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Appendix P

Climate Change Vulnerability Assessment

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Climate Change Vulnerability Assessment Memorandum

Runway End Safety Area, Billy Bishop Toronto City Airport

PortsToronto

60733457

October 2025

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AECOM: 2024-12-21

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2	October 2025	AECOM	Final Climate Change Vulnerability Assessment.

Distribution List

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	✓	PortsToronto
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Land Acknowledgement

Billy Bishop Toronto City Airport operates under its mandate on the traditional territory of many nations, including the Mississaugas of the Credit, the Chippewa, the Haudenosaunee, and the Wendat peoples, and is now home to many diverse First Nations, Inuit and Métis peoples. We respect that the Crown and Mississaugas of the Credit signed Treaty 13, which covers the lands of the City of Toronto. Today, Toronto is still home to Indigenous people, and we are grateful to have the opportunity to meet and work on this territory.

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Appendix C. MS Excel Climate Change Resilience Assessment Model

Acronyms and Abbreviations

RESA .... Runway End Safety Area

1. Introduction

AECOM Canada ULC (AECOM) has been retained by Avia NG to complete an Environmental Assessment for the implementation of Runway End Safety Areas (RESAs) for Runway 08/26 at Billy Bishop Toronto City Airport (the Project). The Billy Bishop Toronto City Airport is owned and operated by PortsToronto (the Project proponent) and is located in the City of Toronto on the Toronto Islands.

The purpose of the Project is to comply with the Canadian Aviation Regulations Part III, Subpart 2, Division VI – Runway End Safety Area (RESA), published in January 2022, which mandate RESAs for airports serving over 325,000 commercial passengers annually. RESAs are designated open spaces at both ends of runways, designed to minimize damage if an aircraft overruns or undershoots the runway. At Billy Bishop Toronto City Airport, the RESA requirements apply only to the primary runway, Runway 08/26, which enables commercial aircraft use.

Although there are no regulatory requirements under the federal or the provincial acts that mandate the Environmental Assessment process for the Project, a Section 82 evaluation under the Impact Assessment Act is required for all Project components that fall on Transport Canada-owned land. A Section 82 evaluation is a requirement under the Impact Assessment Act for projects located on federal lands or being carried out by federal authorities. In the City of Toronto's Official Plan (2024), policies exist that require projects where lakefilling in Lake Ontario is proposed to undertake an Environmental Assessment. As such, PortsToronto has undertaken a non-statutory Environmental Assessment process for the RESA project at Billy Bishop Toronto City Airport.

As part of the Environmental Assessment, PortsToronto has identified and evaluated alternatives for implementing RESAs at Billy Bishop Toronto City Airport. The Environmental Assessment also considers the opportunities to enhance airport operational safety. This includes minimizing regular non-airport and airport vehicular crossings on Runway 08/26, currently necessary for both airport operations and Toronto Islands access requiring co-ordination with the airport traffic control tower. This effort supports Transportation Safety Board of Canada's objective to reduce the risk of runway incursions at airports. Additionally, the Environmental Assessment examined measures to reduce emissions (including greenhouse gases) and ground-based noise levels along the lakefront.

The purpose of this technical memorandum is to assess climate change vulnerability of RESA alternatives.

1.1 Project Background

In 2018, AECOM was retained to complete a Climate Change and Extreme Weather Vulnerability Assessment of PortsToronto Assets (*Climate Change and Extreme Weather Vulnerability Assessments of Ports Toronto Assets* Report by AECOM, May 2019). The project was first initiated after PortsToronto managed record high-water levels in Lake Ontario in 2017 and 2019, seeing a clear need to understand future climate change and extreme weather impacts on operations and assets. The assessment focused on infrastructure in current operations and was completed as an initial screening to determine where more detailed focus could be required in the future. A total 81 different infrastructure components were assessed across seven categories: Outer Harbor Marina, Marina Terminal Property, Ship Channel Bridge, Billy Bishop Toronto City Airport – Access, Billy Bishop Toronto City Airport – Airfield, Corporate Infrastructure, and Security Infrastructure to current and future climate parameters to identify potential interactions. The assessment found that under the future climate conditions, the highest risk was the interaction between the pedestrian tunnel and heavy rainfall.

The assessment has demonstrated heavy rainfall can cause flooding at the entrance of the pedestrian tunnel from increased stormwater runoff, which could have catastrophic implications, according to PortsToronto staff. The remaining medium risks include those to the storm sewers and eastern dock walls due to heavy rainfall, and the electrical supply due to freezing rain. Also, several characteristics have been identified that could increase the vulnerability of the infrastructure to climate events if not sufficiently addressed. One such vulnerability is the inadequacy of storm drainage, which has an insufficient capacity to withstand increases in rainfall, particularly concerning the pedestrian tunnel drop-off area. Other vulnerability characteristics include fuel tanks located on the premises, which, if failed, would have catastrophic consequences, ice storms and freezing rain causing slip/fall risks to operations staff and the public, and de-icing chemicals degrading pavement materials. Assets nearing the end of their service life or in poor condition are also more vulnerable to climate change, and this can be exacerbated if maintenance practices are not prioritized in the future.

1.2 Purpose and Scope of the Study

The primary objective of this Climate Change Vulnerability Assessment is to build on the previous work and conduct a Climate Change Vulnerability Assessment on the proposed RESA Alternatives and the associated infrastructure at Billy Bishop Toronto City Airport. The Climate Change Vulnerability Assessment will be conducted using the Public Infrastructure Engineering Vulnerability Committee High-Level Screening Guide.

The Public Infrastructure Engineering Vulnerability Committee High-Level Screening Guide is a practical tool designed to help assess the potential risks that climate change poses to infrastructure. It provides a structured approach for identifying vulnerabilities and prioritizing areas that need more detailed analysis or immediate action. The guide is flexible and can be applied to various types of infrastructure, from single elements to entire portfolios.

1.3 Study Area

The Project Study Area encompasses all Billy Bishop Toronto City Airport lands involved in the RESA implementation, including the Marine Exclusion Zone. The Marine Exclusion Zone is a buoy-marked area of the lake where vessel entry is prohibited without PortsToronto's authorization. The Project Study Area is illustrated in **Figure 1-1**.

1.4 RESA at Billy Bishop Toronto City Airport

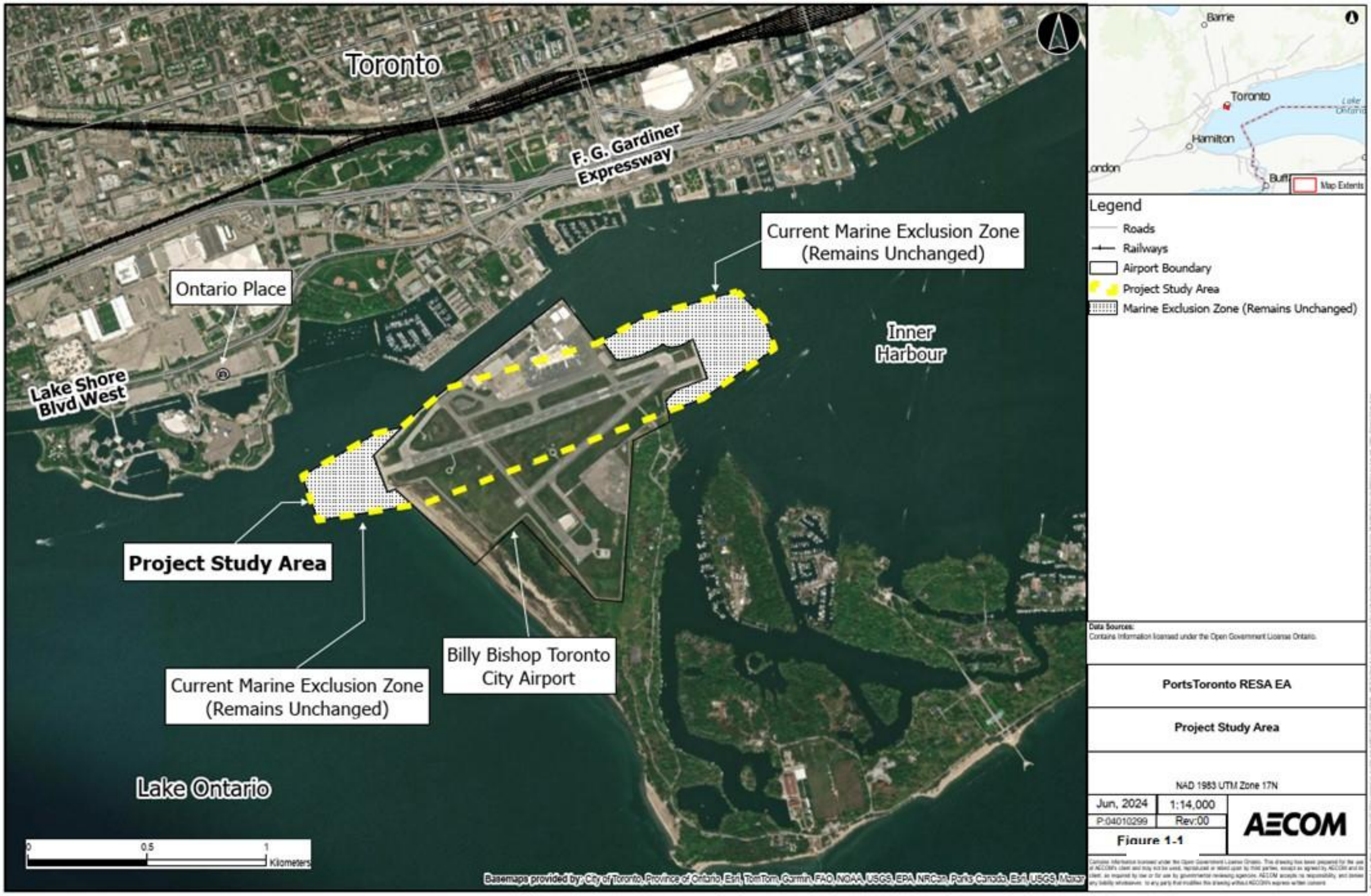
The project involves the implementation of Runway End Safety Areas (RESAs) at Billy Bishop Toronto City Airport, which requires expanding the landmass at both the east and west ends of Runway 08/26. To meet the requirements for RESA implementation, three alternatives were developed, each progressively building on the previous one with increased landmass expansion and additional features. The following outlines the three RESA alternatives and greater details can be found in the Runway End Safety Area – Environmental Assessment Study Report:

RESA 1 – Minimum Landmass

RESA 1 proposes the minimum landmass expansion to meet RESA requirements, extending 54 m from the seawall on the west end (7,850 m^2), and 52 m on the east end (6,100 m^2). On the west end, the breakwater structure will be raised to 81 m above sea level, about 4.5 m above the threshold at Runway 08/26, to prevent wave overtopping and water spray. The breakwater at the east end (Inner Harbour) will be raised to 77 m above sea levels, about 1 to 1.5 m above the threshold, since there is no need to control any waves or water spray.

The proposed layout includes perimeter airfield roads around the RESA ends, providing restricted access across the runway, similar to current access conditions. The road will be managed by the control tower to avoid conflicts with aircraft landing or taking off, as this landmass configuration does not provide sufficient airspace clearance for unrestricted vehicle passage (does not meet Obstacle Limitation Surface requirements). An Obstacle Limitation Surface is an imaginary surface or series of surfaces that define the limits to which objects may project into airspace, to protect the airspace for the safe operation of aircraft during takeoff, landing and emergency operations.

Figure 1-1: Study Area Map



RESA 2- Taxiway Improvements

This alternative builds on RESA 1 – Minimum Landmass by incorporating additional airfield improvements in conjunction with the RESA work at both runway ends. Specifically, it proposes upgrades to Taxiway B at the west end and Taxiway D at the east end to enhance operational efficiency and safety at the airport.

For Taxiway B, the relocation of the Localizer 26 antenna to the new western RESA increases the landmass expansion to the west, reaching 82 m^2 from the seawall (11,800 m^2). The relocation of Taxiway D requires additional landmass to the northeast, bringing the total landmass on the east end to 11,300 m^2. This relocation enables the airport to upgrade its visual approach guidance system for aircraft landing on Runway 26, which is intended to improve aviation safety with a more precise system. All other features from RESA 1- Minimum Landmass remain the same in this alternative.

RESA 3 – Noise Wall and East Utility Conduit

This alternative builds on RESA 2 – Taxiway Improvements by incorporating additional elements. The key new features of RESA 3 include: 1) unrestricted airfield perimeter roads connecting the north and south sides of the airport, 2) a noise wall at the east end along with an extension of the existing noise wall at the west end, and 3) a reserved utility conduit for future hydro, water, and telecommunication services to the Toronto Islands community.

To accommodate these new components and ensure aeronautical airspace clearances over the new roads, security fences, and noise walls, a landmass expansion is required; 73 m from the seawall (29,980 m^2) on the east end and 82 m from the seawall (12,600 m^2) on the west end. All other features from RESA 2 are included in this alternative.

2. Climate Change Vulnerability Assessment

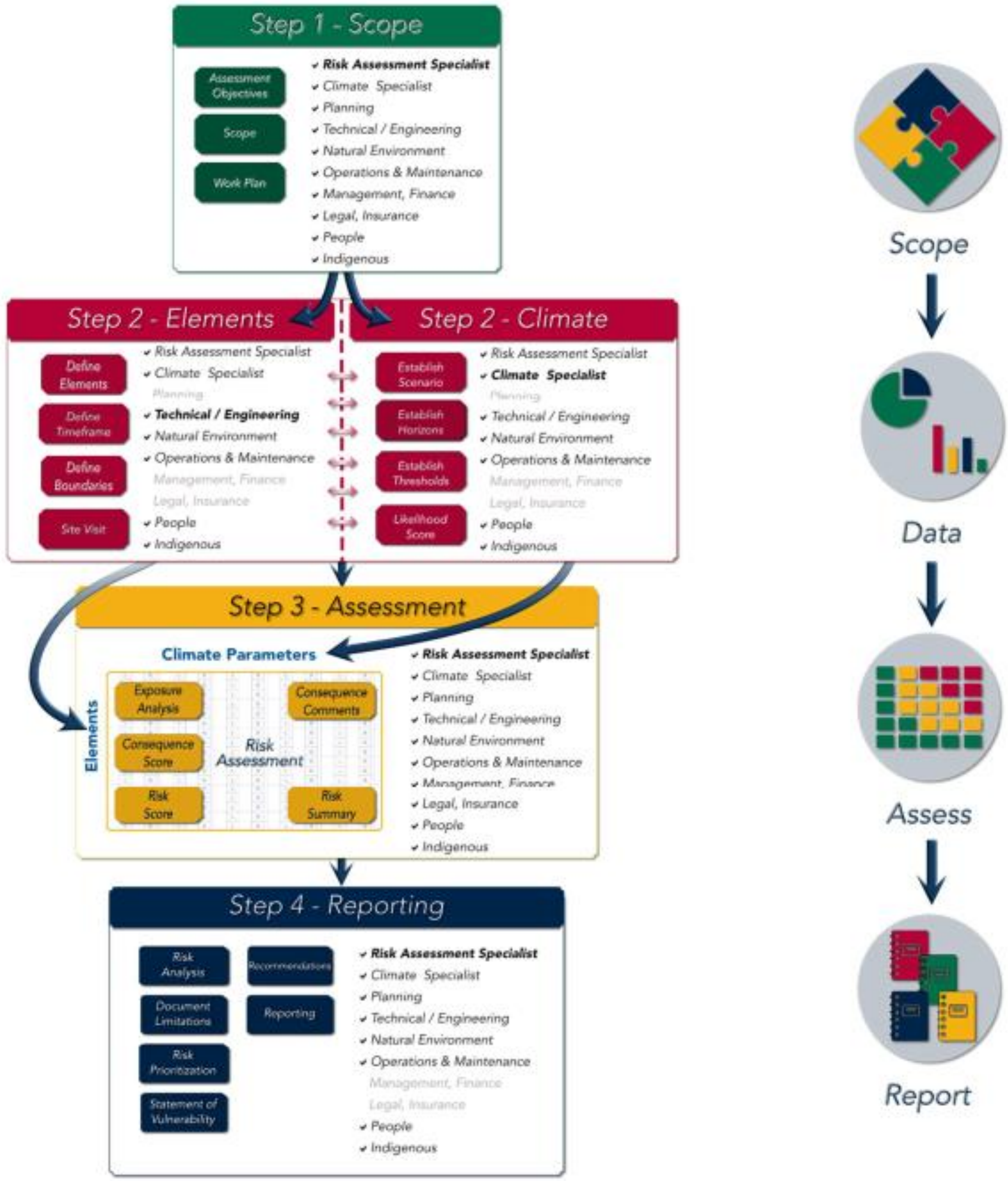
To understand the impacts of the changing climate on the RESA Alternatives assets at Billy Bishop Toronto City Airport, a Climate Change Vulnerability Assessment was conducted. The intent of any Climate Change Vulnerability Assessment is to understand how the future climate may prevent the full realization of the value of the investment in assets. Following the Public Infrastructure Engineering Vulnerability Committee High Level Screening Guide (2022), the project team gained an understanding of the nature and severity of the key climate threats and the potential vulnerabilities of the components of RESA Alternatives. This insight will help inform design, investment, and asset management decisions made by the owner and operators. Preventative and adaptive measures can subsequently be taken to avoid or reduce the risks posed to material, services, infrastructure, and personnel.

2.1 Scope of Work

According to the objective of this project, the scope involves conducting a risk assessment to identify and assess potential vulnerabilities to make recommendations for various project components, activities, and operations to address climate change and extreme weather conditions. A multi-step approach was undertaken to assess the climate-related risks. The main steps consist of:

- The development of the objectives, scope, and work plan (Step 1 in **Figure 2-1**).
- The definition of project elements and the identification of the climate variables for selected time horizons (Step 2 in **Figure 2-1**).
- The analysis of the vulnerability of building components with regards to these hazards (Step 3 in **Figure 2-1**).
- The development of recommendations to increase the resilience of the Project (Step 4 in **Figure 2-1**).

Figure 2-1: Workflow of Public Infrastructure Engineering Vulnerability Committee High-Level Screening Guide



Source: Public Infrastructure Engineering Vulnerability Committee High-Level Screening Guide, 2022

2.2 Data

This section presents the two sets of data required for the Climate Change Vulnerability Assessment. First, the project elements, i.e., the RESA elements and sub-elements are described. Then, to understand the exposure of the identified project elements to climate change and assess the associated risks, a methodology for the climate data analysis is presented along with the selection of potential climate indicators, expected impacts over the lifespan of the infrastructure, and their likelihood of occurrence.

2.2.1 Elements

This section describes asset elements and sub-elements that were determined as relevant to the climate change resilience assessment for their potential sensitivity to certain climate conditions.

According to the *RESA Study Technical Analysis and Findings Discussion Document* by Avia NG (April 2024), the following project elements with their sub-elements, detailed in **Table 2-1**, were identified as relevant to the Climate Change Vulnerability Assessment for their potential sensitivity to certain climate indicators. As the various RESA alternatives are of a similar nature, they share common elements and sub-elements which are assessed versus the actual RESA alternatives. The RESA alternatives containing the elements and sub-elements are also indicated in **Table 2-1.**

Table 2-1: Elements

No.	Elements	Sub-Elements	Present in RESA Alternatives
1	**RESA Surface**	Markings Pavements Vegetated Area Granular Materials Storm Sewers	RESA 1 RESA 2 RESA 3
2	**Noise Walls**	Concrete Anchors Beams Bird Deterrent Panels	RESA 3
3	**NavAids (impacted by alternatives)**	PAPI Localizer 26 Marine Radar	RESA 2 RESA 3
4	**Breakwater and Landmass**	Armour Stone Fill Material	RESA 1 RESA 2 RESA 3

No.	Elements	Sub-Elements	Present in RESA Alternatives
5	**Airfield Pavements (Taxiways B and D)**	Markings Pavements Granular Materials Turf Area Storm Sewers	RESA 2 RESA 3
6	**Security Fences**	Fence Posts Barbwire Signage Jersey Barriers	RESA 1 RESA 2 RESA 3
7	**Shoreline and Dockwalls**	Natural Shoreline Dockwalls (vertical metal sheet pilings)	RESA 1 RESA 2 RESA 3
8	**Airfield Perimeter Roads**	Markings Pavements Granular Materials Turf Area Storm Sewers	RESA 1 RESA 2 RESA 3
9	**Airfield Lighting**	Inset Lights and Signs Cables Circuit Selector Switches Transformers	RESA 1 RESA 2 RESA 3
10	**Staff**	PortsToronto Staff Contractors Consultants Public	RESA 1 RESA 2 RESA 3
11	**Utility Conduit**	Granular Materials Turf Area Storm Sewers	RESA 3

2.2.2 Climate Data

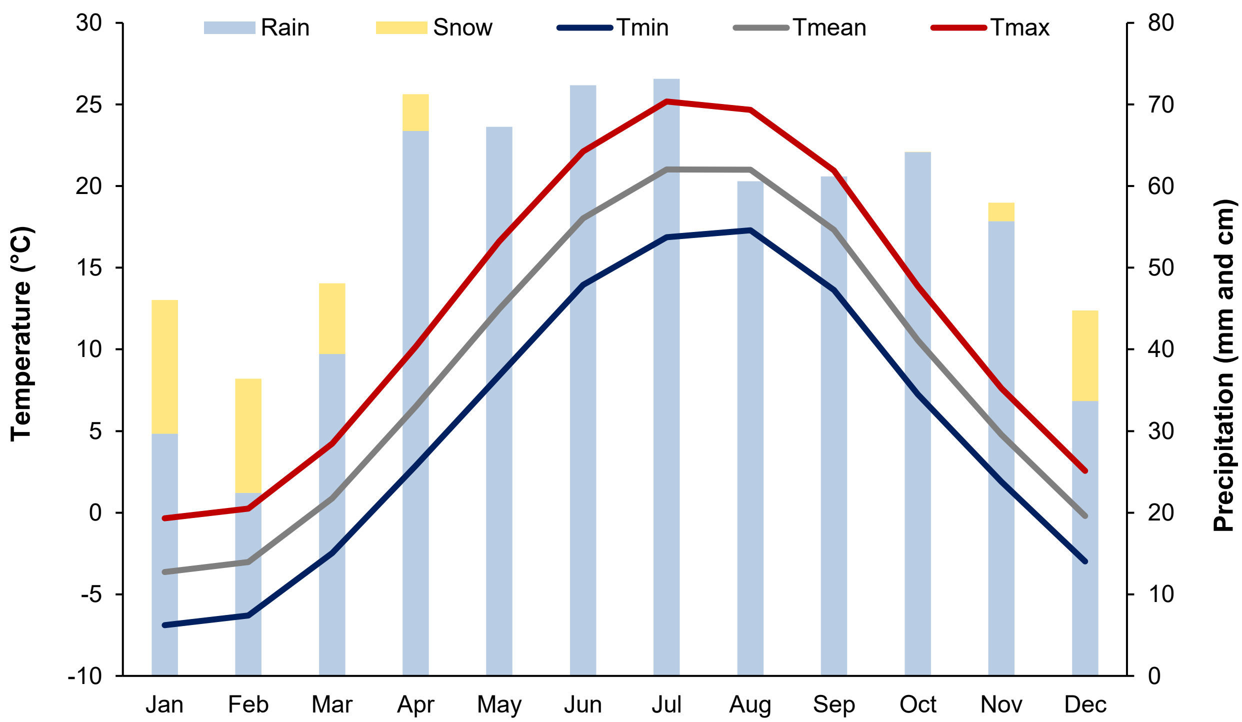
2.2.2.1 Historical Climate Data Sources

To determine the climate-related risks to the RESA, climate conditions were analyzed for both the historical climate normal (1991-2020) and future periods. To this end, climate data collected by Environment and Climate Change Canada and accessed through the Canadian Centre for Climate Services were analyzed (Environment and Climate Change Canada, 2024). The observations were obtained from the meteorological stations called Toronto Island Airport and Toronto City Centre (ON), for the historical climate period. The climate period is long enough to represent the historical climate by averaging out the short-term internal variability.

2.2.2.2 Historical Climate – 1991-2020

The climate is characterized by mild winters, warm summers, and year-round precipitation with the maximum precipitation falling in early summer (**Figure 2-2**). For the historical climate period, the daily mean temperature (Tmean) ranges from -3.6°C in January to 21.0°C in July. Averaged over the time horizon, rainfall amounts are highest in July (73 mm), while the driest month is February, when the airport receives 14 cm of snow and 22 mm of rain.

Figure 2-2: Historical Climate Data (1991-2020) – BBTCA



2.2.2.3 Extreme Climate Events

The Greater Toronto Area has historically suffered from a variety of extreme weather events such as heat waves, cold spells, snowstorms and floods. These events have produced severe economic damage, as well as occasionally the loss of human life.

The Greater Toronto Area has a long history of severe flooding with the first great flood occurring in 1954, when Hurricane Hazel passed over Toronto. Between October 15 and 17, Hurricane Hazel brought about 280 mm of rain in 48 hours, washing out roads, destroying bridges, and damaging houses. In total, 81 people died in Ontario.

In the past two decades, multiple heavy rainfall events have resulted in flooding across Toronto. On July 8, 2013, two storm cells brought a record of 126 mm of rain and resulted in $850 million in damage. Further flooding occurred on August 7, 2018, and July 16, 2024 (Mann, 2019; Mann, 2022). The latter event brought 98 mm of rain over the span of 4 hours (CBC News, 2024).

On the other hand, high temperature events and severe heat waves can cause the death of vulnerable people (such as elderly and children) and test the capacity of the electrical network to keep buildings at tolerable temperatures. The most severe heatwave in Toronto was recorded in July 1936 and reached a maximum of 40.6°C, causing the death of at least 200 Torontonians (City News, 2007). Slightly less intense heatwaves followed in 1948 with temperatures of 38.3°C and in 2005 with 37.6°C.

During the summer months, thunderstorms are a common occurrence for Toronto. They bring heavy rainfall, hail, lightning, and high wind speeds in the form of tornadoes and downbursts. In the Greater Toronto Area, more than 25 tornadoes have been recorded since 1981 (Environment and Climate Change Canada, 2018; NTP, 2024). While most were weaker tornadoes, a tornado with wind speeds of 220 km/h hit the outskirts of Toronto in the community of Woodbridge in Vaughan on August 20, 2009, during the Southern Ontario Tornado Outbreak of 2009. The 9.6 km long tornado damaged more than 650 homes (DeClerq, 2019).

2.2.2.4 Future Climate Data Sources

In preparation for the latest Intergovernmental Panel on Climate Change report (AR6), new emission scenarios were developed – the so-called Shared Socioeconomic Pathways (SSPs). The SSPs include changes to population, economic growth, education, urbanization, and rate of technological development (Riahi, van Vurren, Kriegler, Edmonds, et al., 2017). Using integrated assessment models (IAMs), the socioeconomic conditions of the SSPs were converted into future greenhouse gas emissions and radiative forcings that were consequently used in the General Circulation Models (GCMs) of the latest phase of the Coupled Model Intercomparison Project (CMIP6). The radiative forcing or the change in the atmosphere’s energy balance in 2100 relative to the pre-industrial levels in 1750 is included in the name of each emission scenario. For example, the SSP2-4.5 corresponds to 4.5 Watts/square meter (W/m^2) of radiative forcing by 2100 and therefore a surplus of energy of 4.5 W/m^2 in Earth’s atmosphere.

Future climatic conditions will vary in line with the different emission scenarios. While the global temperature increase is likely to exceed the limit of 2°C set in the Paris Climate Agreement (UNFCCC, Paris Agreement, 2015) for nearly all emission scenarios (IPCC, 2021), the corresponding levels of decarbonization necessary to achieve the Paris Climate Agreement limit are beyond most ambitious decarbonization plans. Although countries have outlined various climate actions in their Intended

Nationally Determined Contributions, GHG emissions keep increasing (Hook & Campbell, 2020; UNFCCC, 2022; Global Carbon Budget, 2023)[1]. The current trajectory lies between an intermediate- and a high-emission scenario. Hence, the intermediate SSP2-4.5 and the high-emission scenario SSP5-8.5 were selected for this project (**Table 2-2**). The SSP5-8.5 scenario (the worst-case scenario) was chosen for this Climate Change Vulnerability Assessment to allow for a conservative assessment of the risks due to climate change, and SSP2-4.5 was chosen to address uncertainties of climate projections by adding a more stable scenario. These two scenarios allow the PortsToronto team to make informed decisions for future planning, investment, and development.

Table 2-2: Emissions Scenarios

Emissions Scenarios	Description
SSP2-4.5	Intermediate scenario - Limits global warming at about 3°C at the end of the century (2081-2100) (relative to pre-industrial levels)
SSP5-8.5	High emissions scenarios - Limits global warming at about 5°C at the end of the century (2081-2100) (relative to pre-industrial levels)

Two future time horizons 2041-2070 and 2071-2100 were analyzed relative to the historical reference period (1991-2020), using two emissions scenarios, i.e., SSP2-4.5 and SSP5-8.5.

2.2.2.5 Future Climate

Projections of future climate were analyzed using the Pacific Climate Impact Consortium (PCIC) database for the Billy Bishop Toronto City Airport. The meteorological station data called Toronto Island Airport and Toronto City Centre were used to offset-correct these projections.

Anthropogenic climate change has already led to observable changes in the local climate and further changes are projected. In recent decades, observations at Billy Bishop Toronto City Airport show an increase in daily air temperature that is projected to persist with continued climate change (**Figure 2-3**). During the historical period, the daily mean temperature was 8.9°C. With climate change, the mean temperature is projected to increase to reach 12.3°C in 2071-2100 for the SSP2-4.5 scenario and 14.7°C for SSP5-8.5.

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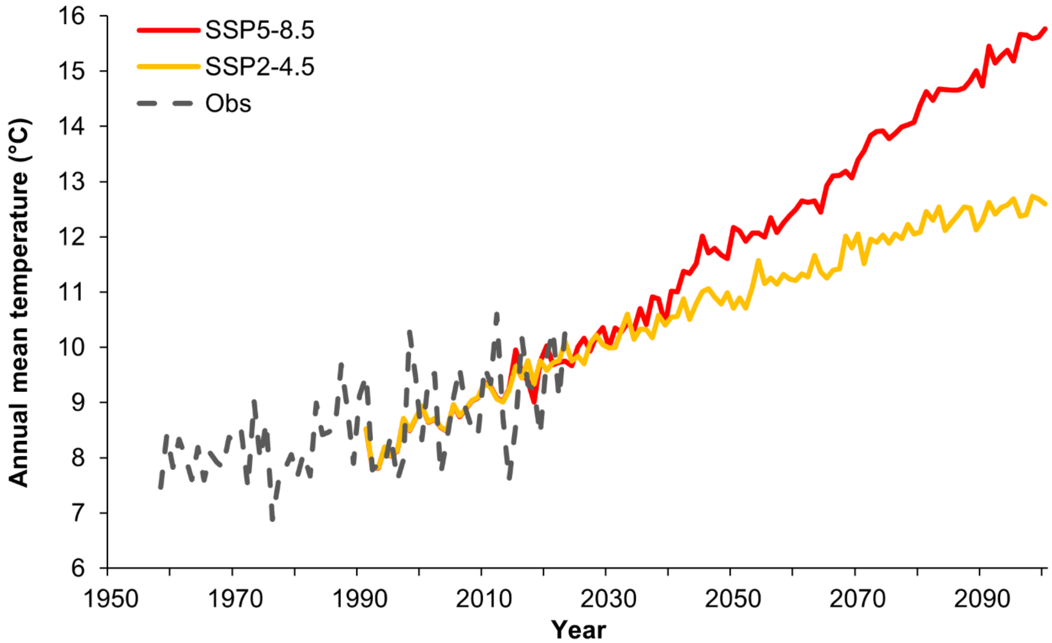
1. Press release on 4 December 2023 discussing preliminary carbon emission data: Global emissions have risen in 2023 by 1.1% compared to the global emissions in 2022. Global Carbon Budget | Fossil CO_2 emissions at record high in 2023.

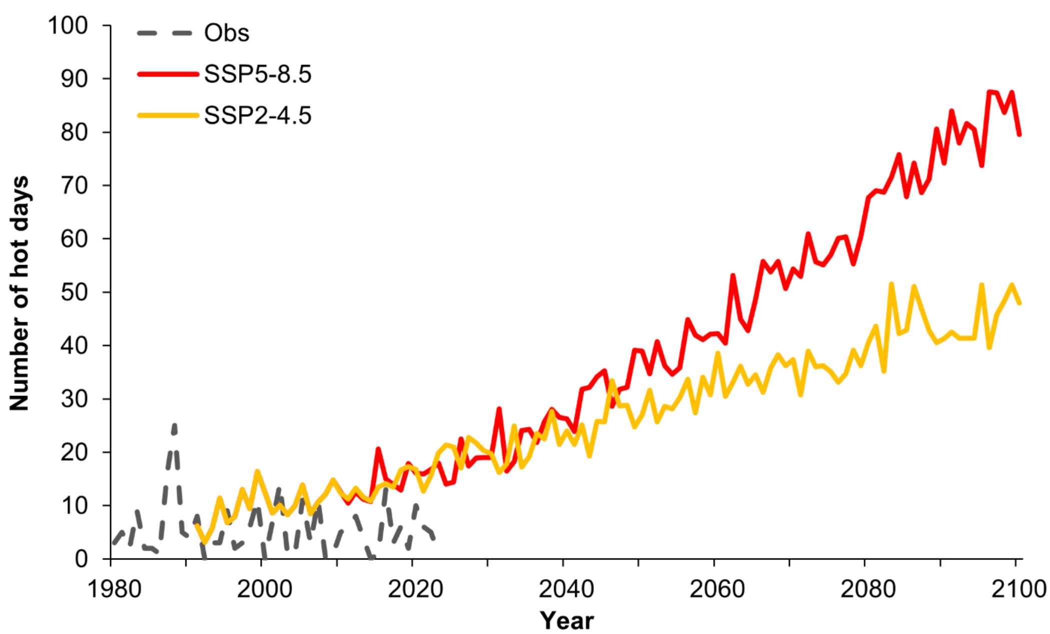
Figure 2-3: Annual Averaged Daily Mean Temperatures



Note: Obs: Observed

During the historical period, an average of 6 hot days – defined as days with a maximum temperature above 30°C – occurred per year. With climate change, the frequency of these hot days will increase, and in 2071-2100, the projections show 37 hot days per year for the SSP2-4.5 scenario and 67 hot days per year for the SSP5-8.5 scenario (**Figure 2-4**).

Figure 2-4: Annual Number of Hot Days for Two Emissions Scenarios



The annual rainfall sum has seen a weak increasing trend since the 1960s. The projections for both SSPs show an increase throughout the century (**Figure 2-5**) and a decrease in snowfall (**Table 2-3**). In 2071-2100, the average rainfall sum per year is projected to increase to 783 mm in the SSP2-4.5 scenario and 832 mm in the SSP5-8.5 one. Over the same period, the average annual snowfall will decrease to 20 cm and 0 cm in the SSP2-4.5 and SSP5-8.5 scenarios, respectively.

Figure 2-5: Annual Rainfall Sums

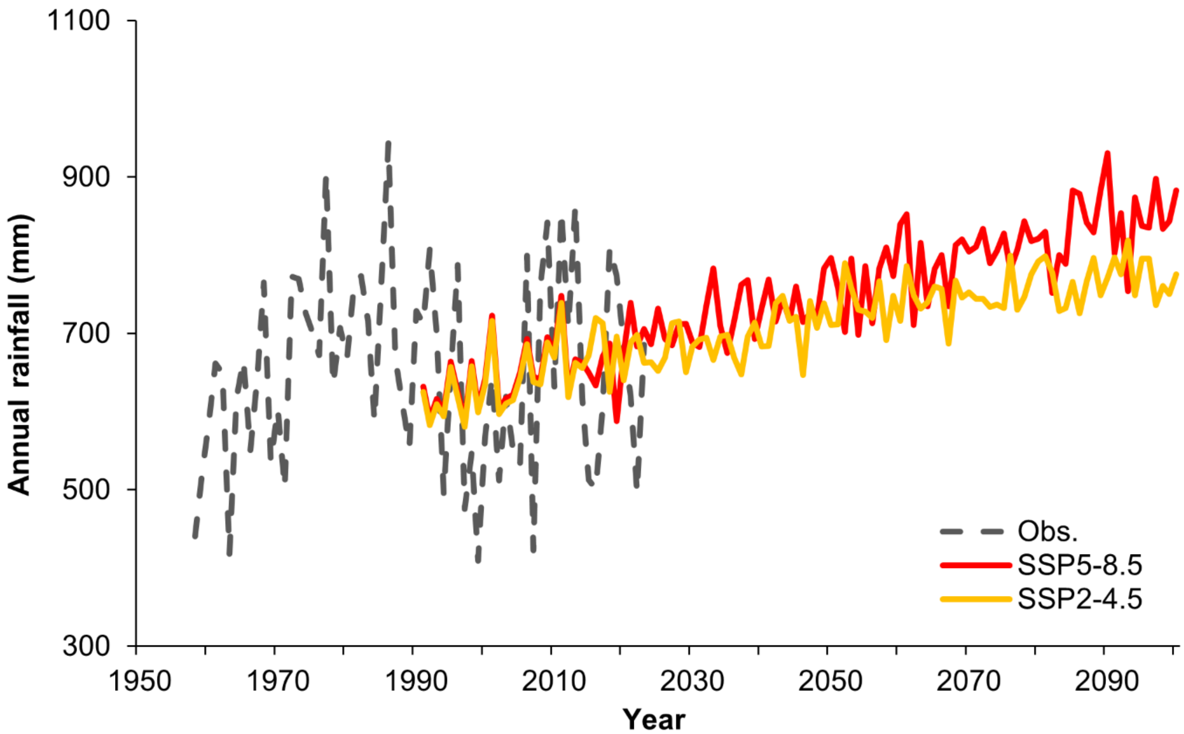


Table 2-3: Projections of Averaged Precipitation Sums

Type of Precipitation	Trend	1991-2020	SSP2-4.5		SSP5-8.5	
			2041-2070	2071-2100	2041-2070	2071-2100
Rain (mm)	Increase	646	733	763	766	832
Snow (cm)	Decrease	57	25	6	6	0

Extreme rainfall events, i.e., historical 100-year events, are projected to happen every 6 years by the end of the century in the SSP5-8.5 scenario. A historical 10-year period-event is projected to happen every year at the end of the century period.

The above-mentioned historical events and observed trends for Billy Bishop Toronto City Airport informed the decision about selecting the climate indicators that should be included in the risk analysis process. The elements listed in **Table 2-1** will be exposed to a series of climate indicators and the resulting risk will be assessed.

2.2.2.6 Toronto's Current and Future Climate (Toronto and Region Conservation Authority 2024 Report)

In December 2024, the City of Toronto published climate projections for Toronto developed by the Toronto and Region Conservation Authority (Lam et al., 2024). The dataset which was developed over the summer of 2024 contains 54 climate indicators (called variables in Lam et al., 2024) for the historical period of 1971 to 2000, and three future time horizons (i.e., 2015-2040, 2041-2070, and 2071-2100). Historical data of the Toronto City station located in downtown Toronto were analysed as the baseline against which the projected change was compared. To provide a range of potential future trajectories, two emission scenarios were used (i.e., SSP2-4.5 and SSP5-8.5).

Key differences between the climate data at Billy Bishop Toronto City Airport (developed specifically for this Climate Change Vulnerability Assessment) and in downtown Toronto (developed by Lam et al., 2024) include:

- Divergent historical periods.
- Different meteorological stations.
- Alternative definitions of climate indicators.
- Distinct impacts of Lake Ontario and urban heat island at the different locations.

These differences lead to an overall warmer and wetter climate at the downtown location used in Lam et al. (2024) compared to the climate at Billy Bishop Toronto City Airport. More details of an in-depth gap analysis are included in **Appendix A**. Despite these differences and in order to homogenise the climate data used for projects in Toronto, the climate data provided in Toronto's Current and Future Climate report were used for the subsequent Climate Change Vulnerability Assessment.

2.2.2.7 Climate Indicators

Climate conditions or events that can cause damage to the infrastructure elements of the RESA at Billy Bishop Toronto City Airport can be represented by climate indicators. Over 51 climate indicators and their multiple sub-indicators were considered and analyzed at a high level. Based on the historical climatological and extreme weather events, supplemented by a literature review, standards and guidelines such as the National Building Code, and expert judgment, the climate indicators listed in Table 2-4 was selected by AECOM for inclusion in the Climate Change Vulnerability Assessment for the RESA. The climate indicators were presented to and discussed with the

PortsToronto team during Climate Change Workshop 1, on June 19, 2024, and were subsequently confirmed by the project team. The inclusion of the Toronto and Region Conservation Authority climate data mandated modifications to some indicator definitions as climate indicators as defined by AECOM are not available in Lam et al. (2024). All indicators are defined in **Table 2-4**.

Changes to the water levels of Lake Ontario due to climate change were assessed based on a review of published literature and regional studies. Lake Ontario as the most eastern of the Great Lakes receives the water from the other upstream lakes, over-lake precipitation, and land runoff, and discharges it into the St. Lawrence River and loses it due to lake evaporation. Hence, variations in inflow due to natural discharge fluctuation of Lakes Michigan, Huron and Erie and the regulated outflow of Lake Superior as well as the regulated flow at the Moses-Saunders Dam influence the level of Lake Ontario (US Army Corps of Engineers, n.y.; Ministry of Northern Development, 2021). Although the in- and outflow are factors influencing the water levels of Lake Ontario, the most important drivers are its own watershed, local precipitation, and evaporation.

Long-term historical observations show constant average lake levels with significant fluctuations between dry and wet years (EPA, 2024). Scientific studies, regional shoreline management plans, and local Toronto Island flood characterization reports paint an inconclusive picture of future water levels with increasing and decreasing average water levels (Notaro et al. 2015; Baird, 2019a; Baird 2019b; Mailhot et al., 2019; Zuzek, 2020; Seglenieks and Temgoua, 2022). Although climate projections indicate large fluctuations in water levels and the potential of increased maxima, the increase is projected to be limited. So, future extreme water levels are projected to be up to 0.3 m higher than the historical record. Given this limited lake level increase, the lake level was not included in the list of selected climate indicators (**Table 2-4**).

Table 2-4: Description of Selected Climate Indicators

Climate Indicator	Description
Air temperature	Annual average of daily mean temperature.
Extreme high temperature	The maximum of daily maximum temperatures (°C), representing the hottest daytime temperature.
Heatwave	Temperature-based heat warning frequency: Forecast of >2 consecutive days with maximum temperature >31°C and minimum temperature >20°C.
Heavy Rainfall	10-year return values for daily rainfall. This indicator uses two angles: • The rainfall amount of future 10-year rainfall events. • The occurrence of a historically 10-year rainfall in the future.

Climate Indicator	Description
Extreme Rainfall	100-year return values for daily rainfall. This indicator uses two angles: • The rainfall amount of future 100-year rainfall events. • The occurrence of a historical 100-year rainfall in the future.
Multi-Day Heavy Precipitation	Maximum amount of 3-day precipitation sum.
Short-Duration High-Intensity Rainfall	Short-duration high-intensity rainfall. This indicator uses the return period of the historical 50-year, 15-minute rainfall event.
Drought	The maximum number of consecutive days when precipitation was less than 0.2 mm (or < 0.2).
Hurricane	Umbrella indicator for the number of hurricanes, intensity (i.e., wind speed), and precipitation. This indicator takes into consideration: • Intensity (wind speed). • Precipitation (mm). Historical occurrences within a 100 km radius (NOAA, 2024), projection based on (Knutson, et al., 2020).
Thunderstorm	Umbrella indicator for the number of thunderstorms and heavy rainfall, heavy wind, tornadoes, lightning, hail, etc. This indicator takes into consideration: • Heavy precipitation (mm). • Tornadoes (professional judgment based on a literature review). • Lightning* (professional judgment based on a literature review). • Hail (professional judgment based on a literature review). *Lightning strikes per year (1999-2018) within 25 km.
Air Quality	Umbrella indicator for multiple pollutants: • Ozone. • Particulate matter ($PM_{2.5}$; wildfire smoke).
Reduced Lake Ice Cover	Reduction in lake ice cover of Lake Ontario.
Lake Acidification	Acidification of Lake Ontario due to the uptake of CO_2.
Biofouling	Cyanobacterial growth, algae bloom, and lake/ocean acidification.
Invasive Species	Climate-tracking plants and animals.
Ice Accretion	Freezing spray during high wind events and storms.

2.2.2.8 Climate Indicator Likelihood/Probability

To determine the climate-related risks to the project, climate indicators, and their probabilities for the current and the three future time periods are developed using the matrix in **Table 2-5**.

Table 2-5: Likelihood Scoring Matrix

Likelihood Score	Change from Base	Method	Rationale
1	↑	Likely occurs less frequently than in the current climate	50 to +100% less than the current climate threshold, mean, frequency, or intensity.
2			10 to 50% less than the current climate threshold, mean, frequency, or intensity.
3	Current Climate	Likely occurs as frequently as the current climate	± 10% of the current climate threshold, mean, frequency, or intensity.
4	↓	Likely occurs more frequently than in the current climate	10 to 50% more than the current climate threshold, mean, frequency, or intensity.
5			50 to +100% more than the current climate threshold, mean, frequency, or intensity.

Source: Public Infrastructure Engineering Vulnerability Committee High-Level Screening Guide, 2021

In this approach, a score is assigned to change relative to the current climate. Considering the current climate and projected changes for the three future time frames, the likelihood scores were calculated for the climate indicators and two emissions scenarios and are presented in **Table 2-6**. In the time horizons evaluated in this assessment, almost all indicators show an increase under climate change conditions. The analysis is based on extracted climate data and a literature review (e.g., Knutson et al., 2020; Etkin, 2018; Seely and Romps, 2015; Chapra et al., 2017; Philips et al., 2015).

Table 2-6: Selected Climate Indicators, Values, Changes and Likelihood Scores Based on the SSP2-4.5 and SSP5-8.5 Emission Scenarios

Climate Indicator	Unit	Hist.	Likelihood	SSP2-4.5						SSP5-8.5					
				2041-2070	Change (%)	Likelihood	2071-2100	Change (%)	Likelihood	2041-2070	Change (%)	Likelihood	2071-2100	Change (%)	Likelihood
Air temperature	°C	7.9	3	11.1	40.5	4	11.9	50.6	5	11.9	50.6	5	14.4	82.3	5
Extreme high temperature						3			3			3			4
Hottest day temperature	°C	31.3	3	32.0	2.2	3	32.8	4.8	3	32.5	3.8	3	34.7	10.9	4
Heat wave						5			5			5			5
Temperature-based heat warning frequency	# of events	0.5	3	1.8	260.0	5	2.6	420.0	5	5.6	1020.0	5	7.3	1360.0	5
Heavy rainfall												5			5
10-year rainfall	mm	69.6	3	84.0	20.2	4	91.2	30.9	4	91.2	31.0	4	105.6	51.7	5
10-year rainfall (69.6 mm)	years	10	3	4.1	59.0	5	3.5	65.0	5	3.5	65.0	5	1.6	83.5	5
Extreme rainfall						5			5			5			5
100-year rainfall	mm	98.4	3	120.0	22.0	4	127.2	29.3	4	127.2	29.3	4	148.8	51.2	5
100-year rainfall (98.4 mm)	years	100	3	22.9	77.1	5	17.5	82.5	5	17.5	82.5	5	7.5	92.5	5
Multi-day heavy precipitation	mm	50.2	3	57.4	14.3	4	58.5	16.5	4	59.1	17.7	4	64.4	28.3	4
Short-Duration High-Intensity	years	32.0	3	16.9	66.2	5	12	76.0	5	15.2	69.6	5	6.8	86.3	5
Drought						3			3			3			4
Number	# of days	13.4	3	13.6	1.5	3	13.7	2.2	3	13.6	1.5	3	13.9	3.7	3
Hurricane						4			4			4			5
Intensity (wind speed)	km/h	62.5	3	-	-	-	65.63	5.0	3	65.63	5.0	3	-	-	-
Precipitation	mm	43.5	3	50.9	16.9	4	54.85	26.1	4	54.63	25.6	4	64.56	48.4	4
Thunderstorm			3			4			4			4			5
Heavy precipitation	mm	25.3	3	29.6	16.9	4	31.9	26.1	4	31.77	25.6	4	37.55	48.4	4
Tornadoes	# of events	0.37	3	-	-	-	-	-	-	-	-	-	-	-	-
Lightning	# of strikes	2807	3	-	-	-	-	-	-	-	-	-	-	-	-
Hail	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Air quality	-	-	3	-	-	4	-	-	4	-	-	4	-	-	5
Reduced Lake Ice Cover	%	6.1	3	-	-	4	-	-	5	2.0	67.2	5	0.5	91.8	5
Lake acidification	pH	8.44	3	-	-	3	-	-	4	-	-	3	8.08	-	4
Biofouling	-	-	3	-	-	3	-	-	4	-	-	4	-	-	4
Invasive species	-	-	3	-	-	4	-	-	4	-	-	4	-	-	4
Ice accretion	-	-	3	-	-	4	-	-	4	-	-	4	-	-	4

Note: "-" denotes instances in which detailed and quantitative information is not available and likelihood scores are developed based on a literature review, professional judgement, etc.
This table combines the climate indicators based on Lam et al. (2024) where available and the climate data developed for Billy Bishop Toronto City Airport during this Climate Change Vulnerability Assessment.

2.3 Risk Assessment

2.3.1 Risk Identification and Analysis

According to the Public Infrastructure Engineering Vulnerability Committee High-Level Screening Guide, risk is a product of likelihood and consequence, if an element is exposed to climate indicators. Therefore, the risk score is obtained by multiplying the likelihood/probability (of the weather/climate event) by the severity/consequence score and exposure:

$$Risk = Exposure \times Likelihood \times Severity$$

The likelihood is estimated using **Table 2-5** and **Table 2-6**, and the binary exposure term is either 0 for no exposure or 1 if the project element is exposed to the climate indicator. Using the equation above, the risk level for all 176 interactions between the sixteen climate indicators and the eleven project elements has been calculated. Forty-nine interactions were assessed to not be impacted by the selected climate indicators and hence were excluded from the risk analysis.

2.3.2 Estimates of Severity

To estimate the level of consequences, five impact categories were identified based on the most relevant aspects regarding risk management for the project. These five impact categories are defined as:

1. **Impact on health and safety**, including occupational hazards and injury to staff or the public because of incidents for which the owner may be liable.
2. **Infrastructure integrity**, including damages or deterioration of essential components and materials.
3. **Operational impact**, including operational delays, process slowdowns, or interruption of services.
4. **Financial impact**, including losses due to additional cost/expense directly attributed to the event, damages to assets to be repaired immediately to maintain operations, or failure to maintain operations.
5. **Reputational exposure,** including negative media coverage, customer dissatisfaction, and negative reviews.

The severity rating (1-Very Low to 5-Very High) and impact categories which were used to guide the risk analysis are detailed in **Table 2-7**.

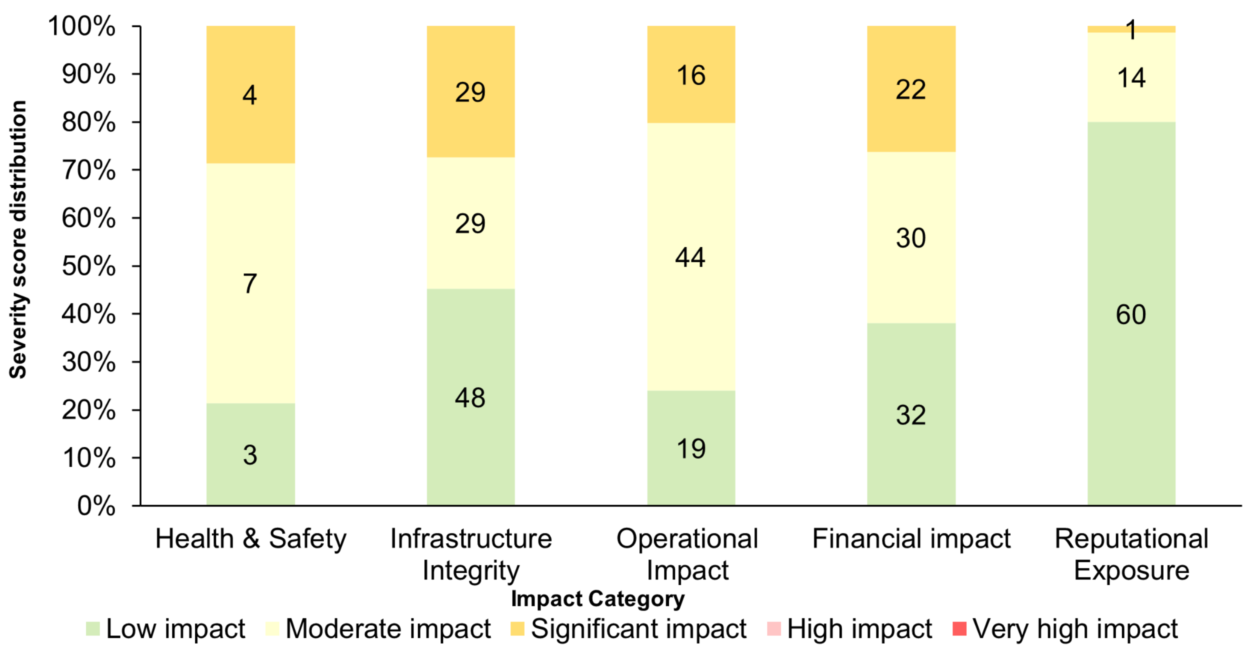
Table 2-7: Impact Severity Rating and Impact Categories

		Impact Categories				
Impact Severity Rating	**Severity**	**Health & Safety**	**Infrastructure Integrity**	**Operational Impact**	**Financial Impact**	**Reputational Exposure**
1	**Very Low**	First aid injury	Negligible Damage Damage <$200k Repairable immediately May require more frequent maintenance and inspection	Operation impacted for a few hours	Less than $200k – additional cost/expense directly attributed to the event or claim against PortsToronto	Limited impact on PortsToronto's reputation
2	**Low**	Medical treatment for a minor injury	Minor damage $200k <Damage <$1M Repairable within 2 hours May require more frequent maintenance and inspection	Operation impacted for less than 12 hours	$200k - $1M – additional cost/expense directly attributed to the event or claim against PortsToronto	Local stakeholders aware and strategic communications in place and ongoing
3	**Moderate**	Bodily injury / Illness with work restrictions	Moderate damage $1M <Damage <$2M Repairable within 12 hours More frequent maintenance and inspection required	Operation impacted from 12 hours to less than 3 days and/or limited-service interruption	$1M - $2M – additional cost/expense directly attributed to the event, or claim against PortsToronto	Limited local media coverage with moderate impact on PortsToronto
4	**High**	Permanent disabling injury or multiple people injured	Moderate damage $2M <Damage <$10M Repairable within 3 days More frequent maintenance and inspection required	Operation impacted for more than 3 days in summer and/or service interruption to the public up to a week	$2M - $10M – additional cost/expense directly attributed to the event or claim against PortsToronto	Several local media coverages including social media
5	**Very High**	Fatality or significant irreversible disability	Significant damage Damage >$10M Repairable > 3 days More frequent maintenance and inspection required	Operation impacted for > month and/or service interruption to the public up to > week	More than $10M – additional cost/expense directly attributed to the event or claim against PortsToronto	Large media coverage (national / international) and strong impact on the brand / image

Based on the impact severity rating in **Table 2-7**, the potential consequences of interactions of climate change and project elements were evaluated. The consequence levels were established using expert judgment and relevant literature. Furthermore, the risk analysis exercise was done on two levels within the AECOM project team, with two risk evaluators and a discussion to assert differences in opinion and come to a consensus. If a consensus could not be reached, or if there was a lack of information and knowledge, other experts were consulted to further refine the analysis. The scores were then confirmed by the PortsToronto team. Although, the incorporation of in Lam et al. (2024) climate projections into the risk assessment this was not revisited with PortsToronto team as the severity rating remained unchanged.

The assessment revealed that of 176 potential interactions between 16 climate indicators and 11 project components, 49 combinations resulted in a no-impact assessment due to no exposure of the elements to climate indicators and were excluded from the subsequent analysis. For the remaining interactions, the impact severity was assessed for each impact category (**Figure 2-6**). The majority of interactions received a *low* severity assessment (ranked 1). The infrastructure integrity is most severely impacted by events with 29 *significant* severity assessments (ranked 3). No *high* (ranked 4) or *very high* consequence interactions (ranked 5) were identified in the risk analysis. This ranking can be used to help prioritize adaptation measures that will minimize impacts related to health and safety of staff, the operation, and the finances of the project.

Figure 2-6: Number of Interactions per Level of Severity for Each Impact Category



2.3.3 Risk Evaluation

The risk matrix was developed according to the Public Infrastructure Engineering Vulnerability Committee High-Level Screening Guide (see **Table 2-8**). The risk equation described in the previous section was used for all climate indicators (**Table 2-6**), in all three-time horizons. This was repeated for all the project elements mentioned in **Table 2-1**. The results below summarize the number of interactions under low, moderate, and high-risk categories and identify how risk levels shift over time due to projected climate changes. The following results are based on projections under the SSP5-8.5 scenario, reflecting a conservative and worst-case planning approach.

For the 1991-2020 period, the assessment indicated:

- 127 interactions result in a low risk.
- 0 interactions result in a moderate risk.
- 0 interactions result in a high risk.

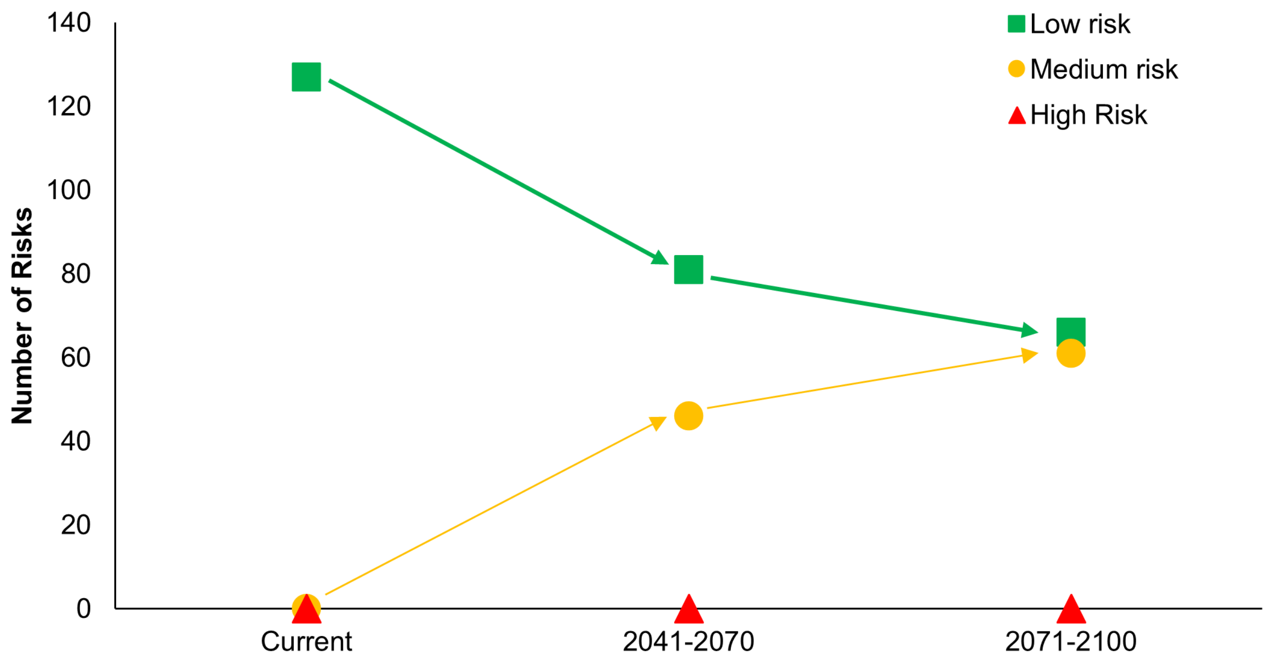
For the 2041-2070 timeframe, the assessment indicated:

- 81 interactions result in a low risk.
- 46 interactions with a moderate risk; of which,
  - 46 interactions changed from low risk to moderate risk.
- 0 interactions with a high risk.

For the 2071-2100 timeframe, the assessment indicated:

- 66 interactions result in a low risk.
- 61 interactions with a moderate risk; of which,
  - 15 interactions changed from low risk to moderate risk.
- 0 interactions with a high risk.

Figure 2-7: Level of Risks of Current and Projected Interactions Between Weather and Project Components/Elements based on SSP5-8.5 Climate Projections



A detailed table of level of severity for each climate indicator and each infrastructure component is included in 0**Appendix B**. A break-down of the risk scoring for the individual interactions of climate indicators and project elements is provided in **Table 2-8**. The risk assessment for 1991-2020, 2041-2070, and 2071-2100 timeframes using the SSP5-8.5 climate projections highlights comparable risks for most of the climate indicators across the three time periods; and a significantly increased risk was observed due to heat waves (temperature-based heat warning frequency), extreme rainfall (100-year return values for daily rainfall), Short-Duration High-Intensity Rainfall (50-year return values for 15-min rainfall), and thunderstorms.

Of the 140 interactions with at least a low-risk assessment, only 64 interactions of medium risk were considered for the subsequent part of the analysis. No high-risk interactions were found during the assessment.

Table 2-8: Risk Evaluation Matrix based on SSP5-8.5 Climate Projections

	Air Temperature			***Extreme High Temperature***			***Heat Wave***			***Heavy Rainfall***			***Extreme Rainfall***			***Multiday Heavy Precipitation***			Short-Duration High-Intensity Rainfall			***Drought***		
Elements	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*
RESA Surface	3	5	5	6	6	8	9	15	15	9	15	15	9	15	15	9	12	12	9	15	15	3	3	3
Noise Walls	3	5	5	6	6	8	6	10	10	3	5	5	6	10	10	6	8	8	6	10	10	3	3	3
NavAids	3	5	5	6	6	8	6	10	10	3	5	5	6	10	10	6	8	8	6	10	10	3	3	3
Breakwater and Landmass	3	5	5	3	3	4	3	5	5	3	5	5	3	5	5	3	4	4	3	5	5	3	3	3
Security Fences	3	5	5	3	3	4	3	5	5	3	5	5	6	10	10	6	8	8	6	10	10	3	3	3
Airfield Pavements (B and D)	3	5	5	6	6	8	9	15	15	9	15	15	9	15	15	9	12	12	9	15	15	3	3	3
Shoreline and Dockwalls	0		0	0	0	0	0	0	0	6	10	10	9	15	15	9	12	12	6	10	10	3	3	3
Airfield Perimeter Roads	3	5	5	6	6	8	9	15	15	9	15	15	9	15	15	9	12	12	9	15	15	3	3	3
Airfield Lighting	3	5	5	3	3	4	3	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Staff	6	10	10	9	9	12	9	15	15	9	15	15	6	10	10	6	8	8	6	10	10	3	3	3
Utility Conduit	3	5	5	6	6	8	9	15	15	9	15	15	9	15	15	9	12	12	9	15	15	3	3	3
Total number of risks per climate parameter and horizon	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Risk Evaluation Matrix Scoring

Severity	Very high	5	5	10	15	20	25
	High	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Low	2	2	4	6	8	10
	Very Low	1	1	2	3	4	5
			1	2	3	4	5
			- 50-100%	-10-50%	Baseline (± 10 %)	+10-50%	+ 50-100%+
			Likelihood				

Risk Rating

Risk (R) = Likelihood x Severity x Exposure		
Low Risk:	R ≤ 9	Controls likely not required
Moderate Risk:	10 ≤ R ≤ 16	Some controls required to reduce risks to lower levels
High Risk:	R > 20	High priority control measures required

	Hurricane			**Thunderstorm**			**Air Quality**			**Reduced Lake Ice Cover**			**Lake Acidification**			**Biofouling**			**Invasive Species**			**Ice Accretion**		
Elements	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*	*Hist*	*2050s*	*2080s*
RESA Surface	6	8	10	6	8	10	0	0	0	0	0	0	0	0	0	3	4	4	0	0	0	3	4	4
Noise Walls	6	8	10	6	8	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NavAids	6	8	10	9	12	15	6	8	10	0	0	0	0	0	0	0	0	0	0	0	0	6	8	8
Breakwater and Landmass	3	4	5	3	4	5	0	0	0	3	5	5	3	3	4	3	4	4	3	4	4	3	4	4
Security Fences	9	12	15	9	12	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	8	8
Airfield Pavements (B and D)	6	8	10	6	8	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	8	8
Shoreline and Dockwalls	9	12	15	9	12	15	0	0	0	3	5	5	3	3	4	3	4	4	3	4	4	3	4	4
Airfield Perimeter Roads	6	8	10	6	8	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	12	12
Airfield Lighting	9	12	15	9	12	15	3	4	5	0	0	0	0	0	0	0	0	0	0	0	0	3	4	4
Staff	6	8	10	9	12	15	6	8	10	0	0	0	0	0	0	3	4	4	3	4	4	6	8	8
Utility Conduit	6	8	10	6	8	10	0	0	0	0	0	0	0	0	0	3	4	4	0	0	0	3	4	4
Total number of risks per climate parameter and horizon	11	11	11	11	11	11	3	3	3	2	2	2	2	2	2	5	5	5	3	3	3	10	10	10

3. RESA Alternatives in a Changing Climate

A summary of benefits and improvements of each RESA alternative related to key climate indicators is outlined below. Each alternative has been assessed for its capacity to address climate risks and its potential to enhance the RESA's resilience in a changing climate.

3.1 RESA 1: Minimum Landmass Expansion

The breakwaters and associated landmass, provide protection due to the reduced lake ice cover, associated winter waves, resulting shoreline erosion, water spray and potential of ice accretion on airport surfaces. In addition, the breakwaters provide protection to the airport assets as a whole in the future due to the reduced lake ice cover, associated winter waves, and resulting shoreline erosion. RESA 1 has no potential to enhance the resiliency of the Toronto Island community nor does it allow for improved airport operational efficiency and safety without changing the direct crossing of the airport and non-airport vehicles of the runway surface.

3.2 RESA 2: Taxiway Improvements

This alternative expanded upon RESA 1 by considering ancillary airfield improvements in conjunction with the RESA work off both runway ends. The breakwaters and associated landmass provide protection due to the reduced lake ice cover, associated winter waves, resulting shoreline erosion, water spray and potential of ice accretion on airport surfaces. In addition, the breakwaters provide protection to the airport assets as a whole in the future due to the reduced lake ice cover, associated winter waves, and resulting shoreline erosion. In this case, improvements to Taxiway B (west end) and Taxiway D (east end) are contemplated based on improving operational efficiency and safety at the airport and eliminating localized flooding that is experienced during extreme precipitation events. Through these additional enhancements, overall airfield efficiency and safety improvements could be established. RESA 2 has no potential to enhance the resiliency of the Toronto Island community.

3.3 RESA 3: Noise Wall and East Utility Conduit

This alternative further expanded upon RESA 2 by considering incremental improvements that would further benefit airport operational safety and offer added community benefits. The new benefits would allow for improved airfield safety through unrestricted access via a perimeter airfield road between the north and south sides of the airport without the need to co-ordinate crossing on an active runway. The benefit of this perimeter airfield road would increase the resiliency of the Toronto Island community when responding to emergency events providing an additional route and additional capacity. The inclusion of space for a future East Utility Conduit will allow for the consolidation and rerouting of utilities crossing the airfield for future maintenance and expansion improving the airport efficiency and safety. In addition, the inclusion of space for a future East Utility Conduit will provide improved response time during times of utility interruptions or outages potentially impact the Toronto Island community, without impacting the airport operation. While noise walls are primarily built for sound reduction, they also offer a reduction of flood risk by acting as barriers that direct or slow down water flow during heavy precipitation.

4. Discussion and Recommendations

In this section, the adaptation measures for the medium risk levels are explained.

4.1 Risk Treatment and Adaptation Measures

The project team identified risk treatment and adaptation measures for reducing or controlling unacceptable risks to acceptable levels based on available literature and professional judgment. These measures are summarized in **Table 4-1**. In this table, the adaptation measures are divided by the implementation stage:

- **Design:** Measures to be incorporated during the design phase of assets for these to be resilient to future climate risks and to prevent costly revamps. It is assumed that the measures suggested here will likely be a part of the capital budget.
- **Operations and Maintenance (O&M):** Measures to be incorporated over the lifespan of the assets during operation and maintenance to ensure resiliency. It is assumed the capacity (e.g., functional HVAC system) already exists; however, more attention is required (e.g., more frequent maintenance). This will likely be a part of the operational budget.
- **Policy:** Measures to be executed to always provide and maintain safe and healthy working conditions. It is assumed that these are soft measures to be taken and include, mostly, interactions between humans. Policy measures may also act as a bridge while design and operation and maintenance measures are implemented.

In the Public Infrastructure Engineering Vulnerability Committee High-Level Screening Guide, the recommendations for adaptation measurements are provided for medium and high risks. A detailed table of adaptation measurements is included in **Appendix C**, with additional information on the effectiveness of the adaptation measures as well as the recommended timeframe for their implementation.

Table 4-1: Summary of Proposed Adaptation Measures

<table>
<tr><th>Climate Indicator</th><th>Asset Type</th><th>Proposed Adaptation Measures</th></tr>
<tr><td rowspan="3">Higher Temperature</td><td>RESA Surface, Airfield Pavements (Taxiways B and D), Airfield Perimeter roads</td><td>■ Apply heat-resistant and reflective marking materials to reduce heat absorption and enhance visibility.
■ Conduct regular inspection and maintenance of the RESA surface to identify any visible damage and prevent it from worsening (during and post event).</td></tr>
<tr><td>Navigational Aids</td><td>■ Improve insulation and /or add reflective covers around navigational aids sensitive equipment to protect it from heat exposure.
■ Develop response plans to address damage to navigational aids caused by climate events.</td></tr>
<tr><td>Staff</td><td>■ Adjust work schedules to cooler parts of the day, such as early morning or late afternoon.
■ Develop emergency response and staffing plans for climate events.</td></tr>
<tr><td>Precipitation</td><td>RESA Surface, Airfield Pavements (Taxiways B and D), Airfield Perimeter roads</td><td>■ Use durable and water-resistant marking materials that can withstand heavy rainfall and remain visible.
■ Design drainage system with increased capacity to handle large volumes of water during heavy rainfall events (minor system and major overland route).</td></tr>
<tr><td>Hurricane, Thunderstorms</td><td>Security Fences</td><td>■ Utilize flexible mounting systems for signage to allow for some movement without causing damage.
■ Elevate critical components such as signage to prevent water damage and maintain visibility during flooding.
■ Install reliable backup power systems, such as generators to ensure that navigational aids remain operational during power outages caused by extreme weather.
■ Design airfield lighting system to withstand high winds and reduce wind load on components such as inset lights and signage.</td></tr>
<tr><td>Air Quality</td><td>Navigational Aids</td><td>■ Improve sealing of all critical components and connections to block contaminants and ensure long-term durability.
■ Develop response plans to address damage to navigational aids caused by climate events.</td></tr>
</table>

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Appendix A

Gap Analysis

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Attachement to
Billy Bishop Toronto City Airport

Runway End Safety Area

Climate Change Vulnerability Assessment Memorandum - DRAFT

Project Name:
RESA Enviornmental Assessment

Project Reference:
60733457

From:
Sonja Drueke

Date:
March 31, 2025

Memorandum

Subject: Climate Data Gap Analysis: Climate Change Vulnerability Assessment Data and new Dataset by Toronto and Region Conservation Authority

Background

Over the course of spring and summer 2024, AECOM Canada ULC (AECOM) developed localized climate projections for the Climate Change Vulnerability Assessment in support of the Environmental Assessment of the Runway End Safety Area (RESA) at Billy Bishop Toronto City Airport. The historical climate data in AECOM 2024 Climate Change Vulnerability Assessment are based on the combined data records of the Toronto Island A and Toronto City Centre meteorological stations by Environment and Climate Change Canada and were analysed for 1991-2020, the most recent climate normal. For the analysis of potential climate change at Billy Bishop Toronto City Airport, two emission scenarios were used – one intermediate scenario with limited mitigation efforts considered (SSP2-4.5) and the very high emission scenario representing the continued burning of fossil fuels (SSP5-8.5). The statistically downscaled climate projections were analysed by AECOM for two future time horizons (i.e., 2041-2070 and 2071-2100). In total, the dataset contains information for more than 50 climate indicators.

In December 2024, the City of Toronto published climate projections in the Toronto's Current and Future Climate report developed by Toronto and Region Conservation Authority for Toronto (Lam et al., 2024). The dataset which was developed over the summer of 2024 contains 54 climate indicators (called variables in Lam et al., 2024) for the historical period of 1971 to 2000 and three future time horizons (i.e., 2015-2040, 2041-2070, and 2071-2100). Historical data of the Toronto City station located in downtown Toronto were analysed as the baseline against which the projected change was compared. To provide a range of potential future trajectories, two emission scenarios were used (i.e., SSP2-4.5 and SSP5-8.5).

The differences between the two analyses are listed in Table 1.

Table 1: Difference between the Analyses

	AECOM 2024 Climate Change Vulnerability Assessment	Toronto and Region Conservation Authority Projections
Historical period	1991-2020	1970-2000
Meteorological station(s)[1]	Toronto Island A and Toronto City Centre (Airport)	Toronto City[2]
Number of climate models	12 selected model ensuring representativeness compared against the full ensemble	26
Location(s) of projections	Extraction of data for Billy Bishop Toronto City Airport	Unspecified location(s) in Toronto
Definition of indicators	Definitions of some climate indicators vary between the analyses	

[1] Both sets of meteorological station records have a high degree of completeness and only few instances of missing data.
[2] Lam et al., 2024, Toronto's Current and Future Climate. Toronto and Region Conservation Authority, Page 12

Although both the SSP2-4.5 and SSP5-8.5 emission scenarios were compared, this summary focuses solely on the SSP5-8.5 as it is the emission scenario that was subsequently used in the AECOM 2024 Climate Change Vulnerability Assessment.

Historical Data

The impacts of climate change are already observable in the historical data at the Environment and Climate Change Canada meteorological stations at Billy Bishop Toronto City Airport (Table 2). For example, the daily mean temperature (Tmean) has increased from 8.3°C in 1971-2000 to 8.9°C in 1991-2020. For the 1971-2000, the daily mean temperature was 0.4°C lower than at the stations at Billy Bishop Toronto City Airport during the same period (Lam et al., 2024). Considering the different historical periods of the AECOM 2024 Climate Change Vulnerability Assessment and the Toronto and Region Conservation Authority dataset (i.e., 1991-2020 vs 1970-2000), the difference in daily mean temperature describing the historical context becomes even greater and reaches 1.0°C. Hence, the AECOM 2024 Climate Change Vulnerability Assessment data describe a warmer historical climate than the Toronto and Region Conservation Authority dataset.

Table 2: Historical Temperatures at Billy Bishop Toronto City Airport and in the Toronto and Region Conservation Authority Dataset

Horizon	AECOM 2024 Climate Change Vulnerability Assessment Data (at Billy Bishop Toronto City Airport)			Toronto and Region Conservation Authority Data		
	Tmin (°C)	Tmean (°C)	Tmax (°C)	Tmin (°C)	Tmean (°C)	Tmax (°C)
1971-2000	4.7	8.3	11.9	3.4	7.9	12.5
1981-2010	5.0	8.7	12.3	-	-	-
1991-2020	5.3	8.9	12.4	-	-	-

Note: Tmin – daily minimum temperature; Tmax – daily maximum temperature

Other temperature-related climate indicators used in both the AECOM 2024 Climate Change Vulnerability Assessment and the Toronto and Region Conservation Authority dataset also differ. For example, the number of days with daily maximum temperatures greater than 30°C (i.e., extreme heat) has increased between 1971-2000 and 1991-2020 from 4.8 to 5.1 days per year at Billy Bishop Toronto City Airport. In the Toronto and Region Conservation Authority dataset, the annual number of extreme heat days was 9.9 for the 1971-2000 period. Despite the warming observed at Billy Bishop Toronto City Airport, the number of extreme heat days at the airport remains lower than at the downtown location in the Toronto and Region Conservation Authority dataset. Both the difference in extreme heat days and in annual air temperature are connected to Toronto's proximity to Lake Ontario. Lake Ontario, as a large body of water with higher heat capacity than the surrounding land, modulates the air temperatures, resulting in higher minimum temperatures and lower maximum temperatures closer to the lake (see also Table A-1 and Table A-2 – attached to this memorandum). Furthermore, the downtown location is impacted by the urban heat island effect that further increases the temperature. Hence, the number of extreme heat days at Billy Bishop Toronto City Airport are lower than further away from the shoreline at the downtown station.

At Billy Bishop Toronto City Airport, the annual precipitation has decreased between 1971-2000 and 1991-2020 (Table 3). While both the annual rainfall and annual snowfall amounts have decreased, the decrease in snowfall is substantially larger than the decrease in rainfall amounts. The annual precipitation amounts in 1971-2000 of the Toronto and Region Conservation Authority dataset is lower than the comparable precipitation amounts at Billy Bishop Toronto City Airport. However, for the other two periods, the amounts have fallen below the Toronto and Region Conservation Authority dataset. Hence, using the Toronto and Region Conservation Authority data describes a wetter historical climate (+46 mm) than the AECOM 2024 Climate Change Vulnerability Assessment dataset.

Table 3: Historical Precipitation at Billy Bishop Toronto City Airport and in the Toronto and Region Conservation Authority Dataset

• Horizon	AECOM 2024 Climate Change Vulnerability Assessment Data (at Billy Bishop Toronto City Airport)			Toronto and Region Conservation Authority Data		
	Rain (mm)	Snow (cm)	Prec (mm)	Rain (mm)	Snow (cm)	Prec (mm)
1971-2000	677	100	779	-	-	753.4
1981-2010	652	74	729	-	-	-
1991-2020	646	57	707	-	-	-

Despite the dataset for Billy Bishop Toronto City Airport describing an overall drier climate, the 1-day maximum precipitation amounts are greater at Billy Bishop Toronto City Airport than for the downtown location. The 1-day maximum precipitation has increased from 42.3 to 44.8 mm between 1971-2000 and 1991-2020. The comparable 1-day maximum precipitation in the Toronto and Region Conservation Authority dataset amounts to 37.3 mm for the 1971-2000 period. Furthermore, the Intensity-Duration-Frequency (IDF) data differs between the two datasets. While the IDF data at Billy Bishop Toronto City Airport is directly obtained from the meteorological station data at the airport, the Toronto and Region Conservation Authority dataset includes two sets of IDF data obtained from idf-cc[3] and climatadata.ca. Billy Bishop Toronto City Airport IDF data shows slightly reduced rainfall rates for the short duration events (i.e., 5 and 10 minutes) and long duration events (12 and 24 hours). For 15-minute to 6-hour duration events, Billy Bishop Toronto City Airport IDF has higher rainfall rates (Table A-3-Table A-5).

Climate Projections

As the exact location(s) for which the climate projections were obtained in the Toronto and Region Conservation Authority dataset is/are not explicitly stated, it is assumed that the location corresponds with the location of the downtown meteorological station for which the historical data were analyzed. To achieve comparable datasets, the Toronto and Region Conservation Authority data was offset corrected by adding or subtracting the difference between the observations and projections for the historical period (1971-2000). This step was necessary as the data used for the AECOM 2024 Climate Change Vulnerability Assessment at Billy Bishop Toronto City Airport were already offset corrected.

The resulting climate projections show a similar pattern of an overall warmer but drier climate at Billy Bishop Toronto City Airport location compared to the downtown location for the future time horizons. For example, the minimum temperature at Billy Bishop Toronto City Airport is projected to be 1.3°C higher than at the downtown location. At the same time, the maximum temperature will be 0.8°C lower (Table 4). When the relative changes for the temperatures are calculated, it is important to carefully select the reference period. If the 1971-2000 period is selected for both datasets, the relative changes are very similar. If, however, the 1991-2020 period is selected for the AECOM 2024 Climate Change Vulnerability Assessment dataset, the relative changes differ substantially.

Table 4: Projected Temperatures at Billy Bishop Toronto City Airport and in the Toronto and Region Conservation Authority Dataset

Horizon	AECOM 2024 Climate Change Vulnerability Assessment Data (at Billy Bishop Toronto City Airport)			Toronto and Region Conservation Authority Data		
	Tmin (°C)	Tmean (°C)	Tmax (°C)	Tmin (°C)	Tmean (°C)	Tmax (°C)
2041-2070	8.8	12.2	15.7	7.5	11.9	16.5
2071-2100	11.3	14.7	18.1	10.0	14.4	18.9
	Change Relative to 1971-2000			**Change Relative to 1971-2000**		
2041-2070	+4.0	+3.9	+3.8	+4.1	+4.0	+4.0
2071-2100	+6.5	+6.4	+6.2	+6.6	+6.5	+6.4
	Change Relative to 1991-2020			**Change Relative to 1971-2000**		
2041-2070	+3.4	+3.4	+3.3	+4.1	+4.0	+4.0
2071-2100	+5.9	+5.8	+5.8	+6.6	+6.5	+6.4

Similar to the finding for the historical dataset, the projections show fewer extreme days at Billy Bishop Toronto City Airport (i.e., closer to Lake Ontario) compared to the downtown data of the Toronto and Region Conservation Authority dataset when extreme heat is defined as days with daily maximum temperature greater than 30°C. When nighttime temperatures (i.e., daily minimum temperatures) greater than 20°C are used to define extreme heat, Billy Bishop Toronto City Airport location shows a greater number of extreme heat days (Table 5). The relative change is more similar when the 1991-2020 period is selected as a baseline for the AECOM 2024 Climate Change Vulnerability Assessment dataset.

Table 5: Projected Extreme Heat Days at Billy Bishop Toronto City Airport and in the Toronto and Region Conservation Authority Dataset

Horizon	AECOM 2024 Climate Change Vulnerability Assessment Data (at Billy Bishop Toronto City Airport)		Toronto and Region Conservation Authority Data	
	Tmax > 30°C	Tmin > 20°C	Tmax > 30°C	Tmin > 20°C
2041-2070	34 days	43 days	44 days	34 days
2071-2100	65 days	76 days	78 days	69 days

[3] The idf-cc tool provides IDF data for gauged and ungauged location across Canada: https://www.idf-cc-uwo.ca/home

Horizon	AECOM 2024 Climate Change Vulnerability Assessment Data (at Billy Bishop Toronto City Airport)		Toronto and Region Conservation Authority Data	
	Tmax > 30°C	Tmin > 20°C	Tmax > 30°C	Tmin > 20°C
	Change Relative to 1971-2000		Change Relative to 1971-2000	
2041-2070	+30 days	+36 days	+34 days	+29 days
2071-2100	+60 days	+68 days	+68 days	+64 days
	Change Relative to 1991-2020		Change Relative to 1971-2000	
2041-2070	+30 days	+32 days	+34 days	+29 days
2071-2100	+60 days	+64 days	+68 days	+64 days

Note: Tmin – daily minimum temperature; Tmax – daily maximum temperature

For Heating and Cooling Degrees Days, the overall pattern of the two dataset continues. While the climate projections for the Heating Degrees Days are similar in both datasets, the Cooling Degrees Days show substantial differences with the downtown station in the Toronto and Region Conservation Authority showing higher Cooling Degrees Days values compared to the AECOM 2024 Climate Change Vulnerability Assessment data for Billy Bishop Toronto City Airport (Table 6). This difference originates from the higher daytime temperatures (i.e., daily maximum temperature) downtown. Lake Ontario modulates the Cooling Degrees Days by lowering daily maximum temperatures.

Table 6: Projected Heating Degrees Days and Cooling Degrees Days at Billy Bishop Toronto City Airport and in the Toronto and Region Conservation Authority Dataset

Horizon	AECOM 2024 Climate Change Vulnerability Assessment Data (at Billy Bishop Toronto City Airport)		Toronto and Region Conservation Authority Data	
	Heating Degrees Days (°-days)	Cooling Degrees Days (°-days)	Heating Degrees Days (°-days)	Cooling Degrees Days (°-days)
2041-2070	2733	256	2760	717
2071-2100	2190	980	2189	1141
	Change Relative to 1971-2000		Change Relative to 1971-2000	
2041-2070	-1030	+387	-1174	+460
2071-2100	-1073	+744	-1745	+885
	Change Relative to 1991-2020		Change Relative to 1971-2000	
2041-2070	-878	+349	-1174	+460
2071-2100	-1421	+706	-1745	+885

The climate projections for Billy Bishop Toronto City Airport show less annual precipitation throughout the century and, hence, Billy Bishop Toronto City Airport remains drier by about 50 mm (Table 7). Similar to the temperature-related climate indicators, a greater agreement between the two dataset is found when the change for the AECOM 2024 Climate Change Vulnerability Assessment data at Billy Bishop Toronto City Airport is calculated relative to the 1991-2020 period. For the 1-day maximum precipitation, the projections are higher for the AECOM 2024 Climate Change Vulnerability Assessment dataset, and the increase is weaker than for the Toronto and Region Conservation Authority dataset when the 1991-2020 period is used as a baseline and larger when the 1971-2000 period is used. The climate projections for the IDF data at Billy Bishop Toronto City Airport (i.e., AECOM 2024 Climate Change Vulnerability Assessment dataset) lie between the two IDF datasets included in the Toronto and Region Conservation Authority dataset (Table A-7-Table A-12).

Table 7: Projected Precipitation at Billy Bishop Toronto City Airport and in the Toronto and Region Conservation Authority Dataset

Horizon	AECOM 2024 Climate Change Vulnerability Assessment Data (at Billy Bishop Toronto City Airport)			Toronto and Region Conservation Authority Data		
	Rain (mm)	Snow (cm)	Prec (mm)	Rain (mm)	Snow (cm)	Prec (mm)
2041-2070	766	7.4	774	-	-	833
2071-2100	832	0.0	832	-	-	880
	Change Relative to 1971-2000			Change Relative to 1971-2000		
2041-2070	+88	-93	-4.8	-	-	+80
2071-2100	+155	-100	+35	-	-	+126
	Change Relative to 1991-2020			Change Relative to 1971-2000		
2041-2070	+119	-50	+68	-	-	+80
2071-2100	+186	-57	+108	-	-	+126

Climate Indicators

Not all climate indicators that were developed for the AECOM 2024 Climate Change Vulnerability Assessment are available or can be derived from the Toronto and Region Conservation Authority dataset (Table 8). For some climate indicators, comparable indicators were found and used to replace the original indicators and their definitions. Alternative definitions were available for

- Extreme high temperature;
- Heat wave;
- Multiday heavy precipitation;
- Drought; and,
- Reduced lake ice cover

For these indicators and the ones for which definitions were identical, the Toronto and Region Conservation Authority dataset was used to determine the historical values and the climate projections and the respective likelihood score. For all other climate indicators, the original values and score were kept (Table 9).

Table 8: List of Climate Indicators Based on AECOM 2024 Climate Change Vulnerability Assessment Climate Data at Billy Bishop Toronto City Airport and Toronto and Region Conservation Authority Climate Data

			AECOM 2024 Climate Change Vulnerability Assessment Climate Data						Toronto and Region Conservation Authority Climate Data					
			Hist (1991-2020)		2050s		2080s		Hist (1971-2000)		2050s		2080s	
Climate Indicator	**Definition**	**Units**	**Values**	**Scores**	**Values**	**Scores**	**Values**	**Scores**	**Values**	**Scores**	**Values**	**Units**	**Values**	**Scores**
Air temperature	Annual average of daily mean temperature	°C	8.9	3	12.2	4	14.7	5	7.9	3	11.9	5	14.4	5
Extreme high temperature	100-year return values for daily maximum temperature	°C	40.3	3	44.5	4	47.6	4	-	-	-	-	-	-
	The maximum of daily maximum temperatures (°C), representing the hottest daytime temperature	°C	-	-	-	-	-	-	31.3	3	32.5	3	34.7	4
Heat wave	Daily maximum temperature > 30°C for at least 3 consecutive days	events	0.5	3	3.9	5	5.0	5	-	-	-	-	-	-
	Temperature-based heat warning frequency: Forecast of >2 consecutive days with maximum temperature >31°C and minimum temperature >20°C	events	-	-	-	-	-	-	0.5	3	5.6	5	7.3	5
Heavy rainfall	10-year return values for daily rainfall	years	10	3	3.0	5	1.0	5	10	3	3.5	5	1.7	5
Extreme rainfall	100-year return values for daily rainfall	years	100	3	18.1	5	6.1	5	100	3	17.5	5	7.5	5
Multiday heavy precipitation	Maximum 5-day precipitation	Mm	63.3	3	70.7	4	75.9	4	-	-	-	-	-	-
	Maximum 3-day precipitation	Mm	-	-	-	-	-	-	50.2	3	59.1	4	64.4	4
Short duration high density rainfall	50-year return values for 15-min rainfall	years	50	3	15.2	5	6.8	5	50	3	11.9	5	5.9	5
Drought	Monthly precipitation is less than the 2nd decile of the historical precipitation for the correspoding month	months	2.4	3	2.4	3	2.5	4	-	-	-	-	-	-
	The maximum number of consecutive days when precipitation was less than 0.2 mm (or < 0.2)	days	-	-	-	-	-	-	13.4	3	13.6	3	13.9	3
Hurricane	Umbrella indicator for number of hurricanes, intensity (i.e., wind speed), and precipitation	-	-	3	-	4	-	5	-	-	-	-	-	-
Thunderstorm	Umbrella indicator for number of thunderstorms and heavy rainfall, heavy wind, tornados, lightning, hail etc.	-	-	3	-	4	-	5	-	-	-	-	-	-
Air quality	Umbrella indicator for multiple pollutant such as ozone and particular matter (PM2.5; wildfire smoke)	-	-	3	-	4	-	5	-	-	-	-	-	-
Reduced lake ice cover	Reduction in lake ice cover of Lake Ontario (annual maximum ice cover)	%	25.9	3	9.3	5	0.0	5	-	-	-	-	-	-
	Reduction in lake ice cover of Lake Ontario (annual average ice cover)	%	-	-	-	-	-	-	6.1	3	2.0	5	0.5	5
Lake acidification	Acidification of Lake Ontario due to the uptake of CO2	pH	8.44	3	-	3	8.1	4	-	-	-	-	-	-
Biofouling	Cyanobacterial growth, algae bloom, and lake/ocean acidification	-	-	3	-	4	-	4	-	-	-	-	-	-
Invasive species	Climate-tracking plants and animals	-	-	3	-	4	-	4	-	-	-	-	-	-
Ice accretion	Freezing spray during high wind event and storms	-	-	3	-	4	-	4	-	-	-	-	-	-

Note: *Definitions of climate indicators printed in italic are used by Lam et al. (2024).*

Table 9: Combined List of Climate Indicators Based on Toronto and Region Conservation Authority and AECOM 2024 Climate Change Vulnerability Assessment Climate Data

			Historical		2050s		2080s	
Climate Indicator	**Definition**	**Units**	**Values**	**Scores**	**Values**	**Scores**	**Values**	**Scores**
Air temperature	Annual average of daily mean temperature	°C	7.9	3	11.9	5	14.4	5
Extreme high temperature (hottest day temperature)	The maximum of daily maximum temperatures (°C), representing the hottest daytime temperature	°C	31.3	3	32.5	3	34.7	4
Heat wave (temperature-based heat warning frequency)	Forecast of >2 consecutive days with maximum temperature >31°C and minimum temperature >20°C	events	0.5	3	5.6	5	7.3	5
Heavy rainfall	10-year return values for daily rainfall	years	10	3	3.5	5	1.7	5
Extreme rainfall	100-year return values for daily rainfall	years	100	3	17.5	5	7.5	5
Multiday heavy precipitation	Maximum 3-day precipitation	mm	50.2	3	59.1	4	64.4	4
Short duration high density rainfall	50-year return values for 15-min rainfall	years	50	3	11.9	5	5.9	5
Drought	The maximum number of consecutive days when precipitation was less than 0.2 mm (or < 0.2)	days	13.4	3	13.6	3	13.9	3
Hurricane	Umbrella indicator for number of hurricanes, intensity (i.e., wind speed), and precipitation		-	3	-	4	-	5
Thunderstorm	Umbrella indicator for number of thunderstorms and heavy rainfall, heavy wind, tornados, lightning, hail etc.		-	3	-	4	-	5
Air quality	Umbrella indicator for multiple pollutant such as ozone and particular matter (PM2.5; wildfire smoke)		-	3	-	4	-	5
Reduced lake ice cover	Reduction in lake ice cover of Lake Ontario (annual average ice cover)	%	6.1	3	2.0	5	0.5	5
Lake acidification	Acidification of Lake Ontario due to the uptake of CO2	pH	-	3	-	3	8.1	4
Biofouling	Cyanobacterial growth, algae bloom, and lake/ocean acidification		-	3	-	4	-	4
Invasive species	Climate-tracking plants and animals		-	3	-	4	-	4
Ice accretion	Freezing spray during high wind event and storms		-	3	-	4	-	4

Reference

Lam, S., Demirbas Caglayan, S., Mahya, M., and David, Y. (2024). Toronto's Current and Future Climate. Toronto and Region Conservation Authority. Toronto, ON

Attachments – Additional Comparisons

Table A-1: Historical Extreme Cold Days at Billy Bishop Toronto City Airport and in the Toronto and Region Conservation Authority Dataset

	AECOM 2024 Climate Change Vulnerability Assessment Data (at Billy Bishop Toronto City Airport)	Toronto and Region Conservation Authority Data
Horizon	**Tmin < -20°C**	**Tmin < -20°C**
1971-2000	1.6 days	3.7 days
1981-2010	1.4 days	-
1991-2020	1.4 days	-

Note: Tmin – daily minimum temperature

Table A-2: Historical Extreme Heat Days at Billy Bishop Toronto City Airport and in the Toronto and Region Conservation Authority Dataset

	AECOM 2024 Climate Change Vulnerability Assessment Data (at Billy Bishop Toronto City Airport)		Toronto and Region Conservation Authority Data	
Horizon	**Tmax > 30°C**	**Tmin > 20°C**	**Tmax > 30°C**	**Tmin > 20°C**
1971-2000	4.8 days	7.8 days	9.9 days	5.0 days
1981-2010	5.7 days	9.3 days	-	-
1991-2020	5.1 days	11.6 days	-	-

Note: Tmin – daily minimum temperature; Tmax – daily maximum temperature

Table A-3: Historical IDF Data at Billy Bishop Toronto City Airport (mm/h)

Duration	2 years	5 years	10 years	25 years	50 years	100 years
5 min	100.0	143.4	172.2	208.6	235.6	262.4
10 min	74.1	102.1	120.7	144.1	161.5	178.8
15 min	62.0	85.6	101.2	120.9	135.5	150.0
30 min	40.4	55.8	66.0	78.9	88.5	98.0
1 h	24.9	34.8	41.4	49.7	55.9	62.0
2 h	14.5	19.4	22.6	26.7	29.7	32.7
6 h	6.0	7.8	9.0	10.5	11.6	12.7
12 h	3.3	4.3	4.9	5.7	6.3	6.8
24 h	1.8	2.3	2.5	2.9	3.2	3.4

Table A-4: Historical IDF Data in the Toronto and Region Conservation Authority Dataset (idf-cc; mm/h)

Duration	2 years	5 years	10 years	25 years	50 years	100 years
5 min	102.8	140.1	169.3	212.3	249.2	290.7
10 min	73.6	96.6	113.8	138.1	158.2	180.0
15 min	58.1	78.6	94.7	118.2	138.4	161.1
30 min	37.3	51.6	62.5	78.2	91.3	105.7
1 h	23.4	32.2	38.4	46.8	53.3	60.1
2 h	13.8	18.9	22.6	27.7	31.9	36.3
6 h	5.7	7.6	9.1	11.2	13.0	15.0
12 h	3.4	4.4	5.2	6.3	7.2	8.1
24 h	1.9	2.5	2.9	3.4	3.8	4.3

Table A-5: Historical IDF Data in the Toronto and Region Conservation Authority Dataset (climatedata.ca; mm/h)

Duration	2 years	5 years	10 years	25 years	50 years	100 years
5 min	106.9	146.6	172.9	206.1	230.8	255.2
10 min	75.4	99.2	114.9	134.8	149.5	164.2
15 min	60.3	82.0	96.4	114.6	128.1	141.5
30 min	38.6	53.4	63.1	75.4	84.6	93.6
1 h	23.8	32.6	38.4	45.7	51.2	56.6
2 h	14.1	19.5	23.0	27.5	30.9	34.2
6 h	5.8	7.9	9.2	10.9	12.2	13.4
12 h	3.5	4.5	5.2	6.1	6.8	7.4
24 h	2.0	2.5	2.9	3.4	3.7	4.1

Table A-6: Projected 1-Day Maximum Precipitation at Billy Bishop Toronto City Airport and in the Toronto and Region Conservation Authority Dataset

Horizon	AECOM 2024 Climate Change Vulnerability Assessment Data (at Billy Bishop Toronto City Airport)	Toronto and Region Conservation Authority Data
2041-2070	49.9 mm	43.8 mm
2071-2100	53.1 mm	47.4 mm
	Change Relative to 1971-2000	**Change Relative to 1971-2000**
2041-2070	+7.6 mm	+6.5 mm
2071-2100	+10.8 mm	+10.1 mm
	Change Relative to 1991-2020	**Change Relative to 1971-2000**
2041-2070	+5.1 mm	+6.5 mm
2071-2100	+8.3 mm	+10.1 mm

Table A-7: Projected IDF Data at Billy Bishop Toronto City Airport Climate Change Vulnerability Assessment (2041-2070; mm/h)

Duration	2 years	5 years	10 years	25 years	50 years	100 years
5 min	125.6	180.1	216.3	262.0	295.9	329.6
10 min	93.1	128.2	151.6	181.0	202.8	224.6
15 min	77.9	107.5	127.1	151.8	170.2	188.4
30 min	50.7	70.1	82.9	99.1	111.1	123.1
1 h	31.3	43.7	52.0	62.4	70.2	77.9
2 h	18.2	24.4	28.4	33.5	37.3	41.1
6 h	7.5	9.8	11.3	13.2	14.6	16.0
12 h	4.1	5.4	6.2	7.2	7.9	8.5
24 h	2.3	2.9	3.1	3.6	4.0	4.3

Table A-8: Projected IDF Data in the Toronto and Region Conservation Authority Dataset (idf-cc; 2041-2070; mm/h)

Duration	2 years	5 years	10 years	25 years	50 years	100 years
5 min	114.7	159.9	194.0	243.2	284.8	339.6
10 min	82.0	110.2	131.0	159.3	182.6	212.0
15 min	64.8	89.7	108.5	135.5	158.3	188.1
30 min	41.5	59.1	71.8	89.9	104.9	123.9
1 h	26.0	37.0	44.3	54.1	61.9	71.1
2 h	15.3	21.7	26.0	32.0	36.9	42.8
6 h	6.3	8.6	10.4	12.9	14.9	17.6
12 h	3.8	5.0	6.0	7.2	8.3	9.6
24 h	2.2	2.9	3.4	4.0	4.5	5.1

Table A-9: Projected IDF Data in the Toronto and Region Conservation Authority Dataset (climatedata.ca; 2041-2070; mm/h)

Duration	2 years	5 years	10 years	25 years	50 years	100 years
5 min	139.0	190.0	224.0	267.0	299.0	331.0
10 min	98.0	110.2	131.0	159.3	182.6	212.0
15 min	78.0	106.0	125.0	149.0	166.0	184.0
30 min	50.0	69.0	82.0	98.0	110.0	121.0
1 h	31.0	42.0	50.0	59.0	66.0	73.0
2 h	18.0	25.0	30.0	36.0	40.0	44.0
6 h	7.5	10.0	12.0	14.0	16.0	17.0
12 h	4.5	5.8	6.7	7.9	8.8	9.6
24 h	2.6	3.2	3.8	4.4	4.8	5.3

Table A-10: Projected IDF Data at Billy Bishop Toronto City Airport (2071-2100; mm/h)

Duration	2 years	5 years	10 years	25 years	50 years	100 years
5 min	148.4	212.8	255.6	309.6	349.7	389.4
10 min	110.0	151.5	179.1	213.9	239.7	265.4
15 min	92.0	127.0	150.2	179.4	201.1	222.6
30 min	60.0	82.8	98.0	117.1	131.3	145.4
1 h	37.0	51.6	61.4	73.8	83.0	92.0
2 h	21.5	28.8	33.5	39.6	44.1	48.5
6 h	8.9	11.6	13.4	15.6	17.2	18.8
12 h	4.9	6.4	7.3	8.5	9.3	10.1
24 h	2.7	3.4	3.7	4.3	4.7	5.0

Table A-11: Projected IDF Data in the Toronto and Region Conservation Authority Dataset (idf-cc; 2071-2100; mm/h)

Duration	2 years	5 years	10 years	25 years	50 years	100 years
5 min	126.6	172.2	204.2	261.2	315.2	365.1
10 min	90.5	118.9	137.5	170.8	200.8	227.3
15 min	71.5	96.7	114.2	145.4	175.1	202.3
30 min	45.9	63.5	75.5	96.8	115.6	133.6
1 h	28.8	39.6	46.7	58.5	67.8	76.6
2 h	17.0	23.2	27.4	34.6	40.5	46.0
6 h	7.0	9.3	10.9	13.8	16.4	18.9
12 h	4.2	5.4	6.3	7.8	9.1	10.2
24 h	2.4	3.1	3.5	4.3	4.9	5.4

Table A-12: Projected IDF Data in the Toronto and Region Conservation Authority Dataset (climatedata.ca; 2071-2100; mm/h)

Duration	2 years	5 years	10 years	25 years	50 years	100 years
5 min	162.0	222.0	262.0	313.0	350.0	387.0
10 min	114.0	150.0	174.0	204.0	227.0	249.0
15 min	91.0	124.0	146.0	174.0	194.0	215.0
30 min	59.0	81.0	96.0	114.0	128.0	142.0
1 h	36.0	49.0	58.0	69.0	78.0	86.0
2 h	21.0	30.0	35.0	42.0	47.0	52.0
6 h	8.8	12.0	14.0	17.0	19.0	20.0
12 h	5.3	6.8	7.9	9.3	10.0	11.0
24 h	3.0	3.8	4.4	5.2	5.6	6.2

Appendix B

Level of Severity for Each Climate Indicator and Each Infrastructure Component

					Risk Analysis										
	Climate (Probability / Likelihood) – SSP5-8.5				Impact Categories (Consequences)					Severity Rating		Justification	Risk Results		
Elements	Climate Indicators	Hist	2050s	2080s	Health & Safety	Infrastructure Integrity	Operational Impact	Financial Impact	Reputational Impact	Impacted (Y/N)	Impact Severity Rating (1-5)		Current	Future (2041-2070)	Future (2071-2100)
RESA Surface															
RESA Surface	Air temperature	3	5	5		1	1	1		Yes	1	Higher temperatures can cause frequent thermal expansion and contraction of pavements, leading to cracking and deformation. Could lead to vegetation stress if the RESA is vegetated.	3	5	5
RESA Surface	Extreme high temperature	3	3	4		2	2	2	1	Yes	2	Extreme high temperatures can cause frequent thermal expansion and contraction of pavements, leading to cracking and deformation. Could lead to vegetation stress if the RESA is vegetated.	6	6	8
RESA Surface	Heat wave	3	5	5		3	2	3	1	Yes	3	Heat waves can cause frequent thermal expansion and contraction of pavements, leading to cracking and deformation. Could lead to vegetation stress if the RESA is vegetated.	9	15	15
RESA Surface	Heavy rainfall	3	5	5		3	3	3	1	Yes	3	Heavy rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the RESA surface.	9	15	15
RESA Surface	Extreme rainfall	3	5	5		3	3	3	1	Yes	3	Extreme rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the RESA surface.	9	15	15
RESA Surface	Multiday heavy precipitation	3	4	4		3	3	3	1	Yes	3	Multiday heavy precipitation can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the RESA surface.	9	12	12
RESA Surface	Short-Duration High-Intensity Rainfall	3	5	5		3	2	3	1	Yes	3	Short-Duration High-Intensity Rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the RESA surface.	9	15	15
RESA Surface	Drought	3	3	3		1		1		Yes	1	Drought and lack of moisture can cause stress of vegetation cover.	3	3	3
RESA Surface	Hurricane	3	4	5		2	2	2	1	Yes	2	Hurricanes with associated intense rainfall and strong winds can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the RESA surface.	6	8	10
RESA Surface	Thunderstorm	3	4	5		2	2	2	1	Yes	2	Thunderstorms with associated intense rainfall and strong winds can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the RESA surface.	6	8	10
RESA Surface	Air quality	3	4	5						No	0	No impact.	0	0	0
RESA Surface	Reduced lake ice cover	3	5	5						No	0	No impact.	0	0	0
RESA Surface	Lake acidification	3	3	4						No	0	No impact.	0	0	0
RESA Surface	Biofouling	3	4	4		1				Yes	1	May obstruct water flow, and resulting in ponding and standing water	3	4	4
RESA Surface	Invasive species	3	4	4						No	0	No impact.	0	0	0
RESA Surface	Ice accretion	3	4	4			1			Yes	1	Ice could form on RESA surfaces.	3	4	4
Noise Walls															
Noise Walls	Air temperature	3	5	5		1	1	1		Yes	1	Higher air temperature (and associated increased sunlight) can cause accelerated degradation of noise walls and elements.	3	5	5
Noise Walls	Extreme high temperature	3	3	4		2	2	2	1	Yes	2	Extreme high temperature (and associated increased sunlight) can cause accelerated degradation of noise walls and elements.	6	6	8
Noise Walls	Heat wave	3	5	5		2	2	2	1	Yes	2	Heat wave (and associated increased sunlight) can cause accelerated degradation of noise walls and elements	6	10	10

		Climate (Probability / Likelihood) – SSP5-8.5			Risk Analysis: Impact Categories (Consequences)					Risk Analysis: Severity Rating		Justification	Risk Results		
Elements	**Climate Indicators**	**Hist**	**2050s**	**2080s**	**Health & Safety**	**Infrastructure Integrity**	**Operational Impact**	**Financial Impact**	**Reputational Impact**	**Impacted (Y/N)**	**Impact Severity Rating (1-5)**		**Current**	**Future (2041-2070)**	**Future (2071-2100)**
Noise Walls	Heavy rainfall	3	5	5		1	1	1		Yes	1	Heavy rainfall could potentially damage sound wall panels and cause localized erosion.	3	5	5
Noise Walls	Extreme rainfall	3	5	5		1	2	2		Yes	2	Extreme rainfall could potentially damage sound wall panels and cause localized erosion.	6	10	10
Noise Walls	Multiday heavy precipitation	3	4	4		1	2	2		Yes	2	Multiday heavy precipitation could potentially damage sound wall panels and cause localized erosion.	6	8	8
Noise Walls	Short-Duration High-Intensity Rainfall	3	5	5		1	2	2		Yes	2	Short-Duration High-Intensity Rainfall could potentially damage sound wall panels and cause localized erosion.	6	10	10
Noise Walls	Drought	3	3	3		1		1		Yes	1	Soil moisture reduction can potentially lead to settling.	3	3	3
Noise Walls	Hurricane	3	4	5		2	1	2	1	Yes	2	The intense rainfall and heavy winds associated with hurricanes can lead to localized erosion and potentially damage sound wall panels.	6	8	10
Noise Walls	Thunderstorm	3	4	5		2	1	2	1	Yes	2	The intense rainfall and heavy winds associated with thunderstorms can lead to localized erosion and potentially damage sound wall panels.	6	8	10
Noise Walls	Air quality	3	4	5						No	0	No impact.	0	0	0
Noise Walls	Reduced lake ice cover	3	5	5						No	0	No impact.	0	0	0
Noise Walls	Lake acidification	3	3	4						No	0	No impact.	0	0	0
Noise Walls	Biofouling	3	4	4						No	0	No impact.	0	0	0
Noise Walls	Invasive species	3	4	4						No	0	No impact.	0	0	0
Noise Walls	Ice accretion	3	4	4						No	0	No impact.	0	0	0
NavAids															
NavAids	Air temperature	3	5	5		1	1	1	1	Yes	1	Higher air temperature may be above operating temperature of electronic components leading to reduced performance or failures.	3	5	5
NavAids	Extreme high temperature	3	3	4		2	2	1	2	Yes	2	Extreme high air temperature may be above operating temperature of electronic components leading to reduced performance or failures.	6	6	8
NavAids	Heat wave	3	5	5		2	2	1	2	Yes	2	Heat waves may be above operating temperature of electronic components for extended periods of time leading to reduced performance or failures.	6	10	10
NavAids	Heavy rainfall	3	5	5		1	1	1		Yes	1	Heavy rainfall may lead to extended periods of water infiltration into the system electrical components, causing corrosion or malfunctioning of the lights and may lead to localized erosion and flooding around the NavAids sites.	3	5	5
NavAids	Extreme rainfall	3	5	5		2	1	1	1	Yes	2	Extreme rainfall may lead to extended periods of water infiltration into the system electrical components, causing corrosion or malfunctioning of the lights and may lead to localized erosion and flooding around the NavAids sites.	6	10	10
NavAids	Multiday heavy precipitation	3	4	4		2	2	1		Yes	2	Multiday heavy precipitation may lead to extended periods of water infiltration into the system electrical components, causing corrosion or malfunctioning of the lights and may lead to localized erosion and flooding around the NavAids sites.	6	8	8
NavAids	Short-Duration High-Intensity Rainfall	3	5	5		2	2	1		Yes	2	Short-Duration High-Intensity Rainfall may lead to extended periods of water infiltration into the system electrical components, causing corrosion or malfunctioning of the lights and may lead to localized erosion and flooding around the NavAids sites.	6	10	10
NavAids	Drought	3	3	3		1				Yes	1	Drought and lack of moisture can cause soil settling around the NavAid systems.	3	3	3

	Climate (Probability / Likelihood) – SSP5-8.5				Risk Analysis: Impact Categories (Consequences)					Severity Rating			Risk Results		
Elements	**Climate Indicators**	**Hist**	**2050s**	**2080s**	**Health & Safety**	**Infrastructure Integrity**	**Operational Impact**	**Financial Impact**	**Reputational Impact**	**Impacted (Y/N)**	**Impact Severity Rating (1-5)**	**Justification**	**Current**	**Future (2041-2070)**	**Future (2071-2100)**
NavAids	Hurricane	3	4	5		2	2	1	2	Yes	2	The heavy winds (flying debris) and extreme rainfall associated with hurricanes can cause damage to NavAid systems or misalignment.	6	8	10
NavAids	Thunderstorm	3	4	5		3	3	1	2	Yes	3	The heavy winds (flying debris) and extreme rainfall associated with thunderstorms can cause damage to NavAid systems or misalignment.	9	12	15
NavAids	Air quality	3	4	5		2	2	1		Yes	2	Increased level of pollutants and accumulation of particulate matter may affect NavAid systems.	6	8	10
NavAids	Reduced lake ice cover	3	5	5						No	0	No impact.	0	0	0
NavAids	Lake acidification	3	3	4						No	0	No impact.	0	0	0
NavAids	Biofouling	3	4	4						No	0	No impact.	0	0	0
NavAids	Invasive species	3	4	4						No	0	No impact.	0	0	0
NavAids	Ice accretion	3	4	4			2			Yes	2	Ice could accumulate on NavAids impacting operations.	6	8	8
Breakwater and Landmass															
Breakwater and Landmass	Air temperature	3	5	5		1				Yes	1	Higher air temperature can cause thermal expansion and contraction of the armour stone and leading to cracks. Additionally, higher air temperature may reduce soil moisture, causing the soil to become dry and compact and resulting in subsidence or erosion.	3	5	5
Breakwater and Landmass	Extreme high temperature	3	3	4		1				Yes	1	Extreme high temperature can cause thermal expansion and contraction of the armour stone and leading to cracks. Additionally, higher air temperature may reduce soil moisture, causing the soil to become dry and compact and resulting in subsidence or erosion.	3	3	4
Breakwater and Landmass	Heat wave	3	5	5		1				Yes	1	Heat wave can cause thermal expansion and contraction of the armour stone and leading to cracks. Additionally, higher air temperature may reduce soil moisture, causing the soil to become dry and compact and resulting in subsidence or erosion.	3	5	5
Breakwater and Landmass	Heavy rainfall	3	5	5		1				Yes	1	Heavy rainfall may lead to localized erosion and ponding/standing water within landmass.	3	5	5
Breakwater and Landmass	Extreme rainfall	3	5	5		1				Yes	1	Extreme rainfall may lead to localized erosion and ponding/standing water within landmass.	3	5	5
Breakwater and Landmass	Multiday heavy precipitation	3	4	4		1				Yes	1	Multiday heavy precipitation may lead to localized erosion and ponding/standing water within landmass.	3	4	4
Breakwater and Landmass	Short-Duration High-Intensity Rainfall	3	5	5		1				Yes	1	Short-Duration High-Intensity Rainfall may lead to localized erosion and ponding/standing water within landmass.	3	5	5
Breakwater and Landmass	Drought	3	3	3		1				Yes	1	Drought conditions and reduction of soil moisture and may lead to subsidence.	3	3	3
Breakwater and Landmass	Hurricane	3	4	5		1				Yes	1	Heavy rainfall associated with hurricanes may lead to localized erosion and ponding/standing water within landmass.	3	4	5
Breakwater and Landmass	Thunderstorm	3	4	5		1				Yes	1	Heavy rainfall associated with thunderstorms may lead to localized erosion and ponding/standing water within landmass.	3	4	5
Breakwater and Landmass	Air quality	3	4	5						No	0	No impact.	0	0	0
Breakwater and Landmass	Reduced lake ice cover	3	5	5		1				Yes	1	Reduced lake ice cover may result in damage associated with wave action or ice accretion due to spray.	3	5	5

	Climate (Probability / Likelihood) – SSP5-8.5				Risk Analysis: Impact Categories (Consequences)					Severity Rating		Justification	Risk Results		
Elements	**Climate Indicators**	**Hist**	**2050s**	**2080s**	**Health & Safety**	**Infrastructure Integrity**	**Operational Impact**	**Financial Impact**	**Reputational Impact**	**Impacted (Y/N)**	**Impact Severity Rating (1-5)**		**Current**	**Future (2041-2070)**	**Future (2071-2100)**
Breakwater and Landmass	Lake acidification	3	3	4		1				Yes	1	May result in cosmetic corrosion of armour stone.	3	3	4
Breakwater and Landmass	Biofouling	3	4	4		1				Yes	1	May obstruct water flow, and result in ponding and standing water.	3	4	4
Breakwater and Landmass	Invasive species	3	4	4		1				Yes	1	Root growth or burrowing of invasive species can destabilize fill material and increase erosion.	3	4	4
Breakwater and Landmass	Ice accretion	3	4	4		1				Yes	1	Ice could form on Breakwater and Landmass.	3	4	4
Security Fences															
Security Fences	Air temperature	3	5	5		1		1		Yes	1	Prolonged exposure to higher air temperatures may cause material degradation.	3	5	5
Security Fences	Extreme high temperature	3	3	4		1		1		Yes	1	Prolonged exposure to extreme high temperatures may cause material degradation.	3	3	4
Security Fences	Heat wave	3	5	5		1		1		Yes	1	Prolonged exposure to heat waves may cause material degradation.	3	5	5
Security Fences	Heavy rainfall	3	5	5		1	1	1	1	Yes	1	Heavy rainfall could lead to localized erosion impacting security fence components.	3	5	5
Security Fences	Extreme rainfall	3	5	5		2	2	2	1	Yes	2	Extreme rainfall could lead to localized erosion impacting security fence components.	6	10	10
Security Fences	Multiday heavy precipitation	3	4	4		2	2	2	1	Yes	2	Multiday heavy precipitation could lead to localized erosion impacting security fence components.	6	8	8
Security Fences	Short-Duration High-Intensity Rainfall	3	5	5		2	2	2	1	Yes	2	Short-Duration High-Intensity Rainfall could lead to localized erosion impacting security fence components.	6	10	10
Security Fences	Drought	3	3	3		1				Yes	1	Drought conditions and reduction of soil moisture and may lead to subsidence.	3	3	3
Security Fences	Hurricane	3	4	5		3	2	2	1	Yes	3	Heavy winds associated with hurricanes can cause physical damage to security fences and sub-elements.	9	12	15
Security Fences	Thunderstorm	3	4	5		3	2	2	1	Yes	3	Heavy winds associated with thunderstorms can cause physical damage to security fences and sub-elements.	9	12	15
Security Fences	Air quality	3	4	5						No	0	No impact.	0	0	0
Security Fences	Reduced lake ice cover	3	5	5						No	0	No impact.	0	0	0
Security Fences	Lake acidification	3	3	4						No	0	No impact.	0	0	0
Security Fences	Biofouling	3	4	4						No	0	No impact.	0	0	0
Security Fences	Invasive species	3	4	4						No	0	No impact.	0	0	0
Security Fences	Ice accretion	3	4	4		2				Yes	2	Ice could form on fences and associated infrastructure.	6	8	8
Airfield Pavements (Taxiways B and D)															
Airfield Pavements (Taxiways B and D)	Air temperature	3	5	5		1	1	1		Yes	1	Higher temperatures can be outside of design temperature of pavements and can lead to deformation.	3	5	5
Airfield Pavements (Taxiways B and D)	Extreme high temperature	3	3	4		2	2	2	1	Yes	2	Extreme high temperatures can be outside of design temperature of pavements and can lead to deformation.	6	6	8
Airfield Pavements (Taxiways B and D)	Heat wave	3	5	5		3	2	3	1	Yes	3	Heat waves can be outside of design temperature of pavements and can lead to deformation.	9	15	15
Airfield Pavements (Taxiways B and D)	Heavy rainfall	3	5	5		3	3	3	1	Yes	3	Heavy rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	9	15	15
Airfield Pavements (Taxiways B and D)	Extreme rainfall	3	5	5		3	3	3	1	Yes	3	Extreme rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to	9	15	15

		Climate (Probability / Likelihood) – SSP5-8.5			Risk Analysis – Impact Categories (Consequences)					Severity Rating			Risk Results		
Elements	Climate Indicators	Hist	2050s	2080s	Health & Safety	Infrastructure Integrity	Operational Impact	Financial Impact	Reputational Impact	Impacted (Y/N)	Impact Severity Rating (1-5)	Justification	Current	Future (2041-2070)	Future (2071-2100)
												flooding and standing water on the taxiway or adjacent grassed areas.			
Airfield Pavements (Taxiways B and D)	Multiday heavy precipitation	3	4	4		3	3	3	1	Yes	3	Multiday heavy rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	9	12	12
Airfield Pavements (Taxiways B and D)	Short-Duration High-Intensity Rainfall	3	5	5		3	2	3	1	Yes	3	Short-Duration High-Intensity Rainfalcan cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	9	15	15
Airfield Pavements (Taxiways B and D)	Drought	3	3	3		1		1		Yes	1	Drought and lack of moisture can cause stress of vegetation cover.	3	3	3
Airfield Pavements (Taxiways B and D)	Hurricane	3	4	5		2	2	2	1	Yes	2	Heavy rainfall associated with hurricanes can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	6	8	10
Airfield Pavements (Taxiways B and D)	Thunderstorm	3	4	5		2	2	2	1	Yes	2	Heavy rainfall associated with hurricanes can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	6	8	10
Airfield Pavements (Taxiways B and D)	Air quality	3	4	5						No	0	No impact.	0	0	0
Airfield Pavements (Taxiways B and D)	Reduced lake ice cover	3	5	5						No	0	No impact.	0	0	0
Airfield Pavements (Taxiways B and D)	Lake acidification	3	3	4						No	0	No impact.	0	0	0
Airfield Pavements (Taxiways B and D)	Biofouling	3	4	4						No	0	No impact.	0	0	0
Airfield Pavements (Taxiways B and D)	Invasive species	3	4	4						No	0	No impact.	0	0	0
Airfield Pavements (Taxiways B and D)	Ice accretion	3	4	4			2			Yes	2	Ice could form on pavement surfaces.	6	8	8
Shoreline and Dockwalls															
Shoreline and Dockwalls	Air temperature	3	5	5						No	0	No impact.	0	0	0
Shoreline and Dockwalls	Extreme high temperature	3	3	4						No	0	No impact.	0	0	0
Shoreline and Dockwalls	Heat wave	3	5	5						No	0	No impact.	0	0	0
Shoreline and Dockwalls	Heavy rainfall	3	5	5		2	2	2	1	Yes	2	Heavy rainfall may lead to increased runoff which may cause localized erosion.	6	10	10
Shoreline and Dockwalls	Extreme rainfall	3	5	5		3	2	2	1	Yes	3	Extreme rainfall may lead to increased runoff which may cause localized erosion.	9	15	15
Shoreline and Dockwalls	Multiday heavy precipitation	3	4	4		3	2	2	1	Yes	3	Multiday heavy rainfall may lead to increased runoff which may cause localized erosion.	9	12	12
Shoreline and Dockwalls	Short-Duration High-Intensity Rainfall	3	5	5		2	2	2	1	Yes	2	Short-Duration High-Intensity Rainfall may lead to increased runoff which may cause localized erosion.	6	10	10
Shoreline and Dockwalls	Drought	3	3	3		1				Yes	1	Drought can result in increased exposure of shoreline to wind and wave action, further accelerating erosion and destabilizing the land.	3	3	3
Shoreline and Dockwalls	Hurricane	3	4	5		3	2	2	1	Yes	3	The intense storms, heavy rainfall, and strong winds associated with hurricanes can cause severe erosion, structural damage, and displacement or failure of pilings.	9	12	15

					Risk Analysis										
	Climate (Probability / Likelihood) – SSP5-8.5				Impact Categories (Consequences)					Severity Rating		Justification	Risk Results		
Elements	Climate Indicators	Hist	2050s	2080s	Health & Safety	Infrastructure Integrity	Operational Impact	Financial Impact	Reputational Impact	Impacted (Y/N)	Impact Severity Rating (1-5)		Current	Future (2041-2070)	Future (2071-2100)
Shoreline and Dockwalls	Thunderstorm	3	4	5		3	2	2	1	Yes	3	Thunderstorms can cause severe erosion, structural damage, and displacement or failure of pilings.	9	12	15
Shoreline and Dockwalls	Air quality	3	4	5						No	0	No impact.	0	0	0
Shoreline and Dockwalls	Reduced lake ice cover	3	5	5		1		1		Yes	1	Increased wave action as a result of reduced lake ice cover can increase erosion along shoreline and potentially dockwalls.	3	5	5
Shoreline and Dockwalls	Lake acidification	3	3	4		1		1		Yes	1	Acidic waters can accelerate the chemical weathering of shorelines, leading to increased erosion and sediment loss. Also, acidic water can corrode metal components more rapidly, compromising the structural integrity.	3	3	4
Shoreline and Dockwalls	Biofouling	3	4	4		1		1		Yes	1	It can increase erosion, accelerate corrosion, and may obstruct drainage, damaging structural integrity or leading to more frequent maintenance.	3	4	4
Shoreline and Dockwalls	Invasive species	3	4	4		1		1		Yes	1	It can increase erosion, accelerate corrosion, and may obstruct drainage, damaging structural integrity or leading to more frequent maintenance.	3	4	4
Shoreline and Dockwalls	Ice accretion	3	4	4			1			Yes	1	Ice could form on shoreline and dockwall surface.	3	4	4
Airfield Perimeter Roads															
Airfield Perimeter Roads	Air temperature	3	5	5		1	1	1	1	Yes	1	Higher temperatures can be outside of design temperature of pavements and can lead to deformation.	3	5	5
Airfield Perimeter Roads	Extreme high temperature	3	3	4		2	2	2	1	Yes	2	Extreme high temperature can be outside of design temperature of pavements and can lead to deformation.	6	6	8
Airfield Perimeter Roads	Heat wave	3	5	5		3	2	3	1	Yes	3	Heat waves can be outside of design temperature of pavements and can lead to deformation.	9	15	15
Airfield Perimeter Roads	Heavy rainfall	3	5	5		3	3	3	1	Yes	3	Heavy rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	9	15	15
Airfield Perimeter Roads	Extreme rainfall	3	5	5		3	3	3	1	Yes	3	Extreme rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	9	15	15
Airfield Perimeter Roads	Multiday heavy precipitation	3	4	4		3	3	3	1	Yes	3	Multiday heavy rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	9	12	12
Airfield Perimeter Roads	Short-Duration High-Intensity Rainfall	3	5	5		3	2	3	1	Yes	3	Short-Duration High-Intensity Rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	9	15	15
Airfield Perimeter Roads	Drought	3	3	3		1		1		Yes	1	Drought and lack of moisture can cause stress of vegetation cover.	3	3	3
Airfield Perimeter Roads	Hurricane	3	4	5		2	2	2	1	Yes	2	Heavy rainfall associated with hurricanes can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	6	8	10
Airfield Perimeter Roads	Thunderstorm	3	4	5		2	2	2	1	Yes	2	Heavy rainfall associated with thunderstorms can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the taxiway or adjacent grassed areas.	6	8	10

	Climate (Probability / Likelihood) – SSP5-8.5				Risk Analysis: Impact Categories (Consequences)					Severity Rating		Justification	Risk Results		
Elements	**Climate Indicators**	**Hist**	**2050s**	**2080s**	**Health & Safety**	**Infrastructure Integrity**	**Operational Impact**	**Financial Impact**	**Reputational Impact**	**Impacted (Y/N)**	**Impact Severity Rating (1-5)**		**Current**	**Future (2041-2070)**	**Future (2071-2100)**
Airfield Perimeter Roads	Air quality	3	4	5						No	0	No impact.	0	0	0
Airfield Perimeter Roads	Reduced lake ice cover	3	5	5						No	0	No impact.	0	0	0
Airfield Perimeter Roads	Lake acidification	3	3	4						No	0	No impact.	0	0	0
Airfield Perimeter Roads	Biofouling	3	4	4						No	0	No impact.	0	0	0
Airfield Perimeter Roads	Invasive species	3	4	4						No	0	No impact.	0	0	0
Airfield Perimeter Roads	Ice accretion	3	4	4			3			Yes	3	Ice could form on roads due to proximity to lake.	9	12	12
Airfield Lighting															
Airfield Lighting	Air temperature	3	5	5		1	1	1	1	Yes	1	Prolonged exposure to high temperatures can lead to potential malfunction or reduced lifespan of electronic components.	3	5	5
Airfield Lighting	Extreme high temperature	3	3	4		1	1	1	1	Yes	1	Prolonged exposure to extreme high temperatures can lead to potential malfunction or reduced lifespan of electronic components.	3	3	4
Airfield Lighting	Heat wave	3	5	5		1	1	1	1	Yes	1	Prolonged exposure to heat waves can lead to potential malfunction or reduced lifespan of electronic components.	3	5	5
Airfield Lighting	Heavy rainfall	3	5	5						No	0	No impact.	0	0	0
Airfield Lighting	Extreme rainfall	3	5	5						No	0	No impact.	0	0	0
Airfield Lighting	Multiday heavy precipitation	3	4	4						No	0	No impact.	0	0	0
Airfield Lighting	Short-Duration High-Intensity Rainfall	3	5	5						No	0	No impact.	0	0	0
Airfield Lighting	Drought	3	3	3						No	0	No impact.	0	0	0
Airfield Lighting	Hurricane	3	4	5		3	3	3	1	Yes	3	Hurricane and associated high winds due to local storms can damage signs.	9	12	15
Airfield Lighting	Thunderstorm	3	4	5		3	3	3	1	Yes	3	High winds and hail associated with thunderstorms can damage signs.	9	12	15
Airfield Lighting	Air quality	3	4	5		1				Yes	1	High level of pollutants and particulate matter in the air can reduce visibility and effectiveness of airfield lighting. Accumulation of particulate matter on lenses.	3	4	5
Airfield Lighting	Reduced lake ice cover	3	5	5						No	0	No impact.	0	0	0
Airfield Lighting	Lake acidification	3	3	4						No	0	No impact.	0	0	0
Airfield Lighting	Biofouling	3	4	4						No	0	No impact.	0	0	0
Airfield Lighting	Invasive species	3	4	4						No	0	No impact.	0	0	0
Airfield Lighting	Ice accretion	3	4	4			1			Yes	1	Ice could form.	3	4	4
Staff															
Staff	Air temperature	3	5	5	2				2	Yes	2	Higher temperatures and heat waves could impact staff's well-being and productivity (e.g., heat exhaustion and heat stroke, dehydration, heat stress).	6	10	10
Staff	Extreme high temperature	3	3	4	3				2	Yes	3	Extreme high temperatures and heat waves could impact staff's well-being and productivity (e.g., heat exhaustion and heat stroke, dehydration, heat stress).	9	9	12
Staff	Heat wave	3	5	5	3				2	Yes	3	Higher temperatures and heat waves could impact staff's well-being and productivity (e.g., heat exhaustion and heat stroke, dehydration, heat stress).	9	15	15

	Climate (Probability / Likelihood) – SSP5-8.5				Risk Analysis: Impact Categories (Consequences)					Severity Rating			Risk Results		
Elements	**Climate Indicators**	**Hist**	**2050s**	**2080s**	**Health & Safety**	**Infrastructure Integrity**	**Operational Impact**	**Financial Impact**	**Reputational Impact**	**Impacted (Y/N)**	**Impact Severity Rating (1-5)**	**Justification**	**Current**	**Future (2041-2070)**	**Future (2071-2100)**
Staff	Heavy rainfall	3	5	5	3				2	Yes	3	Heavy rain can create a hazardous condition, by flooding or slippery surfaces, that can increase the risk of accidents and disrupt maintenance.	9	15	15
Staff	Extreme rainfall	3	5	5	2				2	Yes	2	Extreme rain can create a hazardous condition, by flooding or slippery surfaces, that can increase the risk of accidents and disrupt maintenance.	6	10	10
Staff	Multiday heavy precipitation	3	4	4	2				2	Yes	2	Multiday heavy precipitation can create a hazardous condition, by flooding or slippery surfaces, that can increase the risk of accidents and disrupt maintenance.	6	8	8
Staff	Short-Duration High-Intensity Rainfall	3	5	5	2				2	Yes	2	can create a hazardous condition, by flooding or slippery surfaces, that can increase the risk of accidents and disrupt maintenance.	6	10	10
Staff	Drought	3	3	3	1				1	Yes	1	Drought can exacerbate heat stress and dehydration risks.	3	3	3
Staff	Hurricane	3	4	5	2				2	Yes	2	Hurricane and associated hail, high winds, and precipitation can create hazardous working conditions, pose safety risks, or impede maintenance activities.	6	8	10
Staff	Thunderstorm	3	4	5	3				3	Yes	3	Thunderstorms and associated hail, high winds, and precipitation can create hazardous working conditions, pose safety risks, or impede maintenance activities.	9	12	15
Staff	Air quality	3	4	5	2				2	Yes	2	It can cause health problems, respiratory issues, reducing visibility, and complicating outdoor work and maintenance activities.	6	8	10
Staff	Reduced lake ice cover	3	5	5						No	0	No impact.	0	0	0
Staff	Lake acidification	3	3	4						No	0	No impact.	0	0	0
Staff	Biofouling	3	4	4	1				1	Yes	1	Biofouling often involves the growth of harmful bacteria that can pose health risks to outdoor staff.	3	4	4
Staff	Invasive species	3	4	4	1				1	Yes	1	Invasive species may cause additional risks to staff (ticks and Lyme disease, mosquitos and West Nile Virus, etc.).	3	4	4
Staff	Ice accretion	3	4	4	2				2	Yes	2	May create slip hazards.	6	8	8
Utility Conduit															
Utility Conduit	Air temperature	3	5	5		1	1	1	1	Yes	1	Higher temperatures can cause frequent thermal expansion and contraction, leading to cracking and deformation. Could lead to vegetation stress if the city utility conduit is vegetated.	3	5	5
Utility Conduit	Extreme high temperature	3	3	4		2	2	2	1	Yes	2	Extreme high temperatures can cause frequent thermal expansion and contraction, leading to cracking and deformation. Could lead to vegetation stress if the city utility conduit is vegetated.	6	6	8
Utility Conduit	Heat wave	3	5	5		3	2	3	1	Yes	3	Heat waves can cause frequent thermal expansion and contraction, leading to cracking and deformation. Could lead to vegetation stress if the city utility conduit is vegetated.	6	10	10
Utility Conduit	Heavy rainfall	3	5	5		3	3	3	1	Yes	3	Heavy rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the city utility conduit surface.	9	15	15
Utility Conduit	Extreme rainfall	3	5	5		3	3	3	1	Yes	3	Extreme rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the city utility conduit surface.	9	15	15

					Risk Analysis										
	Climate (Probability / Likelihood) – SSP5-8.5				Impact Categories (Consequences)					Severity Rating		Justification	Risk Results		
Elements	**Climate Indicators**	**Hist**	**2050s**	**2080s**	**Health & Safety**	**Infrastructure Integrity**	**Operational Impact**	**Financial Impact**	**Reputational Impact**	**Impacted (Y/N)**	**Impact Severity Rating (1-5)**		**Current**	**Future (2041-2070)**	**Future (2071-2100)**
Utility Conduit	Multiday heavy precipitation	3	4	4		3	3	3	1	Yes	3	Multiday heavy precipitation can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the city utility conduit surface.	9	12	12
Utility Conduit	Short-Duration High-Intensity Rainfall	3	5	5		3	2	3	1	Yes	3	Short-Duration High-Intensity Rainfall can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the city utility conduit surface.	9	15	15
Utility Conduit	Drought	3	3	3		1		1		Yes	1	Drought and lack of moisture can cause stress of vegetation cover.	3	3	3
Utility Conduit	Hurricane	3	4	5		2	2	2	1	Yes	2	Hurricanes with associated intense rainfall and strong winds can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the city utility conduit surface.	6	8	10
Utility Conduit	Thunderstorm	3	4	5		2	2	2	1	Yes	2	Thunderstorms with associated intense rainfall and strong winds can cause localized erosion and may cause storm sewer capacity overload, leading to flooding and standing water on the city utility conduit surface.	6	8	10
Utility Conduit	Air quality	3	4	5						No	0	No impact.	0	0	0
Utility Conduit	Reduced lake ice cover	3	5	5						No	0	No impact.	0	0	0
Utility Conduit	Lake acidification	3	3	4						No	0	No impact.	0	0	0
Utility Conduit	Biofouling	3	4	4		1				No	1	May obstruct water flow, resulting in ponding and standing water.	3	4	4
Utility Conduit	Invasive species	3	4	4						No	0	No impact.	0	0	0
Utility Conduit	Ice accretion	3	4	4			1			Yes	1	Ice could form on city utility corridor surfaces.	3	4	4

Appendix C

MS Excel Climate Change Resilience Assessment Model

Risk Event	Project Components	Risk	Proposed Adaptation Measure or Risk Treatment	Implementation Timeframe	Effectiveness
Air Temperature	Staff	10	■ O&M: Adjust work schedules to cooler parts of the day or overnight. ■ Policy: Ensure access to water and encourage regular breaks to avoid heat-related illness. ■ Ensure emergency response and staffing plans incorporate climate events.	O&M, Policy	Effective
Extreme High Temperature	Staff	12	■ O&M: Adjust work schedules to cooler parts of the day or overnight. ■ Policy: Ensure access to water and encourage regular breaks to avoid heat-related illness. ■ Ensure emergency response and staffing plans incorporate climate events.	O&M, Policy	Effective
Heat Wave	RESA Surface	15	■ Design: Utilize high albedo surfaces or vegetation to reduce heat absorption and possibly enhance visibility. ■ O&M: Conduct regular inspection and maintenance of the RESA surface.	Design, O&M	Effective
	Noise Walls	10	■ Design: Utilize materials that are resistant to heat and capable of withstanding higher temperatures. ■ Implement thermal sensors or monitoring systems to track temperature variations and flag potential issues related to heat exposure. ■ O&M: Conduct frequent inspections (monthly) to check for signs of heat-related damage or post-event.	Design, O&M	Effective
	NavAids	10	■ Design: Install cooling system for NavAids critical equipment. ■ Improve insulation around NavAids sensitive equipment to protect it from heat exposure and utilize reflective covers. ■ O&M: Conduct regular inspections and monitoring (weekly or post-heat wave event) during heat wave events to identify and address any issues promptly. ■ Install thermal sensors to monitor conditions around NavAids and detect any potential issues related to heat exposure. ■ Policy: Develop response plans to address damage to NavAids caused by climate events.	Design, O&M, Policy	Effective
	Airfield pavements (Taxiways B and D)	15	■ Design: Ensure upper range of pavement design temperature is reflective of future temperature and heatwave. Include additives or enhancements that reduce shoving. ■ O&M: Increase frequency of pavement inspections in response to heat wave (during and post-event).	Design, O&M	Effective
	Airfield Perimeter Roads	15	■ Design: Ensure upper range of pavement design temperature is reflective of future temperature and heatwave. Include additives or enhancements that reduce shoving. ■ O&M: Increase frequency of pavement inspections in response to heat wave (during and post-event).	Design, O&M	Effective
	Staff	15	■ O&M: Adjust work schedules to cooler parts of the day or overnight. ■ Policy: Ensure access to water and encourage regular breaks to avoid heat-related illness. ■ Ensure emergency response and staffing plans incorporate climate events.	O&M, Policy	Effective
	Utility Conduit	10	■ O&M: Increase frequency of pavement inspections in response to heat wave (during and post-event).	O&M	Effective
Heavy Rainfall	RESA Surface	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during heavy rainfall events (minor system and major overland route). ■ O&M: Conduct inspection and required maintenance of RESA surface elements after heavy rainfall. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Airfield Pavements (B and D)	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during heavy rainfall events. ■ O&M: Conduct frequent inspection and maintenance of airfield pavement elements after heavy rainfall. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Shoreline and Dockwalls	10	■ O&M: Increase the frequency of inspections for dockwalls and pilings after heavy rainfall events. ■ Monitor long-term lake level trends for preplanning. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	O&M, Policy	Effective
	Airfield Perimeter Roads	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during heavy rainfall events (minor system and major overland route). ■ O&M: Conduct inspection and required maintenance of service road elements after heavy rainfall. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Staff	15	■ Policy: Provide training on managing and responding to severe weather conditions, including identifying signs of potential flooding indicators and understanding safe work practices. ■ Ensure emergency response and staffing plans incorporate climate events. ■ Ensure notification systems include weather events for rainfall and potential flooding and appropriate staffing response.	O&M, Policy	Effective

Risk Event	Project Components	Risk	Proposed Adaptation Measure or Risk Treatment	Implementation Timeframe	Effectiveness
	Utility Conduit	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during heavy rainfall events (minor system and major overland route). ■ O&M: Conduct inspection and required maintenance of city utility conduit elements after heavy rainfall. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
Extreme rainfall	RESA Surface	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during extreme rainfall events (minor system and major overland route). ■ O&M: Conduct inspection and maintenance of RESA surface elements after extreme rainfall. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Noise Walls	10	■ Design: Design and maintain adequate drainage around noise walls to direct water away and prevent it from accumulating. ■ O&M: Conduct inspection and maintenance (weekly or post-event) to promptly identify and address any signs of water damage. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	NavAids	10	■ O&M: Ensure new NavAids are included in emergency circuits for potential power events as a result of climate events. ■ Ensure NavAids are included in remote monitoring systems. ■ Develop response plans to address damage to Navaids caused by climate events.	O&M, Policy	Effective
	Security Fences	10	■ Design: Install efficient drainage systems around security fences to divert water away and prevent it from pooling at the base. ■ O&M: Conduct inspection and maintenance, before and after heavy extreme events, to identify and repair any water damage or structural issues. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Airfield Pavements (Taxiways B and D)	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during heavy rainfall events (minor system and major overland route). ■ O&M: Conduct inspection and maintenance of airfield pavement elements after extreme rainfall. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Shoreline and Dockwalls	15	■ O&M: Increase the frequency of inspections for dockwalls and pilings (weekly or post-extreme rainfall event). ■ Install automated systems to provide alerts when water levels hit critical thresholds, allowing for prompt actions to prevent damage. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	O&M, Policy	Effective
	Airfield Perimeter Roads	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during extreme rainfall events (minor system and major overland route). ■ O&M: Conduct frequent inspection and maintenance of service road elements (weekly or post-extreme rainfall events). ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Staff	10	■ Policy: Ensure emergency response and staffing plans incorporate climate events. ■ Establish weather monitoring systems and communication protocols to provide real-time updates on rainfall and potential flooding. Utilize this data to adjust work schedules and ensure the safety of staff.	Policy	Effective
	Utility Conduit	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during heavy rainfall events (minor system and major overland route). ■ O&M: Conduct inspection and required maintenance of utility conduit elements after heavy rainfall. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
Multiday heavy precipitation	RESA Surface	12	■ Design: Design drainage system with increased capacity to handle large volumes of water during extreme rainfall events (minor system and major overland route). ■ O&M: Conduct frequent inspection and maintenance of RESA surface elements (weekly or post-multiday heavy precipitation event). ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Airfield pavements (Taxiways B and D)	12	■ Design: Design drainage system with increased capacity to handle large volumes of water during multiday heavy precipitation events (minor system and major overland route). ■ O&M: Conduct frequent inspection and maintenance of airfield pavement elements after multiday heavy precipitation. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective

Risk Event	Project Components	Risk	Proposed Adaptation Measure or Risk Treatment	Implementation Timeframe	Effectiveness
	Shoreline and Dockwalls	12	■ Design: Use corrosion-resistant materials for vertical metal sheet pilings and other components to avoid damage from extended water exposure. ■ O&M: Increase the frequency of inspections for dockwalls and pilings (weekly or post multiday heavy precipitation periods). ■ Install automated systems to provide alerts when water levels hit critical thresholds, allowing for prompt actions to prevent damage. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Airfield Perimeter Roads	12	■ Design: Design drainage system with increased capacity to handle large volumes of water during multiday heavy precipitation events (minor system and major overland route). ■ O&M: Conduct frequent inspection and maintenance of service road elements (weekly or post-multiday heavy precipitation event). ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Utility Conduit	12	■ Design: Design drainage system with increased capacity to handle large volumes of water during multiday heavy precipitation events (minor system and major overland route). ■ O&M: Conduct frequent inspection and maintenance of utility conduit elements (weekly or post-multiday heavy precipitation event). ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
Short-Duration High-Intensity Rainfall	RESA Surface	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during short-duration high-intensity rainfall events (minor system and major overland route). ■ O&M: Conduct frequent inspection and maintenance of RESA surface elements (weekly or post-Short-Duration High-Intensity Rainfall event). ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Noise Walls	10	■ Design: Design and maintain adequate drainage around noise walls to direct water away and prevent it from accumulating. ■ O&M: Conduct regular inspections and maintenances (weekly or post-Short-Duration High-Intensity Rainfall event) to identify and address any signs of water damage promptly. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	NavAids	10	■ O&M: Install backup power systems, such as generators to ensure that NavAids remain operational during power outages caused by extreme weather. ■ Implement remote monitoring systems to track the operational status of NavAids elements and identify issues arising from short-duration high-intensity rainfall. ■ Policy: Develop response plans to address damage to NavAids caused by climate events.	O&M, Policy	Effective
	Security Fences	10	■ Design: Elevate the base of posts and fences above anticipated flood levels to avoid water damage and soil erosion. ■ Install efficient drainage systems around security fences to divert water away and prevent it from pooling at the base. ■ O&M: Conduct regular inspection and maintenance, before and after extreme events, to identify and repair any water damage or structural issues. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Airfield pavements (Taxiways B and D)	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during short-duration high-intensity rainfall events (minor system and major overland route). ■ O&M: Conduct frequent inspection and maintenance of airfield pavement elements (weekly or post short-duration high-intensity rainfall event). ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Shoreline and Dockwalls	10	■ Design: Use corrosion-resistant materials for vertical metal sheet pilings and other components to avoid damage from extended water exposure. ■ O&M: Increase the frequency of inspections for dockwalls and pilings (weekly or after short-duration high-intensity rainfall events). ■ Install automated systems to provide alerts when water levels hit critical thresholds, allowing for prompt actions to prevent damage. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective

Risk Event	Project Components	Risk	Proposed Adaptation Measure or Risk Treatment	Implementation Timeframe	Effectiveness
	Airfield Perimeter Roads	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during extreme rainfall events (minor system and major overland route). ■ O&M: Conduct frequent inspection and maintenance of service road elements (weekly or after short-duration high-intensity rainfall events). ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Staff	10	■ O&M: Provide training on managing and responding to severe weather conditions, including identifying signs of potential flooding indicators and understanding safe work practices. ■ Policy: Develop emergency response and staffing plans for climate events. ■ Establish weather monitoring systems and communication protocols to provide real-time updates on rainfall and potential flooding. Utilize this data to adjust work schedules and ensure the safety of staff.	O&M, Policy	Effective
	Utility Conduit	15	■ Design: Design drainage system with increased capacity to handle large volumes of water during extreme rainfall events (minor system and major overland route). ■ O&M: Conduct frequent inspection and maintenance of utility conduit elements (weekly or post short-duration high-intensity rainfall events). ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
Hurricane	RESA Surface	10	■ Design: Design storm sewer systems with adequate capacity to handle large volumes of water (minor system and major overland route). ■ O&M: Conduct regular inspection and maintenance of storm sewer systems (weekly or post-event) to ensure they are clear of blockages and can operate efficiently during heavy rains. ■ Policy: Implement and maintain early warning systems to give advance alerts of severe weather conditions, allowing for timely protective actions.	Design, O&M, Policy	Effective
	Noise Walls	10	■ Design: Integrate hurricane-resistant design principles to ensure all components can withstand hurricane conditions. ■ O&M: Conduct frequent inspections and maintenance (weekly or post-event) to identify and address any potential weaknesses or vulnerabilities in the noise walls system. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	NavAids	10	■ O&M: Install backup power systems, like generators, to keep NavAids operational during power outages from extreme weather. ■ Implement remote monitoring systems to track the operational status of NavAids and identify issues caused by hurricane conditions. ■ Policy: Develop response plans to address damage to NavAids caused by climate events.	O&M, Policy	Effective
	Security Fences	15	■ Design: Elevate critical components such as signage to prevent water damage and maintain visibility during flooding. ■ Utilize flexible mounting systems for signage to allow for some movement without causing damage. ■ O&M: Conduct regular monitoring and maintenance (weekly or post-event) before and after hurricane events to promptly identify and repair any issues and damage. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Airfield Pavements (Taxiways B and D)	10	■ Design: Design storm sewer systems with adequate capacity to handle large volumes of water (minor system and major overland route). ■ O&M: Conduct regular inspection and maintenance of storm sewer systems to ensure they are clear of blockages and can operate efficiently (weekly or post-event). ■ Policy: Implement and maintain early warning systems to give advance alerts of severe weather conditions, allowing for timely protective actions.	Design, O&M, Policy	Effective
	Shoreline and Dockwalls	15	■ Design: Design shoreline and dockwalls with hurricane-resistant features, including reinforcing structures to withstand strong winds and storm surges. ■ O&M: Install weather monitoring systems to track hurricane forecasts and issue early warnings, aiding in effective preparation and response to storm conditions. ■ Policy: Develop emergency response and staffing plans for climate events.	Design, O&M, Policy	Effective

Risk Event	Project Components	Risk	Proposed Adaptation Measure or Risk Treatment	Implementation Timeframe	Effectiveness
	Airfield Perimeter Roads	10	■ Design: Design storm sewer systems with adequate capacity to handle large volumes of water (minor system and major overland route). ■ O&M: Conduct regular inspection and maintenance of storm sewer systems to ensure they are clear of blockages and can operate efficiently (weekly or post-event). ■ Policy: Implement and maintain early warning systems to give advance alerts of severe weather conditions, allowing for timely protective actions.	Design, O&M, Policy	Effective
	Airfield Lighting	15	■ Design: Design airfield lighting system to withstand high winds and reduce wind load on components such as inset lights and signage. ■ O&M: Implement backup power systems, such as generators, to ensure lighting remains operational in case the primary system fails due to hurricane impacts. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Staff	10	■ O&M: Provide training on handling and responding to severe weather conditions, including identifying potential flooding signs and practicing safe work methods. ■ Policy: Ensure emergency response and staffing plans incorporate climate events. ■ Establish weather monitoring systems and communication protocols to provide real-time hurricane updates, use this information to adjust work schedules, and prioritize staff safety.	O&M, Policy	Effective
	Utility Conduit	10	■ Design: Design storm sewer systems with adequate capacity to handle large volumes of water (minor system and major overland route). ■ O&M: Conduct regular inspection and maintenance of storm sewer systems to ensure they are clear of blockages and can operate efficiently (weekly or post-event). ■ Policy: Implement and maintain early warning systems to give advance alerts of severe weather conditions, allowing for timely protective actions.	Design, O&M, Policy	Effective
Thunderstorm	RESA Surface	10	■ Design: Design storm sewer systems with adequate capacity to handle large volumes of water (minor system and major overland route). ■ O&M: Conduct regular inspection and maintenance of storm sewer systems to ensure they are clear of blockages and can operate efficiently (weekly or post-event). ■ Policy: Implement and maintain early warning systems to give advance alerts of severe weather conditions, allowing for timely protective actions.	Design, O&M, Policy	Effective
	Noise Walls	10	■ Design: Integrate wind-resistant design principles, to ensure all components can withstand thunderstorm conditions. ■ O&M: Conduct frequent inspections and maintenance to identify and address potential weaknesses or vulnerabilities in the noise walls system (weekly or post event). ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	NavAids	15	■ O&M: Install reliable backup power systems, such as generators to ensure that NavAids remain operational during power outages caused by extreme weather. ■ Implement remote monitoring systems to track the operational status of NavAids and identify issues caused by thunderstorms. ■ Policy: Develop response plans to address damage to NavAids caused by climate events. ■ O&M: Conduct frequent inspection and maintenance of all NavAids elements to ensure they are in good condition and capable of withstanding thunderstorms (weekly or post-event).	O&M, Policy	Effective
	Security Fences	15	■ Design: Select material that can withstand strong winds and heavy rain. ■ Apply water-resistant coatings or sealants to protect materials from water damage. ■ O&M: Conduct regular monitoring and maintenance weekly or post-thunderstorm events to identify and repair any issues or damage promptly. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective

Risk Event	Project Components	Risk	Proposed Adaptation Measure or Risk Treatment	Implementation Timeframe	Effectiveness
	Airfield Pavements (Taxiways B and D)	10	■ Design: Design storm sewer systems with adequate capacity to handle large volumes of water (minor system and major overland route). ■ O&M: Conduct regular inspection and maintenance of storm sewer systems to ensure they are clear of blockages and can operate efficiently (weekly or post-event). ■ Policy: Implement and maintain early warning systems to give advance alerts of severe weather conditions, allowing for timely protective actions.	Design, O&M, Policy	Effective
	Shoreline and Dockwalls	15	■ Design: Design shoreline and dockwalls to withstand the impacts of high winds and intense rainfall associated with thunderstorms. ■ O&M: Install weather monitoring systems to track storm conditions and provide early warnings, aiding in effective preparation and response to storm conditions. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Airfield Perimeter Roads	10	■ Design: Design storm sewer systems with adequate capacity to handle large volumes of water (minor system and major overland route). ■ O&M: Conduct regular inspection and maintenance of storm sewer systems to ensure they are clear of blockages and can operate efficiently (weekly or post-event). ■ Policy: Implement and maintain early warning systems to give advance alerts of severe weather conditions, allowing for timely protective actions.	Design, O&M, Policy	Effective
	Airfield Lighting	15	■ Design: Design airfield lighting system to withstand high winds and minimize wind load on components such as inset lights and signage. ■ O&M: Install weather monitoring systems to track storm conditions and provide early warning. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	Design, O&M, Policy	Effective
	Staff	15	■ Policy: Ensure emergency response and staffing plans incorporate climate events. ■ Establish weather monitoring systems and communication protocols to provide real-time thunderstorm updates, use this information to adjust work schedules, and prioritize staff safety.	Policy	Effective
	Utility Conduit	10	■ Design: Design storm sewer systems with adequate capacity to handle large volumes of water (minor system and major overland route). ■ O&M: Conduct regular inspection and maintenance of storm sewer systems to ensure they are clear of blockages and can operate efficiently (weekly or post-event). ■ Policy: Implement and maintain early warning systems to give advance alerts of severe weather conditions, allowing for timely protective actions.	Design, O&M, Policy	Effective
Air quality	NavAids	10	■ O&M: Install air quality monitoring systems to monitor pollutant levels and adjust maintenance schedules and protective measures as needed. ■ Improve sealing of all critical components and connections to block contaminants and ensure long-term durability. ■ Policy: Ensure emergency response and staffing plans incorporate climate events.	O&M, Policy	Effective
	Staff	10	■ Policy: Ensure emergency response and staffing plans incorporate climate events. ■ Establish efficient communication systems to promptly inform staff about air quality changes and required actions. ■ Adjust work schedules to reduce staff exposure to poor air quality. ■ Provide training on the health impacts of poor air quality and best practices to minimize exposure.	Policy	Effective
Ice accretion	Airfield Perimeter Roads	12	■ Design: Consider pavement temperature sensors. ■ Policy: Provide routine inspection of road surfaces and appropriate responses and communication to inform users. Ensure staff training and awareness of slips and falls.	Design, Policy	Effective