

## Flood Resiliency Recommendations – *Revision 9 (142 Rec's)*

January 2022

This document includes a list of recommendations for improving the flood resiliency of buildings. These recommendations were developed in consultation with teams of experts in British Columbia for the BC Housing initiative, [Mobilizing Building Adaptation and Resilience \(MBAR\)](#).

The primary focus of this initiative is to advocate designing for enhanced performance with respect to flood resiliency of new Part 3/4 Buildings governed by the BC Building Code / Vancouver Building By-law – and in particular, with regards to parkades – as the existing resources in this regard were found to be wanting. However, many of these recommendations are also suitable for Part 9 buildings and renovations / upgrades of existing buildings.

This document is intended to be a 'live' document, with recommendations added, removed, and/or revised with increasing industry consultation and feasibility studies. The recommendations are presented in order of development, not importance. The latest version of this document may be downloaded online at [www.horizoneng.ca/wordpress/resources/downloads](http://www.horizoneng.ca/wordpress/resources/downloads).

We would like to thank the building and flood experts, listed at the end of this document, who have contributed to the development of these recommendations or have otherwise increased the understanding of this project team and the communities they serve.

**Any feedback, suggestions, and/or other comments are welcome via the form at [this link](#) or email to Diane Meehan, P.Eng., at [diane@horizoneng.ca](mailto:diane@horizoneng.ca).**

### Resources:

- › [BCBC Letters of Assurance](#): standard Forms of the British Columbia Building Code informing authorities having jurisdiction which aspects of the building (including the design and field reviews) are the responsibility of a particular registered professional
- › Example Design Philosophy Statement ([Building](#) | [Residential](#))
- › [Flood Hazard Land Use Management](#)
  - [Flood Hazard Area Land Use Management Guidelines \(FHALUMG\) \(PDF\)](#)

## Recommended Administrative Measures

Area	No.	Flood Resiliency Measure
National	N1	Prescribe Factor of Safety against buoyancy of ‘tanked’ buildings in the National Building Code (NBC)
	N3	Include structural / mechanical / electrical / elevator considerations during a flood event in Code, based on importance of building
	N4	Specify duration of service period for emergency systems in the NBC
	N5	Emergency notice of flooding to cell phones (i.e., through Alert Ready)
	N6	Require manual back-up for passive systems in the NBC
	N7	Specify Design Life of buildings in the NBC and/or provincial codes
	N8	Encourage the use of provincial Letters of Assurance in the NBC and provide templates
	N9	Collect data on snowpack in consideration of how it might affect downstream flooding
	N10	Update Global Climate Monitoring in consideration of melting ice caps
	N11	Review Sendai Framework
	N12	Assess Public Works Canada Letters of Assurance
	Indigenous	I1
I2		Identify the Flood Risk at First Nations Communities and review for potential overlapping liquefaction hazards
I3		Work with communities to complete resiliency upgrades
I4		Create document which indicates that Culturally Relevant Lands will be prone to flooding, and to identify particular challenges (i.e., develop a reasonable FCL for the community)
I5		Earthquake- and flood-'proof' the community refuge area and extraction / rescue location
I6		Collect Oral Histories from Indigenous People regarding Flood Events
I7		Preservation of Archaeological Sites in Floodplains
Provincial	P1	EGBC to publish Member Advisories (especially with respect to items E1, E2, V1)
	P2	Develop FloodWatchBC (similar to DriveBC)
	P3	Revise Schedule B to include CRP Section which includes for existing C1
	P5	Re-classify ‘large Part 9’ buildings as Part 3/4
	P6	Technical Safety BC to evaluate elevator emergency egress
	P7	Research existing grants for innovative technology related to flood protection and list it on BC Housing website for builders and homeowners to use
Municipal / Jurisdictional	J1	Require Design Philosophy Statement (to go on title)
	J2	Establish Development Permit areas regarding flooding and high groundwater events; require area-specific “do not enter” signage / warning lights and barricades
	J3	Liaise with landlords / stratas regarding business planning to address loss of rental income, restoration, and repair following a flood event, emergency response (shelter-in-place) plans
	J6	Signage when entering a floodplain (sim to ‘sister-city’, nuclear-free zone, etc) “You are entering a floodplain” “You are entering the Lynn-Seymour floodplain” “You are entering the Fraser River floodplain”

Area	No.	Flood Resiliency Measure
BC Housing	H1	Meet with insurers to discuss incentives, premiums, coverage, etc
	H2	Develop value proposition to incentivize developers to implement building adaptation and resiliency best practices, possibly to include certification levels (similar to LEED model), reduced insurance premiums associated with achieving certain certification levels, etc
	H3	Educate planners on the hidden costs of view corridors (a vertical 'squeeze' pushes buildings further down into the ground)
	H4	Educate owners on opportunities to upgrade BAR prior to and following (i.e., during clean-up and replacement of interior systems/finishes) a flood event - "Build Back Better"
	H5	Compile a Document Library of existing resources
	H6	Publish documents (reports, guidelines, bulletins, etc) especially which can be referenced by others in other documents
	H7	BC Housing initiative to reach out to regulatory bodies of different professions and invite them to participate in MBAR - free seminar about MBAR (home inspectors, realtors, insurance brokers)

## Recommended Overall Measures

Area	No.	Flood Resiliency Measure
Coordinating Registered Professional (CRP)	C1	In consultation with design team, prepare a Design Philosophy Statement and have it placed on title
	C2	Development Permit line item on Schedule B to be moved to a new CRP section
	C3	Consider sea gates with manual back-up if self-rising systems are specified (require storage near where they will be used)
	C4	Consider 'short cuts' for floodwaters to and within a building (i.e. shafts, soil gas vents, electrical conduits, etc.)
	C5	Specify warning signage or flashing lights at parkade entries showing when to not enter parkade (e.g., webcams on watercourse levels, moisture sensors in parkade, signs similar to forest fire warning signs)
	C6	When FARL <sup>1</sup> becomes FCL <sup>2</sup> during the lifespan of the building, future design team to upgrade in conformance with Design Philosophy Statement
	C7	Moisture sensors to be monitored and alarmed
	C8	Maintenance and Operations Manual to include section on education of tenants
	C9	Vent shafts at parkade/property perimeter could serve as emergency exit points and deep sumps for pumping flood waters - See detail prepared in this regard on Horizon's website
	C10	Consider cascade effects, i.e., fire due to flood, flood due to fire, power outages, closure of municipal infrastructure during the event (roads, sanitation/solid waste, potable water), seismic, etc
	C11	Address Amenity Area of Refuge requirements including reasonable expected duration of temporary power and provision of waste storage
	C12	Compile list of all above-grade openings (at or above FCL) which may require raising or retrofitting in the future (e.g., with a sea gate)
	C13	Compile Schedule of Building Elements with associated Design Life (and Warranty Period) and include in Design Philosophy Statement
	C14	Look at who plays roll of CRP in First Nations Projects
	C15	CRP to address I7

<sup>1</sup> Flood Adaptation and Resiliency Level: site-specific elevation(s) to which to consider future flooding.

<sup>2</sup> Flood Construction Level: Required minimum elevation of underside of floor system (or top of concrete slab) for habitable space, typically set by local authorities, per FHALUMG, or other.

## Recommended Design Measures

Area	No.	Flood Resiliency Measure
Architectural	A1	Raise electrical outlets
	A2	Include for water-resistant internal walls and finishes; water resistant cladding
	A3	Specify mold/decay-resistant materials for flooring (e.g., concrete/tile flooring instead of timber/carpet; steel or 'blue wood' rather than timber studs)
	A4	Consider hydrostatic forces on internal walls where flooding could be 'uneven'
	A5	Elevate tops of window wells, exterior rim elevations for vent shafts (consider using elevated top of vent shafts as a pedestal for public art), door thresholds, parkade ramp 'crowns'
	A6	Enhance Amenity Room / fitness facilities to provide Emergency Community Hub to be used during an emergency, potentially with passively powered (e.g., photovoltaics) charging ports, refrigerator, microwave, and thermal hot water
	A8	Use Architectural reveals / drainage channels within the slab to direct water to the 'deep' building sump to facilitate clean-up
	A9	Openings that may lead to life-safety issues, 'flash flooding', or submerging of basement or parkade must be given higher design consideration
	A10	Alarmed flood doors for below grade structures

Structural	S1	Design against buoyancy / uplift during construction (FOS = 1.05 or 1.10?)
	S2	Design against buoyancy / uplift SLS (FOS = 1.25?)
	S3	Design against buoyancy / uplift during flood events (FOS = 1.05?); discuss selection of Maximum Design Groundwater Elevation with geotechnical engineer and upon what it is based (i.e., whether it includes a freeboard component, what is the estimated return period, etc)
	S4	Design against potential hydrostatic forces on internal walls (i.e., associated with selective 'sealing' of specific rooms); consider weep holes at max allowable water depth
	S5	Consider cascade effects including loss of tie-down anchor resistance for buoyancy due to a seismic event
	S6	Design against potential hydrodynamic forces on above grade structural elements including foundation walls
	S7	Consider weight of water (and future landscaping) over suspended slabs below the FCL
	S8	Consider potential scour

Building Envelope	B1	Consider top termination of waterproofing/drainage membranes applied to exterior building walls up and to lap to slab membranes below FCL <sup>3</sup> elevation; consider utilizing a concrete curb with waterproofing up to FCL
	B2	Consider performance and discharge of area drains in landscaped plazas below FCL
	B3	Consider material durability with respect to potential deterioration due to wetting (consider salinity or contamination of water)
	B4	Consider integrity of dampproofing / waterproofing seals under a few feet of water head
	B5	Utilize concrete curbs to elevate sill plates of framing and other moisture-sensitive materials (potentially including architectural cladding of clad columns)
	B6	Consider adding drains to architectural cladding of columns

<sup>3</sup> Flood Construction Level: Required minimum elevation of underside of floor system (or top of concrete slab) for habitable space, typically set by local authorities, per FHALUMG, or other.

Area	No.	Flood Resiliency Measure
Mechanical	M1	Require pumping of plumbing fixtures below certain level (similar to City of Vancouver 'fixture restriction')
	M2	In the event of municipal sewers being full of floodwaters, restrict flushing of toilets in (especially elevated) suites
	M3	In the event of municipal sewers being full of floodwaters, turn off water to suites
	M4	Consider emergency storage of sewage (e.g. in stormwater detention tank?)
	M5	Consider inclined flapper backflow valves for sanitary sewer (i.e., "normally open" instead of "normally closed" backflow valves typically used for storm sewer)
	M6	Maintain backflow valves (include as an item in maintenance manual)
	M7	Vent shafts could serve as emergency exit points and deep sumps for dewatering of flooded parkades (sump portion to extend below parkade slab-on-grade) - See detail prepared in this regard on Horizon's website
	M8	Consider cascade effects including power outages, sewer backup and/or failure (including due to power outages)
	M9	Consider appropriate sealing of utility penetrations through the building envelope below the FCL (and/or FARL?)
	M10	Ensure any temporary construction dewatering systems (e.g., as may be required to manage buoyancy) are suitably decommissioned at the end of the project
Elevators	V1	Locate elevator machine rooms on roof (i.e., above FCL, as opposed to in the parkade)
	V2	Monitored/alarmed moisture sensor in pit with battery backup
	V3	Shut down elevator at/above main floor during a flood; should not be allowed or able to descend into flooded/flooding parkade
	V4	Separate panel to allow 'safe' operation of elevator for floors above FCL / main floor during a flood event
	V6	Consider communication for trapped individuals if elevator phone fails (e.g., cell-phone signal booster in elevator shaft)
	V7	Consider emergency communication to PA system (local wireless, battery / back-up power)
	V8	Monitored, alarmed, occupancy sensors with battery backup
	Electrical	E1
E2		Locate electrical room, unit substation, generator and fuel, etc on a floor above FCL (and/or FARL?)
E3		Seal annulus between conduits and cables in below-grade utilities (i.e., from electrical infrastructure [PMT, vista switch, Hydro] and communications infrastructure [Telus, Shaw], etc) and consider potential for T drains to serve as entrances for water
E4		Consider photovoltaics (PV) and/or thermal solar as passive backup system, including daily use in select areas as a check that system is functional and for some cost recovery; ensure batteries remain fully charged but use surplus passive energy to augment purchased power
E5		Consider safe reconnection to grid
E6		Upgrade battery capacity as new technology becomes available
E7		Allow for 1.5 hours of battery backup to cover risk of start-up problems with generator
E8		Install moisture sensor at lowest point of all electrical rooms below FCL - monitored and alarmed, with battery backup
E9		Consider cascade effects including power outages
E10		Locate penetrations through the building envelope for electrical / communications utilities above the FCL (and/or FARL?)

Area	No.	Flood Resiliency Measure
Geotechnical	G1	Selection of “Maximum Design Groundwater Elevation” to consider seasonal and tidal effects with freeboard to account for year-to-year variability
	G2	Consider event where interflow merges with ambient groundwater (seepage)
	G3	Consider return period of Maximum Design Groundwater Elevation
	G4	Consider cascade effects including loss of tie-down anchor resistance for buoyancy due to a seismic event
	G5	Consider potential salinity or pollution of groundwater with respect to possible impacts on building and systems
	G6	Consider stiffness of secant pile walls (and elevation of top of secant pile wall) with respect to potential hydrostatic pressure developing on building foundation walls due to infiltrated water (overland or interflow)
	G7	Consider potential scour of foundations
	G8	Consider impacts of temporary and/or permanent dewatering systems over the life of the building, including off-site

Environmental	En1	Consider potential for temporary and/or permanent dewatering systems to draw contaminants towards the site
	En2	Consider impact of dewatering on environment, including base stream flows, aquifers, etc
	En3	Consider potential increase in elevation of water table due to infiltration on site and corresponding effects on foundation drainage systems for existing proximate developments

Landscape	L1	Consider incorporating flood walls in landscaping design (or practicality for/of future install)
	L2	Consider using flood-/contamination-resilient plant species
	L3	Final grading should slope down and away from building per Building Code
	L4	Consider reparability of landscaping features following a flood
	L6	Consider permeability of (base course for) landscaping elements and ability to conduct water

## Other Measures

Area	No.	Flood Resiliency Measure
Builders	B11	Builders to provide Owners with maintenance manual including specifications, maintenance frequencies, record drawings, etc

Owners / Strata	O1	Carry out maintenance of building systems
	O2	Carry out upgrades to building systems and other elements in future as risks increase and building components become obsolete
	O3	Responsible for ensuring code requirements are met
	O4	Understand insurance coverage and exclusions (overland water flow etc)
	O5	Develop Road Map for action to take for existing / new structures for Owners to reference

Area	No.	Flood Resiliency Measure
Public	Pu1	Consider public acceptance of risk, including return periods and expected performance during various flood events; drive industry to adopt flood resilience
	Pu2	Encourage education regarding maintenance and upgrading of systems per Best Practice

Property Managers	Mg1	Develop and host webinars for Stratas / Owners

## Measures Adapted from Intact Centre on Climate Adaptation

Governments	Provide up-to-date and future-looking flood-risk maps and property-level flood risk information through a free online portal, similar to the service provided by Flood Factor in the United States.
	Distribute home flood-protection materials to residents through property-tax mailings and online channels (such as emails, newsletters, and social media) to encourage the use of simple actions to reduce the risks of basement flooding.
	Collaborate with partners, such as the Canadian Red Cross, who have trained staff and volunteers to promote flood resilience measures with door-to-door campaigns, events and online learning opportunities.
	Incorporate flood resilience measures into government asset-management plans and longterm financial planning; establish funding programs to offset the costs of flood resilience retrofits to homeowners.
	Ensure that flood forecasting and warning systems are in place and provide sufficient time to deploy flood-protection measures in case of a flood emergency.

Insurance brokers	Participate in the professional training about home flood protection offered through the Insurance Brokers Association of Canada.
	When clients are buying or renewing homeowners' or tenants' insurance, inform them about practical ways to reduce the risk of basement flooding, as well as about available flood insurance coverage. Some insurance companies offer discounted premiums to homeowners who act decisively to reduce their risks.

Mortgage lenders	Develop incentives to encourage home buyers and homeowners to retrofit their homes to be more resilient to flooding (for example, through extending green mortgage programs to include support for flood resilience retrofits).
	Participate in professional training about home flood protection offered through Mortgage Professionals Canada.
	Educate clients who are securing or renewing mortgages about practical ways to mitigate flood risks at home.

Real estate agents	Participate in professional training about home flood protection.
	Give clients information about property flood risks, and practical ways to protect their homes.
	In the United States, real estate listings already contain flood risk information on prominent platforms, including realtor.com

## Measures Adapted from Intact Centre on Climate Adaptation

<b>Home Inspectors</b>	Participate in professional training about home flood protection offered through the Canadian Association of Home and Property Inspectors and Carson Dunlop.
	Include an assessment of flood risks in home-inspection reports, and educate clients about how to mitigate their flood risk at home.
<b>Retailers</b>	Engage customers in campaigns to reduce their flood risks, focusing on people who are undertaking home renovations.
<b>Commercial owners and managers</b>	Integrate flood resilience into commercial asset-management plans and long-term financial planning.
<b>Neighbourhood / community groups</b>	Educate residents about available flood-risk maps and no-cost or low-cost flood risk-reduction actions using door-to-door campaigns, events and online learning opportunities. Send home flood-protection materials to residents in the mail.
	Educate residents about incentive programs that may be available through local governments and utilities to limit their flood risk.
	Learn about local flood forecasting and warning systems and help residents prepare emergency plans and emergency kits.
<b>Local utility companies</b>	Develop incentives for utility customers to retrofit their properties to increase flood resilience; offer credits for actions that reduce stormwater runoff.



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