below.

- 3 Is the middle score and represents a "Moderate" consequence score, wherein the infrastructure is assumed to be designed to historical industry standards and factors of safety that are resilient to historic climate events (the baseline), and where consequences in a historic extreme climate event are expected to be within normal design tolerances, incurring normal wear and tear and maintenance expectations.

- 4 Represents a “High” consequence score, wherein historic design standards are met but a historic extreme event could cross a design threshold and cause higher levels of consequence.
- 5 Represents a “Very High” consequence score, wherein historic design standards are met but a historic extreme event could result in catastrophic failure or loss of service.
- 2 represents a “Low” consequence score, wherein historic design standards are met but a historic extreme could cause low levels of consequence.
- 1 represents a “Very Low” consequence score, wherein historic design standards are met and a historic extreme event has almost no impact or consequences, and
- No consequence score in the table below indicates that SMEs assessed that the infrastructure element was not sufficiently Exposed to the Climate Hazard to warrant scoring.

Table 1-3 Elements and Consequences Scores

	Element	Extreme Heat	Extreme Cold	Extreme Precipitation	Short Duration High-Intensity Precipitation	Drought	Frost Season	Frost Free Season	Permafrost Depth	Wind	Freeze-Thaw Cycles	Tundra Fires
1	Intake (wet well 20 m deep) and Screen at the Bottom of Lake Qikiqtalik	1	1	1	1	1			1		1	
2	Raw Water Pumping Station (RWPS)	1	1	1	1				1	3	1	
3	Electrical Distribution to RWPS + Backup Generator	1	1	1	1					3	3	3
4	2 Parallel Pipelines with Overburden	3	3	3	3	1	1	1	3	3	1	1
5	Reinforcement of the Road parallel to the pipeline			3	3				3	1	3	
6	Pipeline Water Crossing at Niaqunnguk (Apex) River (vertical columns supporting a crib)	3	3	1	1		1	1		3	3	
7	Retrofit of Bridge at Niaqunnguk (Apex) River	3	3	2	2		1	1		1	3	
8	New Reservoir - 8 retention structures (dams, dykes, berm)		3	2	2		3	1	2	3	3	
9	Spillway		3	2	2		3	1		3	3	
10	New Access Road to New Reservoir, and Ring Road partially atop the New Reservoir			3	3				2	1	3	
11	Valve Access and Control Building at New Reservoir	1	3	1	1				2	3		1
12	Buried Conveyance Pipeline Between New Reservoir and Lake Geraldine (requires heat tracing)		1						3		3	
13	Electrical Distribution + Backup Generator at Control Building and Buried Conveyance Pipeline	1	1	1	1					3	3	3

The consequence scores (Table 1-3) were combined with the likelihood scores (Table 1-2) to determine the overall risk scores shown in Table 1-4 below. Risk was calculated as Risk = Likelihood (scored 1-5) X Consequence (scored 1-5). Based on the PIEVC HLSG guidelines, risk scores are classified as Low (risk scores 1-9), Medium (risk scores 10-16), and High risk (risk scores 17-25).

Table 1-4 combines the scores in Table 1-2 and Table 1-3 and shows all element/hazard interactions with Medium risk scores. Element/hazard interactions scored as Low risk were not assessed further and are not shown in

Table 1-4 . None of the element/hazard interactions resulted in a High-risk score in any period between the baseline and the end of the century.

Risk scores in Table 1-4 are indicated for each 30-year time-period namely Historic (ie. the baseline) from 1971-2000, Medium Term projections from 2041-2070 (the 2050s), and Long Term projections from 2071-2100 (2080's). For example, the risk scores for the element "2 Parallel Pipelines with Overburden" interacting with the climate hazard, "Extreme Heat" results in a Risk score of 9 historically, 15 in the 2050s and 15 in the 2080s (indicated in the table as 9-15-15).

The table also includes the "Justification" for the risk scores, which reflects the opinions and judgments of the Subject Matter Experts (SMEs) in the climate risk assessment workshop.

Table 1-4 Hazard Interactions Risk Score of 10 or Higher in any period

Element	Climate Parameter	Risk Scores for Baseline-2050s-2080s	Justification
Raw Water Pumping Station (RWPS)	Wind	9-12-12	This building will be above ground and exposed to wind. Extreme wind can cause damage to the station.
			Additional notes: *Permafrost has little impact because the building will be anchored in rock, not permafrost.* *Tundra fires have little impact because it is not built on peat bog but on rock.*
Electrical Distribution to RWPS + Backup Generator	Wind	9-12-12	Wind (especially in combination with freezing precipitation) can blow down power poles and cause distribution line failure which would cut power to the RWPS.
	Tundra Fires	9-12-15	Power poles will be partially built on areas of thick bog which are susceptible to tundra fires and could cause distribution line failure which would cut off power to the RWPS.
			Additional notes: *Precipitation has little impact because the equipment will be on equipment pads. Drainage is being considered to mitigate precipitation risks.*
2 Parallel Pipelines with Overburden	Extreme Heat	9-15-15	Expansion and contraction due to temperature changes could cause the pipe to shift out of its anchoring. This could cause exposure, leaks, cracks, and general damage.

Element	Climate Parameter	Risk Scores for Baseline-2050s-2080s	Justification
	Extreme Precipitation	9-12-12	The overburden is susceptible to erosion from rain which would increase the chance of damage to the pipe. Flotation could be a concern if an extreme rain event caused flooding in lower elevation spots, and if the pipe was empty. This would cause shifting and expose the pipe to damage.
	Short Duration High-Intensity Precipitation	9-12-15	See the justification for Extreme Precipitation.
	Permafrost Depth	9-12-15	There is an area of the pipe that is susceptible to movement as a result of the permafrost freezing and thawing, causing the ground to move up and down. This could cause exposure and damage. However, as the depth of the permafrost is projected to increase, the risk of permafrost interacting with the pipes decreases.
	Wind	9-12-12	The overburden is susceptible to erosion from wind which would increase the chance of damage to the pipe.
			Additional notes: *Drought could cause drying out of the overburden which could cause destabilization, but this was considered low risk because the design primarily has free-draining material, and therefore does not have a high saturation profile. Furthermore, most of the water will be maintained by capillary action.*
Reinforcement of the Road parallel to the pipeline	Extreme Precipitation	9-12-12	The road is susceptible to erosion by rain, which would cause the road to be damaged or unusable.
	Short Duration High-Intensity Precipitation	9-12-15	See justification for Extreme Precipitation.
	Permafrost Depth	9-12-15	The existing road has isolated soft zones where the permafrost is sometimes at the surface and sometimes much deeper, which if not accounted for could cause the road's foundation to fail.
Pipeline Water Crossing at Niaqunnguk (Apex) River (vertical	Extreme Heat	9-15-15	The expansion and contraction due to temperature changes could cause the water crossing to bend, causing damage to the crossing structure or the pipeline it carries.

Element	Climate Parameter	Risk Scores for Baseline-2050s-2080s	Justification
columns supporting a crib)	Wind	9-12-12	Extreme wind could knock over or displace the water crossing, causing damage to the water crossing or the pipeline it carries.
Retrofit of Bridge at Niaqunnguk (Apex) River	Extreme Heat	9-15-15	Expansion and contraction due to temperature changes could cause premature deterioration of the bridge.
	Short Duration High-Intensity Precipitation	6-8-10	Intense precipitation could cause flooding/ponding, and premature damage to the bridge.
New Reservoir - 8 retention structures (dams, dykes, berm)	Extreme Cold	9-6-3	Despite its low-risk score, this risk has been included due to its unique nature. Ice sheets can ram up against the water side of the dams. This could result in physical damage. The primary concern is water level fluctuations within the reservoir which will be dropping through the winter, exposing the face to freezing which could result in thermal impacts on the liner.
	Short Duration High-Intensity Precipitation	6-8-10	Extreme precipitation can cause erosion which can weaken the dam. Increased precipitation events could result in leaching from potential acid-generating rock (PAG) if PAG rock is present.
	Permafrost Depth	6-8-10	In general, permafrost zones could cause the ground to shift and reduce the stability of the dams. However, current site conditions are such that ice-poor permafrost is present, thus reducing this risk. As depth to the permafrost layer increases the risk to the 8 retention structures decreases.
	Wind	9-12-12	Wind can cause erosion to the dam. Wind can also cause ice sheets to hit the dam and cause damage.
Spillway	Short Duration High-Intensity Precipitation	6-8-10	Extreme precipitation (coupled with wind events) can cause the overtopping of dykes and dams, resulting in their erosion. This can also cause damage to the spillway.
	Wind	9-12-12	Extreme wind events at times when the dam is full could cause overtopping of dykes and dams, resulting in their erosion. This can also cause damage to the spillway.

Element	Climate Parameter	Risk Scores for Baseline-2050s-2080s	Justification
New Access Road to New Reservoir, and Ring Road partially atop the New Reservoir	Extreme Precipitation	9-12-12	Extreme precipitation can cause erosion and degradation of the road rendering it impassable. If the dam overflows and water flows over the spillway, this may damage the section of the road that passes over the spillway.
	Short Duration High-Intensity Precipitation	9-12-15	See justification for Extreme Precipitation.
	Permafrost Depth	6-8-10	There is some risk with permafrost depth changes to the road structure integrity because it is partially built atop permafrost.
			Additional notes: *Wind is not a concern because though parts of the road are elevated i.e. above the dam, the road is being built out of blast rock.*
Valve Access and Control Building at New Reservoir	Permafrost Depth	6-8-10	Parts of the building may come into contact with the permafrost. The exact extent of the impact is as yet unknown because the New Reservoir will cause the talik under Lake Geraldine to expand, which may cause the building’s footprint to be completely free of permafrost year-round.
	Wind	9-12-12	This building will be above ground and exposed to wind. Extreme wind can cause damage to the station.
Buried Conveyance Pipeline Between New Reservoir and Lake Geraldine (requires heat tracing)	Permafrost Depth	9-12-15	At the time of construction, there will be no local permafrost at the pipeline location. However, after the construction of the adjacent dam, the permafrost may rise and impact the conveyance pipeline.
Electrical Distribution + Backup Generator at Control Building and Buried Conveyance Pipeline	Wind	9-12-12	Wind (especially in combination with freezing precipitation) can blow down power poles and cause distribution line failure which would cut power to the control building.
	Tundra Fires	9-12-15	Power poles will be partially built on areas of thick bog which are susceptible to tundra fires and could cause distribution line failure which would cut power to the control building.

3.2 *Describe all of the risk mitigation measures that will be taken to improve the climate resiliency of your project.*

Table 1-5 below aligns with Table 1-4 above and describes the risk mitigation measures associated with each element at medium risk (no elements were found to be at high risk). These risk mitigation measures were developed by the climate risk assessment team and validated in a meeting with the SMEs from the climate risk assessment workshop.

Table 1-5 Elements, Climate Parameters and Mitigation

Element	Climate Parameter	Mitigation
Raw Water Pumping Station (RWPS)	Wind	The building will be designed to have appropriate structural integrity according to the National Building Code of Canada. Although scientific research regarding changes to wind frequency and intensity are inconclusive, building designers should consider the structural sensitivity to increased wind loads and if warranted consider adjusting design parameters such as a factor of safety or other wind load design calculations.
Electrical Distribution to RWPS + Backup Generator	Wind	Electrical Provider to design with electrical code standards with consideration for wind combined with freezing rain. Although scientific research regarding changes to wind frequency and intensity are inconclusive, electrical distribution designers should consider the structural sensitivity to increased wind loads and freezing rain, and if warranted consider adjusting design parameters such as factor of safety or other wind load design calculations.
	Tundra Fires	Power poles vulnerable to tundra fire may be designed and built with corrugated steel bases filled with sand to act as firebreaks. Other alternatives and best practices to mitigate the risk from tundra fires may be considered.
2 Parallel Pipelines with Overburden	Extreme Heat	Anchor blocks will be included to hold the pipe in place to counter the effects of expansion and contraction due to temperature changes. The design also incorporates the placement of a berm of soil over the pipes which moderates temperature and mitigates Ultraviolet degradation to the pipe.
	Extreme Precipitation	The berm of soil over the pipes will be armoured with blast rock to prevent erosion from extreme precipitation. Culverts will be placed under the pipe to mitigate damming of water and flooding, which could otherwise potentially cause pipe flotation if the pipes are empty at the time of a flood. Regular inspections will serve to inform periodic maintenance and mitigate risks from the long-term effects of erosion on the berm.

Element	Climate Parameter	Mitigation
	Short Duration High-Intensity Precipitation	See mitigation from Extreme Precipitation.
	Permafrost Depth	The organic mat under the pipes will be stripped away and the pipes will be found on shot rock. Thermal characteristics between the pipe interactions with permafrost will be accounted for in the design process for long-term stability based on the assumption of depths to the permafrost layer increasing over time.
	Wind	The berm over pipes will be surfaced with shot rock to mitigate wind erosion.
Reinforcement of the Road parallel to the pipeline	Extreme Precipitation	The road will be designed to manage precipitation loads. Road design criteria involving climate variables such as for rain intensity, duration, and frequency (IDF) will consider projected changes to the end of the century (ie. climate change-adjusted IDF curves for drainage design).
	Short Duration High-Intensity Precipitation	See mitigation from Extreme Precipitation.
	Permafrost Depth	Road design best practices for permafrost will be applied. Additional aggregate will be added in permafrost-sensitive areas to insulate the permafrost and mitigate the rate of permafrost melting.
Pipeline Water Crossing at Niaqunnguk (Apex) River (vertical columns supporting a crib)	Extreme Heat	The pipeline will be designed by heat parameters projected to the end of the century.
	Wind	The water crossing will be designed for wind loads. Although scientific research regarding changes to wind frequency and intensity are inconclusive, structural designers should consider the structural sensitivity to increased wind loads and if warranted consider adjusting design parameters such as a factor of safety or other wind load design calculations.
Retrofit of Bridge at Niaqunnguk (Apex) River	Extreme Heat	The bridge will be designed by heat parameters projected to the end of the century.

Element	Climate Parameter	Mitigation
	Short Duration High-Intensity Precipitation	Bridge design will account for high water. High water calculations shall consider precipitation parameters projected to the end of the century.
New Reservoir - 8 retention structures (dams, dykes, berm)	Extreme Cold	The dams will be designed to withstand ice sheets and waterside exposure to freezing temperatures as water is drained from the lake for consumption.
	Short Duration High-Intensity Precipitation	The dam will be designed for a Probably Maximum Flood scenario, which accounts for projections beyond the end of the century (greater than a 1 in 1000 year storm), due the high impact the dam's failure would have given its proximity to a city. Potential Acid Generating (PAG) rock will not be used in the construction of the dams.
	Permafrost Depth	All overburden will be stripped from beneath the footprint of the dams and dykes, allowing the dams to be founded on bedrock. Thermal monitoring will be conducted within the dams to assess the variability of the permafrost layer.
	Wind	The dams will be designed with industry best practices to withstand ice sheet movements.
Spillway	Short Duration High-Intensity Precipitation	The spillway will be designed to account for precipitation conditions as required by the Canadian Dam Guidance documentation. Calculations shall consider precipitation parameters projected to the end of the century.
	Wind	The spillway will be designed to account for wind conditions as required by the Canadian Dam Guidance documentation. Although scientific research regarding changes to wind frequency and intensity are inconclusive, spillway designers should consider the sensitivity to increased wind loads and if warranted consider adjusting design parameters such as a factor of safety or other wind load design calculations.
New Access Road to New Reservoir, and Ring Road partially atop the New Reservoir	Extreme Precipitation	The road and associated dam spillway will be designed to manage precipitation loads. Design criteria involving climate variables such as for rain intensity, duration, and frequency (IDF) will consider projected changes to the end of the century (ie. climate change-adjusted IDF curves for drainage design).
	Short Duration High-Intensity Precipitation	See mitigation from Extreme Precipitation.

Element	Climate Parameter	Mitigation
	Permafrost Depth	Road design best practices for permafrost will be applied. Additional aggregate will be added in permafrost-sensitive areas to insulate the permafrost and mitigate the rate of permafrost melting.
Valve Access and Control Building at New Reservoir	Permafrost Depth	The building will be designed to withstand thermal impacts due to permafrost.
	Wind	The building will be designed to have appropriate structural integrity according to the National Building Code of Canada. Although scientific research regarding changes to wind frequency and intensity are inconclusive, building designers should consider the structural sensitivity to increased wind loads and if warranted consider adjusting design parameters such as a factor of safety or other wind load design calculations.
Conveyance Pipeline Between New Reservoir and Lake Geraldine (requires heat tracing)	Permafrost Depth	The pipeline will be designed to mitigate thermal impacts from permafrost.
Electrical Distribution + Backup Generator at Control Building and Buried Conveyance Pipeline	Wind	Electrical Provider to design in accordance with electrical code standards with consideration for wind combined with freezing rain. Although scientific research regarding changes to wind frequency and intensity are inconclusive, electrical distribution designers should consider the structural sensitivity to increased wind loads and freezing rain, and if warranted consider adjusting design parameters such as factor of safety or other wind load design calculations.
	Tundra Fires	Power poles vulnerable to tundra fire may be designed and built with corrugated steel bases filled with sand to act as firebreaks. Other alternatives and best practices to mitigate the risk from tundra fires may be considered.

3.3 *Please list all of the climate change data and tools that were used to determine the risks to your project.*

Climatedata.ca was used to gather the climate data. The dataset from CMIP6 was used for the SSP5 – 8.5 and SSP2 – 4.5 scenarios. The tool used for the climate risk assessment with the PIEVC High Level Screening Guide.

4 CLIMATE OBJECTIVES

4.1 *Does your community/municipality have a Climate Action Plan and if yes, does your project align with this plan?*

The City of Iqaluit has a "**Strategic Plan Update (June 10th, 2019)**," which emphasizes issues related to climate change, sustainability, and resilience.

The 2019 revision of the strategic plan lists 5 main goals:

1. Enhance good governance,
2. Build sustainable infrastructure,
3. Become an employer of choice,
4. Serve our residents with excellence, and
5. Become an Arctic leader in sustainable economic development.

This project, to provide a reliable source of drinking water to meet Iqaluit's developing needs, is directly aligned with goal 2, and many of the objectives and actions within goal 2, such as:

- Plan future infrastructure taking into account population growth, climate change and environmental considerations, and existing infrastructure.
- Implement a drinking water management plan.
- Establish a 5-year capital plan based on an integrated approach involving planning, finance, engineering and operations to effectively manage existing assets and plan future projects. The plan should incorporate: – Water and wastewater.
- Develop a long-term supplementary water source, and
- Revise the General Plan to include climate change provisions, and develop resiliency plans for changing permafrost conditions, and natural and man-made hazards. Plan infrastructure accordingly.

This project will contribute to meeting drinking water needs and enhance Iqaluit's resilience and quality of life. Designing the project with climate change in mind aligns with the goals to plan infrastructure according to the challenges of the future, as well as the challenges of today.

In addition to the City of Iqaluit's Strategic Plan (2019), the "**City's By-Law #898, General, Plan By-Law (2020)"** stipulates the following:

- The City of Iqaluit will develop mechanisms to study and monitor the impacts of climate change.
    - It will work with the community to obtain and share this information and build the knowledge base and adaptive capacity of the community.
- The City of Iqaluit will take a precautionary approach to development by incorporating the best current knowledge on climate change impacts into its decision-making.

    - By creating a monitoring system, the City will increase its knowledge base and develop policies that build the adaptive capacity of the community.

By undertaking this climate risk assessment and report, the project is in alignment with the City's by-law with the following direct comparison to the by-law stipulations noted above:

- The City of Iqaluit can consider the climate report one of the mechanisms to study the impacts of climate change.
    - The information in this report can be shared with the community to build the knowledge base and adaptive capacity of the community.
- The City of Iqaluit will receive this report as part of a precautionary approach to development by incorporating current knowledge on climate change impacts into its decision-making.
    - This report will serve the City to increase its knowledge base to help build the adaptive capacity of the community.

A third form of climate action plan for the City of Iqaluit is the "**Sustainable Community Plan (2014-2019)**." This Climate Lens Report is in alignment with the City's Sustainability Community Plan actions, goals, and initiatives as identified in the following excerpts from the City's plan:

- The Sustainable Community Plan looks ahead 50 years to what we want our community to be.
- Iqaluit's climate is changing, and with these changes come many impacts for our community; we must consider climate change in our future planning.
- Climate change has the potential to impact Iqaluit in several areas including buildings, roads, water supply, wastewater treatment and waste disposal.
- Our future planning would be incomplete without taking into account climate change projections.
- Understanding climate change is important for Iqalummiut because it will affect and impact us throughout our lives, our family's lives, and the lives of our future generations.
- Learning about and understanding climate change in Iqaluit is the first step to taking action.
- The next step contains two ways we can prepare for and respond to climate change: 1) Reduce further climate change by taking mitigation actions that reduce greenhouse gas emissions or increase the earth's ability to absorb these emissions naturally, and 2) Plan for changes by taking adaptation actions to prepare for expected changes in the climate.

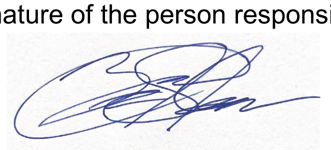
5 ATTESTATION

I, the undersigned, as authorized by my organization, confirm the statements above are true and accurate, and attest that:

- Opportunities to quantify and minimize GHG emissions during the construction and operation of the project will be considered in the planning, design and development/ implementation of this project to the extent possible;
- And, climate change risks and adaptation and resiliency measures will be considered in the siting/location, design/build, and planned operation and maintenance of this project to the extent possible and reflecting the project's cost, criticality and vulnerability.

Infrastructure Canada may follow up on the results of the Climate Lens to confirm the required information or to request further details. Consequently, information used to complete the Climate Lens will be retained.

Signature of the person responsible for completing the Climate Lens:



[April 23, 2024]

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Appendix A

Definitions of Climate Hazard Indicators

Appendix A: Definitions of Climate Hazard Indicators

Table A-1 Definitions of Climate Hazard Indicators

Climate Hazard Indicator	Definition
Hottest day, (degrees C)	The Hottest Day describes the warmest daytime temperature in the selected period. In general, the hottest day of the year occurs during the summer months.
Mean temperature (degrees C)	Mean temperature describes the average temperature for the 24-hour day.
Maximum temperature (degrees C)	Maximum temperature describes the warmest temperature of the 24-hour day. Typically, but not always, the maximum temperatures occur during the day and so this variable is commonly referred to as the daytime high.
Coldest Day (degrees C)	The Coldest Day describes the lowest nighttime temperature in the selected period. In general, the coldest day of the year occurs during the winter months.
Days T<-25C (days)	Days with Tmin <-25°C describes the number of days where the lowest temperature of the day is colder than -25°C. This index indicates the number of extremely cold days in the selected period.
Minimum temperature (degrees C)	Minimum temperature describes the coldest temperature of the 24-hour day. Typically, but not always, the minimum temperature occurs at night and so this variable is commonly referred to as the nighttime low.
Max 1 day (mm)	Maximum 1-Day Total Precipitation describes the largest amount of precipitation (rain and snow combined) that falls within a single 24-hour day for the selected period. This index is commonly referred to as the wettest day of the year.
Max 5 days (mm)	Maximum 5-day Precipitation describes the largest amount of precipitation (rain and snow combined) to fall over 5 consecutive days.
Total Precipitation (mm)	Total Precipitation describes the total amount of precipitation (rain and snow combined) that falls within the selected period.
Wet days >10 mm (days)	Wet Days >=10mm describes the number of days where at least 10 mm of precipitation (rain and snow combined) falls in the selected period.
100-year 1 hour storm (mm)	Maximum 1-hour precipitation based on a 100-year return period.

Climate Hazard Indicator	Definition
50-year 1 hour storm (mm)	Maximum 1-hour precipitation based on a 50-year return period.
25-year 1 hour storm (mm)	Maximum 1-hour precipitation based on a 25-year return period.
# dry periods > 5 days	The Number of Periods with more than 5 Consecutive Dry Days describes the number of times when daily precipitation totals are less than 1mm a day for six or more days straight.
First Fall Frost (time of year)	The First Fall Frost marks the approximate end of the growing season for frost-sensitive crops and plants. When the lowest temperature of the day is colder than 0°C for one consecutive day (after July 15th) the date of the first fall frost is established.
Last Spring Frost (time of year)	The Last Spring Frost marks the approximate beginning of the growing season for frost-sensitive crops and plants. When the lowest temperature of the day remains above 0°C for one consecutive day (before July 15th) the date of the last spring frost is established.
Frost days (days)	Frost Days describes the number of days where the coldest temperature of the day is lower than 0°C.
Ice days (days)	Ice Days describe the number of days where the warmest temperature of the day is not above 0°C.
Frost Free Season (days)	The Frost Free Season is the approximate length of the growing season during which there are no freezing temperatures to kill or damage frost-sensitive plants. This index describes the number of days between the Last Spring Frost and the First Fall Frost.
FT Cycles (days)	This is a simple count of the days when the air temperature fluctuates between freezing and non-freezing temperatures on the same day. Freeze-thaw cycles can have major impacts on infrastructure. Water expands when it freezes, so the freezing, melting and re-freezing of water can, over time, cause significant damage to roads, sidewalks, and other outdoor structures.
Tundra Fires	This refers to instances of fires that can occur in tundra climates, where the peat bog burns. This can have major impacts on infrastructure that is sensitive to fire.

Appendix B

SSP 2-4.5 Data and Likelihood Scores

Appendix B: SSP 2-4.5 Data and Likelihood Scores

Table B-1 SSP 2 - 4.5

Climate Hazards	Climate Hazard Indicator	Historic value (1971-2000)	Medium-term forecast (2041-2070)	% Change	Interim Score	Likelihood Score	Long term forecast (2071-2100)	% change	Interim Score	Likelihood Score	Data source
Extreme Heat	Hottest day, (degrees C)	19.4	22	+13.4%	4	5	23.3	+20.1%	4	5	Climatedata.ca
	Mean temperature (degrees C)	-9.8	-5.4	+44.9%	4		-4.2	+57.1%	5		Climatedata.ca
	Maximum temperature (degrees C)	-6.4	-2.2	+65.6%	5		-1.1	+82.8%	5		Climatedata.ca
Extreme Cold	Coldest Day (degrees C)	-41.5	-35.4	+14.7%	2	2	-33.3	+19.8%	2	1	Climatedata.ca
	Days T<-25C (days)	100	53	-47%	2		34	-66%	1		Climatedata.ca
	Minimum temperature (degrees C)	-13.2	-8.7	+34.1%	2		-7.3	+44.7%	2		Climatedata.ca
Extreme Precipitation	Max 1 day (mm)	24	27	+12.5%	4	3	29	+20.8%	4	4	Climatedata.ca
	Max 5 days (mm)	43	46	+7.0%	3		49	+14.0%	4		Climatedata.ca

Climate Hazards	Climate Hazard Indicator	Historic value (1971-2000)	Medium-term forecast (2041-2070)	% Change	Interim Score	Likelihood Score	Long term forecast (2071-2100)	% change	Interim Score	Likelihood Score	Data source
	Total Precipitation (mm)	441	445	+0.9%	3		482	+9.3%	3		Climatedata.ca
	Wet days >10 mm (days)	7 days	8	+14.3%	4		9	+28.6%	4		Climatedata.ca
Short Duration High-Intensity Precipitation*	100-year 1 hour storm (mm)	13.5	17	+25.9%	4	4	19	+40.7%	4	4	Climatedata.ca
	50-year 1 hour storm (mm)	12.2	16	+31.1%	4		17	+39.3%	4		Climatedata.ca
	25-year 1 hour storm (mm)	11	14	+27.3%	4		16	+45.5%	4		Climatedata.ca
Drought	# dry periods > 5 days	17	15	-11.8%	3	3	14	-17.6%	2	2	Climatedata.ca
Frost Season	First Fall Frost (time of year)	Aug 29	Sept 23	n/a	2	2	Sept 28	n/a	2	2	Climatedata.ca

Climate Hazards	Climate Hazard Indicator	Historic value (1971-2000)	Medium-term forecast (2041-2070)	% Change	Interim Score	Likelihood Score	Long term forecast (2071-2100)	% change	Interim Score	Likelihood Score	Data source
	Last Spring Frost (time of year)	June 22	June 8	n/a	2		June 3	n/a	2		Climatedata.ca
	Frost days (days)	274	240	-12.4%	2		233	-15.0%	2		Climatedata.ca
	Ice days (days)	221	193	-12.7%	2		185	-16.3%	2		Climatedata.ca
Frost Free Season	Frost Free Season (days)	67 days	111	+65.7%	5	5	118	76.1%	5	5	Climatedata.ca
Permafrost Depth	Mean Air Temperature as Proxy	3				4				5	Climatedata.ca
Wind	Wind Gusts	3				4				4	Literature Review
Freeze-Thaw Cycles	FT Cycles (days)	39 days	35	-10.3%		3	33	-15.4%		2	Climatedata.ca
Tundra Fires	Tundra Fires	3				4				4	SME Advice

*For short-duration high-intensity precipitation, the historical value is based on a range of 1976-2005, as opposed to 1971-2000.

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