North Shore Sea Level Rise Adaptive Management Strategy

Adaptation Measures Toolkit

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CATEGORIES	ID	ADAPTATION MEASURES	APPLICABILITY
Category A: Planning and Governance Measures	A-1	ENCOURAGE THE UPTAKE OF PRIVATE FLOOD INSURANCE	MEDIUM
	A-2	RISK AVOIDANCE AND TOLERANCE POLICIES	MEDIUM
	A-3	FLOODPLAIN DEVELOPMENT MANAGEMENT TOOLS	HIGH
	A-4	COASTAL FLOODPLAIN URBAN STORMWATER MANAGEMENT PLANNING	HIGH
	A-5	FUTURE INTERTIDAL AREA LAND PRESERVATION	HIGH
	A-6	FORMALIZE NORTH SHORE COLLABORATIVE ADAPTATION PLANNING GOVERNANCE	HIGH
Category B: Building and Site Measures	B-1	BUILDING AND SITE-SCALE MEASURES FOR EXISTING PROPERTIES	LOW
	B-2	BUILDING-SCALE MEASURES FOR NEW CONSTRUCTION	HIGH
	B-3	PARCEL-SCALE LAND RAISING AND SITE GRADING	MEDIUM
	B-4	PARCEL-SCALE WAVE ATTENUATION (SHORELINE SITES)	MEDIUM
Category C: Community-scale Structural Flood Protection Measures	C-1	DIKE AND SEAWALLS	HIGH
	C-2	TEMPORARY / DEMOUNTABLE FLOOD BARRIERS	LOW
	C-3	STORM SURGE BARRIERS	LOW
	C-4	INTERNAL URBAN DRAINAGE ADAPTATION	HIGH
	C-5	NEARSHORE WAVE ATTENUATION STRUCTURES	MEDIUM
Category D: Community-scale Nature-Based Measures	D-1	RESTORATION OF NATURALLY RESILIENT ENVIRONMENTS	MEDIUM
	D-2	ENGINEERED NATURE-BASED MEASURES	HIGH
	D-3	SHORELINE RESHAPING	LOW
Category E: Critical Infrastructure Resilience	E-1	MUNICIPAL PUMP STATION RESILIENCE	HIGH
	E-2	POWER TRANSMISSION INFRASTRUCTURE RESILIENCE	HIGH
	E-3	TRANSPORTATION INFRASTRUCTURE RESILIENCE	HIGH
Category F: Response & Recovery Phase Risk Reduction Measures	F-1	FLOOD FORECASTING AND OPERATIONAL PLANNING	LOW
	F-2	RECOVERY PHASE RISK REDUCTION	LOW
Category G: Community and Cultural Resilience Measures	G-1	PUBLIC AWARENESS AND RISK REDUCTION EMPOWERMENT	HIGH
	G-2	PROTECTION OF CULTURAL SITES	HIGH
	G-3	EMPOWERING NON-GOVERNMENTAL STAKEHOLDERS TO INCREASE RESILIENCE	HIGH

INTRODUCTION

The Adaptation Toolkit is a reference document containing options for the North Shore partners to consider exploring as they develop detailed adaptation plans. The categories are:

- **A – Planning and Governance Measures,** which include policies and objectives that North Shore partners can use to regulate and reduce risk levels,
- **B – Building and Site Measures,** which are site-specific and reduce risk on an individual building or lot level,
- **C - Community-scale Structural Flood Protection Measures,** which are large-scale, engineered measures to reduce flood exposure,
- **D – Community-scale Nature-based Measures,** which utilize landscape features that reduce flood risk while providing environmental or social co-benefits,
- **E – Critical Infrastructure Resilience Measures,** which are strategies to increase the resilience of existing critical infrastructure
- **F - Response and Recovery Phase Risk Reduction Measures,** which can be planned in advance to make the consequences of flooding less severe and to leverage the recovery phase for effective and long-term risk reduction, and
- **G – Community and Cultural Resilience Measures,** which encourage preparedness from other actors and aim to reduce risk to cultural assets.

The sub-measures contained within each category should be thought of 'tools' within the toolkit of each partner, to be drawn upon as a resource when developing detailed adaptation plans for a specific area. The applicability ratings were developed based on professional judgement, with considerations of the unique characteristics of the North Shore region.

CATEGORY A:

PLANNING AND GOVERNANCE MEASURES

A-1 ENCOURAGE THE UPTAKE OF PRIVATE FLOOD INSURANCE

High Level Approach

Accommodate

Sub-measure

A-1-1	Provide information to residents and businesses about coastal flood risk (now and in the future) and introduce the option of flood insurance
A-1-2	Provide information about flood insurance during development application process
A-1-3	Encourage flood insurance for development permit
A-1-4	Encourage flood insurance for businesses during licensing process

Description

As of the writing of this report, coastal overland flood insurance is an emerging opt-in private insurance product in the region. Similar to other insurance policies, coastal overland flood insurance can be used to reduce the impact of flooding and accelerate recovery.

Flood insurance is an alternative approach to provincial/federal disaster financial assistance (DFA) programs. This is also an area of emerging policy as provincial policy indicates that DFA may not provided in areas where flood insurance is available for purchase. As the private coastal flood insurance market develops further, this policy may be applied widely.

The North Shore partners could develop and implement policies and programs to encourage flood insurance for new developments and/or business licenses.

Pros

- Shares flood risk with the insurance market
- Alternative to disaster financial assistance programs
- May lead to risk reduction through discouraging occupation of high-risk areas and/or densification of risk areas

Cons

- Potential equity and affordability issues
- Careful implementation required to avoid undesired outcomes (e.g., the introduction of flood insurance subsidies can encourage development in high-risk areas)
- Uncertainty related to emerging market

A-1 ENCOURAGE THE UPTAKE OF PRIVATE FLOOD INSURANCE

Applicability on the North Shore

Flood insurance is particularly applicable for commercial and industrial land uses where economic risk is a primary consideration for sea level rise adaptation. The availability and structure of flood insurance for First Nation reserves, including commercial tenants of reserves, requires further study. A recent study (Thistlethwaite *et al.,* 2020) found that Canadians have limited knowledge of flood insurance coverage, expect governments to fund most of flood recovery through disaster assistance and are reluctant to pay for both insurance and property-level flood protection measures.

APPLICABILITY: MEDIUM

A-2 RISK AVOIDANCE AND TOLERANCE POLICIES

High Level Approach

Avoid

Sub-measure

A-2-1	Coastal flood risk tolerance definition in risk-based or hazard scenario-based terms (OCP, by-law, or DPA) for different asset classes and/or land uses (e.g. critical infrastructure/facilities, commercial, residential, etc.)
A-2-2	Special flood risk tolerance areas by land use (e.g. non-hazardous industrial) through OCP/DPA/area planning tools
A-2-3	Density restriction in higher hazard areas (zoning/covenant)
A-2-4	Existing critical infrastructure relocation policy (at replacement/upgrade)
A-2-5	New critical infrastructure location policy
A-2-6	Proactive property acquisition in high-risk areas
A-2-7	Post-flood property acquisition
A-2-8	Development potential transfer/swap

Description

The North Shore partners can use a wide variety of land use planning tools to limit and/or disincentivize occupation of areas at risk from coastal hazards.

Examples include voluntary programs such as development potential transfer, moving critical infrastructure, and social and operations facilities out of the floodplain at the end of building life cycle (or sooner if necessary), or by creating a comprehensive buy-out strategy to actively reduce population numbers and development in the floodplain. An example of an in-progress buy-out strategy in BC is the municipality of Grand Forks.

An important initial step to support these activities would be to define a baseline risk tolerance thresholds which could be used to guide the development and application of policy tools. Risk tolerance can be defined in either risk-based terms (e.g. tolerable annualized property damage cost per hectare due to coastal flooding) or hazard scenario-based terms (e.g. flooding not tolerable at a return period less than 10-years, and 200-year return period maximum flood depths greater than 0.5 m are not tolerable).

After a baseline level of risk tolerance is defined, policy tools can be designed to manage land use to maintain risk below the tolerance threshold. Other tools can be developed for areas and situations where a higher level of risk tolerance may be permitted to enable certain economic activities (e.g. water-oriented industries, other industrial activities) with certain conditions (e.g. management of hazardous waste risk).

A-2 RISK AVOIDANCE AND TOLERANCE POLICIES

Pros

- Risk avoidance is the most effective form of risk reduction
- Risk tolerance policies support transparent and evidence-based policy and decision making
- Shoreline property acquisition can be linked with measures to preserve intertidal habitat or create new waterfront park space as sea level rise occurs

Cons

- Difficult to define risk tolerance (lack of senior government policy)
- Land use and development restrictions have secondary impacts (e.g. economic, equity)
- Property acquisition is an emerging approach in Canada, but can still be contentious

Applicability on the North Shore

There is already a history of managing natural hazards through tolerable risk criteria on the North Shore; the District of North Vancouver has risk tolerance criteria for geohazard risk management including loss-of-life risk tolerance criteria.

Many of the policy tools required to manage land use and density for flood risk exist (e.g. OCPs, DPAs, etc.). However, there are few examples of proactive property acquisitions or density restrictions for future sea level rise risk.

The risk avoidance concepts have limited applicability for Port lands. Generally Port lands are already low-lying areas along shoreline margins; moving to higher ground would require that the Port acquire more lands, which becomes less feasible when adjoining areas are already built out for other development types.

APPLICABILITY: MEDIUM

A-3 FLOODPLAIN DEVELOPMENT MANAGEMENT TOOLS

High Level Approach	Accommodate

New construction with a concrete raised foundation

Sub-measure

A-3-1	Building floodproofing (flood construction level (FCL), setback, allowable uses below FCL, etc.) requirements policy tools (by-law, DPA), including variation by land use / asset type
A-3-2	Site-level land raising and grading requirements policy tools (DPA, area-wide design guidelines, etc.)
A-3-3	Special measures for industrial sites with hazardous material storage and/or generation

Description

These measures focus on policy tools to require the implementation of building and site level measures for risk management.

Requirements for building-level floodproofing (including flood construction levels, setbacks between shorelines and structures and/or between flood protection infrastructure and structures, and allowable uses below the FCL) can be specified in a variety of tools including floodplain by-laws, development permit areas (DPAs), and site-wide design guidelines for special areas.

The existing program of floodproofing can be expanded upon and made more flexible by specifying different requirements by building type, land use, and development life cycle (temporary/permanent). In particular, if achieving the FCL is very difficult due to site grade, policies can be created to specify acceptable land uses below the FCL (e.g., parkade below FCL but all residential is required to be above the FCL). Adding these types of variations are preferred over blanket, area-wide exemptions to FCLs.

Specific approaches for implementing floodplain development management requirements are presented as separate adaptation measures (B-1 for new developments and B-2 for existing developments).

Floodplain building standards are also starting to receive more attention at the national regulatory / building code level. It is understood that CSA standards are being developed for building resilience to flooding.

Floodproofing hazardous materials storage and generation sites lessen the risks of a potential release into floodwaters during a coastal flood event. Further to this point, a contamination response plan ensures that staff have a preplanned protocol to follow in case of the failure of floodproofing measures.

A-3 FLOODPLAIN DEVELOPMENT MANAGEMENT TOOLS

Pros	Cons
• Cost of adaptation shared with development costs	• Risk reduction is reliant on redevelopment • Careful balance required as strict policies may lead to the need for area-wide exemptions (if developments are unable to meet the requirements) which can negate the risk reduction benefit. • Requires updates to other policies (e.g., max allowable building height) • Does not address areas between buildings

Applicability on the North Shore

Floodproofing (with a focus on flood construction levels) already occurs on the North Shore through a variety of policy tools. This policy tool is highly applicable for Port lands and objectives; making use of lands which are marginal or unsuitable for other developments is a good fit if terminals and other port-related industries can be made somewhat tolerant of minor flood conditions. However, if certain Port lands were designated as flood tolerant, and employed floodproofing tools, then lands inland of Port sites would need to employ their own flood protection measures.

APPLICABILITY: HIGH

A-4 COASTAL FLOODPLAIN URBAN STORMWATER MANAGEMENT PLANNING

High Level Approach	Resist	Accommodate

Storm drain

Storm drain

Sub-measure

A-4-1	Coastal floodplain urban stormwater level of performance studies and policy
A-4-2	Storm sewer network upgrades for sea level rise
A-4-3	Overland urban drainage route and pump station land tenure planning

Description

Master drainage planning and integrated stormwater management planning on North Shore watersheds can be updated to identify the impacts of sea level rise on drainage systems, update design criteria for drainage infrastructure, and plan for required drainage work upgrades in the future. The typical level of performance for drainage infrastructure on the North Shore involves conveying rainfall storms ranging in size up to the 10-year return period event through the subsurface sewer network and conveying larger events through overland drainage paths (typically roads). Both subsurface and surface drainage routes lead directly to the sea or indirectly via a creek. As sea levels rise, the level of performance of existing drainage systems in low-lying areas will be impacted.

To maintain the level of performance, upgrades to sewer network capacity may be required. In particular, existing sewer outfalls into the sea may need to be upgraded to flapgates/floodboxes and possibly pump stations, which would involve a very significant cost, likely on the order of hundreds of millions of dollars. Alternatives to converting all outfalls to pump stations may include adopting a different level of performance for stormwater systems in coastal floodplain areas, implementing pressurized stormwater sewer systems, implementing large storage ponds to reduce pumping capacity requirements, and incorporating new overland drainage routes directly to the sea into shoreline land raising concepts.

A-4 COASTAL FLOODPLAIN URBAN STORMWATER MANAGEMENT PLANNING

Pros

- Incorporates sea level rise into short- and long-term stormwater management and watershed management
- Opportunities for new approaches (e.g., pressurized highland to lowland stormwater pipes, overland drainage routes incorporated into land raising, large stormwater storage ponds) to reduce the need for converting outfalls into pump stations

Cons

- Maintaining the existing urban stormwater level of service through existing systems may require very significant capital costs for floodboxes and pump stations

Applicability on the North Shore

Urban stormwater management planning is already a well-established practice and program on the North Shore. Incorporating sea level rise considerations and adaptation planning can be implemented into on-going and future planning activities.

APPLICABILITY: HIGH

A-5 FUTURE INTERTIDAL AREA LAND PRESERVATION

High Level Approach	Accommodate	Advance

Cates Park / Whey-ah-Wichen in the District of North Vancouver

Ambleside Park in the District of West Vancouver

Sub-measure

A-5-1	Designate existing shoreline parks for future intertidal area
A-5-2	Acquire shoreline properties for future intertidal area
A-5-3	Land reclamation (advance) to build future intertidal area
A-5-4	Intertidal area habitat balance and habitat banking

Description

Sea level rise will impact intertidal areas and the environmental habitats they support. Coastal squeeze (intertidal area loss) will occur in areas where dikes and seawalls are built to prevent the landward shifting of the high tide line.

This measure involves various policy tools to preserve land for future intertidal area and habitat. Existing shoreline parks could play a major role in adapting intertidal area habitat if park spaces are designated for future reshaping to support intertidal habitat. If adaptation concepts include dikes, locating them along a setback alignment will provide more opportunities for future intertidal area.

New parks or habitat areas could be established if shoreline properties are acquired, either through a comprehensive buyout strategy or through opportunistic purchases.

An alternative approach would involve gradual land reclamation over time to build land for future intertidal habitat.

Finally, the land preservation efforts could be managed and tracked through an intertidal habitat offsetting and banking program which could be used to support dike and seawall projects in other areas on the North Shore that would result in intertidal area loss. Examples of existing habitat banking in BC include the North Fraser Habitat Compensation Bank (established in 1993).

A-5 FUTURE INTERTIDAL AREA LAND PRESERVATION

Pros

- Preserve land for intertidal area habitat to offset habitat loss in other areas
- Environmental co-benefits

Cons

- Land acquisition may be required

Applicability on the North Shore

Without an existing system of seawalls and dikes, the North Shore is well suited to thoughtfully plan for sea level rise adaptation that minimizes intertidal area habitat impacts. This measure would also be complementary to a suite of other historic and on-going environmental stewardship initiatives in Burrard Inlet and Howe Sound, including intertidal habitat restoration in Maplewood Flats.

APPLICABILITY: HIGH

A-6 FORMALIZE NORTH SHORE COLLABORATIVE ADAPTATION PLANNING GOVERNANCE

High Level Approach	Avoid	Resist	Advance	Retreat	Accommodate

Sub-measure

A-6-1	Formalize a North Shore sea level rise adaptation working group or office
A-6-2	Establish North Shore wide sea level rise adaptation utility charge
A-6-3	Establish Development Cost Charge (DCC) for sea level rise adaptation infrastructure

Description

The multi-jurisdictional partnership formed to address North Shore sea level rise adaptation in this report could be continued as a permanent working group, potentially chaired by NSEM.

Examples of taxes similar to adaptation utility taxes can be found in low-lying jurisdictions such as Richmond and Delta to fund diking systems and maintenance.

Specific implementation requirements of establishing a Development Cost Charge for sea level rise adaptation infrastructure will require further study.

Pros

- More efficient coordination and pooling of resources.
- Potentially more access to funding.

Cons

- On-going consensus building across communities requires significant effort.

Applicability on the North Shore

The North Shore is uniquely suited to establishing a regional sea level rise or general adaptation planning authority/office given its topographic conditions, history of collaboration, the existing structure of NSEM, and its current condition without significant existing flood protection infrastructure.

APPLICABILITY: HIGH

CATEGORY B:

BUILDING AND SITE MEASURES

B-1 BUILDING AND SITE-SCALE MEASURES FOR EXISTING PROPERTIES

High Level Approach

Accommodate

Demountable flood barrier around a doorway

Sub-measure

B-1-1	Temporary or demountable flood barriers around structure
B-1-2	Flood doors, floodproof coatings, and backflow prevention valves
B-1-3	Foundation alterations to raise structure

Description

Building and site measures for retrofitting existing buildings increase their resilience and enable them to withstand coastal hazards. Site-scale floodproofing can reduce exposure to hazards until it is time for the redevelopment of the site.

The role of North Shore partners in this measure would largely be to enable individual property owners to access technical resources and to enable implementation through permitting requirements and potential risk reduction incentives.

Pros

- Allows existing structures to remain in place
- Not reliant on redevelopment
- Share cost of adaptation with property owners
- Enable property-level resilience and adaptation empowerment

Cons

- May not be feasible for all sites and for deep flood hazard areas
- Significant education and household-level responsibility needs (e.g. difficult to enforce how people use areas below flood level within private property)
- Typically requires variances for additional height (to accommodate raising buildings) or other development regulation changes
- Reliant on property owner interest and uptake.

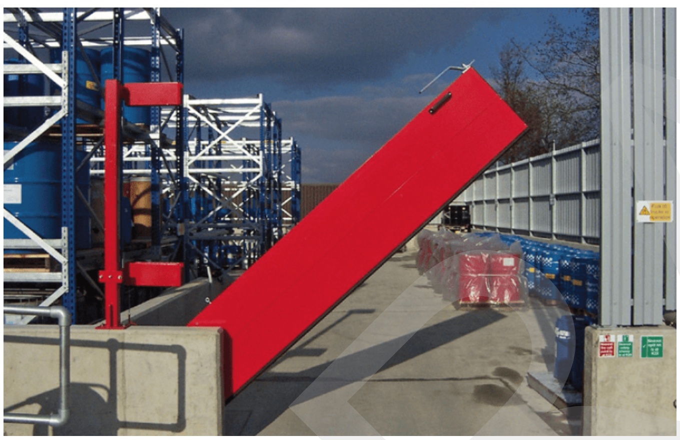
B-1 BUILDING AND SITE-SCALE MEASURES FOR EXISTING PROPERTIES

Applicability on the North Shore

Applicability may be limited to special cases where adaptation timeframe or other reasons would not allow the implementation of adaptation measures through redevelopment. Unlikely to be required or desired in the short-term, except for very low-lying properties. Community interest may rise after coastal flood events.

APPLICABILITY: LOW

Additional Reference Photos

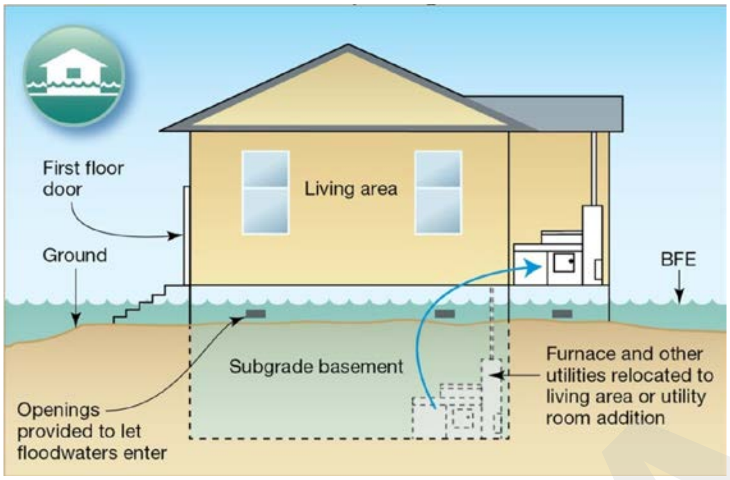


Flood barrier at site entryway

B-2 BUILDING-SCALE MEASURES FOR NEW CONSTRUCTION

High Level Approach

Accommodate



Wet floodproofing

Sub-measure

B-2-1	Dry floodproofing by fill or structure (e.g. reinforced concrete)
B-2-2	Wet floodproofing (flow-through paths and flood-resistant materials)
B-2-3	Building foundation tanking and sump pumping
B-2-4	Electrical/mechanical/district energy equipment flood proofing by tanking or elevation
B-2-5	Parkade entrance flood barriers
B-2-6	Amphibious architecture (experimental)
B-2-7	Modular architecture for adaptive raising / adding floors (experimental)

Description

Building measures for new building construction consist of requirements to ensure that new buildings are built to either avoid impacts or lessen the impacts of coastal flooding.

Conventional and best practice sub-measures include dry floodproofing (flood construction level (FCL) elevation by fill or structure), setbacks, and elevation/tanking of electrical and mechanical equipment.

In medium-density buildings, parkades are often acceptable below the FCL, but flooding could still result in significant property damages to vehicles and other storage in parkades. Accordingly, new building designs can include automatic floodgate barriers at parkade entrances to prevent parkade flooding.

Other forms of architecture may emerge in the future for sea level rise adaptation, including concepts that have received some recent research such as amphibious architecture or modular/adaptive buildings. Development and building regulations may require updates to enable future concepts.

Pros

- Cost of adaptation shared with development
- Highly effective in areas undergoing redevelopment

Cons

- Highly reliant on redevelopment
- Raised buildings potentially impact neighbourhood character.
- Loss of developable living space below FCL.

B-2 BUILDING-SCALE MEASURES FOR NEW CONSTRUCTION

Applicability on the North Shore

Floodproofing (with a focus on flood construction levels) already occurs on the North Shore through a variety of policy tools. A local example of raised buildings is the Seaspan office on Pemberton Ave, which is built on stilts.

APPLICABILITY: HIGH

Additional Reference Photos

Amphibious architecture

Parkade entrance flood barrier

B-3 PARCEL-SCALE LAND RAISING AND SITE GRADING

High Level Approach	Accommodate

Land raising to flood construction level

Grade transition from land raising down to existing road incorporated into public plaza

Sub-measure

B-3-1	Full site-wide land raising to flood construction level
B-3-2	Partial site-wide land raising to tolerable flood level for access and egress
B-3-3	Setback between shoreline and structure
B-3-4	Setback between shoreline and flood protection infrastructure or land tenure for future setback
B-3-5	Overland drainage path incorporation into shoreline land raising

Description

Parcel-scale land raising is a significant opportunity for effective sea level rise adaptation on the North Shore. This measure involves raising the elevation of land on a property (in addition to the building itself) either to the full flood construction level or to a lower elevation above which flooding impacting access/egress would only occur on an infrequent and tolerable basis. In industrial areas where the implementation of shoreline dikes may impede water access, land raising can be an effective solution by enabling individual properties to choose to raise their property elevation based on their flood risk tolerance.

While effective through essentially raising the property out of the floodplain, land raising requires close coordination with neighbouring properties and is best achieved after an area-wide planning process has identified land raising areas and elevations. Land raising is also likely a preferred measure for areas located outside of community-scale structural measures (e.g. dikes).

B-3 PARCEL-SCALE LAND RAISING AND SITE GRADING

Key features for land raising to consider include grades for utilities, site grading for access/egress, and the preservation/upgrading of overland drainage paths to the sea for shoreline sites. Individual parcels can have more agency in choosing when and how much they want to raise their grade.

Land raising would also reduce the reliance on the redevelopment of waterfront parcels to enable the implementation of a specific dike alignment. Additionally, this approach can also be advantageous over diking by incorporating new overland drainage routes into the land raising plans instead of dikes that may trigger the need for the construction of drainage pump stations. Finally, another advantage of land raising is that it may be compatible with site capping practices typically involved in the redevelopment of properties with contaminated soils.

Pros

- Cost of adaptation shared with development
- Highly effective in areas undergoing redevelopment
- Can be implemented over time

Cons

- Highly reliant on redevelopment
- Site-wide land raising requires close coordination with neighbouring properties and area-wide planning
- Potential to increase risk if density increased in floodplain

Applicability on the North Shore

Parcel-scale land raising is not common on the North Shore, but would be applicable to much of the low-lying industrial sites (that do not need waterside land at sea level for their operations) as they redevelop and for redevelopment areas resulting in medium or high density construction where land raising is cost effective. The Port has a history of in-filling and building up sites (including Neptune, G3, and Lynnterm), mainly using dredged river sand.

APPLICABILITY: MEDIUM

B-4 PARCEL-SCALE WAVE ATTENUATION (SHORELINE SITES)

High Level Approach	Accommodate	Resist


Greenshores shoreline


Riprap revetment shoreline

Sub-measure

B-4-1	Greenshores and natural shorelines for low slope wave attenuation
B-4-2	Engineered beach shoreline
B-4-3	Riprap revetment shoreline
B-4-4	Seawall shoreline
B-4-5	Near-shore engineered/nature-based breakwaters

Description

For shoreline sites, particularly west of the Lions Gate bridge, wave attenuation is a key aspect of building/site floodproofing.

A variety of shoreline approaches are available to attenuate waves and reduce erosion risk, ranging from natural shorelines which reduce wave energy through vegetation and shallow slopes to engineered seawalls and nearshore breakwaters.

Pros

- Wave attenuation reduces flood construction level

Cons

- Potential environmental impacts if not designed for environmental co-benefits
- Seawalls and engineered shorelines may contribute to coastal squeeze (loss of intertidal habitat)

B-4 PARCEL-SCALE WAVE ATTENUATION (SHORELINE SITES)

Applicability on the North Shore

Applicability is low for port-related waterfront lands where deep water is required for industry and wave attenuation (other than through seawalls) may not be feasible. Applicability is higher for park and public space shorelines. Applicability will likely vary by site specifics for residential waterfront parcels.

APPLICABILITY: MEDIUM

CATEGORY C:

COMMUNITY-SCALE STRUCTURAL FLOOD PROTECTION MEASURES

C-1 DIKE AND SEAWALLS

High Level Approach

Resist

Advance

Dike incorporated in between development and waterfront public trails

Sub-measure

C-1-1	Shoreline dike
C-1-2	Setback dike
C-1-3	Dike incorporated into linear park corridor
C-1-4	Dike incorporated into road corridor
C-1-5	Dike incorporated into rail corridor
C-1-6	Dike incorporated into land reclamation (advance)
C-1-7	Dike with seawall edge
C-1-8	Standalone seawall / floodwall

Description

Dikes and seawalls are often the primary line of flood protection and a key component of different adaptation concepts; it is worthwhile to note that there is currently no diking system on the North Shore.

Dikes are linear, raised earthfill embankments that hold back water from the sea and rivers/creeks. Dikes with a 4 m wide crest and 3H:1V side slopes are the conventional form of flood protection in BC with consistent application along the lower Fraser River and its estuarine islands, including Richmond and Delta.

Seawalls are engineered, impermeable vertical walls that form the water-side edge of waterfront lands. In some cases, sea walls are standalone flood walls as they are taller than the land behind them.

While conventionally treated as standalone infrastructure, there is an emerging movement towards incorporating dikes and seawalls into other land forms and infrastructure to provide co-benefits in response to multiple pressures on sparsely available land, particularly along the shoreline. For example, dikes and seawalls can be incorporated into parks, urban waterfront areas, larger and higher density developments, road corridors and rail corridors.

The alignment of dikes and seawalls will have a significant impact on future intertidal area. If aligned along the existing shoreline edge, they will contribute to coastal squeeze (loss of intertidal area), but set back from the shoreline, they can accommodate future intertidal habitat.

Dikes can generally be constructed to heights of several metres, but as dike height increases so does the expected settlement of the dike due to pressure on underlying soils. In very soft ground (e.g. mudflat areas), a dike may need to be at first constructed to double its required height to accommodate 50% settlement post-construction. While dikes are an effective measure for managing flood risk, they can also contribute to increasing risk in certain situations without careful planning. For example, new dikes in river/creek mouth areas can increase river/creek flood hazards if they limit or prevent the free overflow of river/creek flooding into the sea. Dikes also introduce a new hazard into the

C-1 DIKE AND SEAWALLS

management framework: dike breach hazard. In certain situations, dike breach hazards and related risk could be more severe than the pre-diking condition. Additionally, as dike height increases, the hazard intensity related with dike breaches increases as well. Without careful land use planning behind dikes, it is even possible that dikes can increase the flood risk immediately behind the dike based on the potential damage related to a dike breach. Finally, dikes can also contribute to increasing risk by introducing a false sense of security and/or through encouraging higher density development. Careful technical analysis, planning, and repeat risk assessments are required for the implementation of dikes.

Pros

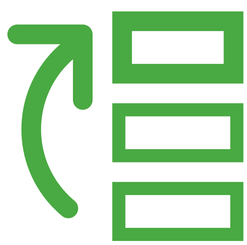
- Can be incorporated into other infrastructure and land uses for co-benefits
- Protects existing buildings and land behind structure (preserves status quo land use behind dike)
- Several opportunities for use of rail lines on the North Shore for dike rights-of-way.

Cons

- Significant financial and administrative resources required for implementation and management
- Challenging to implement into urban and natural areas without pre-existing right-of-way for diking
- Can increase flood hazards/risks through dike breach introduction and/or attraction of density increase
- Can contribute to coastal squeeze (intertidal area loss) and can disrupt natural sediment dynamics
- Aesthetic and view impacts if not incorporated into landscapes well
- Cannot be implemented piecemeal (no benefits until whole dike completed).

Applicability on the North Shore

Diking in BC is regulated by the Province through the Inspector of Dikes Office (Ministry of Forests, Lands, and Natural Resource Operations and Rural Development) which provides technical and administrative guidance defining standard diking in BC. The Province requires new dikes to be under the jurisdiction of local government diking authorities. There are few examples of standard dikes on the North Shore and the municipalities are not currently undertaking formal diking authority roles.



APPLICABILITY: HIGH

Implementing standard dikes on the North Shore will be challenging due to a combination of factors including a lack of existing rights-of-way for diking and due to the existing urban and natural shoreline typologies that are not well suited for application of provincial guidelines (most suited for rural and agricultural settings).

Dikes and seawalls on the North Shore would be most successfully implemented through integration with other infrastructure and land uses. Examples include incorporating dikes into linear park corridors, road corridors, and land raising as part of large development parcels; dikes do not need to be at water's edge when combined with other measures.

Additional Reference Photos

C-1 DIKE AND SEAWALLS

Flood wall

Existing Lower Mainland coastal diking system

C-2 TEMPORARY / DEMOUNTABLE FLOOD BARRIERS

High Level Approach

Resist

Vehicle entrance automated flood gate

Sub-measure

C-2-1	Rail crossing manually-operated flood gate
C-2-2	Vehicle and pedestrian entrance automated flood gate (e.g., floodbreak)
C-2-3	Flexible linear tube flood barrier (e.g., tigerdam) / temporary modular flood barriers
C-2-4	Vertical extension additions to dikes and seawalls

Description

Temporary flood barriers are structural measures that are activated (either manually or automatically) ahead of or during a flood event.

They are often applied as secondary measures for individual developments or in some cases as part of primary flood protection systems in conditions where a permanent dike or seawall is not feasible, such as crossing of transportation corridors.

Temporary flood barriers are useful to safeguard specific sites or close specific gaps, but typically need labour to erect in advance of flooding. These can include sliding flood gates, stop log style structures, a series of barriers that can be linked for a desired length, and linear plastic tubes that can be filled with water to act as a vertical barrier.

Another type of barrier is a passive flood barrier which can rise automatically without human intervention and without a power source. Applications of this technology exist mostly in the United States for vehicle/pedestrian entrances to buildings and larger applications where levees cross major roads.

Pros

- Solution to conditions where structures or infrastructure is in conflict with dike/seawall alignment
- Potential to add to sites that have not redeveloped and may not meet current FCLs

Cons

- Risk of failure due to mechanical systems
- Reliance on operational labour force
- Reliance on uncertain flood forecasting

C-2 TEMPORARY / DEMOUNTABLE FLOOD BARRIERS

Applicability on the North Shore

APPLICABILITY: LOW

Temporary / demountable flood barriers are not a preferred structural measure for providing a primary line of flood protection on the North Shore due to several factors. In particular, they are not a passive form of flood protection and would rely heavily on an operational context that does not exist at this time. As a comparison of other more appropriate contexts, the United Kingdom does use and deploy demountable flood barriers for coastal flood risks, but they have a national level agency (UK Environment Agency) which coordinate and implements the works. While North Shore municipalities do have operational capacity to prepare and respond to minor flood events, a move to a major system of demountable barriers would require a significant expansion of this capacity.

The measure is likely most applicable on the North Shore as a secondary approach to add resilience and redundancy to developments in the coastal floodplain, particularly for properties where the risk tolerance is lower than the normal (e.g. industrial sites with hazardous materials or critical operation facilities). The measure may also be applicable to certain low-lying facilities that are at risk now and a permanent solution has not been developed. For example, the District of West Vancouver deploys a tube-style barrier around its waterfront Silk Purse Gallery and Music Box building during the winter season to protect against current flood hazards."

Additional Reference Photos

Flexible linear tube flood barrier (tigerdam)

Rail crossing manually-operated flood gate

C-3 STORM SURGE BARRIERS

High Level Approach

Resist

Sub-measure

C-3-1	Large-scale storm surge barrier
C-3-2	Creek mouth storm surge barrier

Thames Barrier in the United Kingdom

Maeslantkering storm surge barrier in the Netherlands

Description

Storm surge barriers, or sea gates, are large-scale dynamic structures that are used to prevent the rise in ocean water level due to storm surge from expanding into harbours, inlets, and upstream into creeks, rivers, and drainage canals.

Storm surge forecasting and water level monitoring is used to determine when to start to close the barrier to prevent the rise of water level on the protected side of the barrier. The threshold for closing the barrier is typically linked to the elevation of the lands being protected by the barrier and the related flood risk tolerance.

The barriers typically replace diking and seawalls as the primary line of flood protection and allow the protected area shoreline to remain in a status-quo condition or allow for diking and seawalls constructed to a lower level of protection.

Large storm surge barriers installed at the mouths of inlets can negatively impact and fish/marine mammal passage by impacting hydraulics. In conditions where the barrier is closed frequently, the water quality and salinity inside the protected side of the inlet can change.

Smaller barriers installed at creek mouths or drainage canal mouths can help reduce the size of required diking upstream along the watercourse.

C-3 STORM SURGE BARRIERS

Pros

- Single infrastructure piece solution that can reduce the need for other measures

Cons

- Addresses storm surge, not sea level rise stillwater levels / nuisance high tide flooding
- Significant environmental impact potential
- Potential negative impacts to navigation and port operations
- Potentially not cost-effective unless local storm surge heights become larger than those observed in today's climate
- Reliance on operational capacity and mechanical systems during flood conditions
- Reliance on uncertain storm surge forecasting

Applicability on the North Shore

A large storm surge barrier located at a narrow location on Burrard Inlet would have many serious negative environmental impacts that would not be in line with various environmental stewardship initiatives on-going in the region. A flood barrier at First Narrows could severely impact shipping operations.

The frequency that barriers are closed generally increases with sea level rise. This measure is typically best suited to areas where the storm surge component of a coastal flood event is a few to several meters (e.g. Atlantic coast of North America) and less suited to areas, such as the North Shore, where the amount of storm surge (~1 m maximum recorded) and the amount of sea level rise are similar (1 m by Year 2100). In the latter scenario, sea level rise may become the primary driver for closing the barrier and the frequency of barrier may be impractically high, particularly for navigation.

APPLICABILITY: LOW

Barriers at the mouths of North Shore creeks are also not preferred because of the potential for impacts to fish habitat and passage. Similar to large storm surge barriers, the benefits would be limited as diking would still be required upstream along the watercourse. Pump stations added to the barriers to reduce the need for diking would likely not be economically feasible given the intense rainfall patterns that define large design flows on North Shore creeks.

C-4 INTERNAL URBAN DRAINAGE ADAPTATION

High Level Approach

Resist

Flapgate at outfall

Sub-measure

C-4-1	Flapgates for stormwater outfalls
C-4-2	Floodboxes and pump stations with drainage canals / surface storage
C-4-3	Floodboxes and pump stations with subsurface reservoirs
C-4-4	Upper stormwater network pressurized pipes and outfalls

Description

Sea level rise adaptation planning is often most well known for ideas on how to resist coastal floodwaters or to accommodate developments to periodic coastal flooding. However, just as important is the consideration of the impact of sea level rise on the performance of urban stormwater (rainfall runoff) systems.

The level of service for these systems involves conveying runoff from rainfall events up to the 10-year return period event (10% annual exceedance probability) in a subsurface stormwater pipe network and safely conveying larger events on roads or other rights-of-way leading to creeks or directly to the ocean. As sea level rise occurs, stormwater systems in low-lying areas may not meet the existing level of service due to loss of the elevation gradient driving gravity drainage. Additionally, existing stormwater outfalls may become paths for coastal flooding which would render dikes and seawalls ineffective.

The conventional adaptation approach involves installing flapgates on stormwater outfalls. These gates prevent coastal floodwaters from entering the outfall and results in backwatering of the pipe. If the backwatering results in performance below the level of service (e.g. surface flooding occurring during events with a return period lower than 10 years), the outfall may need to be replaced by a floodbox and pump station. A floodbox is a large outfall structure and a pump station can pump internal drainage over the sea level / dike. The sizing of floodboxes and pump stations depends on the level of service, inflow to the station, and the volume of storage at the station and in the system which can attenuate peak flows. In urban areas, it is generally more difficult to have large volume storage for pump stations; underground options can also be limited in size and are more costly.

C-4 INTERNAL URBAN DRAINAGE ADAPTATION

Description Continued

An alternative approach to reduce the need for and size of pump stations that may be appropriate for the North Shore is to take advantage of steep topography to convey as much of the rainfall runoff by gravity as possible. Stormwater networks located on elevations above the coastal floodplain could be drained directly to the ocean without pumping through pressurized pipes that would build up enough hydraulic head to convey the water. Internal drainage in low-lying areas could be conveyed using smaller pump stations and/or through developing a different level of performance, particularly for areas where dikes and seawalls are not implemented and a higher level of coastal flood risk tolerance may be established."

Pros

- Adapt stormwater network to sea level rise to maintain level of service (or define new level of service)
- Where effective, pressurized stormwater pipe systems could reduce pump station costs (capital cost comparison will vary by site-specific factors, but operation and maintenance costs are expected to be significantly less)

Cons

- Large costs and land demands for new pump stations

Applicability on the North Shore

Given the dense and comprehensive development existing on the North Shore, internal urban drainage adaptation will be an important component of sea level rise adaptation. Pump stations and their associated storage volume needs will be challenging to implement on the North Shore given existing land uses and density. One opportunity would be to incorporate dikes, pump stations, and parks to make the most use of land and achieve multiple co-benefits. Alternative approaches, such as pressurized pipe systems, require investigation to determine feasibility and cost-effectiveness.

APPLICABILITY: HIGH

C-5 NEARSHORE WAVE ATTENUATION STRUCTURES

High Level Approach	Resist	Advance

Sub-measure

C-5-1	Breakwaters
C-5-2	Groynes

Nearshore breakwater in Virginia.

Ogden Point Breakwater in Victoria.

Description

Wave attenuation structures such as breakwaters are constructed offshore to reduce the intensity of wave action and therefore minimize wave effects. Reducing wave effects through these structures can be used to lower the required elevation of dikes and seawalls and flood construction levels. This measure does not reduce the coastal flood stillwater base level.

Breakwaters and groynes can be designed to incorporate environmental habitat features, but the construction footprint is likely to result in negative environmental impacts. Designs can also incorporate public amenity features (e.g. piers, lookouts, etc.).

Another potential negative impact of this measure is an alteration of natural sediment dynamics, including sediment transport and deposition/erosion patterns. Careful analysis, planning, design, construction, and monitoring is often required.

Pros

- Reduces wave effects and in turn dike crest elevations and flood construction levels
- Can be linked with public amenity and park concepts for co-benefits

Cons

- Construction footprint environmental impacts
- Sediment dynamics interruption potential
- Can be a navigational hazard

C-5 NEARSHORE WAVE ATTENUATION STRUCTURES

Applicability on the North Shore

Wave hazards on the North Shore require further study, particularly for areas west of the Lion's Gate Bridge which are more exposed. Breakwaters and groynes may be applicable in wider floodplain areas east of the Lion's Gate Bridge.

APPLICABILITY: MEDIUM

Additional Reference Photos

Example of a breakwater

Example of a breakwater

CATEGORY D:

COMMUNITY-SCALE NATURE-BASED MEASURES

D-1 RESTORATION OF NATURALLY RESILIENT ENVIRONMENTS

High Level Approach: Resist

North Vancouver mudflats in the 1940s

Sub-measure

D-1-1	Mudflat and salt marsh restoration
D-1-2	Beach nourishment
D-1-3	Submerged vegetation and reef wave dissipation
D-1-4	Clam gardens incorporated into breakwaters and mudflats

Description

Nature-based features have been proven to reduce the severity of coastal flooding, generally through wave dissipation, in addition to providing environmental co-benefits. Mudflats, marshes, beaches, and submerged vegetation all can be incorporated into the shoreline to reduce wave energy and have a direct benefit to flood protection systems.

Beach and/or mudflat nourishment from onshore or offshore sources is a popular adaptation approach that is applied in Europe and in parts of the United States. There are no large examples of sediment nourishment in BC currently. Smaller sediment replenishment projects are often paired with engineered beach designs. One local, successful example is the shoreline restoration work conducted by the District of North Vancouver in partnership with the Tsleil-Waututh Nation in Cates Park (Whey-ah-wichen) to protect the eroding headland which is a cultural site with archaeological assets.

A clam garden breakwater, in addition to wave dissipation, could provide improved water quality, carbon sequestration and cultural co-benefits, like local shellfish harvesting, in line with long-term environmental stewardship initiatives for the Burrard Inlet led by the Tsleil-Waututh Nation.

Pros

- Contributes to managing wave effects for flood risk reduction
- Environmental, social, and cultural co-benefits

Cons

- Not a standalone adaptation solution
- Uncertain performance and required monitoring and maintenance

D-1 RESTORATION OF NATURALLY RESILIENT ENVIRONMENTS

Applicability on the North Shore

The North Shore shoreline is diverse and different sub-measures will be applicable in different areas. Port lands are least well suited for natural shoreline restoration due to the necessity for deep water and the high frequency of vessel-generated waves.

APPLICABILITY: MEDIUM

Additional Reference Photos

Clam garden

Marsh grass plantings

D-2 ENGINEERED NATURE-BASED MEASURES

High Level Approach	Resist

Sub-measure

D-2-1	Dike slope habitat ('living dike')
D-2-2	Engineered beach
D-2-3	Barrier island breakwater habitat ('living breakwater')
D-2-4	Nearshore reef wave dissipation

Engineered nearshore reef

Engineered beach

Description

These measures combine natural elements with engineered works. These measures are often desired when nature-based concepts are incorporated into flood protection infrastructure and/or there is other infrastructure nearby which will rely on the measures for protection. Adding an engineering component can increase the reliability of the measure and deliver the required performance from the beginning as opposed to waiting for natural habitats to develop over time.

There is an established practice for engineered nature-based measures in BC, but it is mostly focused on rainwater green infrastructure and creek/river bioengineering for bank protection. A growing movement is to incorporate this approach into sea level rise adaptation and flood protection, but there are no major constructed projects at this time.

Pros

- Contributes to managing wave effects for flood risk reduction
- Environmental, social, and cultural co-benefits

Cons

- Not a standalone adaptation solution
- Uncertain performance and required monitoring and maintenance

D-2 ENGINEERED NATURE-BASED MEASURES

Applicability on the North Shore

The North Shore is well positioned to be a leader in incorporating engineering nature-based measures into its sea level rise adaptation plans because it does not already have a well established system of dikes. Other areas in the Lower Mainland must find ways to incorporate nature-based approaches into existing structures that are often too costly to relocate, replace, or modify significantly. In particular, the North Shore has the opportunity to build any future shoreline sea dikes to a high living dike standard that reduces wave effects and erosion protection requirements and provides multiple co-benefits.

APPLICABILITY: HIGH

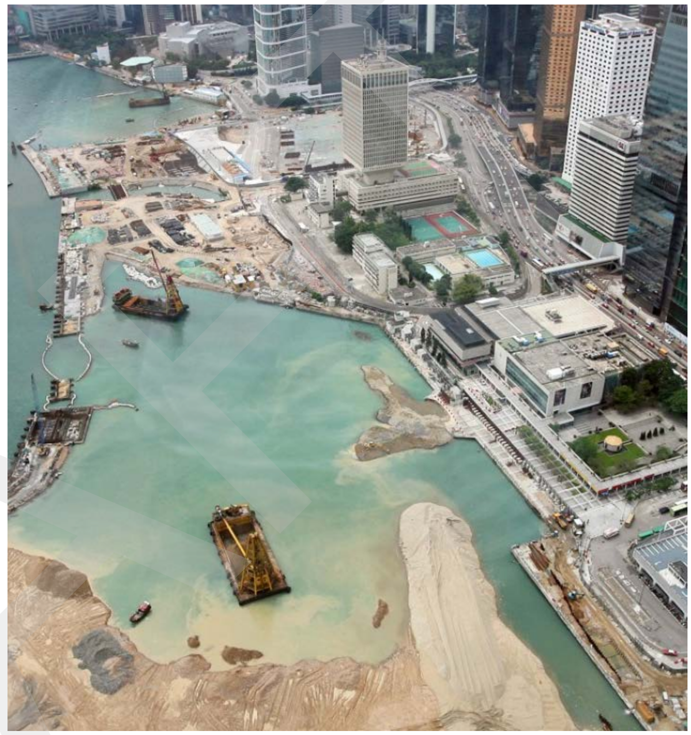
D-3 SHORELINE RESHAPING

High Level Approach	Advance	Accommodate

Sub-measure

D-3-1	Shoreline retreat (future intertidal area)
D-3-2	Shoreline advance (land reclamation for future intertidal area)

Shoreline Sediment Nourishment (Before and After)



Shoreline advance in Hong Kong

Description

Shoreline reshaping measures can be used to address coastal squeeze (intertidal area loss) by providing future intertidal area.

Managed land use change and gradual shoreline development retreat can be used to create natural space for migration of the intertidal zone. In some areas, it may be most appropriate to alter the shoreline in advance of sea level rise whereas other areas can be left to change gradually and naturally. An alternative approach would be to use land reclamation approach to build future intertidal areas.

Pros

- Offset and minimize intertidal habitat loss
- Environmental, social, and cultural co-benefits

Cons

- Negative habitat impacts in the short-term
- Challenges related to obtaining space for reshaping (managed retreat)

D-3 SHORELINE RESHAPING

Applicability on the North Shore

Shoreline reshaping is likely only to be applicable in limited areas with existing shoreline parks where park land use can be changed over time. Other areas with existing development may not be applicable unless paired with an opportunistic or comprehensive property acquisition program. Port lands are not well suited for shoreline reshaping given the deep bathymetry required for port activities.

APPLICABILITY: LOW

CATEGORY E:

CRITICAL INFRASTRUCTURE RESILIENCE

E-1 MUNICIPAL PUMP STATION RESILIENCE

High Level Approach	Accommodate

Sub-measure

E-1-1	Pump station floodproofing by elevation
E-1-2	Floodproofing by tanking
E-1-3	Relocation
E-1-4	Backup power

Barrowtown Pump Station in Abbotsford

No. 4 Road pump station in Richmond

Description

Municipal sanitary, stormwater, and potable water pump stations are critical infrastructure components that can significantly complicate recovery efforts after a flood if they are damaged by flooding. Damage to sanitary pump stations, in particular, can result in floodwaters contaminated with wastewater which can be a health hazard both during the flood and after the flood resulting in significant building restoration efforts and delayed re-entry following evacuation orders.

Key components that can be damaged include electrical controls, mechanical components including internal piping, and power sources.

Measures to increase the resilience of pump stations to flooding include relocation away from high hazard areas, floodproofing, and backup power supply. Relocation is not always an option, particularly for sanitary pump stations which by necessity are located at the lowest topography to collect and pump wastewater.

Pros

- Reduced flood impacts and reduced recovery time and effort

Cons

- Relocation is not always an option
- Backup power and floodproofing increase cost

E-1 MUNICIPAL PUMP STATION RESILIENCE

Applicability on the North Shore

The North Shore has many pump stations that would be directly impacted by coastal flooding without adaptation and others that would be indirectly affected due to flood impacts to power sources (substations). Over the coming decades, many pump stations will need to be upgraded and there is an opportunity to add significant resilience to this critical infrastructure.

APPLICABILITY: HIGH

Additional Reference Photos

Wiggins Pump Station (Burnaby)

E-2 POWER TRANSMISSION INFRASTRUCTURE RESILIENCE

High Level Approach

Accommodate

Avoid

Sub-measure

E-2-1	Substation relocation
E-2-2	Substation flood protection and equipment floodproofing
E-2-3	Electrical kiosk and vault floodproofing design guidelines

Substation flood protection

Substation flood protection

Description

Electrical power transmission infrastructure is a critical infrastructure that can significantly complicate recovery efforts after a flood if damaged.

In general, there are 2 layers of infrastructure to consider: substations located in the floodplain and local infrastructure (kiosks, vaults and transmission lines) located in the floodplain. The former is critical because damage would not only impact the floodplain, but could expand far beyond the flooded area. The latter (kiosks, vaults and transmission lines) are also important because without improving the resilience of these infrastructure components, the electrical utility may shutdown the grid in a flooded area as a precautionary step. Furthermore, if the area under transmission lines is to be raised (for land raising or dike concepts), it would be prudent to coordinate with other maintenance work, to avoid moving the lines more than once.

Ideally, new or replacement substations would be located outside of the floodplain. Alternatively, substations can be floodproofed through permanent or temporary structural flood protection works (e.g. ring dike or flood wall with gate) and/or specific critical equipment raising.

Pros

- Increased resilience and reduced recovery time and effort

Cons

- Cost of replacing before end-of-life or of floodproofing

E-2 POWER TRANSMISSION INFRASTRUCTURE RESILIENCE

Applicability on the North Shore

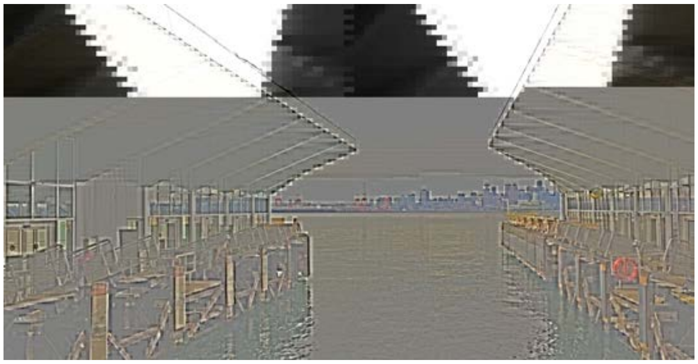
Relocating or floodproofing of the BC Hydro substations within the coastal floodplain would significantly reduce the estimated impact of flooding on businesses, critical social facilities, and vulnerable people.

APPLICABILITY: HIGH

E-3 TRANSPORTATION INFRASTRUCTURE RESILIENCE

High Level Approach

Accommodate



Current Lonsdale Quay Seabus terminal

Sub-measure

E-3-1	Translink Lonsdale Quay SeaBus terminal upgrade
E-3-2	BC Ferries Horseshoe Bay terminal upgrade
E-3-3	Gradual road raising through asset management
E-3-4	Emergency routes raising
E-3-5	Railway corridor raising

Description

Upgrading the SeaBus and BC Ferries terminal are site-specific opportunities to increase flood resilience to reduce the impacts of flooding and reduce the recovery time after a flood. For both facilities, it is important to note that access to the water needs to be maintained and upgrades would likely focus on critical mechanical/electrical infrastructure, the use of flood resilient building materials, and access/egress.

Raising linear infrastructure is a more broad, regional option to coordinate along jurisdictions to raise roads above flood levels to either act as flood protection themselves (i.e. roads on top of a dike) or to avoid nuisance flooding on vulnerable roads and emergency routes before structural measures are implemented or in areas where structural approaches are not preferred. Road raising can be achieved gradually through asset management and area-specific planning, or it can be done in some cases as an individual capital project.

Rail corridor raising would provide an opportunity for community scale flood protection and for protection of the rail system, but raising is complicated given slope design constraints of railways. Additionally, the level of risk tolerance for a rail operation may be higher than the overall community.

Pros

- Raising linear infrastructure protects it, and also acts as protection for land behind it
- Ocean transit facilities are critical transportation links in BC

Cons

- High cost to raise large portions of road
- Rail raising may not be feasible

E-3 TRANSPORTATION INFRASTRUCTURE RESILIENCE

Applicability on the North Shore

Given that there are no existing coastal dikes on the North Shore, road raising is a distinct option for achieving flood protection either as part of primary flood protection dikes or through adding secondary resilience in combination with land raising concepts.

APPLICABILITY: HIGH

Additional Reference Photos

Raised road

CATEGORY F:

RESPONSE & RECOVERY PHASE RISK REDUCTION MEASURES

F-1 FLOOD FORECASTING AND OPERATIONAL PLANNING

High Level Approach	Avoid	Resist	Advance	Retreat	Accommodate

Stockpiled sandbags in advance of a flood

GNSS tide gauge in Sweden

Sub-measure

- F-1-1 Coastal water level monitoring and forecasting
- F-1-2 Wave hazard monitoring and forecasting
- F-1-3 Operational response planning
- F-1-4 Operational response stockpile (temporary barriers, etc.)

Description

Flood forecasting is an important component of operational response planning. The Province of BC developed the StormSurgeBC (www.stormsurgebc.ca) coastal water level forecast which provides multi-day stillwater level forecasts. This information can be incorporated into local operational planning, including informing flood preparedness during spring perigean (king) tide periods and during significant storm surge events. Water level forecasting information is relevant now to low-lying areas of the North Shore which experience seasonal flooding and will become relevant to larger areas as sea level rise occurs.

Wave hazard forecasting and information sharing may be of interest to areas west of the Lion's Gate Bridge which are more affected by wind-generated waves. However, wave conditions are often very site-specific and general forecasting may not be effective.

Operational response planning and stockpiling of flood-fighting materials and equipment is relevant for current low-lying areas that experience flooding during king tide events and will be impacted most in larger events.

F-1 FLOOD FORECASTING AND OPERATIONAL PLANNING

Pros

- Operational response can reduce impacts and damages associated with flooding, particularly in smaller events

Cons

- Not effective without other measures, particularly in large flood events
- Reliance on forecasting programs which can be uncertain

Applicability on the North Shore

Very few locations on the North Shore currently flood regularly and require seasonal flood forecasting and response. However, as sea level rise occurs, more areas will be exposed to seasonal or infrequent flooding where operational response and flood fighting measures may be effective. There is a potential for NSEM to coordinate response roles as issues emerge over time. This measure may be more effective currently for some of the low-lying industrial and port lands where land raising or diking may not be a preferred approach.

APPLICABILITY: LOW

F-2 RECOVERY PHASE RISK REDUCTION

High Level Approach

Accommodate

Avoid

Sub-measure

F-2-1	Post-damage property acquisition program
F-2-2	Build back better policies for redevelopment after damage

Description

Response and recovery measures include steps that the partners can take in advance of a flood event to ensure that flood recovery is as effective as possible.

In particular, policies can be developed to indicate a desire to discourage redevelopment or densification in high-risk areas after a major flood has caused significant damage. This can involve a post-flood property acquisition program or build back better policies to increase resilience through floodproofing. The concept 'build back better' was defined by the UN Sendai Framework for Disaster Risk Reduction and uses disaster as a trigger to create more resilient nations and societies than before through the implementation of risk reduction measures.

Pros

- Post-flood managed retreat or avoid strategies can be highly effective at reducing risk
- Build back better approach can leverage post-flood recovery momentum for increased resilience

Cons

- Resistance to post-flood property acquisitions and redevelopment restrictions

Applicability on the North Shore

Given the timeline for sea level rise projections, proactive planning and managing risk through redevelopment is likely a more efficient route to risk reduction than large programs aimed at using post-flood recovery as an opportunity to reduce risk. The Port may have the capacity and interest to acquire lands which are deemed flood-prone in a post-damage property acquisition program.

APPLICABILITY: LOW

CATEGORY G:

COMMUNITY AND CULTURAL RESILIENCE MEASURES

G-1 PUBLIC AWARENESS AND RISK REDUCTION EMPOWERMENT

High Level Approach

Accommodate

Flood hazard signage

Sub-measure

G-1-1	Education and awareness campaign - everyone has a role to play
G-1-2	Education materials to promote safe use of foreshore, estuaries, and waterfront
G-1-3	Public signage for flood hazard area
G-1-4	Flood insurance education
G-1-5	Neighbourhood level flood maps and response plans
G-1-6	Home and business flood assessment and resilience planning incentive program

Description

Increasing public awareness of coastal flood hazards will allow individuals to take steps towards increasing their personal resiliency to flooding.

Education for the public could include permanent signage in flood hazard areas or in coastal recreational areas like Ambleside Park or Maplewood Flats to increase general awareness of tides, currents, and wave hazards. Signage is relatively cost effective and would require little upkeep. More involved public education work could include awareness campaigns about the steps that individuals can take to become more prepared for coastal flood events, as well as to encourage the uptake of flood insurance by property-owners in the floodplain.

The creation of neighbourhood level flood maps would allow for high resolution, specific analysis of flood consequences and therefore response plans tailored to that area. An example of neighbourhood-level response planning could be the creation of NeighbourHubs (which are designated meeting places that integrate emergency supplies; built examples are on the Arbutus Greenway in Vancouver and Leonard St. in Victoria).

Pros

- A knowledgeable public is a prepared public

Cons

- Educational campaigns would need to occur on a recurring basis, to ensure that the level of knowledge remains high as the North Shore population changes

G-1 PUBLIC AWARENESS AND RISK REDUCTION EMPOWERMENT

Applicability on the North Shore

The difficulty of implementation varies between these sub-measures. Carrying out the low-barrier steps, such as creating signage, would be a straightforward first step to take. Measures such as creating an on-going educational campaign would take more effort. Therefore, the degree of public awareness-raising can be flexible to accommodate the capacity and budget of the partners.

APPLICABILITY: HIGH

Additional Reference Photos


Search Twitter

PreparedBC
@PreparedBC

Get your property flood-ready while home during #COVID19

✅Store valuables and important documents in water-tight containers or on shelves & upper floors

✅ Clear gutters

✅ Clear nearby storm drains

Learn more at preparedbc.ca/floods #EPWeek2020 #YouGotThis

9:43 AM · May 8, 2020 · Twitter Web App

Flood preparedness and resilience public information shared by EMBC on social media

G-2 PROTECTION OF CULTURAL SITES

High Level Approach

Resist

Accommodate


North Shore shoreline

Sub-measures

- G-2-1 Special floodproofing measures
- G-2-2 Consider options to cap known archaeological sites
- G-2-3 Proactive data collection of known cultural and archaeological sites
- G-2-4 Drainage measures to mitigate flooding and cross-contamination

Description

Special flood protection measures may be required to protect important cultural and archaeological sites from future flooding and damage. In some areas where flooding cannot be prevented, data collection to record historic use and information about cultural sites may be an important way to preserve important cultural information. For options for heritage buildings, refer to measures B-1 and C-2.

Pros

- Protects or documents critical cultural resources that are important for knowledge sharing, community health, and spiritual practices

Cons

- May be difficult to adequately protect sites without damage or preventing access

Applicability on the North Shore

Archaeological site locations are sensitive, and protected under the Heritage Conservation Act; furthermore, archaeological sites must not be altered without a permit from the Province. Considerations must be made towards the security of private information regarding the locations of cultural and archaeological sites. Therefore, other partners should follow the lead of Squamish Nation and other local First Nations, including the Tsleil-Waututh Nation in supporting these measures.

APPLICABILITY: HIGH

G-3 EMPOWERING NON-GOVERNMENTAL STAKEHOLDERS TO INCREASE RESILIENCE

High Level Approach: Accommodate

Children's drawing about the causes of coastal flooding

Sub-measure

G-3-1	Homeowner flood risk assessment and resilience planning program with incentives
G-3-2	Build awareness of alternative social, health, and emergency response facilities outside of high-risk areas
G-3-3	Encouraging business flood risk assessment and continuity planning program for businesses and social services with incentives/regulations/by providing resources
G-3-4	Youth and school education programs about flood resilience
G-3-5	Flood insurance incentives/requirements

Description

Empowering non-governmental stakeholders to take actions to reduce their flood vulnerability will increase the overall societal resilience to coastal flood hazards. This can be accomplished through a variety of means, through integrating flood hazard awareness in school programs, through incentivizing homeowner/business risk assessments or through public engagement with more detailed adaptation planning.

These measures build on the public awareness-raising from measure G-1, and provide resources to residents so they are able to be more prepared for a coastal flood.

Integrating flood resilience in schools could fall under the current curriculum of Science 7 (under the topic of "evidence of climate change over geological time and the recent impacts of humans") or Earth Sciences 11 ("effects of climate change on water sources").

Pros

- In concert with actions taken by governments, individual actions can increase resilience
- Youth programs allow knowledge into communities that may not engage with other educational programs due to barriers such as language

Cons

- Must be coupled with governmental action to protect all residents, or else is ineffective

G-3 EMPOWERING NON-GOVERNMENTAL STAKEHOLDERS TO INCREASE RESILIENCE

Applicability on the North Shore

Thoughtful design and planning of incentives / resources / educational materials will allow future work towards this measure to proceed more easily. Once the materials exist, raising awareness of incentives and resources would need to be on-going, as well as monitoring their rates of use by residents.

APPLICABILITY: HIGH