CLIMATE RESILIENCE FRAMEWORK & STANDARDS FOR PUBLIC SECTOR BUILDINGS

BRITISH COLUMBIA

Version 1.0

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This document was developed for the British Columbia (B.C.) Climate Action Secretariat, Ministry of Environment and Climate Change Strategy (the Ministry) by a consultant team led by RDH Building Science.

The writing team consisted of:

- Laura Simandl, RDH Building Science Inc
- Christy Love, RDH Building Science Inc

The development of this document benefited from the valuable input of:

- Robin Hawker, Integral Group
- Lisa Westerhoff, Integral Group
- Rob Lepage, RDH Building Science Inc

The following consultants were involved in the development of the "Minimum Climate Resilience Standards" (Chapter 3 of this document):

- Chris Doel, Integral Group
- Kevin Shea, Integral Group
- Mike Currie, Kerr Wood Leidal Associates
- Jeff Marvin, Kerr Wood Leidal Associates
- Laurel Morgan, Kerr Wood Leidal Associates
- Stephen Kooiman, Prism Engineering Ltd.
- Julianne Pickrell-Barr, Prism Engineering Ltd.

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Advisory Committee:

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Working Group:

- Citizen Services
- BC Housing
- BC Transit
- Infrastructure BC
- Interior Health
- Northern Health
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- Royal Roads University
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HOW IS THIS DOCUMENT ORGANISED?

- **Chapter 1** provides background on the policy landscape in B.C., who this document is for, and discusses the importance of climate resilient buildings.
- **Chapter 2** outlines and discusses the process for incorporating climate resilience into capital projects (the Framework) and includes detailed instruction and reference material. The Framework applies to both new and existing buildings.
- **Chapter 3** contains tabulated minimum design and retrofit requirements for new and existing public sector organization buildings (the Standards).
- **Appendix A** presents background material on climate change, global climate models (GCMs), climate projections for the world and more specifically, British Columbia.
- **Appendix B** provides guidance on determining design service life, a Global Warming Level (GWL) and climate-projected design parameters for public sector organization projects.
- **Appendix C** provides background on climate risk assessments, summarizes existing climate risk assessments frameworks, and provides guidance on portfolio-level climate risk assessments.
- Key terms in this document are italicized and their definitions are provided in the **Glossary**.

CHAPTER 1:

INTRODUCTION

> ***Chapter Includes:***
>
> 1.1 The policy landscape in B.C.
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> 1.2 Who is this document for?
>
> 1.3 Why build climate resilient buildings?

This Climate Resilience Framework and Standards for Public Sector Buildings document (the Framework and Standards) builds upon leading work from provincial public sector organizations (PSOs) in British Columbia (B.C.) to apply a systematic and consistent approach to improve the climate resilience of public sector buildings.

This document applies to health authorities, school districts, post-secondary institutions, publicly funded crown corporations and agencies, and the Government of British Columbia (the Province) for use in new and existing building projects. It includes a climate resilience framework (the Framework) for early project planning stages to develop an understanding of climate risks to a building, and to build climate resilience strategies into project design through application of minimum climate resilience standards (the Standards).

The Standards will be implemented through the Province's updated Environmental, Social and Governance Framework for Capital (ESGFC). The ESGFC establishes a requirement for taxpayer-supported capital projects to achieve climate resilience and greenhouse gas (GHG) emission reduction goals for the following public sector buildings projects:

- Construction of new or replacement facilities.
- Additions to existing buildings, and
- Major alterations to existing buildings where more than 75% of a building's fundamental components are being replaced (*e.g.*, structural components, major mechanical or electrical systems, and/or building envelope).

Climate change can lead to long-term compromised performance or catastrophic failures of buildings, which can in turn result in downstream consequences including loss of life, injury, loss of services, loss of economic productivity, and psychological impacts to occupants. It can also jeopardize progress made to reduce GHG emissions and the ability to meet emission reduction targets due to increased cooling demand, unplanned maintenance, operational needs and retrofits required due to changing climate conditions. It is therefore essential to consider GHG emission reductions and climate resilience measures together in early planning and design.

PSOs are already experiencing the impacts of climate change on public sector buildings and occupants. In the summer of 2021, B.C. experienced a heat dome - the deadliest climate-related disaster on record in Canada with 619 deaths across the province over a seven-day period [1]. The event affected the public sector resulting in increased cooling demand and utility costs, inadequate cooling for building occupants, temporary closure of facilities, and system failures. The devastating wildfires that occurred during the event resulted in the loss of a healthcare facility. An event like the June 2021 heat dome, estimated to occur only once every 1000 years in the current climate, is projected to occur roughly every 5 to 10 years by 2040 with 2°C of global warming [2] [2].

Several months after the 2021 heat dome, an atmospheric river hit the southwest region of B.C. during the rainiest autumn on record. Two days of intense precipitation led to extensive floods and landslides, resulting in damage to provincial infrastructure and the closure of government facilities such as schools and a provincial Animal Health Centre lab. At this lab, the only accredited full-service veterinary diagnostic laboratory in B.C., over 100 staff were displaced for 5 months; expensive equipment was damaged, and there were significantly increased turnaround times for important services.

Climate resilient public sector buildings have the potential to save lives, reduce long-term operational and maintenance costs for government, complement GHG emission reduction strategies and maintain standards of service delivery in a changing climate.

The Framework and Standards take a low carbon resilience approach to increase climate resilience while also lowering GHG emissions. This document provides guidance on applying the Framework and the Standards to building projects for compliance with the ESGFC. The Framework and Standards require new buildings and major renewals to assess climate risks to the proposed building, apply the minimum standards for medium to high-risk climate hazards, use future climate data as a sensitivity analysis (for energy modeling and for system design) and to document and report on the process.

This document will be maintained as a living document to be kept up to date with evolving climate science, best practices and lessons learned.

1.1 The Policy Landscape in B.C.

Environmental, Social and Governance Framework for Capital

The province applies an Environmental, Social and Governance Framework for Capital (ESGFC) that guides the delivery of key government priorities through the development of provincial public sector projects. The ESGFC was created to support the achievement of lasting labour, environmental, economic and social benefits for people in B.C. by leveraging the province's investments in public infrastructure projects. The ESGFC has been updated to support CleanBC objectives by developing clear requirements for capital expenditures to meet CleanBC energy efficiency, emission standards and climate resiliency measures.

Capital Asset Management Framework

The Capital Asset Management Framework sets out the Province's expectations for the delivery and management of capital assets [3]. It is composed of best practice guidelines and tools to support public sector agencies by describing principles, standards, policies and processes for managing capital assets such as schools, hospitals and transportation infrastructure.

The Climate Preparedness and Adaptation Strategy and CleanBC Roadmap to 2030

In June 2022, the Province released the Climate Preparedness and Adaptation Strategy (CPAS) [4]. The CPAS outlines actions to strengthen foundations for success, build safe and healthy communities, foster resilient species and ecosystems, and advance a climate ready economy and resilient infrastructure. Low carbon resilient public sector buildings that have incorporated the Framework and Standards are a key action in the strategy.

The CPAS works with the CleanBC Roadmap to 2030 plan to achieve the province's climate change objectives [5]. The CPAS includes, as a guiding principle, the alignment of emissions reductions with climate preparedness and adaptation. It recognizes that strategically aligning actions for climate resilience and GHG emissions reductions can enhance the effectiveness of both while also avoiding risks and generating economic, ecological and social benefits.

B.C.'s Climate Change Accountability Act

The Minister of Environment and Climate Change Strategy is required by law to submit a report to the legislature each year outlining progress on climate action including managing climate change risks and progress toward achieving GHG emission reduction targets. This includes descriptions of actions taken and expenditures made to manage climate change risks.

Supporting Market Transformation

While building codes in British Columbia and the rest of Canada state that climate change effects must be considered in the design of a building, they do not yet provide detailed guidance on how to do this. The ESGFC requirement to consider future climate change risks in building planning and design will provide an opportunity for the building sector to gain expertise in designing for climate resilience in advance of these requirements in future updates to building codes.

Other provincial organizations already require the consideration of climate risk for buildings and infrastructure. The B.C. Ministry of Transportation and Infrastructure requires the consideration of climate risk through a technical circular [6]. B.C. Health Authorities have developed Climate Resilience Guidelines for BC Heath Facility Planning [7].

1.2 Who is This Document For?

The Framework and Standards were designed to be used by provincial capital ministries, PSOs (both decision makers and building managers) and their consultants for building projects within the scope of the ESGFC.

The approach described for achieving climate resilience at the building level and the Standards were designed to be transferable between different building types and processes within B.C.'s PSOs.

They are meant to be flexible enough to fit different types of building projects by different organizations over various timelines.

1.3 Why Build Climate Resilient Buildings?

A climate-resilient building is sited, designed, built, and operated with projected climate conditions and risk in mind, to ensure that it is able to keep services, programs, and businesses operating throughout the building's intended service life (definition adapted from [8]).

There is a growing body of research that is quantifying the potential costs of climate change impacts on infrastructure and the co-benefits of investing in low carbon climate resilient infrastructure to protect people, critical services and the economy.

The costs of weather-related disasters in Canada, driven by a changing climate, have increased 1250 per cent in the past 50 years, with average losses of $112 million per event between 2010–2019 [9]. For example, flooding is the largest cause of damage and loss to buildings and homes in Canada with costs potentially increasing by a factor of almost 10 by 2100 if buildings are not built or adapted to be resilient to a changing climate [10, 11]. Risks associated with other climate change-related hazards are also increasing. In 2021, the Ministry's Climate Action Secretariat completed a series of pilot projects that looked at a selection of public sector buildings and identified that the total annual cost from physical climate impacts was increasing with climate change.

The resilience of buildings can be achieved through ***adaptation***, which refers to managing the negative impacts of climate change by minimizing the ***vulnerability*** of the building (propensity of a building to be adversely affected [12]). The actions in this process are known as ***climate resilience measures***, and may take the form of a project, technology, or process that improves adaptation.

Table 1 provides a comprehensive list of relevant climate hazards anticipated for various regions in British Columbia, the impacts that may affect building systems, and climate resilience measures that can be implemented in new buildings to address some of these impacts.

Investing in climate resilient infrastructure is an effective way to protect people and services. Climate change may pose a high risk of impacting infrastructure, but there is also a high potential for taking meaningful action to reduce those risks while realizing multiple co-benefits The Global Commission on Adaptation estimated that every $1 spent on measures to make new infrastructure resilient to climate impacts results in a savings of $4 to $5 in the future [13], with important co-benefits including:

- Improved public health, and reduction in casualties, injuries and post-traumatic stress following a major event,
- Reduced future property repair, reconstruction or maintenance costs,
- Reduced future losses associated with direct and indirect service interruption, and reduced loss of services to the community,
- Reduced environmental impact,
- Increased property value, and
- Increased occupant comfort.

TABLE 1:
Climate Hazards and Examples of Climate Resilience Measures for New Buildings

CLIMATE HAZARD	DESCRIPTION	EXAMPLES OF IMPACTS ON BUILDING SYSTEMS	EXAMPLES OF CLIMATE RESILIENCE MEASURES
Warming Climate and Extreme Heat Events	Overheating – Increased severity and frequency of heatwaves	• Increased indoor air temperature (and increased use of cooling systems) • Increased probability of HVAC system failure • Overheating of electrical (or other) systems • Increased peak power demand from utility (may result in periodic power outages)	• Design cooling systems for projected climate • Design building envelope to have superior thermal performance (increased insulation, increased airtightness, high performance windows)
	Overheating – Increased average temperatures		
	Humidity – Increased average relative humidity	• Increased indoor humidity (and increased use of dehumidification systems) • Fungal (*i.e.,* mold) growth	• Design building to maintain acceptable relative humidity to code compliance under future climate projections
Flooding	Riverine Flooding – Accumulation of extreme water levels from rivers	• Inundation of building basement or lower levels • Damage to building materials or building contents • Damage to structure (from hydrostatic pressure or impact loading) • Potable water scarcity from sewer overflow • Building access/egress is challenging or not possible • Exceeding capacity of drainage systems (wastewater and/or stormwater) • Increased corrosion of building materials • Erosion at building foundation	• Floodproofing strategies, such as for new buildings, elevating the structure • Site selection to ensure that building is not constructed in a floodplain • Design structure to withstand hydrostatic and impact loads, or allow the basement level to be inundated (release pressure)
	Pluvial Flooding – Accumulation of extreme water levels from rainfall		
	Coastal Flooding (from Sea Level Rise, Storm Surge, and Wave Effects)		

TABLE 1 Continued

CLIMATE HAZARD	DESCRIPTION	EXAMPLES OF IMPACTS ON BUILDING SYSTEMS	EXAMPLES OF CLIMATE RESILIENCE MEASURES
Wildfires	Interface Fire – Increased frequency and severity of wildfires	• Damage to building structure and/or components • Utility service disruption (*e.g.*, water contamination, power outages, etc.)	• Select building envelope materials (*e.g.*, cladding, roofing) that are non-combustible • Ensure adequate separation distance from adjacent structures
	Air Quality - Increased frequency and severity of wildfire smoke events	• Decreased indoor air quality	• Include minimum MERV-13 filters in non-healthcare facilities, and HEPA filters in healthcare or long-term care facilities • Ensure building is designed to be air-tight
Strong Wind Events	Wind – Increased frequency of gales and extreme wind events	• Uplift of roof, loss of roof and enclosure elements • Damage of building from windborne debris (*e.g.*, broken windows) • Snapped power lines from fallen trees or windborne debris (causes power outages)	• Design building to withstand wind loading from projected climate • Select building envelope materials to be resistant to current and projected wind loads (*e.g.*, impact-resistant materials)
	Wind – Increased frequency and severity of wind-driven rain	• Damage of building interior and building contents	• Design building envelope to be air- and water-tight
Cold Snaps, Extreme Snowfall Events, and Ice Storms	Ice Storms – Increased frequency and severity	• Snapped power lines from fallen trees or windborne debris (causes power outages)	• Include back-up power supplies
	Snow – Increased frequency and intensity of snow, or total annual precipitation	• Roof collapse from increased snow load, or rain on snow events	• Design building to withstand greater of the current and climate-projected snow loads

TABLE 1 Continued			
CLIMATE HAZARD	DESCRIPTION	EXAMPLES OF IMPACTS ON BUILDING SYSTEMS	EXAMPLES OF CLIMATE RESILIENCE MEASURES
Cold Snaps, Extreme Snowfall Events, and Ice Storms	Ice Storms – Increased frequency and severity	• Snapped power lines from fallen trees or windborne debris (causes power outages)	• Include back-up power supplies
	Cold Snaps – Increased frequency and severity of cold snaps	• Decreased indoor air temperature, consequently increasing use of heating systems • Snapped power lines resulting in power outages • Frozen pipes • Damage to foundation because of frost heave, or subsidence • Rupture of water lines	• Design building envelope to have superior thermal performance (increased • insulation, increased airtightness, high performance windows). • Include back-up power supplies • Concrete mixes for exposed concrete superstructures or foundations could include air- entrainers to increase resistant to freeze thaw cycles
	Hail – Increased frequency and severity of hail	• Damage to building roof • Damage to rooftop mechanical systems • Damage to skylights	• Select durable impact-resistant roofing, skylight assemblies, and rooftop systems
Droughts	Water Shortage – Increased frequency and severity of droughts	• Reduced supply of potable water	• Have water shutoffs to limit usage to critical areas/uses during a water shortage event

Notes:

Some climate hazards have little scientific projection information available because of lack of data (*e.g.,* storm surge, lightning, sub-hourly weather phenomenon).

Examples of impacts listed here are limited to those associated with building systems (and not downstream impacts associated with occupant well-being, loss of services, economic loss, etc.).

Buildings are the only infrastructure type considered here (*i.e.,* transportation, municipal, agricultural, and others are not considered).

CHAPTER 2:

FRAMEWORK FOR CLIMATE RESILIENT BUILDINGS

In this Chapter, we present the Climate Resilience Framework (the Framework), which is a building-level (and project-specific) approach for PSOs that can guide the:

1. design and construction of new climate resilient buildings, and
2. retrofit of existing buildings for climate resilience.

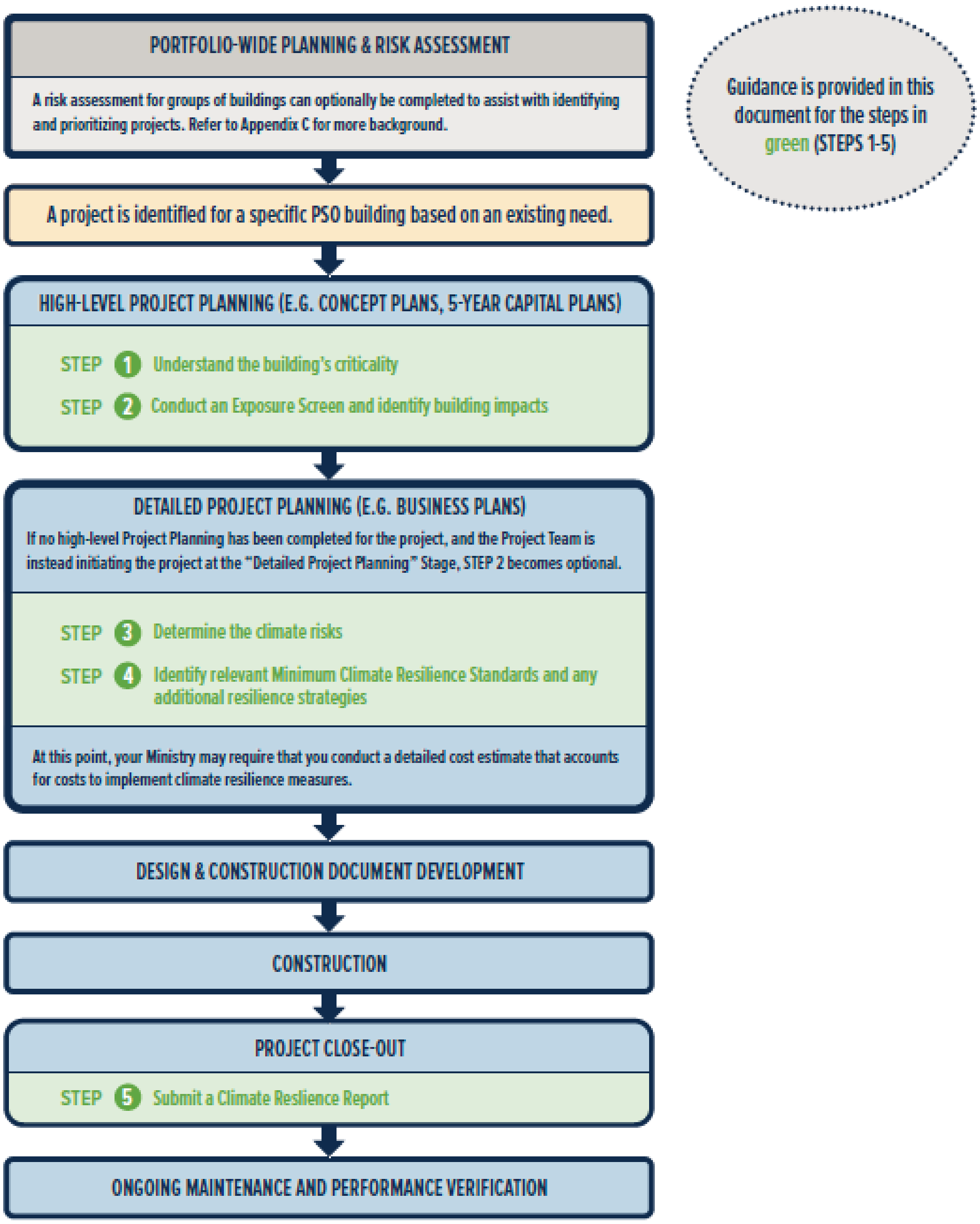
Chapter Includes:

The Framework was developed with consideration of key principles from well-known climate risk management standards (*e.g.,* ISO 31000, ISO 14090) and pre-existing assessment frameworks (*e.g.,* Climate Lens, PIEVC HLSG, PIEVC Protocol).

The Framework and accompanying **Minimum Climate Resilience Standards** (the Standards) are intended to guide the design process for all PSO projects subject to the ESGFC. They do not provide guidance for projects initiated in response to an emergency (such as existing buildings that have been damaged by a natural disaster), although it is recognized that emergency response plans specific to extreme climate events are also necessary. **Figure 1** presents a simplified diagram to show the major steps of the Framework. The figure demonstrates where each step fits with respect to a typical project-specific roadmap, and in relation to portfolio-level planning and risk assessments.

The steps in the Framework cover high-level and detailed project planning to build a preliminary understanding of the climate hazards and future conditions that the building may experience over its design service life. The high-level planning step provides an opportunity for high-level costing and early design to be informed by future climate and key resilience considerations. The detailed project planning steps will build an understanding of the climate risks that the building (and its components) may be exposed to. This information then allows for risk- informed strategies to guide the application of the Standards or additional resilience strategies in business plan development, procurement, and design.

PSOs may conduct a portfolio-wide climate risk assessment prior to any specific-building level risk assessment. A short section introducing portfolio-level climate risk assessments is presented in **Appendix C, Section 3.**



2.1 High-Level Project Planning

If your Ministry requires a high-level project plan, **STEP 1** and **STEP 2** of the Climate Resilience Framework (the Framework) must be completed during this phase of the project.

STEP 1: Identify the building's criticality

Input	Project details
Outputs:	Criticality Classification of the building
Completed by:	Internal PSO Project Team

As one of the first steps of this framework, the PSO Project Team must determine the criticality of the building to its occupants, the community and/or province.

The internal PSO team is directed to **Table 2** for guidance. There are four possible Criticality Classifications, which have been adapted from the National Building Code of Canada's "Importance Categories." Assigning a Criticality Classification to the building will help the project team to frame the discussion around the downstream impacts to the building from various climate change hazards and identify operational requirements during an emergency or disaster event in **STEP 2**.

TABLE 2:
Criticality classification of buildings

CRITICALITY CLASSIFICATION 1), 3)	DESCRIPTION 1)	EXAMPLES
Post-disaster	A building that is essential to the provision of services in the event of a disaster	• Hospitals and emergency treatment facilities • Control centres for air, land and marine transport
High	Buildings that are likely to be used as post-disaster shelters, or Facilities that contain toxic, explosive or hazardous substances in sufficient quantities to be dangerous to the public if released	• Schools (elementary, middle, secondary)
Normal (2)	All buildings other than those classified as post-disaster, high importance, or low importance	• Office buildings • Multi-unit residential buildings
Low	Buildings that present a low hazard to human life in the event of failure, and/or do not perform	• Buildings with low human occupancy • Minor storage buildings

Notes:

Adapted from National Building Code of Canada 2020, Table 4.1.2.1 “Importance Categories for Buildings”. The Importance Categories in NBC 2020 were developed primarily for identifying what kind of loads a building’s structural system will need to be designed for. Here the application differs slightly, and for this reason, we have named them “Criticality Classifications.” The Criticality Classification of a building is used to determine what climate resilience measures need to be applied to the project, for all building systems (mechanical, electrical, plumbing, structure, etc.).

<u>Where a building classified as a “normal” criticality contains refuge areas, this must be noted.</u> The number of refuge areas will be added to the classification. For example, if a multi-unit residential building has two refuge areas it should be classified as a “Normal criticality building with two refuge areas.”

PSOs may elect to classify their buildings with a higher criticality than indicated here. For example, a PSO may elect to classify any building with 24-hour, 7 days a week occupancy by a vulnerable population as “high” criticality building with respect to climate risk.

STEP 2: Conduct an Exposure Screen and identify building impacts	
Input:	Project details (location, design, site layout)
Outputs:	A list of climate change-related hazards relevant to the project site, and list of possible impacts on the building as a result
Completed by:	Internal PSO Project Team

The internal PSO Project Team will complete an Exposure Screen. This is the identification of climate change-related hazards that are relevant to the project site. The ***exposure*** (degree to which a building is exposed to climate hazard) depends on the building's location, site layout, and design.

For each of the climate hazards listed in **Table 3**, the team must ask the following questions (NOTE: if the Project Team answers "Yes" to any of the following questions, then the building is exposed to the hazard):

1. **Response to Historical Patterns:** Is the building located in an area that has previously been impacted by this climate hazard, and did it result in negative impacts to the building and/or site?
2. **Response to Climate Projections:** Do climate projections indicate that this climate hazard may be an increased concern in the future, and could the building (or one of its systems/components) be compromised in response to this hazard?

The "References" column in **Table 3** includes resources to help the Project Team determine whether a climate hazard has affected the region in the past and/or whether it will in the future. Background on climate change projections is presented in **Appendix A**. Note that use of the PCIC Design Value Explorer tool [14] requires some understanding of ***design service life*** and Global Warming Level; these are discussed in **Appendix B**.

For climate hazards that have previously caused operational challenges, it is reasonable to assume that they will increase in severity or frequency.

Note that at this step, the team should not be concerned with quantifying the *likelihood* of a climate hazard, just whether it could occur at the project site area, and whether it would negatively impact the building (and/or its subsystems) if it did occur. For each climate hazard that has been identified as applicable to the project, identify as many potential impacts on building systems as relevant. Examples of impacts to new buildings are presented in **Table 1**.

Having input/collaboration with climate specialists at **STEP 2** of the Framework may not be needed but could provide value to the project.

Table 3:
List of Climate hazards and references for determining project applicability

CLIMATE HAZARD	DESCRIPTION	REFERENCES
Warming Climate and Extreme Heat Events	Heatwaves (extreme high temperature events)	• PCIC Design Value Explorer (variables: Summer design July dry-bulb temperature 97.5%, Summer design July wet-bulb temperature 97.5%) [14] • Plan2Adapt (variable: Cooling degree-days) [15]
	Increased average seasonal temperatures	• Plan2Adapt (variable: Temperature) [15]
	Increased average relative humidity	• PCIC Design Value Explorer (variables: Summer design July wet-bulb temperature 97.5%, Annual mean relative humidity) [14]
Flooding	Riverine flooding	• Plan2Adapt (variables: Precipitation as Snow, and Precipitation) [15] • PCIC Design Value Explorer (variables: 1/50 1-day rainfall, or 1/10 15min rainfall, annual total precipitation) [14] • Floodplain mapping (note: these are historical and sometimes several years out-of-date; these should not be relied on exclusively) • Topographic information to understand siting of the building (*e.g.,* if the building is located on a hill, riverine or coastal flooding are unlikely to be concerns)
	Pluvial flooding	
	Coastal flooding	
Wildfires	Interface wildfire events	• NRC's 2021 National guide for wildland-urban interface fires [15] → Figure 6 (historical wildfire hazard map) → Table 3 (Exposure Level using the Simplified Method) • If already impacting the region, hazard is anticipated to increase frequency and/or severity
	Wildfire smoke events (i.e., reduced air quality)	• If already impacting the building, anticipated to increase frequency and/or severity

TABLE 3 Continued		
CLIMATE HAZARD	DESCRIPTION	REFERENCES
Strong Wind Events	Gales and extreme wind events	• PCIC Design Value Explorer (variables: 1/50 Annual maximum wind pressure, or 1/10 Annual maximum wind pressure) [14] • Historic events
	Wind-driven rain events	• PCIC Design Value Explorer (variable: 1/5 Driving rain wind pressure) [14]
Cold Snaps, Extreme Snowfall Events, and Icestorms	Ice storm events	• PCIC Design Value Explorer (variables: 1/50 Annual maximum snow load, 1/50 annual maximum rain-on-snow) [14] • Historic events
	Extreme snowfall events (or increased total annual precipitation)	
	Cold snaps	
	Hail	
Droughts	Water shortages	• Can use average summer temperature as a proxy

2.3 Detailed Project Planning

For a project beginning in the **Detailed Project Planning** stage, **STEP 1** and **STEP 2** are optional for the internal PSO team, as the qualified professional responsible for **STEP 3** (Climate Risk Assessment) will conduct their own detailed/comprehensive assessment of exposure and impacts (as part of **STEP 3**).

STEP 3: Determine the Climate Risk

Input:	Project details, building details
Outputs:	List of medium to high risks (with associated risk scores), and any special risk cases
Completed by:	A qualified professional (*e.g.,* a licensed professional engineer and/or climate specialist) responsible for completing the Climate Risk Assessment

A ***Climate Risk Assessment*** is an essential tool for achieving climate change resilience in building projects. A risk assessment is important for establishing the ***likelihood*** of a given hazard impacting a building or a building component combined with the ***consequence*** should the hazard occur. The reader is directed to **Appendix C** for background on climate risk assessments, and a summary of existing climate risk assessment frameworks/tools.

The internal PSO Project Team will hire a qualified professional (*e.g.,* a licensed professional engineer, or a climate specialist) to perform the assessment. Project teams are welcome to use any well-established risk assessment tool (see **Appendix C, Section 2** for some options). The tools vary in the level of detail and effort required. For most projects at the planning stage, a high-level climate risk assessment is likely to be adequate; however, the professional of record will make the final recommendation whether a more detailed risk assessment should be conducted. The qualified professional will select a timeframe for analysis based on the building's design service life and will determine the Global Warming Level (GWL) most appropriate for the analysis in consultation with the internal PSO Project Team, and design team (refer to **Appendix B** for background).

By completing a high-level risk assessment during the **Detailed Project Planning Stage**, the project team will develop a good understanding of the project's climate-related risks as they may affect the occupants, building components, and the building's ability to deliver its intended services.

From the results of the climate risk assessment, the Project Team will compile a list of “medium” to “high” risks for the project with their associated scores, and includes any “special” cases, where although a “low” risk score is assigned, there may be a significant impact on the building should the hazard occur, for example, risks with a:

- low likelihood and high consequence, or
- high likelihood and low consequence.

It is possible that one of the conclusions of the high-level risk assessment is that a more detailed risk assessment or engineering analysis is required at the **Design Stage** of the Project. The following are examples of situations where a more detailed assessment may be justified:

1. The high-level risk assessment indicated significant risk of certain hazards,
2. The level of uncertainty associated with the high-level risk assessment is unacceptable,
3. The project is high-profile (has a high dollar cost, high complexity, provides important services to the community), and/or
4. The building is considered “post-disaster” or “high criticality” (**Table 2**).

A high-level climate risk assessment may not be required for a project under certain scenarios. One such case is where a climate risk assessment has previously been performed for the building (in the case of an existing building project), and the new project fits within the context of the previous climate risk assessment. Note, however, that our climate is continuously changing, and that new climate data and updates to projections are becoming available every few years. If the climate risk assessment is more than 5 years old, it is recommended that a new high-level risk assessment be conducted.

An example of a high-level climate risk assessment is the **Public Infrastructure Engineering Vulnerability Committee High Level Screening Guide (PIEVC HLSG)** that is managed by the Institute of Catastrophic Loss Reduction (ICLR) [50]. This climate risk assessment framework became available in February 2022. PIEVC HLSG is a quicker, simplified and streamlined version of an older tool called the Public Infrastructure Engineering Vulnerability (PIEVC) Protocol.

STEP 4: Identify the relevant minimum climate resilience requirements

Input:	List of medium to high risks keyed to major systems/components, and any special risk cases
Outputs:	Relevant sections and clauses from the Standards
Completed by:	Design Team, Project Team and/or external consultants

The objective of this step is to identify opportunities and strategies for improving the climate resilience of the building.

This step involves identifying which sections of the Standards (see **Chapter 3**) are applicable to the project. The Standards provide minimum climate resilient design and performance requirements for public sector organization building projects. PSOs may be encouraged or required to go above and beyond these requirements (by code requirements, ministry requirements, etc.).

Factors that will determine which sections and clauses of the Standards are applicable to your project include:

- Results of the Climate Risk Assessment; all relevant standard sections for "medium," "high" or "special case" risks apply.
- Classification of the project type as 'new construction' or 'existing building renewal':
  - There are two sets of Standards: one for new buildings and one for existing buildings. Existing building renewal projects often have added complexity associated with renewals, and some strategies that would be applicable for new building projects (such as selection of site location to reduce risk) are not applicable to existing building projects.
  - If the project is an existing building renewal, only Standards sections and clauses that are relevant to the defined scope of work need to be considered. For example, if the renewal is limited to the building envelope, clauses related to stormwater detention and drainage design need not apply.
- Criticality Classification of the building (refer to **Table 2**), building occupancy type, occupant demographic (*i.e.,* consideration as to whether there is a 'vulnerable' population) and operational requirements during an emergency or disaster event.

If the building has a Criticality Classification of ‘high’, ‘post-disaster’ or it has refuge areas, the requirements for climate resilient design are more stringent than those for ‘normal’ or ‘low’ criticality buildings. For example, requirements for back-up power capacity and duration differ based on the Criticality Classification (*i.e.,* there are requirements outlined in the Standards specifically for each of these classifications).

Other considerations when identifying relevant Standards clauses for the project:

- Project-specific requirements.
- For certain projects, such as hospitals, there may be existing standards that contain more stringent requirements than those provided in the Standards, or design requirements that prevent the implementation of certain Standards. Wherever this is the case, the more stringent requirements must be followed, and any deviations from the Standards must be clearly documented and justified.
- Global warming level (GWL) and climate-projected design parameters
- Certain Standards clauses incorporate references to design thresholds; for example, the stipulated Global Warming Level (GWL) and associated climate-projected design.

2.4 Design & Construction Document Development Stages

This section provides some recommendations for the design, and the construction development stages of the project.

If a screening-level climate risk assessment was conducted at the **Detailed Project Planning Stage**, and one of the findings from the qualified professional was that a more detailed climate risk assessment should be considered (either for the whole building, or limited portions of systems that are at higher risk), this assessment will be conducted during the **Design Stage**. Having early collaboration between the qualified professional and design team will bring the best value to the project.

PSOs must also ensure that minimum climate resilience requirements identified in **STEP 4** are communicated to the proponents, along with any additional, building-specific design requirements. It is recommended that PSOs require that proponents demonstrate how the design requirements will be implemented (or more specifically, which design strategies address the minimum climate resilience requirements for the project) during the bidding stage of the project. These requirements can be included in the Owner's Project Requirements (OPR) document.

2.5 Project Close-out

STEP 5: Submit a "Climate Resilience Report"	
Input:	Results from the High-Level Project Planning (if applicable) Results from Detailed Project Planning Stage (if applicable)
Outputs:	Climate Resilience Report
Completed by:	Internal PSO Project team with the assistance of external consultants if desired

A final Climate Resilience Report is to be submitted to the Climate Action Secretariat at the completion of the project.

The report should include the following elements (these are presented as a minimum, and may be exceeded by other reporting requirements from the climate risk assessment methodology selected, or other)[1]:

1. Attestation of completeness by the project manager or professional of record
2. Introduction/background to the project
3. Criticality Classification of the building
4. Climate risk assessment results[2]:
   a. The name and credentials of the qualified professional performing the assessment and providing results.
   b. A statement of assumptions, limitations and scope including:
      - What was considered, and what was omitted?
      - Which timeframes were considered, and what future climate scenarios were used?
   c. The climate risk assessment framework/methodology used for the project, including rationale for its selection, and for the level of detail.

[1] This list has been adapted from ISO 14090:2019 and PIEVC HLSG reporting requirements

[2] It is recommended that the qualified professional who performed the risk assessment write this portion of the report. Alternatively, the qualified professional can submit a separate report, which will be included in the appendix of the Climate Resilience Report.

d. Presentation of the climate risks to the project (including risks to service delivery, programs, and businesses).

e. Commentary (either qualitative or quantitative) regarding uncertainties associated with the assessment.

f. A statement that describes:

- The climate change impacts and opportunities.
- Context regarding the level of assessment, method used, and application of findings.

5. The minimum climate resilience requirements identified as relevant to the project (including the Standards section numbers)[3].

a. Justification for what measures were incorporated to meet these requirements.

b. Justification for deviations from the Standards, for example:

- if project required more stringent requirements because of project-specific requirements,
- any exemptions permitted by municipalities or other government agencies
- conflicting climate resilience measures.

c. Appendix documentation of additional findings of any professional consultants hired as required by the Standards requirements.

6. Conclusion

7. References

[3] It is recommended that the design team and/or external consultants be involved in the writing of this report section.

2.6 Ongoing Maintenance and Performance Verification

Monitoring of building performance over time should be considered. Monitoring permits continued observation of building performance, ensuring continued functionality in the face of changing climate conditions. Performing periodic assessments of performance for gradual climate hazards will allow for modifications or improvements where necessary and will also assist in defining future projects.

Additionally, after a building project is complete (renewal or new construction), building assets (components, systems, etc.) need to be maintained to ensure that they continue to perform well as they age, and to minimize risks associated with climate hazards.

For mechanical systems, this may present as regular changing of lubricants or filters. For building envelope systems, examples include resealing/recaulking window perimeters, replacing window insulating glass units or repainting exterior cladding.

Maintenance items specific to minimizing climate risks, such as landscaping activities to reduce fire hazard, may not currently be included in existing maintenance procedures and will need to be incorporated into future asset management and planning activities.

CHAPTER 3:

MINIMUM CLIMATE RESILIENT STANDARDS

The following chapter presents the proposed Minimum Climate Resilience Standards (the Standards) for public sector buildings. There are two sets of the Standards: one for new buildings and one for existing buildings.

Each version of the Standards is organized into seven (7) parts. In Parts 1 to 6, the standard clauses are organized by the climate hazard to which they respond. Part 7 contains the standard clauses that address power outages (that can be caused by one or more climate hazards).

In these tables, “must” is used to express a requirement (*i.e.*, the project team is obliged to satisfy the provision); “should” is used to express a recommendation which is strongly advised but not required; and “may” is used to express an option.

Chapter Includes:

3.1 Minimum Climate Resilience Standards for New Buildings

PART 1:
Minimum Standards for New Building Resilience To Warming Climate and Extreme Heat Events

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
1	All new public sector buildings must be designed to address the warming climate using both passive and active strategies accounting for climate projections at the end of design service life.		
	NOTE: In the subsequent requirements, the mechanical equipment will be designed for a "Global Warming Level" (GWL), i.e., a global temperature increase, relative to pre-industrial temperatures. The GWL will be determined by a qualified professional for the building and key building components at the climate risk assessment phase of the project. Guidance on how to determine the climate-projected design parameters based on the GWL is presented in Appendix B of this document. The requirements in this standard apply to buildings that are conditioned.		
1.1	The building envelopes of all new buildings must have enhanced thermal performance.	Thermal	**Building Envelope**
	a) The thermal energy demand intensity (TEDI) of the building must meet the highest step of the BC Energy Step Code (or an equivalent performance for buildings that are not regulated by the BC Energy Step Code).	Thermal energy demand intensity is a metric of the annual heating required by the building for space conditioning and for conditioning of ventilation air, estimated using an energy model in accordance with BC Building Code section 10.2.3.4, per square metre of conditioned floor space. Target a minimum effective R-value of the building enclosure of R-10 (consultant expertise). A building's effective R-value must be determined as per BC Building Code.	**Building Envelope**
	b) The building envelope must have superior airtightness.		**Building Envelope**
	i) All buildings must achieve an airtightness minimum target of 1.27 L/s·m² at 75Pa during whole building final airtightness testing. An airtightness target of less than 1L/s·m² is strongly encouraged.	Relevant standard values presented in industry for whole building airtightness targets: • 1.27 L/s·m² at 75Pa for healthcare facilities ("Climate Resilience Guideline for BC Health Facility Planning & Design," [7].) • 0.28 L/s·m² at 75Pa (U.S. Passive House Certification) • 1.3 L/s·m² at 75Pa for Commercial Building (U.S. Corps of Engineers) • L/s·m² at 75Pa for Commercial Building (NBCC, IECC, ASHRAE 90.1) • L/s·m² at 75Pa for Part 3 buildings (City of Vancouver's Building Bylaws) • 0.6 ACH50 (air changes per hour) at 50Pa for all buildings (Passivhaus Institut), 0.6 m³/hr·m² at 50Pa for larger buildings (Passivhaus Institut) Relevant standard values for single unit or per-unit airtightness targets: • ACH at 50Pa (City of Vancouver's Building Bylaws) • BC Housing's Illustrated Guide – Achieving Airtight Buildings presents design principles and provides recommendations and industry best practices for ensuring airtight buildings [17]. It provides examples of design, construction, and testing checklists for guidance, and that could also be required for compliance documentation.	
	ii) Post-construction airtightness testing is required. Mid-construction airtightness testing is strongly recommended.	As per BC Building Code section 10.2.3.5., Part 3 buildings shall be tested for airtightness in accordance with: • ASTM E779, Standard Test Method for Determining Air Leakage Rate by Fan Pressurization, or • USACE Version 3, Air Leakage Test Protocol for Building Envelopes. The City of Vancouver's Building Bylaws (VBBL) requires that mid-construction airtightness testing be completed for new Part 9 residential buildings, but mid-construction airtightness testing is not currently required for Part 3 buildings.	
1.2	All new buildings must supplement passive cooling strategies with active cooling strategies.	Sensible cooling demand is the demand on mechanical cooling equipment for the reduction of the indoor temperature.	**Building Envelope**
	a) Buildings should be designed to minimize sensible cooling demand through passive strategies, such as reduced window to wall ratios, exterior shading, enhanced glazing materials (e.g., low Solar Heat Gain Coefficient coatings), and increased insulation thicknesses.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	**Building Envelope**
	b) All buildings except for low-occupancy buildings must be equipped with mechanical cooling systems. Sub-requirements for the design of mechanical cooling systems:		**Mechanical**
	i) Mechanical systems, ductwork and terminal units must be designed to enable full functionality at future design temperatures at the end of the system's service life. Equipment is to be sized to meet Global Warming Level relative to pre-industrial temperatures based on the design service life of the equipment. Buildings must have a system capable of ensuring a Standard Effective Temperature not exceeding 27°C, determined in accordance with ASHRAE 55 (2017), using future shifted climate data, throughout the entire building's service life.	National Building Code of Canada design parameters, shifted according to global temperature rise over pre-industrial, are available at Environment and Climate Change Canada ("Climate-Resilient Buildings and Core Public Infrastructure," Appendix 1.2 Tables [18]). Refer to Appendix B of this document for guidance. End of life of mechanical equipment typically precedes the end of life the building. For this reason, the global temperature increase used for determining design parameters of the mechanical equipment is to be based on expected service life of equipment (not the building). At time of equipment renewal, the new equipment will be designed to account for updated projected global temperatures. Passive House specifies that all part of a home must stay below 25°C at least 90 percent of the time.	

			Future shifted weather files have been produced by the Pacific Climate Impacts Consortium for all locations in Canada in the CWEC 2016 dataset and files are freely available at: https://www.pacificclimate.org/data/weather-files [19]. NRC has long-term building simulation time-series data and reference year data available [20, 21]. Future climate data are also available at the ClimateData.ca portal [22].	
1.2	b)	ii) Mechanical heating and cooling systems must meet CleanBC low-carbon requirements, and/or the Government of BC/BC Hydro's 5-year electrification plan requirements.	British Columbia's CleanBC Roadmap [5]. This states that after 2030 all new space and water heating equipment will be at least 100% efficient. BC Hydro's five-year electrification plan (reference: https://news.gov.bc.ca/releases/2021PREM0059-001861) [23].	
		iii) Mechanical systems must be 'upgradeable' at end of service life to be adapted to changing climate projections. Future space requirements and access requirements should be considered and documented during design. Distribution systems must be designed to accommodate future loads at end of building's design service life.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	
1.3	The energy model for all new buildings must evaluate and demonstrate resilience to current and future climate conditions and extreme temperature events.			**Modelling**
	a)	A building must demonstrate adequate performance in passive cooling mode appropriate for the building's criticality and occupancy type.	For guidance on determining the building's Criticality Classification, refer to Table 2 in this document.	**Modelling**
		i) The model must demonstrate that the building performs at, or better than, a prescribed Cooling Energy Demand Intensity (CEDI) target, to promote a cooling approach that incorporates occupant demand reduction, comfort, and climate resilience. This should be demonstrated using the appropriate future weather files, aligned with the selected Global Warming Level (i.e., global temperature increase).	CEDI targets have not been determined. Passive house has a cooling energy demand requirements of 15 kWh/m²/year. The Passive House 'cooling energy demand' is defined as the energy required for cooling the space per year and includes cooling of ventilation air. The "Future Climate Design for Multi-family Buildings" study completed for UBC (2021) demonstrated that 15kWh/m²/year CEDI was achievable for Step 3 and 4 multi-family buildings in Vancouver in a 2050 climate through implementation of passive shading strategies [24].	
		ii) The energy modelling must include and report on sensitivity analysis for resilience during extreme climate events (wildfire smoke events, heat waves, and power outages). During these scenarios, measures such as natural ventilation and mechanical cooling are limited or turned off in the model. The scenarios could require compliance with adjusted criteria.	The University of Toronto's "Thermal Resilience Design Guide" presents a modelling methodology for thermal autonomy and passive habitability [25]. NRC has proposed the Reference Summer Weather Years (RSWY) methodology for evaluating overheating risk. Future shifted RSWY files may enable a sensitivity analysis for more extreme temperatures in future conditions [26, 27]. The City of Vancouver Energy Modelling Guidelines presents some guidelines, although the ASHRAE 55-2010 defined metric is not sufficient to address the magnitude of overheating (i.e., consecutive hours above a threshold), nor zone specific variations [28]. Additional work is required to establish a common definition and metrics to evaluate overheating risk.	
	b)	An energy professional (such as an energy modeller, or professional engineer) must conduct a thermal bridging analysis as per either the City of Vancouver's Energy Modelling Guidelines (2018), or CSA Z5010:21. • Thermal bridging calculation methodology. Excessive cladding attachments or other penetrations that cause thermal bridging should be avoided unless required for design against future wind loading.	Adapted from: • City of Vancouver Energy Modelling Guidelines [28], and • CSA Z5010 - Thermal bridging calculation methodology.	**Modelling**
	c)	All buildings must be modelled using current weather files (or current standard practice) plus a sensitivity test using a climate file representative of the stipulated Global Warming Level (GWL) (i.e., global climate temperature increases from pre-industrial times).	Selection of future climate files for modelling should account for design service life of building and/or building components, and the selected Global Warming Level (refer to Appendix B of this document for guidance).	**Modelling**

PART 2:
Minimum Standards For New Building Resilience To Flooding

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
2	All new public sector buildings must be designed to be resilient to flooding events (fluvial, pluvial, coastal) that can be expected over the building's service life (*i.e.*, increased precipitation and sea level rise).		
	NOTE: In the subsequent requirements, the Flood Construction Level (FCL) follows the definition provided in the Flood Hazard Area Land Use Management Guidelines 2018 Amendment, provincial regulation, and/or as defined by local bylaw. The FCL should represent a 200-year return period event at the end of the buildings design service life (*i.e.*, with an allowance for climate change). For coastal areas, the FCL should also include a sea level rise allowance to the end of design service life climate projections.	Adapted from Flood Hazard Area Land Use Management Guidelines 2018 Amendment [29].	
2.1	For all new buildings, the site must be selected to limit the flood hazard wherever possible, while avoiding the construction of new buildings in areas that are: • in a floodplain area that is not protected by a standard dike under the jurisdiction of a government organization; or • in an alluvial fan area that is not protected by structural flood protection works (*e.g.*, debris barrier, berm) under the jurisdiction of a government organization unless such use is consistent with local bylaws or provincial regulation (whichever takes priority), and a site assessment is conducted by a licensed qualified professional to confirm that the site is safe for intended use.		**Hydrological, Civil, Geotechnical**
2.2	For post-disaster, high criticality, or normal criticality buildings that contain refuge areas during a flood or other emergency, the building should not be located in a floodplain or alluvial fan area. If locating the building in a floodplain is unavoidable, a site assessment is to be conducted by a qualified licensed professional to confirm that the site would be safe for the intended use subject to additional flood protection measures. Flood protection measures must ensure that the building is able to function during an emergency.	For guidance on determining the building's Criticality Classification (*i.e.*, whether it is a high criticality, post- disaster or normal criticality building), refer to Table 2 in this document.	**Hydrological, Civil, Geotechnical**
2.3	Any proposed buildings must be set back from a watercourse or the sea in accordance with the Flood Hazard Area, Land Use Management Guidelines 2018 Amendment, provincial regulation, and/or by local bylaw.	Flood Hazard Area Land Use Management Guidelines 2018 Amendment [29].	**Hydrological**
2.4	For any building that is to be located in a protected floodplain, or protected fan area, or is otherwise confirmed to be safe for the intended use, an FCL is to be established as per the 'Note' at the top of this table. The FCL must be applied to the underside of wood floor or top of concrete floor. The FCL may be achieved by land filling, structural means, or any combination thereof.		**Hydrological, Civil, Geotechnical**
2.5	No area below the FCL should be used for habitation, business areas, storage of goods damageable by floodwaters, or fixed equipment damageable to floodwaters, unless permitted under local bylaw, and reasonable measures (which must be determined by a licensed qualified professional) are taken to prevent or protect against flooding.	Adapted from Flood Hazard Area Land Use Management Guidelines 2018 Amendment [29], and ASCE 24-14 Flood Resistant Design and Construction.	**Architectural**
2.6	The building must be designed for the safe ingress/egress of occupants in cases where flood velocities are expected to exceed 1 metre per second.		**Architectural**
2.7	The building design must ensure that the building is able to function with essential building services during the design flood event. The following are sub-requirements:		**Various**
	a) Main electrical switchgear and important equipment for safety requirements (*e.g.*, emergency generators, transfer switches, fire alarm panels, telecommunication rooms) must be located above the FCL. This requirement includes the equipment itself, and also the electrical connections. Where required to meet life safety provisions of the code, certain exterior electrical components may be installed below the FCL. Ensure that water sensors and alarms are installed to detect leaks.	CSA C22.1:21 Canadian Electrical Code, Part I has new requirements related to design of electrical equipment for flooding events. Main service cannot be located below the FCL. Sump pump electrical receptacles must be located above the FCL or be suitable for submersion. Adapted from IBC 2021, Chapter 27 Electrical panels can be equipped with Wi-Fi-enabled breaker switches so that they can be remotely shut-off.	**Electrical**
	b) Elevator cabs that descend below the FCL must be equipped with controls to prevent it from descending into floodwaters. Elevator shafts must be top driven and designed to resist flood loads.	Adapted from ASCE 24-14 Flood Resistant Design and Construction	**Electrical, Structural**
	c) Ensure that rooftop equipment is not at risk of flooding. Rooftop equipment must be placed on curbs higher than elevation of perimeter scuppers.	Adapted from" Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	**Mechanical, Electrical**
	d) Tanks below the FCL and either attached to or beneath the building, must be anchored and resist a minimum of 1.5 times the potential buoyant or flood forces assumed to act on empty tanks.	Adapted from ASCE 24-14 Flood Resistant Design and Construction	**Mechanical, Structural**
2.8	Stormwater drainage and detention must be designed for storm events that consider climate change to end of design service life. The following are sub-requirements for drainage and detention design of buildings:		**Various**

PART 2:
Minimum Standards For New Building Resilience To Flooding - Continued

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
2.8	a) Ensure that infiltration, capture and conveyance systems account for adjusted climate projections based on end of service life IDF curves, and for infiltration capacity lost due to development.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7]. To determine climate-projected IDF curves, the designer can use the approach outlined in Appendix B of this document to determine the climate-projected precipitation-related design parameters. The percent increase of these design parameters can be applied to historic IDF curves to approximate future IDF curves. CSA PLUS 4013:19 "Technical Guide: Development, interpretation, and use of rainfall intensity-duration- frequency (IDF) information: Guideline for Canadian water resources practitioners" was updated in 2018 to reflect latest understanding of climate change.	**Stormwater**
	b) Post-development flow rates of discharge for stormwater runoff discharged from the building property must not exceed the peak flow rate pre-development conditions (*i.e.*, the property's use immediately preceding development) for 10-year return period and smaller storm events. IDF curves representing historical rainfall periods shall be used for estimating pre-development design flow calculations, and IDF curves representing future climate conditions for end of service life shall be used for estimating post-development design flow calculations. On-site detention can be achieved using non-infiltrating storage devices (*e.g.*, underground detention tanks) and/or infiltrating green infrastructure (*e.g.* rain gardens, permeable pavements, infiltration trenches, rainwater tree trenches, green roofs) that is designed by a qualified professional to incorporate detention into green infrastructure design.	Adapted from City of Vancouver Rainwater Management Bulletin [30].	**Stormwater**
	c) 90 percent of average annual rainfall volume that falls on vehicle-accessible and other pollutant-generating surfaces must be captured and treated on site to enhance climate resilience in the watershed by improving water quality.	Adapted from" Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	**Stormwater**
	d) Installation of sump pumps for downslope and basement storm system connection on site must have back-up power situated above the FCL.		**Stormwater**
	e) One-way backflow preventers must be installed on storm drains where the basement or any habitable floor elevation is below the design hydraulic grade line of the storm sewer services.		**Stormwater**
	f) Where reliable future climate loads are not available, capacity of roof drainage and rainwater leaders should be increased by 20 to 30 percent above current building code or local bylaw requirements to account for future climate projections. On flat roofs, scupper drains must be placed every 30 metres around the perimeter of the roof.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	**Stormwater**
	g) Property grade should slope down and away from building (for the entire building perimeter) at a minimum of 5 percent slope for a minimum distance of 6 metres (or to the property line if closer), with the exception of impervious surfaces (*e.g.*, walkways), which can be sloped a minimum of 2 percent away from building.	Adapted from International Building Code 2021, Chapter 18	**Stormwater**
	h) Stormwater design solutions must also meet the minimum requirements of any applicable Integrated Stormwater Management Plans (ISMP), provincial regulation, or local bylaws.		**Stormwater**
2.9	One-way valves (backwater valves) must be installed for sanitary drains.		**Sewer**
2.10	The building envelope located below the FCL must be designed for exposure to floodwaters, and with long-term durability as a consideration (the building envelope should still have comparable service life after a flooding event). The following are general sub-requirements for the building envelope:		**Building Envelope**
	a) Below-grade waterproofing strategies must be designed for the service life of the building.		**Building Envelope**
	b) Building envelope materials selected for components below the FCL should be non-absorbent and 'flood damage- resistant' materials. Materials that get wet during a flood event should be easy to clean, and dry, or alternatively, be designed to be 'sacrificial', and easy to replace without impacting the occupancy of the building after a flood event.	Adapted from: "Climate Resilience Guideline for BC Health Facility Planning & Design," [7], ASCE 24-14 Flood Resistant Design and Construction, and BSI-128: Designing for Floods	**Building Envelope, Structural**
2.11	The building structure must be designed for loading due to floodwaters, with long-term durability as a consideration (the structure should still have comparable service life after a flooding event). The following are general sub-requirements for the building structure:		**Structural**
	a) The structure must be designed against hydrostatic, hydrodynamic and impact loads from flood events.	ASCE 24-14 Flood Resistant Design and Construction (current Canadian National Building Codes do not have any specific flood design provisions; however, they are targeted for 2025). Until then, it is recommended that International Building Code and ASCE codes be consulted for flood resilient design of structures.	**Structural**
	b) Structural materials selected for components below the FCL should be non-absorbent and 'flood damage-resistant'.		**Structural**

	c) Wherever fill is used, it is required to be stable under conditions of flooding (this includes rapid rise and drawdown, prolonged inundation, erosion, scour). Compaction of structural fill is required. Fill sides must not be steeper than 1:1.5. Fill must not adversely affect adjacent properties by increasing surface water elevation on their properties, or by directing flows towards them.	Adapted from ASCE 24-14 Flood Resistant Design and Construction, and Flood Hazard Area Land Use Management Guidelines (section 5.4).	**Structural, Geotechnical, Hydrological**
2.12	Additional structural requirements for resilience to coastal flooding (caused by tides, storm surge, wave effects, and other sources)		
	a) Metal connectors and fasteners which may be exposed to salt water, salt spray or other corrosive agents must be corrosion resistant or galvanized after fabrication.	ASCE 24-14 Flood Resistant Design and Construction American Concrete Institute.	**Structural**
	b) Concrete mixes must be designed adequately against chloride and sulphate ingress and have low water to cement ratios. Use of concrete admixtures and epoxy-coated rebar may be required.	ACI 318, Building Code Requirements for Structural Concrete and Commentary.	**Structural**

PART 3: Minimum Standards For New Building Resilience To Wildfires

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
3	All new public sector buildings located in regions deemed to be in the wildland-urban interface (WUI) must be designed to be resilient to wildfire. All new public sector buildings regardless of whether or not they are located in the WUI must provide adequate indoor air filtration to protect against wildfire smoke events.	Wildfire concerns are not explicitly addressed in the National Building Code of Canada (NBC), or the National Fire Code of Canada (NFC) (as of December 2021). Infrastructure Canada published a national guide in 2021, the "National Guide for Wildland-Urban Interface Fires." This document is a resource; however, it is not currently a legislated requirement.	
	NOTE: Wildfire concerns are currently not explicitly addressed in the National Building Code of Canada (NBC) nor in the National Fire Code of Canada (NFC) (as of December 2021).		
3.1	For new buildings located in the WUI, building envelope materials must be selected to be resilient to wildfire events. The building envelope materials selected must either: Meet all of the following sub-requirements, or Comply with NRC's "National Guide for Wildland-Urban Interface Fires" with consultation from a qualified professional.	Refer to NRC's "National Guide for Wildland-Urban Interface Fires" (2021) for guidance on determining whether the building is located in the wildland-urban interface (WUI) [16]. The document presents requirements for materials and constructions based on results of a hazard assessment, exposure screen and determination of a "Construction Class." Terminology notes: A non-combustible material meets the acceptance criteria of *CAN/ ULC-S114, Test for Determination of Non-Combustibility in Building Materials*.	**Architectural, Building Envelope**
	a) Roof assemblies must be non-combustible. Sub-requirements for roof assemblies:		
	Materials selected for roofs should satisfy Class A of: CAN/ULC-S107, Standard Test Methods for Fire Tests of Roof Coverings, or ASTM E108 Standard Test Methods for Fire Tests of Roof Coverings.	Adapted from: University of Toronto's "Thermal Resilience Design Guide" states that roofs should satisfy Class A of *ASTM E108 Standard Test Methods for Fire Tests* [25]. NRC's "Guide for Wildland-Urban Interface Fires", section 3.3.5, states that roof coverings should have a Class A classification when tested using CAN/ ULC-S107, Fire Tests of Roof Coverings [16]. CSA S504:19 Fire resilient planning for northern communities Clay tiles, concrete slate, metal roofing and most fiberglass asphalt singles typically comply [25].	**Architectural, Building Envelope**
	ii) Roof penetrations (e.g., pipes), flashings, and drip edges must be made of non-combustible materials.	Adapted from NRC's "Guide for Wildland-Urban Interface Fires" (2021), section 3.3.5 [16].	
	iii) Roof gutters, downspouts, and connectors must be non-combustible. Roof gutters must be covered with approved non-combustible, corrosion- resistant screens or guards to minimize accumulation of debris.	Adapted from: NRC's "Guide for Wildland-Urban Interface Fires", section 3.3.6, states that "gutters and downspouts should be non-combustible, and fitted with corrosion- resistant, non-combustible screens or guards." [16] *NFPA 1144* (2018), section 5.3.2, states that "roof gutters, downspouts and connectors shall be non-combustible and roof gutters shall be covered with an approved non-combustible means to minimize accumulation of debris." CSA S504:19 Fire resilient planning for northern communities	
	b) Cladding material selected for the building must be non-combustible (*i.e.*, combustible materials such as natural wood, hardboard and vinyl are prohibited).	NRC's "Guide for Wildland Urban Interface Fires" (2021), section 3.3.2 [16].	**Building Envelope**
	i) Materials selected for cladding must have a 1-hour rating determined using *CAN/ULC-S101, Fire Endurance Tests of Building Construction and Materials.*	NRC's "Guide for Wildland Urban Interface Fires" (2021), section 3.3.2.7 [16].	
	ii) All penetrations in the exterior wall cladding should be sealed with no gaps greater than 3mm.	NRC's "Guide for Wildland Urban Interface Fires" (2021), section 3.3.2.5 [16].	
	c) Finishes for eaves, soffits, and roof projections must be constructed using non- combustible materials (*i.e.*, combustible materials such as natural wood, hardboard and vinyl are prohibited).	Adapted from: University of Toronto's "Thermal Resilience Design Guide" [25]. NRC's "Guide for Wildland-Urban Interface Fires", section 3.3.7 requires that materials must be tested using ASTM E2957, *Standard Test Method for Resistance to Wildfire Penetration of Eaves, Soffits and Other Projections* with three replicate tests. Refer to NRC's Guide, section 3.3.7, for more details [16].	**Architectural**

	d)	Exterior glazing must satisfy the following sub-requirements: Glazing must be multi-layered (*i.e.*, at minimum, dual pane) with an outer pain of tempered or heat-strengthened glass. Plastic bubble skylights are prohibited. Windows and skylights must be tested using *SFM Standard 12-7A-2, Exterior Windows.* Roll-down metal fire doors released automatically by fusible links, or shutters (must be made of non-combustible material) are recommended.	Adapted from: University of Toronto's "Thermal Resilience Design Guide" [25]. NRC's Guide for Wildland-Urban Interface Fires (2021), section 3.3.9 [16]. Solid wood, aluminum and pultruded fiberglass windows perform better than vinyl. Vinyl windows are discouraged (University of Toronto's "Thermal Resilience Design Guide," [25]).	**Architectural, Building Envelope**
	e)	Exterior doors must satisfy the following sub-requirements: Doors must be made of non-combustible assemblies. Glazing in doors must satisfy relevant sub-requirements of 3.1.d) above.	Adapted from: NRC's "Guide for Wildland-Urban Interface Fires," section 3.3.9 [16]. University of Toronto's "Thermal Resilience Design Guide" [25].	**Architectural, Building Envelope**
	f)	Vents must resist the intrusion of flames and embers and should be screened with non-combustible wire mesh or hardware cloth (with openings no larger than 3mm).	Adapted from University of Toronto's "Thermal Resilience Design Guide" (2019) states that louvers, hoods, and vents must be screened with wire mesh or hardware cloth, with openings no larger than 1/8 inch (3mm) [25]. Vents must be tested in accordance with *ASTM E2886, Standard Test Method for Evaluating the Ability of Exterior Vents to Resist the Entry of Embers and Direct Flame Impingement*. NRC's "Guide for Wildland-Urban Interface Fires," section 3.3.8, allows vents to be tested in accordance with *ASTM E2886*, and 3 tests be performed following the acceptance criteria described in NRC's Guide, section 3.3.8.1 [16]. CSA S504:19 Fire resilient planning for northern communities, requires 3mm non- combustible screened or rated vents and openings	**Architectural**
	g)	Decks must be constructed from materials that are non-combustible.	Adapted from University of Toronto's "Thermal Resilience Design Guide" [25]. NRC's Guide for Wildland-Urban Interface Fires allows decks to be tested in accordance with ASTM E2726, *Standard Test Method for Evaluating the Fire-Test- Response of Deck Structures to Burning Brands and ASTM E2632, Standard Test Method for Evaluating the Under-Deck Fire Test Response of Deck Materials* and satisfy several performance requirements [16].	**Architectural**
3.2	For new buildings located at the WUI, the site must be designed to reduce the risk of wildfire hazard in proximity to the building.			**Site**
	a)	The separation distance from adjacent structures (accessory buildings, or buildings on adjacent lots) shall not be less than 10 metres.	Adapted from NFPA 1144 (2018) Standard for Reducing Structure Ignition Hazards from Wildland Fire, section 5.1.3, which requires that separation distances between the primary structure and accessory structures on each lot and structures on adjacent lots shall not be less than 30ft.	**Site**
	b)	Vegetation and landscaping within 10 metres of the building foundations should be modified as required to minimize risk of wildland fires. The building site must be maintained free of dry grasses and fine fuels.	Refer to NRC's Guide for Wildland Urban Interface Fires, section 3.4.1.1. and 3.4.1.2. for more guidance [16].	**Site**
	c)	Unprotected heat sources are not permitted within 10 metres of the primary structure.	Adapted from NFPA 1144 2018 Standard for Reducing Structure Ignition Hazards from Wildland Fire (Section 5.12)	**Site**
	d)	Fencing within 10m of the furthest projection of the building should be constructed using non-combustible materials.	Adapted from NRC's Guide for Wildland Urban Interface Fires, section 3.3.10.7 [16].	**Site**
3.3	For all new buildings, adequate air filtration is required in the event of a wildfire, so that indoor air contaminants and particulates do not exceed maximum levels for the well-being of occupants. The following are sub-requirements for ensuring adequate indoor air quality of the building:			**Mechanical**
	a)	Minimum of MERV-13 filter is required for all public sector buildings. For healthcare facilities and long-term care homes, systems must be designed to be HEPA-filter capable at minimum (*i.e.*, HEPA-filters may not need to be used continuously, however, mechanical systems must be compatible with these types of filters). HEPA-filters must be stored on site.	California government recommends installation of high-efficiency (MERV 13 or higher) filters [31]. "Evidence on the Use of Indoor Air Filtration as an Intervention for Wildfire Smoke Pollutant Exposure" (a CDC document) concludes that "HEPA filter and electrostatic precipitators seem to be effective in reducing exposure to air pollutants produced by wildfires and can potentially limit the negative health impacts from exposure as well"; whereas there is less evidence supporting gas-phase filters or effectiveness of ESP filters [32]. BC Housing MBAR documents for wildfire resilience, suggest installation of filters of MERV 11 or higher for all outdoor air building ventilation systems, and the use of HEPA filters and activated carbon filters in refuge areas [33].	**Mechanical**
	b)	The building must have sufficient airtightness to prevent infiltration of contaminants. Refer to Part 1, Section 1.1 of the Standards document for minimum whole building airtightness requirements.		**Architectural / Building Envelope**
	c)	For facilities that have refuge areas (irrespective of Criticality Classification of the building), ensure that space has dedicated HVAC system sized for 100 per cent outdoor air capacity and appropriate filtration for wildfire events that may accommodate the community for 14 days. This space must also be designed to accommodate overheating events where applicable (refer to Part 1) and power outages where applicable (refer to Part 7).	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	**Mechanical**

PART 4: MINIMUM STANDARDS FOR NEW BUILDING RESILIENCE TO STRONG WIND EVENTS

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
4	All new public sector buildings are to be resilient to strong wind events in locations where these have been identified as a current or future risk.		
	NOTE: In the subsequent requirements, climate-projected design parameters are based on a "Global Warming Level" (GWL) relative to pre-industrial temperatures. The GWL for the building is determined by a qualified professional at the climate risk assessment phase of the project. Guidance on how to determine climate-projected design parameters for the building and its components based on this GWL is presented in Appendix B of this document.		
4.1	The building structural system must be designed to withstand the greater of: • wind loading dictated by current building code requirements, and • future wind loading per climatic projections at the end of the building's design service life. The design should also consider the risks of increased frequency and intensity of tornadoes per climatic projections at the end of the building's design service life.	Refer to Appendix B of this document for guidance on determining climate-projected design loads/parameters.	**Structural**
4.2	Site elements and any other outdoor accessories such as lighting, shades, and signage must be properly anchored.		**Structural, Site**
4.3	Building envelope materials (cladding, roof, windows, doors, etc.) must be selected to withstand current and projected wind loads. Consider strategies such as impact- resistant materials, or shutters for windows and doors.	Institute for Catastrophic Loss Reduction's "Protect your home from Severe Wind" presents designs strategies for resilience to strong wind events [34]. For roof design, Climate-RCI web application tool, and CSA A123.26: Performance requirements for climate resilience in low slope membrane roofing systems, may be relevant.	**Building Envelope**
4.4	Roof vents must be rated for high winds.		**Mechanical**
4.5	Rooftop equipment must be constructed and anchored to withstand the greater of: • wind loading dictated by current building code requirements, and • future wind loading per climatic projections for the end of design service life of the equipment. The design should also consider the risks of increased frequency and intensity of tornadoes per climatic projections.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7]. Refer to Appendix B of this document for guidance on determining climate-projected design loads/parameters.	**Mechanical, Electrical**
4.6	All new buildings that are considered post-disaster, high criticality, or normal criticality buildings with refuge areas, must satisfy the requirements of Part 7 "MINIMUM STANDARDS FOR NEW BUILDING RESILIENCE TO POWER OUTAGES."	For guidance on determining the building's Criticality Classification (*i.e.*, whether it is a high criticality, post-disaster or normal criticality building), refer to Table 2 in this document.	**Electrical**

PART 5: Minimum Standards For New Building Resilience To Droughts

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
5	All new public sector buildings must have measures in place to provide resilience to drought.		
5.1	The potable water system must be designed such that in water shortage events, potable water uses can be limited to those that are deemed critical. This can be achieved by designing correct branching and isolation valves to shut-off certain systems.		**Mechanical**
5.2	The landscape should be designed to be drought resilient. Plants should be non- invasive and drought tolerant.	Adapted from Climate Resilience Guidelines for BC Health Facility Planning & Design [7].	**Landscape**
5.3	Smart irrigation strategies should be used (such as drip irrigation, and rainwater storage).	Adapted from Climate Resilience Guidelines for BC Health Facility Planning & Design [7].	**Landscape**

PART 6:
Minimum Standards For New Building Resilience To Cold Snaps, Extreme Snowfall Events, Ice Storms

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
6	All new public sector buildings are to be resilient to cold snaps, extreme snowfall events, and/or ice storms, per climate projections to end of design service life.		
	NOTE: In the subsequent requirements, the Owner will stipulate a "Global Warming Level" (GWL) relative to pre-industrial temperatures. The GWL will be determined by a qualified professional at the climate risk assessment phase of the project. Guidance on how to determine the climate-projected design parameters for the building and its components based on the GWL is presented in Appendix B of this document.		
6.1	Building structures and all secondary structural elements must be designed for snow loads to the greater of: • the current climate loads, and • end of design service life climate projected loads.	Refer to Appendix B of this document for guidance on determining future climate design loads/parameters.	**Structural**
6.2	Concrete structures exposed to potential wetting and drying should use concrete mixes with reduced water to cement ratios (and admixtures) and air entrainment to minimize the risk of concrete degradation from freeze-thaw cycles.	*ASTM C666, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.*	**Structural**
6.3	Roofs should be designed to allow for snow to slide off the roof wherever possible. Ensure that no roof penetrations or equipment restrain the snow, so that large loads do not develop on these elements. As many building owners historically have requested the use of snow stops (or snow guards) to be placed on sloping roofs to reduce hazard for building occupants and the public, it is recommended that the safety of building occupants and general public that may use adjacent spaces be considered in design of roofs that intentionally shed snow.	Adapted from Climate Resilience Guidelines for BC Health Facility Planning & Design [7].	**Structural, Architectural**
6.4	Wherever required for life safety (such as critical entry points) ensure that there is an adequate snow removal approach in place for the anticipated level of snowfall. These may include snow melting systems (e.g., radiant heating, hydronic heating), covered entryways, and/or others.	Adapted from Climate Resilience Guidelines for BC Health Facility Planning & Design [7].	**Mechanical, Electrical**
6.5	Site and building should be designed to allow space for snow dumps (snow cleared from roof and around the building).		**Site**
6.6	All new buildings that are considered post-disaster, high criticality, or are normal criticality buildings with refuge areas, must satisfy the requirements of Part 7 "MINIMUM STANDARDS FOR NEW BUILDING RESILIENCE TO POWER OUTAGES."	For guidance on determining the building's Criticality Classification (*i.e.*, whether it is a high criticality, post-disaster or normal criticality building), refer to Table 2 in this document.	**Electrical**

PART 7:
Minimum Standards For New Building Resilience To Power Outages

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
7	All new post-disaster, high criticality, and normal criticality public sector buildings with refuge areas must be equipped with secondary sources of energy to supply power during short-term shortages or interruptions in grid power.		
	NOTE: In the below requirements, "back-up power" refers to non-life safety power that is deemed essential for occupant well-being (e.g., water, heating).		
7.1	Back-up generators, renewable energy production (e.g., solar PV), energy storage (battery back-up, thermal storage, kinetic storage), EV charging infrastructure that can provide secondary source of energy, or a combination thereof, are required to supply 'off-grid' power during a power outage event. Requirements for non-life safety back-up power supply duration will be dictated by the criticality of the building and its purpose. Minimum durations and service-levels are presented below (wherever other applicable mandates are more stringent, those should be adhered to). Power must be provided for these timeframes without need for refueling.	Refer to 2021 BC Electrical Code (section 64-900) for requirements related to energy storage systems. Emergency power (for life safety and critical power systems) must follow BC Building Code, BC Electrical Code requirements and/or other applicable codes/standards (e.g., CSA 282).	**Electrical**
	a) For high criticality buildings (*e.g.*, schools), or normal criticality buildings that contain refuge areas, 24 hours of non-life safety back-up power deemed essential for occupant well-being (*e.g.* heat, water) is required for all refuge areas, such that occupants can remain in the buildings safely and with a degree of comfort for this period of time. Note that non-life safety power is to be provided to the refuge areas (*i.e.*, it is not required for the whole building).	For guidance on determining the building's Criticality Classification (*i.e.*, whether it is post- disaster, high criticality or normal criticality building), refer to Table 2 in this document. The City of Toronto's "Minimum Backup Power Guidelines for MURBs" (Oct. 2016) presents the scenario where there are refuge areas, for which "backup power is provided to meet non-life safety requirements that are considered essential for occupant well-being (*e.g.* water supply, heating, elevators), such that occupants can remain in their building safely and with a degree of comfort for at least 72 hours" [35]. 72 hours is the general emergency preparedness standard advocated by Government of Canada. During the 2013 ice storm, it took Toronto Hydro approximately 72 hours to restore power to 86 percent of customers without power at peak [35].	**Electrical**
	b) For post-disaster buildings, 72 hours of non-life safety back-up power essential for occupant well-being (*e.g.*, heat, water) is required for all areas that are deemed critical for the continued (and uninterrupted) operation of facility (*i.e.* not limited to only 'refuge areas').	For guidance on determining the building's Criticality Classification (*i.e.*, whether it is a high criticality or post-disaster building), refer to Table 2 in this document.	**Electrical**
7.2	Adequate temperature regulation for back-up power supplies (cooling or heating) must be installed to ensure reliable performance of the equipment during a power outage event. For example, where generators are used for back-up power, generators are to be selected to operate in extreme maximum temperatures per climatic projections (*e.g.* rated for 50°C). Similarly, if extreme minimum temperatures are anticipated, they may need to be equipped with cold weather kits. Battery storage systems must be designed for extreme minimum and maximum temperatures per climatic projections.		**Electrical**
7.3	The Building Management System (BMS) and/or electrical infrastructure must be designed such that it can segregate load, so that important systems can be prioritized. BMS used to reduce/segregate loads must mechanically disconnect the loads to reduce the demand factors for a reduction of calculated electrical load on an electrical system per 8-106 of the BC Electrical Code. Back-up power must be provided for BMS systems.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	**Electrical**
7.4	For post-disaster and high criticality buildings, the total capacity of back-up power systems must be sized to be 20 percent more than current maximum demand to take into consideration growth in future power demand of the building.		**Electrical**
7.5	Strategies and a written plan for temporary load shedding to reduce power consumption of non-essential areas should be developed.		**Electrical**
7.6	The energy modeller must conduct a sensitivity analysis where power outage is simulated (in line with Section 1.3). The energy modeller/engineer must verify that heating/cooling/ventilation and/or other operational requirements are satisfied for the building's criticality and occupancy type.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	**Modelling**
7.7	A potable water source guaranteed to still operate during a power outage (*i.e.*, relying on gravity-alone and not pumping) must be provided. Potable water supply must last a minimum of 72 hours for normal and high criticality buildings if limited to critical functions. Potable water supply must last a minimum of 96 hours for post-disaster buildings if limited to critical functions.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7]. 72 hours is the general emergency preparedness standard advocated by Government of Canada.	**Mechanical**

3.2 Minimum Climate Resilience Standards for Existing Buildings

PART 1:
MINIMUM STANDARDS FOR EXISTING BUILDING RESILIENCE TO WARMING CLIMATE AND EXTREME HEAT EVENTS

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
1	At the time of renewal, existing public sector buildings must be retrofitted to address the warming climate using both passive and active strategies.		
	NOTE: In the subsequent requirements, the Owner will stipulate a "Global Warming Level" (GWL) relative to pre-industrial temperatures for which equipment will be designed. The GWL will be determined by a qualified professional at the climate risk assessment phase of the project. Guidance on how to determine the climate- projected design parameters based on this GWL is provided in Appendix B of this document.		
1.1	At the time of building envelope renewal, existing public sector buildings must be retrofitted with assemblies that enhance thermal performance.		**Building Envelope**
	a) Select high performance building envelope materials (opaque walls, high performance roof, high performance glazing) to improve thermal performance of the building. Identify opportunities for minimizing sensible cooling demand using passive strategies such as enhanced glazing materials (e.g., low Solar Heat Gain Coefficient Coatings).	To be determined whether prescriptive component targets or whole building performance-based targets are desired and/or consistent with building policy currently under development. Prior to policy implementation, requirements of NECB or ASHRAE 90.1 are to be satisfied (whichever is most appropriate for the building archetype).	**Building Envelope**
	b) Detail renewal work to improve airtightness. Where post-construction airtightness testing is feasible, target an improved airtightness of 2 $L/s{\cdot}m^2$.	This airtightness target is equal to the current NEW building requirement of 2 $L/s{\cdot}m^2$ at 75Pa for Commercial Buildings per NBCC, IECC, and ASHRAE 90.1.	**Building Envelope**
1.2	Post-disaster, high-importance buildings, and buildings with refuge areas must be retrofit to provide active (mechanical) cooling designed for the stipulated Global Warming Level. The following are sub-requirements:		**Mechanical**
	a) For high-criticality and post-disaster buildings, cooling must be supplied to occupied areas, sized to meet climate projections at end of equipment's design service life (Standard Effective Temperature not exceeding 27ºC, determined in accordance with ASHRAE 55 (2017) is a recommended threshold), sensitive spaces (*e.g.*, electrical rooms), will require a system capable of tempering the air to maintain the room temperature to acceptable levels depending on the room use. retrofitting of existing mechanical cooling systems to meet the above requirements should occur at the next system renewal but may need to be sooner for critical facilities.	National Building Code of Canada design parameters, shifted according to global temperature rise over pre-industrial, are available at Environment and Climate Change Canada Appendix 1.2 Tables [18]). Passive House specifies that all part of a home must stay below 25ºC at least 90 percent of the time. Future shifted weather files have been produced by the Pacific Climate Impacts Consortium for all locations in Canada in the CWEC 2016 dataset. The files are freely available at https://www.pacificclimate.org/data/weather-files [19]. NRC has long-term building simulation time-series data and reference year data available [20, 21]. Future climate data are also available at the ClimateData.ca portal [22] [22].	**Mechanical**
	b) For buildings that are not classified as high-importance or post-disaster, but contain refuge areas, cooling must be provided at a minimum for these spaces, these refuge spaces must have a system capable of tempering air to maintain the temperatures to acceptable levels (Standard Effective Temperature not exceeding 27ºC, determined in accordance with ASHRAE 55 (2017) is a recommended threshold), These retrofits should be performed at the latest, at the end of service life of the existing mechanical equipment.	For guidance on determining the building's Criticality Classification (*i.e.*, whether it is a high criticality or post-disaster building), refer to Table 2 in this document. Passive House specifies that all part of a home must stay below 25ºC at least 90 percent of the time.	**Mechanical**
	c) Newly installed mechanical heating and cooling systems must meet CleanBC low-carbon requirements, and/or the Government of BC/BC Hydro's 5-year electrification plan requirements.	British Columbia's CleanBC Roadmap (reference: https://www2.gov.bc.ca/assets/ gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_2030.pdf). This states that after 2030 all new space and water heating equipment will be at least 100% efficient [5]. BC Hydro's five-year electrification plan [23].	**Mechanical**
1.3	Where active cooling is being added to an existing building that has a poor performing enclosure, passive cooling measures must also be incorporated. Two examples that would satisfy this requirement are:		**Building Envelope, Modelling**
	a) If window performance is poor (*e.g.*, single or double pane non-thermally broken aluminum windows), it is strongly recommended that windows be replaced prior to or in concert with adding mechanical cooling.		
	b) Methods of exterior shading should also be considered and incorporated where feasible to improve resilience and reduce added operating costs from mechanical cooling.		
1.4	For retrofit projects of sufficient scale or complexity that an energy model is required, the model must evaluate and demonstrate resilience to current and future climate conditions and extreme weather events, and satisfy the following sub-requirements:		**Modelling**
	a) All buildings must be modelled using current weather files plus a sensitivity test using a climate file representative of the Owner's stipulated global climate temperature increase.		**Modelling**

PART 1:
Minimum Standards For Existing Building Resilience To Warming Climate And Extreme Heat Events - Continued

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS		RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
	b)	The building must show adequate performance in passive cooling mode appropriate for the building's criticality and occupancy type. The model must demonstrate that the building performs at, or better than, a prescribed Cooling Energy Demand Intensity (CEDI) target, to promote a cooling approach that incorporates occupant comfort, energy efficiency and climate resilience.	CEDI targets have not been determined. EnerPHit has a cooling energy demand requirements of 15 kWh/m²/year.	Modelling
		ii) The energy modeller must complete and report on a sensitivity analysis for resilience during extreme climate events (wildfire smoke events, heat waves, and power outages). During these scenarios, measures such as natural ventilation and mechanical cooling are limited or turned off in the model. The scenarios could require compliance with adjusted criteria.	University of Toronto's "Thermal Resilience Design Guide" version 1.0 presents a modelling methodology for thermal autonomy and passive habitability [25]. NRC has proposed the Reference Summer Weather Years (RSWY) methodology for evaluating overheating risk. Future shifted RSWY files may enable a sensitivity analysis for more extreme temperatures in future conditions [27, 26]. City of Vancouver Energy Modelling Guidelines, although the ASHRAE 55- 2010 defined metric is not sufficient to address the magnitude of overheating (i.e., consecutive hours above a threshold), nor zone specific variations. Additional work is required to establish a common definition and metrics to evaluate overheating risk [28]. Three relevant resources are: NRC's Development of Assessment Criteria for overheating risk analysis in buildings, and CIBSE TM 59 and TM 52, which use three criteria to evaluate overheating risk.	
	c)	An energy professional must conduct thermal bridging analysis as per either City of Vancouver Energy Modelling Guidelines (2018), or CSA Z5010:21 - Thermal bridging calculation methodology. Excessive cladding attachments or other penetrations that cause thermal bridging should be avoided.	City of Vancouver Energy Modelling Guidelines [28], CSA Z5010:21 - Thermal bridging calculation methodology	Modelling

PART 2:
Minimum Standards For Existing Building Resilience To Flooding

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
2	At the time of renewal, existing public sector buildings must be retrofitted to improve resilience to flooding events (fluvial, pluvial, coastal) if the site is located in an area that may have risk of flooding per future climatic projections.		
	NOTE: In the subsequent requirements, the Flood Construction Level (FCL) is defined in the Flood Hazard Area Land Use Management Guidelines 2018 Amendment, provincial regulation, and/or defined by local bylaw. The FCL should represent a 200- year return period event with an allowance for climate change. For coastal areas, the FCL should also include a sea level rise allowance to end of design service life.	Adapted from "Flood Hazard Area Land Use Management Guidelines" 2018 Amendment [29].	
2.1	If the building is located in an area that is: • in a floodplain area that is not protected by a standard dike under the jurisdiction of a government organization; or • in an alluvial fan area that is not protected by structural flood protection works (e.g., debris barrier, berm) under the jurisdiction of a government organization, the building should not be used as a high criticality or post-disaster structure. For normal or low criticality buildings, a site assessment should be conducted by a qualified licensed professional to confirm that the site would be safe for the intended use.		**Hydrological, Civil, Geotechnical**
2.2	For a building located in a protected floodplain or alluvial fan that is considered a high criticality or post-disaster building, habitable spaces, business areas, storage of good damageable by floodwaters, or fixed equipment damageable by floodwater must be elevated above the FCL. The building must be able to function with essential building services during a flood event.	Adapted from Flood Hazard Area Land Use Management Guidelines 2018 Amendment [29].	**Various**
	a) Main electrical switchgear and important equipment for safety requirements (*e.g.*, emergency generators, transfer switches, fire alarm panels, telecommunication rooms) must be relocated above the FCL. This requirement includes the equipment itself, and also the electrical connections. Where required to meet life safety provisions of the code, certain exterior electrical components may be installed below the FCL.	Adapted from IBC 2021, Chapter 27.	**Electrical, Mechanical**
	b) Elevator cabs that descend below the FCL must be equipped with controls to prevent them from descending into floodwaters.	Adapted from ASCE 24-14 Flood Resistant Design and Construction	**Electrical, Mechanical**
	c) Tanks below the FCL and are either attached to or beneath the building, must be anchored and resist a minimum of 1.5 times the potential buoyant or flood forces assumed to act on empty tanks.	Adapted from ASCE 24-14 Flood Resistant Design and Construction	**Structural**
	d) A reasonable method for building access and egress during times of flood inundation must be provided.	Adapted from ASCE 24-14 Flood Resistant Design and Construction	**Architectural**
2.3	For a building located in a protected floodplain or alluvial fan that is considered a normal or low criticality building, habitable spaces, businesses, storage of goods damageable by floodwaters, or fixed equipment susceptible to damage by floodwaters should be relocated above the FCL, unless permitted under local bylaw (or provincial regulation) and reasonable measures are taken to prevent or protect against flooding (as determined by a licensed qualified professional). The building should be able to function with essential building services during a flood event. This may necessitate that main electrical switchgear and important safety requirement are re-located above the FCL. Where required to meet life safety provisions of the code, certain exterior electrical components may be permitted to remain below the FCL.	Adapted from ASCE 24-14 Flood Resistant Design and Construction	**Architectural**
2.4	Stormwater drainage and detention should be upgraded to accommodate storm events that consider climate change to the end of design service life for buildings that are intended to remain in use and occupied for the long term, particularly high-criticality and post-disaster buildings. The following are recommendations for the upgrade of stormwater drainage and detention systems during renovation and renewal:		**Stormwater**
	a) Ensure that upgrades for infiltration, capture and conveyance systems account for adjusted climate projections based on end of design service life IDF curves.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7]. To determine climate-projected IDF curves, the designer can use the approach outlined in Appendix B of this document to determine the climate-projected precipitation-related design parameters. The percent increase of these design parameters can be applied to historic IDF curves to approximate future IDF curves. CSA PLUS 4013:19 "Technical Guide: Development, interpretation, and use of rainfall intensity-duration-frequency (IDF) information: Guideline for Canadian water resources practitioners" was updated in 2018 to reflect latest understanding of climate change.	**Stormwater**
	b) On-site stormwater capture and detention capacities should be increased. On- site detention capacity can be increased using non-infiltrating storage devices (*e.g.*, underground detention tanks) and/or green infrastructure (*e.g.* rain gardens, permeable pavements, infiltration trenches, rainwater tree trenches). A full stormwater system upgrade, where undertaken, should be to the same level as requirements for new buildings, including detention		**Stormwater**

	storage to the local design service level for end of design service life climate change conditions.		
	c) 90 percent of the average annual rainfall volume that falls on vehicle-accessible and other pollutant-generating surfaces should be captured and treated on site.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	**Stormwater**

PART 2: MINIMUM STANDARDS FOR EXISTING BUILDING RESILIENCE TO FLOODING 0 Continued

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
2.4	d) A qualified professional (*e.g.*, a licensed engineer with experience in the discipline of concern) should assess whether a foundation drain or other collection system and a sump pump is needed to reduce or mitigate flooding. Sump pumps must be equipped with back-up power located above the FCL.		**Stormwater, Structural**
	e) One-way valves (backflow preventers) on storm drains should be installed where the basement or any habitable floor elevation is below the design hydraulic grade line of the storm sewer service.		**Stormwater**
	f) During roof renewal, provide adequate sloping for low slope roofs, and ensure that scupper drains are placed every 30 metres around the perimeter of the roof. Install new drain screens where none currently exist.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	**Stormwater**
	g) Stormwater design solutions must also meet the minimum requirements of any applicable Integrated Stormwater Management Plans (ISMP) or local bylaws.		**Stormwater**
	h) Wherever possible, modify the property grade of non-impervious surfaces (for the entire building perimeter) to slope down and away from building at a minimum of 5 percent slope for a minimum distance of 6 metres.	Adapted from IBC 2021, Chapter 18	**Civil**
2.5	When significant building envelope renewals occur, envelope materials that are non-absorbent and flood damage-resistant must be selected for areas below the FCL. Materials that get wet during a flood event must be easy to clean, and dry, or, alternatively, be designed to be 'sacrificial', and easy to replace without affecting re- occupancy of the building after a flood event.	Adapted from: "Climate Resilience Guideline for BC Health Facility Planning & Design," [7], ASCE 24-14 Flood Resistant Design and Construction, and BSI-128: Designing for Floods	**Building Envelope**
2.6	If the building is considered a high criticality or post-disaster building, a licensed structural engineer must provide an assessment of the structure's preparedness for hydrostatic, hydrodynamic and impact loads from future flood events.		**Structural**
2.7	Incorporate the following additional structural requirements for resilience to coastal flooding (caused by tides, storm surge, wave effects, and other sources):		**Structural**
	a) Metal connectors and fasteners exposed to salt water, salt spray or other corrosive agents must be corrosion resistant or galvanized after fabrications.	ASCE 24-14 Flood Resistant Design and Construction	**Structural**

PART 3:
Minimum Standards For Existing Building Resilience To Wildfires

		DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
3		At the time of renewal, existing public sector buildings located in regions deemed to be at the wildland-urban interface (WUI) must be adapted to be resilient to wildfire. All existing public sector buildings regardless of whether or not they are located at the WUI must provide adequate indoor air filtration to protect against wildfire smoke events.		
3.1		During building envelope renewal, the building envelope materials selected must either: • Meet all of the following sub-requirements, or • Comply with NRC's "National Guide for Wildland-Urban Interface Fires" with consultation from a qualified professional. If the building is a high criticality building, or a post-disaster building, the building envelope retrofit should be considered prior to the normal renewal cycle.	Refer to "National Guide for Wildland-Urban Interface Fires" for guidance on determining whether the building is located at a wildland-urban interface (WUI) [16]. The document presents requirements for materials and constructions based on results of a hazard assessment, Exposure Screen and determination of a "Construction Class." Terminology notes: A non-combustible material meets the acceptance criteria of CAN/ ULC-S114, Test for Determination of Non-Combustibility in Building Materials.	**Architectural, Building Envelope**
	a)	Roof assemblies must be non-combustible. Sub-requirements for roof assemblies: Materials selected for roofs must satisfy Class A of: *CAN/ULC-S107, Standard Test Methods for Fire Tests of Roof Coverings*, or *ASTM E108 Standard Test Methods for Fire Tests of Roof Coverings*.	Adapted from: University of Toronto's "Thermal Resilience Design Guide" (2019) states that roofs should satisfy Class A of *ASTM E108 Standard Test Methods for Fire Tests.* NRC's "Guide for Wildland-Urban Interface Fires" (2021), section 3.3.5, states that roof coverings should have a Class A classification when tested using *CAN/ ULC-S107, Fire Tests of Roof Coverings* [16]. CSA S504:19 Fire resilient planning for northern communities. Clay tiles, concrete slate, metal roofing and most fiberglass asphalt singles typically comply (reference: Thermal Resilience Design Guide," 2019).	**Architectural, Building Envelope**
		ii) Roof penetrations (*e.g.*, pipes), flashings, and drip edges must be made of non-combustible materials.	Adapted from NRC's "Guide for Wildland-Urban Interface Fires" (2021), section 3.3.5 [16].	
		iii) Roof gutters, downspouts, and connectors must be non-combustible. Roof gutters must be covered with approved non-combustible, corrosion-resistant screens or guards to minimize accumulation of debris.	Adapted from: NRC's "Guide for Wildland-Urban Interface Fires" , section 3.3.6, states that "gutters and downspouts should be non-combustible, and fitted with corrosion- resistant, non-combustible screens or guards." [16]. NFPA 1144 (2018), section 5.3.2, states that "roof gutters, downspouts and connectors shall be non-combustible and roof gutters shall be covered with an approved non-combustible means to minimize accumulation of debris." CSA S504:19 Fire resilient planning for northern communities	
	b)	Sub-requirements for renewal of cladding: i) Must use non-combustible materials (unless it can be demonstrated that exposure level permits the use of ignition-resistant material as per NRC's Guide for Wildland Urban Interface Fires Exposure Screening).	NRC's "Guide for Wildland-Urban Interface Fires", section 3.3.2 [16].	**Architectural, Building Envelope**
		ii) Combustible materials are prohibited; this includes natural wood, hardboard and vinyl.		
		iii) Materials selected for cladding must have a 1-hour rating determined using *CAN/ULC-S101, Fire Endurance Tests of Building Construction and Materials.*	NRC's "Guide for Wildland Urban Interface Fires", section 3.3.2.7 [16].	
		iv) All penetrations in the exterior wall cladding should be sealed with no gaps greater than 3mm.	NRC's "Guide for Wildland Urban Interface Fires", section 3.3.2.5 [16].	
	c)	Finishes for eaves, soffits, and roof projections must be constructed using non- combustible materials (i.e., combustible materials such as natural wood, hardboard and vinyl are prohibited).	Adapted from: University of Toronto's "Thermal Resilience Design Guide" [25]. NRC's "Guide for Wildland-Urban Interface Fires", section 3.3.7 requires that materials must be tested using *ASTM E2957, Standard Test Method for Resistance to Wildfire Penetration of Eaves, Soffits and Other Projections* with three replicate tests. Refer to NRC's Guide, section 3.3.7, for more details [16].	**Architectural, Building Envelope**
	d)	Exterior glazing must satisfy the following sub-requirements: Glazing must be multi-layered (i.e., at minimum, dual pane) with an outer pain of tempered or heat-strengthened glass. Plastic bubble skylights are prohibited. Windows and skylights must be tested using *SFM Standard 12-7A-2, Exterior Windows.* Roll-down metal fire doors released automatically by fusible links, or shutters (must be made of non-combustible material) are recommended.	Adapted from: University of Toronto's "Thermal Resilience Design Guide" [25] NRC's "Guide for Wildland-Urban Interface Fires" (2021), section 3.3.9 [16]. Solid wood, aluminum and pultruded fiberglass windows perform better than vinyl. Vinyl windows are discouraged [25].	**Architectural, Building Envelope**
	e)	Exterior doors must satisfy the following sub-requirements: Doors must be made of non-combustible assemblies. Glazing in doors must satisfy relevant sub-requirements of 3.1.d) above.	Adapted from: NRC's "Guide for Wildland-Urban Interface Fires," section 3.3.9 [16]. University of Toronto's "Thermal Resilience Design Guide" [25].	**Architectural, Building Envelope**

PART 3:
Minimum Standards For Existing Building Resilience To Wildfires 0 Continued

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS		RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
	f)	Vents must resist the intrusion of flames and embers and should be screened with non-combustible wire mesh or hardware cloth (with openings no larger than 3mm).	Adapted from University of Toronto's "Thermal Resilience Design Guide" (2019) states that louvers, hoods, and vents must be screened with wire mesh or hardware cloth, with openings no larger than 1/8 inch (3mm). Vents must be tested in accordance with *ASTM E2886, Standard Test Method for Evaluating the Ability of Exterior Vents to Resist the Entry of Embers and Direct Flame Impingement.* NRC's Guide for Wildland-Urban Interface Fires, section 3.3.8, allows vents to be tested in accordance with ASTM E2886, and 3 tests be performed following the acceptance criteria described in NRC's Guide, section 3.3.8.1 [16]. CSA S504:19 Fire resilient planning for northern communities	**Architectural**
	g)	Decks must be constructed from materials that are non-combustible.	Adapted from University of Toronto's "Thermal Resilience Design Guide" [25]. NRC's "Guide for Wildland-Urban Interface Fires," allows decks to be tested in accordance with *ASTM E2726, Standard Test Method for Evaluating the Fire-Test- Response of Deck Structures to Burning Brands and ASTM E2632, Standard Test Method for Evaluating the Under-Deck Fire Test Response of Deck Materials* and satisfy several performance requirements [16].	**Architectural**
3.2	The building site must be adapted to reduce the risk of wildfire hazard in proximity to the building.			**Site**
	a)	Any new outbuildings, or accessory buildings, should be constructed more than 10 metres away from the building.	Adapted from: *NFPA 1144 2018 Standard for Reducing Structure Ignition Hazards from Wildland Fire* (Section 5.1), and University of Nevada, "Wildfire Home Retrofit Guide"	**Site**
	b)	Vegetation and landscaping within 10 metres of the building foundations should be modified as required to minimize risk of wildland fires. The building site must be maintained free of dry grasses and fine fuels.	Refer to NRC's "Guide for Wildland Urban Interface Fires," section 3.4.1.1. and 3.4.1.2. for more guidance.	**Site**
	c)	Unprotected heat sources are not permitted within 10 metres of the primary structure.	Adapted from *NFPA 1144 2018 Standard for Reducing Structure Ignition Hazards from Wildland Fire* (Section 5.12)	**Site**
	d)	Fencing within 10 metres of the furthest projection of the building should be constructed using non-combustible materials.	Adapted from NRC's "Guide for Wildland Urban Interface Fires," section 3.3.10.7 [16].	**Site**
3.3	Building HVAC systems must be upgraded or supplemented to provide adequate air filtration in the event of a wildfire, so that indoor air contaminants and particulates do not exceed maximum levels for the well-being of occupants. The following are sub-requirements for ensuring adequate indoor air quality of the building:			**Various**
	a)	Minimum of MERV-13 filter is required for all public sector buildings. For healthcare facilities and long-term care homes, systems must be designed to be HEPA-filter capable at minimum (i.e., HEPA-filters may not need to be used continuously, however, mechanical systems must be compatible with these types of filters). HEPA-filters must be stored on site. This may require redesign of system to account for impact on the static pressure.	California government recommends installation of high-efficiency (MERV-13 or higher) filters (https://ww2.arb.ca.gov/protecting-yourself-wildfire-smoke). "Evidence on the Use of Indoor Air Filtration as an Intervention for Wildfire Smoke Pollutant Exposure" (a CDC document) concludes that "HEPA filter and electrostatic precipitators seem to be effective in reducing exposure to air pollutants produced by wildfires and can potentially limit the negative health impacts from exposure as well"; whereas there is less evidence supporting gas-phase filters or effectiveness of ESP filters [32]. BC Housing MBAR documents for wildfire resilience, suggest installation of filters of MERV-11 or higher for all outdoor air building ventilation systems, and the use of HEPA filters and activated carbon filters in refuge areas [33].	**Mechanical**
	b)	For facilities that have refuge areas, ensure that space has dedicated HVAC system sized for 100 percent outdoor air capacity with adequate filtration (as per Section 3.3a) that may accommodate the community for 14 days.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [7].	**Mechanical**
	c)	When building enclosure is renewed, increase the airtightness to prevent filtration of contaminants. Airtightness target of 2 L/s-m^2; however, it is recognized that depending on the degree of renewal, this may not be achievable or testable.		**Architectural, Building Envelope**

PART 4: Minimum Standards For Existing Building Resilience To Strong Wind Events

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
4	At the time of renewal, existing public sector buildings must be retrofitted to improve resilience to strong wind events.		
	NOTE: In the subsequent requirements, climate-projected design parameters are based on a "Global Warming Level" (GWL) relative to pre-industrial temperatures. The GWL will be determined by a qualified professional at the climate risk assessment phase of the project. Guidance on how to determine climate-projected design parameters for the building and its components based on the GWL is presented in Appendix B of this document.		
4.1	Buildings must be assessed by a licensed structural engineer. If projected wind loads at end of design service life (per climatic projections) are higher than the values used during the design of the structure, the project and design teams should consider implementing retrofits including: • additional fasteners or structural screws for securing building envelope materials (roof, cladding, etc.) during building enclosure renewal, select building envelope assemblies (cladding, roof, etc.) that are resistant to wind loads. If risk of external debris is high, consider designing the structure with impact resistant materials provide coverings or storm shutters for non-impact-resistant windows.	Refer to Appendix B of this document for guidance on determining climate-projected design loads/parameters.	**Structural**
4.2	Existing rooftop equipment must be anchored such that it can withstand the greater of: • wind loads at the building's end of design service life per future climate projections, and • wind loads projected at the end of service life of the equipment. Design decisions should be justified based on age of the building.	Adapted from Climate Resilience Guidelines for BC Health Facility Planning & Design which states: "When locating equipment on the roof cannot be avoided, all rooftop equipment is to be constructed to withstand the year 2050 wind loads as per future climate projections." [7].	**Structural**
4.3	Roof vents should be rated for high winds.		**Mechanical**
4.4	Site elements and any other outdoor accessories such as lighting, shades, and signage must be properly anchored.		**Site**
4.5	All existing buildings that are post-disaster, high criticality, or normal criticality buildings with refuge areas, should meet requirements of Part 7 "MINIMUM STANDARDS FOR EXISTING BUILDING RESILIENCE TO POWER OUTAGES".	For guidance on determining the building's Criticality Classification (i.e., whether it is a high criticality, post-disaster or normal criticality building), refer to Table 2 in this document.	**Electrical**

PART 5: Minimum Standards For Existing Building Resilience To Droughts

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
5	At the time of renewal, existing public sector buildings must develop measures to improve resilience to drought.		
5.1	Landscape should be evolved to be drought resilient; replacement plants must be non-invasive and drought tolerant.	Adapted from Climate Resilience Guidelines for BC Health Facility Planning & Design [7].	**Landscape**
5.2	The building site should use smart irrigation strategies (such as drip irrigation, and rainwater storage).	Adapted from Climate Resilience Guidelines for BC Health Facility Planning & Design [7].	**Landscape**

PART 6:
Minimum Standards For Existing Building Resilience To Cold Snaps, Extreme Snowfall Events, Ice Storms

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
6	At the time of renewal, existing public sector buildings are to be retrofitted to improve resilience to cold snaps, extreme snowfall events, or ice storms.		
	NOTE: In the subsequent requirements, the Owner will stipulate a "Global Warming Level" (GWL) relative to pre-industrial temperatures. The GWL will be determined by a qualified professional at the climate risk assessment phase of the project. Guidance on how to determine the climate-projected design parameters for the building and its components based on the GWL is presented in Appendix B of this document.		
6.1	For roof renewal, if the projected snow loads for the end of design service life of the building are greater than design code loads from the period of design, structural reinforcement of the roof structure may be required. If this is the case, a licensed structural engineer must be consulted.	Refer to Appendix B of this document for guidance on determining future climate design loads/parameters.	**Structural**
6.2	For roof renewal, the roof should be retrofitted to allow for snow to slide off wherever feasible. No roof penetrations or equipment should restrain the snow, to prevent large loads from developing on these elements. As many building owners historically have requested the use of snow stops (or snow guards) to be placed on sloping roofs to reduce hazard for building occupants and the public, it is recommended that the safety of building occupants and general public that may use adjacent spaces be considered in design of roofs that intentionally shed snow.	Adapted from Climate Resilience Guidelines for BC Health Facility Planning & Design [7].	**Structural, Architectural**
6.3	Wherever required for life safety (such as critical entry points) ensure that there is an adequate snow removal approach in place for the anticipated level of snowfall. These may include snow melting systems (*e.g.* radiant heating, hydronic heating), covered entryways, and/or others.	Adapted from Climate Resilience Guidelines for BC Health Facility Planning & Design [7].	**Site, Mechanical**
6.4	Drainage systems should have adequate capacity for future snowfall projections.	Adapted from Climate Resilience Guidelines for BC Health Facility Planning & Design [7].	**Stormwater**
6.5	All existing buildings that are post-disaster, high criticality, or are normal criticality buildings with refuge areas, should meet requirements of Part 7 "MINIMUM STANDARDS FOR EXISTING BUILDING RESILIENCE TO POWER OUTAGES."	For guidance on determining the building's Criticality Classification (i.e., whether it is a high criticality, post-disaster or normal criticality building), refer to Table 2 in this document.	**Electrical**

PART 7:
Minimum Standards For Existing Buildings Resilience To Power Outages

	DESCRIPTION OF REQUIREMENTS AND SUB-REQUIREMENTS	RELEVANT CODES, STANDARDS, AND SUPPORTING REFERENCES	CATEGORY
7	At the time of renewal, existing high-criticality, post-disaster, or normal criticality buildings with refuge areas must be equipped with secondary power sources to supply power during short-term shortages or interruptions in grid power.		
	NOTE: In the below requirements, "back-up power" refers to non-life safety power. Emergency power systems (for life safety and essential power systems) must at minimum follow BC Building Code and BC Electrical Code requirements.		
7.1	Back-up generators, renewable energy production (*e.g.*, solar PV), energy storage (battery back-up, thermal storage, kinetic storage), or combination thereof, EV charging infrastructure that can provide secondary source of energy, are required to supply 'off-grid' power during a power outage event. Requirements for non-life safety back-up power supply duration will be dictated by the criticality of the structure and its purpose. Minimum durations and service-levels are presented below (wherever existing mandates are more stringent, these should be adhered to). Power must be provided for these timeframes without need for refueling.	Refer to 2021 BC Electrical Code (section 64-900) for requirements related to energy storage systems. Emergency power (for life safety and critical power systems) must follow BC Building Code, BC Electrical Code requirements and/or other applicable codes/standards (e.g., CSA 282).	**Electrical**
	a) For high criticality buildings (*e.g.*, schools), or normal criticality buildings that contain refuge areas, 24 hours of non-life safety back-up power deemed essential for occupant well-being are required for all refuge areas, such that occupants can remain in the buildings safely and with a degree of comfort for this period of time. Note that non-life safety power is to be provided to the refuge areas (*i.e.*, it is not required for the whole building).	For guidance on determining the building's Criticality Classification (*i.e.*, whether it is post-disaster, high criticality, or a normal criticality building), refer to Table 2 in this document. While MURBs are not typically considered "high criticality" structures in the Canadian NBC, the City of Toronto's "Minimum Backup Power Guidelines for MURBs" (Oct., 2016) presents the scenario where there are refuge areas for which "backup power is provided to meet non-life safety requirements that are considered essential for occupant well-being (*e.g.*, water supply, heating, elevators), such that occupants can remain in their building safely and with a degree of comfort for at least 72 hours" [35]. 72 hours is the general emergency preparedness standard advocated by Government of Canada. During the 2013 ice storm, it took Toronto Hydro approximately 72 hours to restore power to 86 percent of customers without power at peak [35].	**Electrical**
	b) For post-disaster buildings, 72 hours of non-life safety back-up power essential for occupant well-being (*e.g.*, heat, water) is required for all areas that are deemed critical for the continued (and uninterrupted) operation of facility (*i.e.*, not limited to only 'refuge areas').	For guidance on determining the building's Criticality Classification (*i.e.*, whether the building is a post-disaster building), refer to Table 2 in this document.	**Electrical**
7.2	Adequate temperature regulation for back-up power supplies (cooling or heating) must be installed to ensure reliable performance of the equipment during a power outage event. For example, where generators are used for back-up power, generators are to be selected to operate in extreme maximum temperatures per climatic projections (*e.g.*, rated for 50°C). Similarly, battery storage systems must be designed for extreme minimum and maximum temperatures per climatic projections.		**Electrical**
7.3	The Building Management System (BMS) and/or electrical infrastructure must be designed such that it can segregate load. BMS used to reduce/segregate loads must mechanically disconnect the loads to reduce the demand factors for a reduction of calculated electrical load on an electrical system per 8-106 of the BC Electrical Code. Back-up power must be provided for BMS systems.	Adapted from "Climate Resilience Guidelines for BC Health Facility Planning & Design," [35].	**Electrical**
7.4	For post-disaster and high criticality buildings, the total capacity of back-up power systems must be sized to be 25 percent more than current maximum demand of the standby distribution system to take into consideration future load expansion of the systems that are critical to the facility.		**Electrical**
7.5	Strategies and a written plan for temporary load shedding to reduce power consumption of non-essential areas should be developed.		**Electrical**
7.6	If the renewal is significant enough to require a whole building energy model, the modeller must conduct a sensitivity analysis where power outage is simulated (in line with Section 1.4. Modeller/engineer is to verify that heating/cooling/ventilation and/or other operational requirements are satisfied for building criticality and occupancy type.	Adapted from "Climate Resilience Guideline for BC Health Facility Planning & Design," [35]. For guidance on determining the building's Criticality Classification (*i.e.*, whether the building is a post-disaster building), refer to Table 2 in this document.	**Modelling**
7.7	A potable water source guaranteed to still operate during a power outage (*i.e.*, relying on gravity-alone and not pumping) must be provided. Potable water supply must last a minimum of 72 hours for normal and high criticality buildings if limited to critical functions. Potable water supply must last a minimum of 96 hours for post-disaster buildings if limited to critical functions.	Adapted from, "Climate Resilience Guidelines for BC Health Facility Planning & Design," [35]. 72 hours is the general emergency preparedness standard advocated by Government of Canada.	**Mechanical**

GLOSSARY OF KEY TERMS

Adaptation: in human systems, the process of adjustment to actual or expected climate and its effects to reduce harm and/or exploit beneficial opportunities (definition adapted from IPCC [12]).

Climate: the average weather (variables include temperature, precipitation, wind, etc.) over a period of time; typically, over 30 years as defined by the World Meteorological Organization (WMO) (definition adapted from IPCC [12]).

Climate change: a change in the state of the climate, which can be identified by changes in the mean and or variability of its properties that persist for an extended period of time; typically, decades or longer. Climate change can be due to natural processes or anthropogenic changes (definition adapted from IPCC [12]).

Climate hazard: climate-related physical event or trend that is a potential source of harm in terms of loss of life, injury, other health impacts, as well as damage and loss to property, infrastructure, services, ecosystems, resources (definition adapted from IPCC [12]).

Climate impacts: refers to effects on natural and human systems caused by one or more climate hazards. Typically refers to effects on lives, human health, infrastructure, ecosystems, economy, services, or cultural assets.

Climate projection: simulated response of the climate system to a scenario of future emissions or concentrations of greenhouse gases (GHGs), concentrations of aerosols, and changes in land use.

Climate resilience measures: strategies in the form of a project, technology, or process that improve a building's ability to adapt to the effects of climate change.

Climate risk assessment: the qualitative and/or quantitative estimation of climate risk (definition adapted from [12]).

Consequence: also referred to as climate impacts (see *climate impacts*).

Design service life: service life specified by the designer in accordance with the expectations of the owners of the building and requirements of CSA S478 (definition adapted from CSA 478, [36]).

Ecoprovince: areas of uniform climate, geological history and physiography (*i.e.,* a mountain range, a large valley, a plateau) [37].

Exposure: the presence of people, species, environmental functions, services, resources, infrastructure, or economic, social or cultural assets in places and settings that could be adversely affected (definition adapted from IPCC, [12]).

Greenhouse gases (GHGs): gaseous constituents of the atmosphere, both natural and anthropogenic that absorb and emit radiation in specific wavelengths within the spectrum of radiation emitted by the Earth's surface, by the atmosphere itself, and by the clouds. This property causes the "greenhouse effect" (definition adapted from IPCC, [12]).

Global climate models (GCMs): numerical models that simulate the physics of natural processes (such as atmospheric physics, sea ice physics, ocean processes) of the Earth, and the physics of *global warming.*

Global warming: refers to the change in global surface temperature relative to a baseline; in this document, the baseline is the global surface temperature in 1850-1900 (definition adapted from IPCC, [12]).

Likelihood: the chance of a specific outcome occurring, probabilistically (definition from IPCC, [12]).

Mitigation: a human intervention to reduce greenhouse gas emissions into the atmosphere or that enhances the "sinks" to store these gases (definition adapted from [12] and [38]).

Representative concentration pathways (RCPs): scenarios that include timeseries of emissions and concentrations of the full suite of greenhouse gases (GHGs) and aerosols, and chemically active gases as well as land use. They describe different levels of solar energy that is absorbed by the atmosphere (*i.e.,* radiative forcing) based on the varying levels of GHGs and emissions in the atmosphere.

Resilience: the capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation (definition from IPCC, [12]).

Risk: the potential for adverse consequences for human or ecological systems. Risk results from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards (definition from IPCC, [12]).

Shared socioeconomic pathways (SSPs): represent various socio-economic scenarios of how the global community will respond, mitigate, and adapt to the climate change crisis. These are used as inputs to global climate models.

Vulnerability: a propensity to be adversely affected; includes the concept of being sensitive or susceptible to harm, and the lack of capacity to adapt (definition adapted from IPCC, [12].

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Appendix A:

Climate Change Fundamentals, Climate Modeling, Climate Projections for B.C., and Design Parameters

Climate Change Fundamentals

Climate Change and Its Causes

Climate defines the expected range of weather patterns that are likely to occur at a given location over a period of time (typically averaged over a 30-year period) [39]. We can think of climate as the long-term pattern of weather in a particular geographical area.

Climate change describes changes in the state of the climate that persist for extended periods (*e.g.*, decades or more) [39]. In this document, the term refers to effects caused by human activities (*i.e.,* anthropogenic activities), which are the dominant source of the climate change observed since the mid-20th century [39].

The increase in global average surface temperatures (both of land and ocean), as well as warming of the atmosphere has been unequivocally linked to increased concentrations of greenhouse gases (GHGs) in the atmosphere[4] [12]. GHGs are released into the atmosphere through various means, with the combustion of fossil fuels (coal, natural gas, oil, etc.) as the predominant source.

Global Climate Trends To-date

The black line in **Figure A.1** shows that there has been a steady increase in the average global surface temperature since the second half of the industrial revolution

[4] Annual atmospheric concentrations have reached 410 ppm for carbon dioxide (CO_2), 1866 ppb for methane (CH_4), and 332 ppb for nitrous oxide (N_2O) in 2019 [12]. In 2019, atmospheric CO_2 concentrations were higher than any time in the last 2 million years, and CH_4 and N_2O were higher than at any time in the last 800,000 years. Concentrations for additional GHGs can be found in

(circa 1850 to 1900) of 1.07°C [12], [40]. The global surface temperature has increased at a faster rate since 1970 than in any other 50-year time period in the last 2000 years [12].

In 2015, the Intergovernmental Panel on Climate Change (IPCC), the body of the United Nations that evaluates climate science, set the 'aspirational' target for the global community to limit the increase of global surface temperature to 1.5°C above preindustrial temperatures. The signatories of the Paris Agreement, including Canada, have made a pledge to limit the increase in average global surface temperatures to 2.0°C above preindustrial temperatures.

In 2015, it was estimated that 20-40% of the global population were living in regions that had already experienced average surface warming greater than 1.5°C [41]. This is because temperature increases occur at different rates depending on geographical location. For example, there are larger increases over land than over ocean (1.4 to 1.7 times more). Polar regions are also experiencing greater surface temperature changes than lower latitudes (this is called polar amplification). The Arctic is estimated to be warming at a rate that is two times the rate of global warming [12].

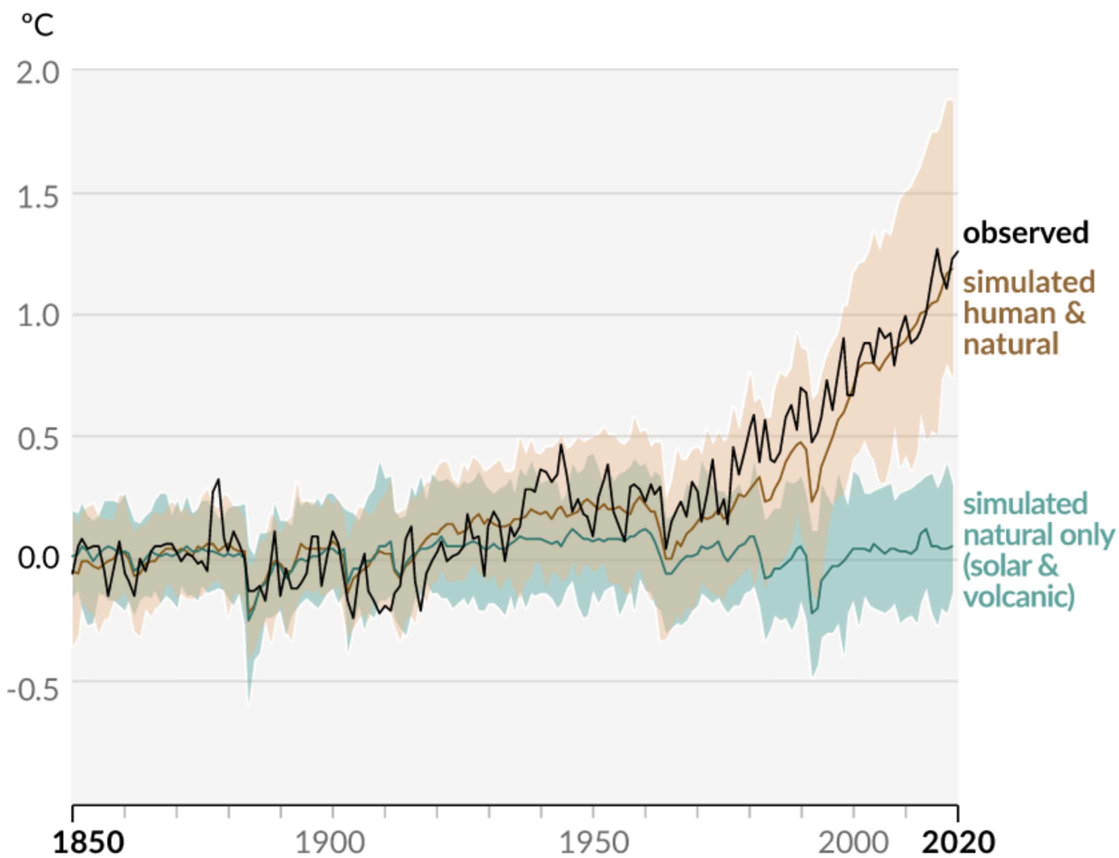


Figure A.1 History of changes in global average surface temperatures (averaged annually) with respect to 'baseline' surface temperatures in 1850. Global surface temperatures fluctuate over the short-term from natural processes but have been steadily trending upwards since the second half of the industrial revolution (circa 1850-1900). The black line in this figure represents the observed (measured) global average surface temperature change. The green and brown lines represent simulations of global average surface temperature changes. The green line represents simulated temperature changes if only natural factors (*i.e.*, assuming no anthropogenic effects) are considered, whereas the brown line simulates the effect of both human and natural factors.

We observe that the brown line agrees well with the black line (observed temperature changes), whereas the green line does not. This supports IPCC's conclusions that anthropogenic effects are the main driver of global warming. Figure modified from [12].

- While global surface temperature is the most closely followed climate change-related trend, other documented trends and ***climate hazards*** have also been observed:
- Heat extremes have increased in frequency and intensity across most land regions since the 1950s (Section A.3.1 in **[12]**).
- Precipitation has increased over most land area (Section A.1.4, and Section A.3.2 in **[12]**); both the frequency and intensity of heavy precipitation events have increased.
- The global mean sea level has risen 0.2m between 1901 and 2018 (Section A.1.7 in **[12]**); this is faster than over any preceding century in at least the last 3000 years (Section A.2.4 in **[12]**).
- Agricultural and ecological droughts have increased in some regions (Section A.3.2 in **[12]**).
- Glaciers are retreating, and there has been a decrease of Arctic Sea ice area (Section A.1.5 in **[12]**). In 2011- 2020, the annual average Arctic Sea ice area reached its lowest level since at least 1850 (Section A.2.3 in **[12]**).
- Spring snow cover is decreasing in the Northern atmosphere (Section A.1.5 in **[12]**).
- The oceans are warming, particularly in the upper ocean (0-700m depth) (Section A.1.6 in **[12]**).

- The likelihood of compound extreme events, such as simultaneous heatwaves and droughts (Section A.3.5 in **[12]**), has increased since the 1950s.

Global Climate Projections

The previous section described historical climate trends. It is equally important for decision makers to understand:

"What is the climate going to look like in the future?"

To answer this question, climate scientists make climate projections using computer models called ***global climate models*** (GCMs), which:

- Simulate the physics of natural processes (such as atmospheric physics, sea ice physics, ocean processes) and the physics of ***global warming***, and
- Account for the effects of socio-economic trends (such as future technology use and development, urbanization, education, population growth, economic growth, and resource availability) on GHG emissions.

Assumptions related to future GHG concentrations, aerosol concentrations and land-use changes (among others) are required as inputs in these models.

The Intergovernmental Panel on Climate Change (IPCC) Working Group I's portion of the Sixth Assessment Report (AR6) released in 2021, uses a compilation of results from a number of global climate models developed by climate modelling groups around the world. This initiative is called the Coupled Model Intercomparison Project, version 6, or CMIP6.

These future scenarios consist of two complementary components:

1. ***Representative Concentration Pathways (RCPs)***, which describe different levels of solar energy that is absorbed by the atmosphere (*i.e.,* radiative forcing) based on the varying levels of GHGs in the atmosphere. To provide perspective, RCP 1.9 is the best-case scenario, and RCP 8.5 represents a "business-as-usual" scenario, where past human practices causing GHG emissions continue.
2. ***Shared Socioeconomic Pathways (SSPs)***, which represent various socio-economic scenarios of how the global community will respond, mitigate, and adapt to the climate change crisis (*i.e.,* they project greenhouse gas emissions based on different climate policies). For perspective, SSP1, 'Sustainability' is the best-case pathway, whereas SSP5, 'Fossil-Fueled Development' is the business-as-usual scenario.

Broadly speaking, the RCPs set pathways for GHG concentrations in the atmosphere, and SSPs outline which reductions in emissions will (or will not) be achieved based on various policy approaches. The IPCC selected five combinations of RCPs and SSPs to represent various future climate scenarios following the naming convention "SSPx-y," where 'x' is the SSP, and 'y' is the RCP

- SSP1-1.9 represents a future with **very low** GHG emissions,
- SSP1-2.6 represents a future with **low** GHG emissions,
- SSP2-4.5 represents a future with **intermediate** GHG emissions,
- SSP3-7.0 represents a future with **high** GHG emissions, and
- SSP5-8.5 represents a future with **very high** GHG emissions.

The output of the models show that compared to pre-industrial times, the global surface temperature averaged over 2081–2100 is:

- **very likely** to be higher by 1.0°C to 1.8°C under the **very low** GHG emissions scenario (SSP1-1.9),
- very likely to be higher by 2.1°C to 3.5°C in the intermediate GHG emissions scenario (SSP2-4.5), and
- very likely to be higher by 3.3°C to 5.7°C under the **very high** GHG emissions scenario (SSP5-8.5) **[12]**.

The CMIP6 scenarios have not been simulated past the year 2100, and so infrastructure that may exist past this time horizon may be subjected to even greater levels of warming.

The main take-away from the IPCC modelling though, is that if we do not act quickly as a society to curb our GHG emissions into the atmosphere, the targets set by the Paris Agreement will quickly be surpassed (**Figure A.2**).

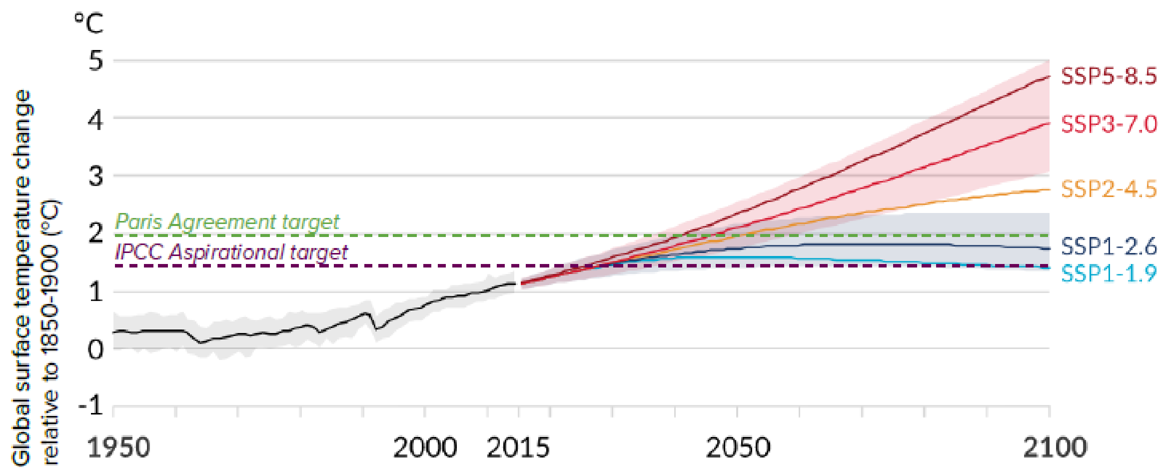


Figure A.2 Projected global surface temperature change relative to 1850-1900, for five future climate scenarios- os. SSP1-1.9 is a 'very low' GHG emissions scenario, SSP1-2.6 is a 'low' GHG emissions scenario, SSP2-4.5 is an 'intermediate' GHG emissions scenario, SSP3-7.0 is a 'high' emissions scenario, and SSP5-8.5 is 'very high' GHG emissions scenario. This figure is modified from [12].

Climate Projections for B.C.

Existing online tools have been developed specifically for the regions of British Columbia and the Yukon to help visualize climate futures. The Plan2Adapt tool developed by the Pacific Climate Impacts Consortium (PCIC) provides projected changes in temperature, precipitation, and other variables for a selected region (either a regional district, health authority region, forestry region, or ***ecoprovince***), for a selected timeframe of interest (the options include 1) 2020s: 2010-2039, 2) 2050s: 2040-2069, or 3) 2080s: 2070-2099).

The Plan2Adapt tool is a simplified version of PCIC's Climate Explorer (PCEX), a tool developed for technical users who need climate change information for engineering and impact studies. This PCEX tool is for "locating, visualizing and downloading data describing projected future climate conditions for regions of interest within the Pacific and the Yukon Region" [42].

Both the Plan2Adapt and PCEX tools use data from ***global climate models*** that have been downscaled (*i.e.,* the grid resolution has been reduced). Plan2Adapt tool has not yet been updated to reflect the latest CMIP6, but PCEX has. Regardless, both still provide valuable information for long-range capital planning, policy decisions and for gaining an understanding of the effects of climate change in our communities. For access to the CMIP6 downscaled data, readers are directed to [43].

Table A.1 below summarizes climate projections for B.C. using the downscaled CMIP6 data. It is important to note that Table A.1 provides annual climate projections for the province, and there will be more variation at a regional scale, and seasonally (particularly precipitation, which varies greatly depending on geographic location).

TABLE A.1
Climate Projections for British Columbia

CLIMATE VARIABLE 1)	CLIMATE SCENARIO 2)	TIME PERIOD			
		2021-2040	2041-2060	2061-2080	2081-2100
Annual Temperature Change (°C)	SSP1-2.6	+2.27	+1.58	+1.74	+1.56
	SSP2-4.5	+1.48	+1.87	+2.43	+2.95
	SSP5-8.5	+1.71	+2.36	+3.88	+5.68
Annual Precipitation Change (%)	SSP1-2.6	+4.44	+5.59	+6.43	+6.15
	SSP2-4.5	+4.56	+5.69	+8.71	+9.67
	SSP5-8.5	+5.71	+7.33	+11.25	+15.51

Notes:

Ensemble median values (*i.e.*, 50th percentile) are reported for changes in annual temperature and annual precipitation. These values were extracted from the CMIP6 tabular data available at the Government of Canada website [44]. Note that the following climate projections are with respect to the baseline climate during the historical period of 1995-2014.

In simplest terms, SSP1-2.6 represents a low GHG emissions scenario, SSP2-4.5 represents an intermediate GHG emissions scenario, and SSP5-8.5 represents a high GHG-emissions scenario.

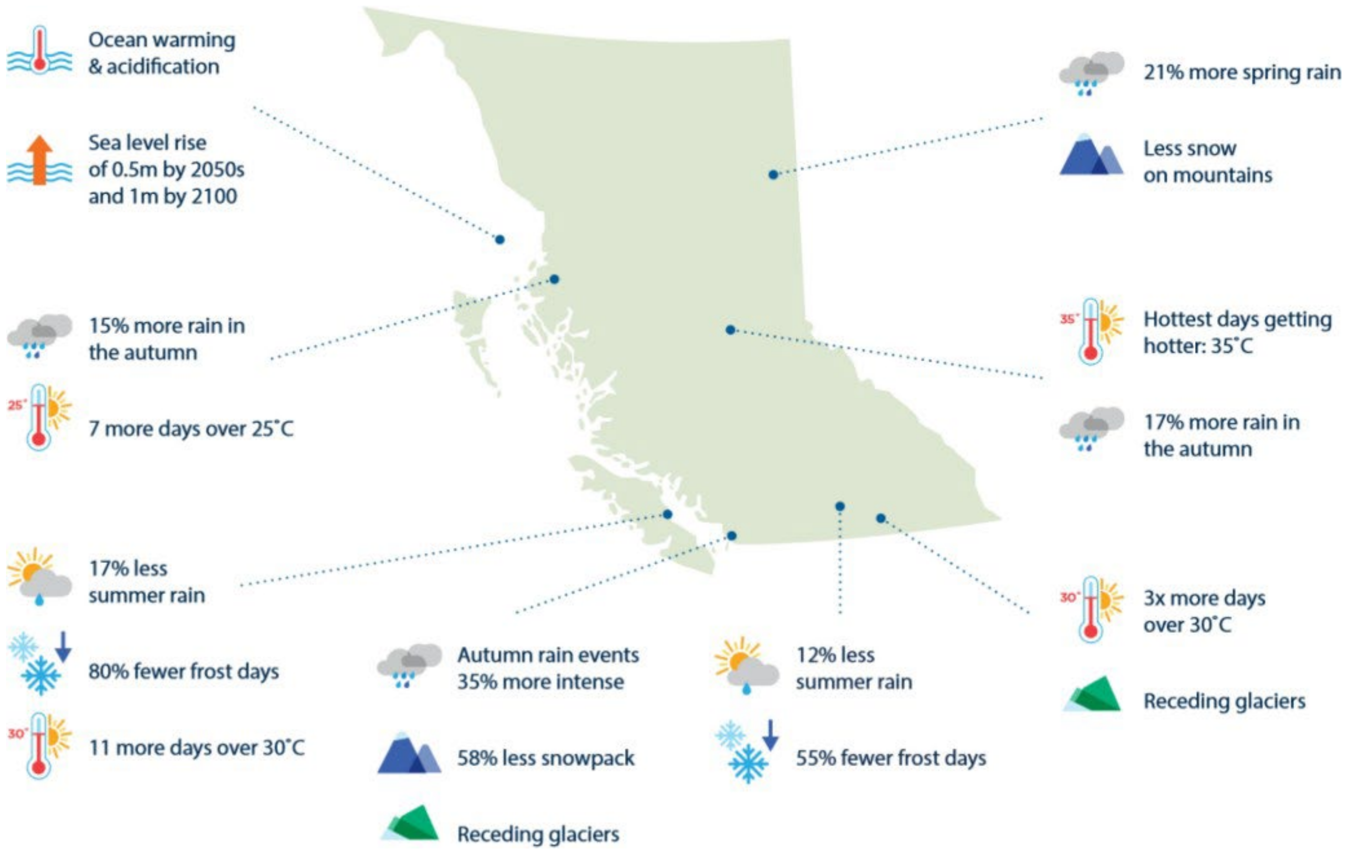


Figure A.3 presents examples of some of the projected climate change trends that can be expected for various locations in British Columbia.

Appendix B:

“Climate-Projected” Design Parameters

To ensure that a building and its components are designed to withstand the future climate, the project team will need to select design parameters that account for climate projections (referred here to as “climate-projected” design parameters). These design parameters must be selected in consideration with the design service life of the building, and/or the service life of the building’s components.

For example, for a new building constructed in 2022, with a design service life of 60 years, the building must be designed such that it will perform well under the 2040 climate (and ideally until the end of service life; *i.e.,* 2082). For long-lived building components (*e.g.,* the building structure), design service lives will be equivalent to the building itself, so design parameters will be selected accordingly. For other components, with only a fraction of the design service life of the building (*e.g.,* HVAC system with a 30-year design life), the design will not consider climate projections as far in the future.

To what degree the building and/or its components’ performance is deemed ‘acceptable’ at end of life, will be decided by the project team, and should consider the building’s Criticality Classification.

The following four steps can be used to determine the “climate-projected” design parameters:

1. ***Design Service Life of a Building and its Components.***

   Determine the design service lives of your building and its components.

   For guidance on determining the minimum *design service life* of a new building, refer to Table 1 “Categories of design service life for buildings” in CSA 478:19 Durability in buildings [36]. Note that the Table presents the minimum design service life; it is recommended that this estimate be carefully considered since in practice, PSO buildings typically have much longer service lives than originally intended. The end of service lives of historical and existing PSO buildings of the same use category/type should be consulted for reference.

Once the *design service life* of the building has been established, determine the design service lives of the building components. For guidance on the minimum design service lives of building components, refer to Table 2 “Categories of failure” in CSA 478. The design service life of components is presented as a per cent of the building design service life. As previously noted, for an existing building renewal project, the focus can be on the design service lives for each of the <u>relevant</u> building components (*i.e.,* building components within the scope of the project). At the **High-Level Planning** Stage of a project, the Project Team can focus on major systems, *i.e.*, structural, enclosure, mechanical, electrical, plumbing.

2. *Select a GHG Emission Scenario.*

Section 1 of Appendix A described how the Intergovernmental Panel on Climate Change (IPCC) develops simplified GHG emissions scenarios by making various assumptions on future policies of global economic and industrial development.

At this point, the project team will select one of the following GHG emissions scenarios:

1. Low GHG emissions (*i.e.*, strong climate policy)
2. Intermediate GHG emissions (*i.e.*, moderate climate policy)
3. High GHG emissions (*i.e.*, weak climate policy)
4. Very high GHG emissions (*i.e.*, no, or very weak climate policy)

When selecting the emissions scenario, the Project Team should also consider the buildings’ Criticality Classification (see Table B.1 below). For instance, buildings with high or very high criticality must maintain core functions and services, even in worst-case scenario events. For such buildings, it is recommended that the Project Team assume a “Very high GHG emissions” scenario.

3. *Determine the Global Warming Level (GWL)*

Based on the design service lives determined in Step 1, and the emissions scenario selected in Step 2 (in consideration of the buildings' Criticality Classification), one can use the following Table to determine the corresponding Global Warming Level (GWL), also referred to as the "Owner's stipulated global temperature increase" in the Standards.

For example, if the project team selected a "Very high GHG emissions" scenario (*i.e.*, the worst-case scenario), and the building had a planned end of service life of 2080, then a GWL of 3.0°C would be appropriate.

When the estimated end-of-service life falls between the tabulated "year of exceedance values" in the Table below, select the GWL that corresponds to the year that is closest to the building's end-of-service life (under the GHG emissions scenario selected).

Table B.1
Determining the Global Warming Level

GHG Emissions Scenario		Global Warming Level (relative to 1986-2016 baseline) *							
		0.5°C	1.0°C	1.5°C	2.0°C	2.5°C	3.0°C	3.5°C	4.0°C
Criticality Classification	Very High Emissions	2023**	2035	2047	2059	2069	2080	2090	2100
	High Emissions		2046	2070	2087	-	-	-	-
	Intermediate Emissions				-	-	-	-	-
	Low Emissions		-	-	-	-	-	-	-
Design Life									

The above table has been adapted from [18], Table 2.1, and is based on the CMIP5 ensemble of global climate models.

* The climate described by the 1986-2016 baseline is approximately 0.8°C warmer than the pre-industrial baseline (used for the UNFCCC Paris Climate Targets and Goals).

** The "years of exceedance" specified in the table refer to the central year within the 30-year time period during which the specified global warming level is irrevocably exceeded by the CMIP5 ensemble mean. A dash ("–") indicates that warming at the level specified does not occur before 2100 for the emissions scenario indicated.

4. ***Determine Design Parameters.***

Based on the Global Warming Level (GWL) determined in the previous step, the design team will be able to select adjusted National Building Code of Canada design values for the building's location.

In the Environment and Climate Change Canada (2020) study, "**Climate-Resilient Buildings and Core Public Infrastructure: an assessment of the impact of climate change on climatic design data in Canada**"(hereafter "CRBCPI provides projected changes in design values for 675 locations of towns and cities across Canada [18]. These results are provided as Excel spreadsheets for each GWL in 0.5°C increments from 0.5°C to 3.5°C, relative to a 1986-2016 baseline period. Alternatively, the PCIC **Design Value Explorer** Tool can be used (which adopts the same baseline).

Continuing the example from Step 3 for a GWL of 3°C, using the spreadsheet **Appendix1.2_+3.0C_NBCC**, select the row that corresponds to the building's location. If the PCIC Design Value Explorer tool is being used, then the inputs of: "Future change relative to 1986-2016" and "3°C above 1986-2016" would be selected.

As pointed out in the CRBCPI, the appeal of the GWL approach is that it is expected to promote transparency and relatability, as most global pledges are based on GWL, rather than on scenarios and future time periods separately (*e.g.*, the Paris Agreement target of 2.0ºC).

Additional Considerations when Designing to Climate Projections

As discussed in the CRBCPI Plain language summary report [26], the appropriate use of the climate-projected design values provided in Appendix 1.2 or in PCIC's Design Value Explorer requires an understanding of the confidence levels (or "tiers") attributed to the projections of different climate variables (Table B.2). The three confidence tiers are defined as:

- Tier 1: High confidence variables, for which change factors could - with care - be used directly when designing new infrastructure, if justified from an engineering perspective.
- Tier 2: Medium confidence variables, which are more suitable for framing potential ranges of future change or exploring uncertainty associated with design.
- Tier 3: Low confidence variables, for which direct use is discouraged. These variables are better suited to exploring the potential impacts of climate change on structural reliability in different warming and load combination scenarios.[26]

Temperature	Precipitation	Ice and Snow	Wind
Max. mean daily air temperature	Annual total precipitation	Ice accretion thickness (1/20)	Hourly wind pressures (1/10)
Min. mean daily air temperature	Annual rain	Permafrost extent	Hourly wind pressures (1/25)
Annual mean air temperature	15 min rain (1/10)	Rain load (1/50)	Hourly wind pressures (1/50)
Design temperatures January 1%	One day rain (1/50)	Snow load (1/50)	Hourly wind pressures (1/100)
Design temperatures January 2.5%	Relative humidity		Driving rain wind pressures (1/5)
Design temperatures July 2.5% dry			
Design temperatures July 2.5% wet			
Degree days below 18 C			

Additional reference for CRBCPI Plain Language Summary document:

[26] “Climate-Resilient Buildings and Core Public Infrastructure Report: Plain language summary,” Government of Canada, Ottawa, 2021.

Appendix C:

Background on Climate Risk Assessments and Existing Risk Assessment Frameworks

Background on Climate Risk Assessments

The term ‘risk’ accounts for:

- ***likelihood*** (or probability) of an event occurring,
- consequence (or severity) of the event taking place, and the
- exposure of an asset.[1]

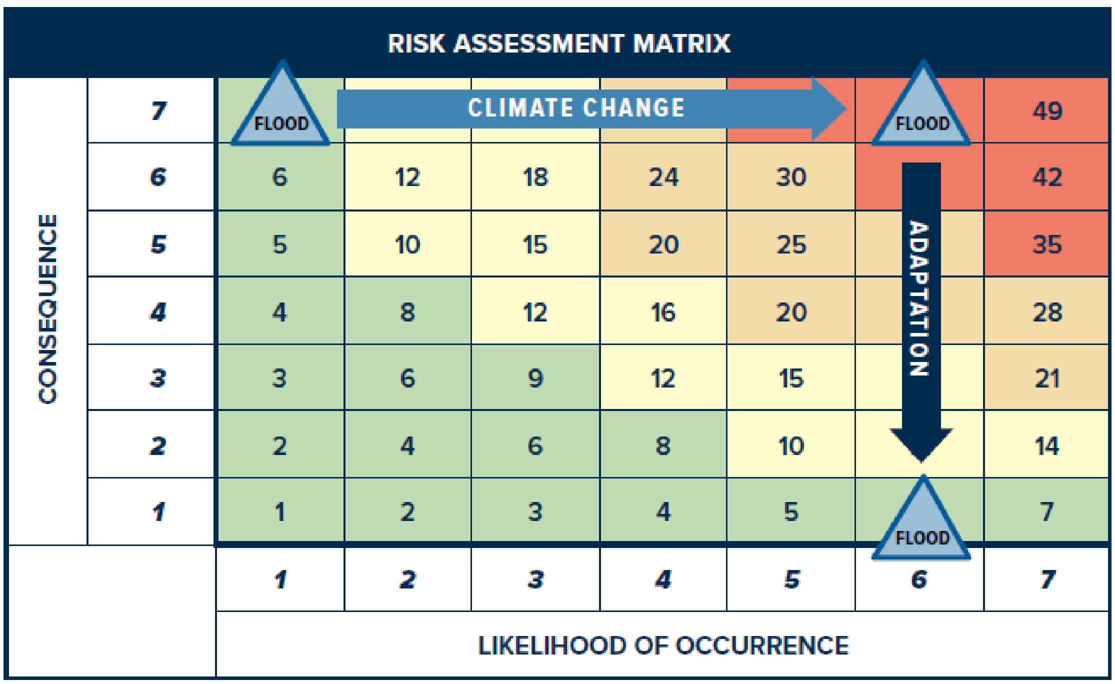
In the context of this document, the ‘event’ is a climate hazard (*e.g.,* extreme heat event) and the ‘asset’ is the building (or building component).

There are several different types of risk analysis methodologies. A semi-quantitative or “mixed-method” approach is selected here, where individual risk events are considered independently, and they are categorized by comparative scores rather than probability [45]. This approach is preferred over probabilistic methods because the Project Team is not required to have comprehensive datasets of historic climate-related hazard events, and it can illustrate comparative risk and consequences in a visually accessible way [46]. This approach is also preferred over a purely qualitative approach because it is more rigorous for categorizing risk.

In a semi-quantitative risk assessment approach, the objective is to assign a risk score to any risks associated with a building component or system. The risk scores are described as either “high,” “medium,” or “low.”

A risk assessment matrix is a common tool for semi-quantitative risk assessments. [Figure C.1](#) demonstrates, using a risk assessment matrix, how the risk of flooding to a hypothetical building (or building component) will increase in response to climate change (light blue arrow). It also demonstrates how adaptation of the building or building component (*i.e.,* the implementation of ***climate resilience measures***) can reduce the risk (dark blue arrow). The climate resilience measures selected, and the level of acceptable risk will depend on the building.

For example, if the building is considered "post-disaster," all possible measures may need to be implemented to minimize the potential risk.



Existing Climate Risk and Vulnerability Assessment Tools

1. *Climate Lens Assessment*

Climate Lens is an assessment that applies to several existing programs in Canada: Infrastructure Canada's Investing in Canada Infrastructure Program (ICIP), Disaster Mitigation and Adaptation Fund (DMAF) and Smart Cities Challenge [48]. The assessment includes a "Climate Change Resilient Assessment" as one of its two components (the other, the "Greenhouse Gas (GHG) Mitigation Assessment" is not relevant here). Climate Change Resilient Assessment is described as a risk management approach to "anticipate, prevent, withstand, respond to, and recover and adapt" from climate change related disruptions or impacts. The framework presented is consistent with ISO 31000 (Risk Management Standard), a globally recognized approach for assessing any type of risk (*i.e.,* it is not limited to only climate-related risks).

2. *ISO 31000: 2018 Risk Management*

ISO 31000 is a risk management process framework developed by the International Standards Organization. It outlines the high-level concept and step-by-step process for completing a risk assessment for application across a broad range of scales (*e.g.*, corporate, finance, insurance, community, infrastructure, etc.). The ISO 31000 risk assessment process outlines three primary steps: 1) scope, context, criteria, 2) risk assessment (including risk identification, analysis, and evaluation), and 3) risk treatment. While the ISO 31000 standard is not tailored to assessing climate change risk, it is a globally recognized standard that is frequently referenced as a foundation for more detailed climate risk assessment standards in Canada (*e.g.*, Climate Lens, PIEVC, B.C. Strategic Climate Risk Assessment Framework).

3. *ISO 14091: 2021: Adaptation to Climate Change: Guidelines on Vulnerability, Impacts and Risk Assessment*

ISO 14091:2021 outlines the most recent guidance from ISO on completing a climate change risk assessment, and how the concept of vulnerability can inform risk. The standard outlines a broad 3-step process for completing a climate change risk assessment, including 1) preparing (*e.g.,* establish the context, objectives, methodology and team), 2) implementing the assessment (*e.g.* screening and developing impact chains, identifying indicators, acquiring data, assessing adaptive capacity, evaluating risk, and analysing cross-sectoral interdependencies), and 3) communicating results (*e.g.,* reporting, informing planning and action. The standard recommends the use of climate scenario events to ground discussion on risk and provides examples for impact chain graphics that integrate the concept of vulnerability and risk to inform overall impact prioritization and action planning.

4. ***Public Infrastructure Engineering Vulnerability (PIEVC) Protocol***

   This framework was developed by Engineers Canada and Natural Resources Canada (NRCan) and is now managed jointly by the Institute for Catastrophic Loss Reduction (ICLR) and the Climate Risk Institute [49]. This framework is used for conducting detailed risk assessments, and is most appropriate for high risk, or high dollar value projects. An online tool is available for this framework.

   In the PIEVC protocol, risk (R) is calculated as the product of the probability (**likelihood**) of an event occurring (P) and the severity of the impacts (**consequence**) of the event on the performance of the infrastructure component, should this event occur (S) (i.e., R = P x S).

5. ***Public Infrastructure Engineering Vulnerability Committee High Level Screening Guide (PIEVCE HLSG)***

   This framework is a modified version of the PIEVC Protocol. It is a quicker, "more streamlined and less complex version" of the PIEVC Protocol methodology, which can be used for high-level climate risk assessments [50].

   PIEVC HLSG can be used as an initial screening step before conducting a more detailed assessment with the PIEVC Protocol. This risk assessment framework is managed by ICLR. The documentation and online tool became available in February 2022.

6. ***Climate Risk and Resilience Assessment provided in the Climate Resilience Guidelines for BC Health Facility Planning & Design.***

   The Climate Resilience Guidelines for BC Health Facility Planning & Design (the Guidelines) outline a step-by- step process and key resources to support more resilience design of healthcare facilities [7]. The risk assessment and resilience planning framework in the Guidelines follow a four-step process, with each step tied to each typical phase of design. The four steps involve 1) Exposure Screen (at the high-level master planning phase), 2) Climate Risk Assessment (at the concept and business planning phase), 3) Resilient Design Review (at the procurement/ RFP development phase), and 4) Compliance Audit (at the implementation/project agreement phase). The Guidelines also outline broad resilience objectives and resilience strategy best practices to inform facility design.

7. ***B.C. Strategic Climate Risk Assessment Framework***

In 2019, the Province of B.C. completed a Preliminary Strategic Climate Risk Assessment assessing the likelihood and consequence of 15 climate risks across the Province [51]. Results from the assessment indicate which climate hazards are most significant across the province, and which areas of the Province may be particularly susceptible. Alongside the assessment report, the province published a Climate Risk Assessment Framework document explaining their methodology and providing guidance for how other actors in B.C. could use the framework for their own, tailored assessments. While the framework is best suited for community- or regional-scale assessment (rather than building or site-specific), it outlines important risk assessment tools that can be adapted to risk assessments for public sector buildings. Key resources of interest include guiding principles and key definitions that can be consistently applied at smaller scales. The framework also provides likelihood and consequence criteria, risk rating definitions, and a sample risk register spreadsheet that can be adapted to more specific public sector contexts.

8. ***B.C.'s Hazard, Risk and Vulnerability Analysis Tool (HRVA)***

The hazard, risk and vulnerability analysis (HRVA) are a process developed by Emergency Management B.C. (with support from local authorities, First Nations, and the government) that can be used to identify hazards likely to cause an emergency or disaster at a community level, and to assess the likelihood of the hazard occurring [52].

Local authorities in British Columbia are mandated to conduct an HRVA. An online tool is available to facilitate the process.

Guidance for Portfolio-level Climate Risk Assessments

A portfolio-level climate risk assessment follows a similar procedure to a building-specific climate risk assessment; however, the risk assessment is completed for groups of buildings rather than for an individual building. PSOs may need or want to perform a portfolio-level climate risk assessment to identify or prioritize building-specific projects.

A portfolio-level assessment allows a PSO to identify climate risk reduction projects that may not have been previously identified or part of a capital plan. An example would be the retrofitting of multi-family residential buildings to provide mechanical cooling, which for some building types (for example, seniors' housing) may be identified and prioritized prior to any previously scheduled heating, ventilation, and air conditioning (HVAC) equipment renewal.

The following filters can be considered when performing a portfolio-level climate risk assessment to identify potential priority regions, buildings, or projects (the following list has been adapted from PIEVC High Level Screening Guide documentation [50]):

- **Building type** – for example, the project team may opt to include only one building archetype in the assessment (e.g., all multi-family housing buildings)
- **Geographic region** – for example, the project team may select a representative set of buildings for each location/climate zone
- **Importance of building** – select buildings based on their public importance, and/or organizational importance
- **Availability of data** – select buildings for which there is sufficient data
- **Buildings previously impacted by historic climate events**, or buildings located in areas with high current or projected climatic impacts
- **Age of buildings** – select buildings at a certain stage in their lifecycle.