SEA LEVEL RISE ADAPTATION PRIMER

A TOOLKIT TO BUILD ADAPTIVE CAPACITY ON CANADA'S SOUTH COASTS

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This Primer is a resource for coastal management authorities (mainly local governments) to help them identify and evaluate options for adapting to the impacts of sea level rise and associated hazards. The Primer is intended to be relevant for southern coastal regions across Canada with application to British Columbia, Quebec, and the Atlantic region.

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Solutions d'adaptation aux changements climatiques pour l'Atlantique

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Cover photos:

Photo 1 (top): Stock photo

Photo 2 (bottom far left): Dune protection consisting of sand fence with spruce boughs, Souris Causeway, P.E.I. *(Photo: D. Jardine)*

Photo 3 (bottom middle left): 18th century mooring ring at Fortress of Louisbourg *(Photo: Ambrose MacNeil)*

Photo 4 (bottom middle right): West Vancouver, B.C. Seawall

Photo 4 (bottom middle right): Fraser River Park Vancouver, B.C. *(Photo: Hay & Company Consultants Inc.)*

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Executive Summary

Climate change is here, increasing global loss of life and property damage as weather patterns change. We now know that with climate change comes rising seas – and that this sea level rise will dramatically affect Canada's southern coastal communities.[1] These communities will require resilience and adaptive capacity to ensure their long-term sustainability.

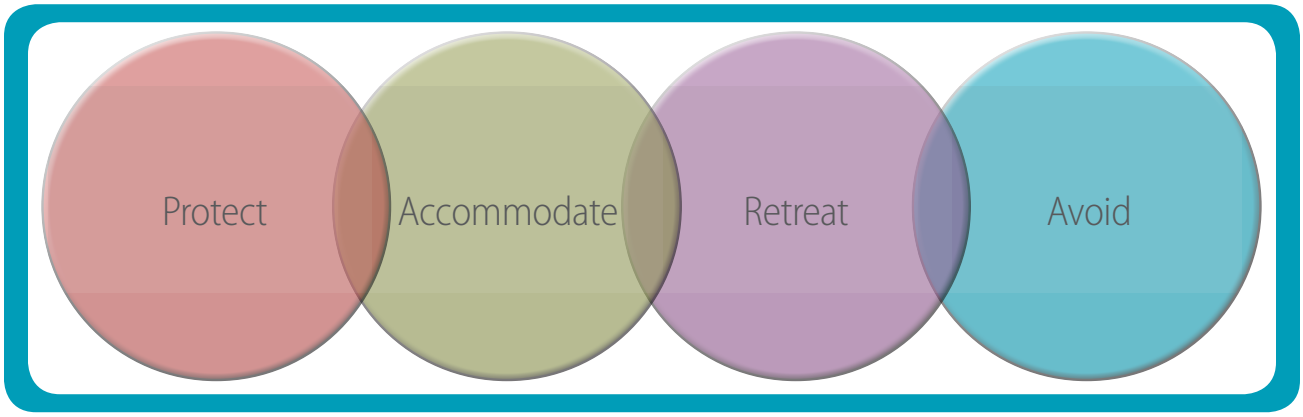
Coastal hazards associated with sea level rise include:

- Coastal inundation and reduced drainage capacity;
- Coastal erosion;
- Changes to coastal habitats and loss of wetlands such as salt marshes;
- Reduction in coastal sea ice; and
- More frequent and intense storms, storm surge and wave action.

This Primer provides an introduction to past and future sea levels, an overview of four different **adaptation strategies**, a recommended framework for decision making and finally a total of 21 **adaptation tools** to support local adaptation action.

The B.C. Ministry of the Environment commissioned the preparation of this Sea Level Rise Adaptation Primer for Canada's Atlantic and Pacific coasts. Although this Primer was prepared in B.C., legislative provisions, policies and local government applications discussed in this Primer include B.C., southern Quebec and the Atlantic coasts of New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador. Coastal communities along Hudson Bay and in the Arctic face a different set of vulnerabilities and were not considered within the context of this research.

Adaptation strategies to sea level rise can be grouped as follows:



Protect is a reactive strategy to protect people, property and infrastructure from sea level rise and is typically the first response considered. Protecting the coastline through structural mechanisms such as dikes, seawalls and groynes has been the traditional approach to dealing with sea level rise in many parts of the world. With increasing sea level rise and coastal vulnerability, this strategy may be prohibitively expensive and have limited long-term effectiveness in highly vulnerable locations.

Accommodate is an adaptive strategy that allows continued occupation of coastal areas while changes are made to human activities and/or infrastructure to adapt to sea level rise. Accommodation can also involve retrofitting a building or making it more resilient to the consequences of sea level rise. Other accommodation measures may include liability reduction, such as a covenant indemnifying governments from the consequences of coastal hazards regardless of protection works undertaken.

1 (Intergovernmental Panel on Climate Change (IPCC) 2007).

Retreat or Managed Retreat refers to any strategic decision to withdraw, relocate or abandon private or public assets at risk due to sea level rise and associated coastal hazards. Retreat is an adaptive strategy to limit the use of structural protection, discourage development in areas subject to sea level rise, and plan for the eventual relocation of buildings and infrastructure to areas with no risk or lesser risk.

Avoid involves ensuring new development does not take place in areas subject to coastal hazards associated with sea level rise or where the risk is low at present but will increase over time. This may involve identifying future "no build" areas within local government planning documents. A wide range of planning tools may be involved, leading to a decision to avoid development in areas subject to moderate to high risk. An avoid strategy may involve land acquisition or the transfer of development potential to areas of lower risk.

These adaptation strategies are not mutually exclusive. Two or more strategies may be applied in different geographic areas by the same local government. The most appropriate strategy for a geographic area may also change over time. To implement these strategies, a wide range of adaptation tools are available.

Adaptation tools included in this Primer should be considered in the context of information gathering, public education and community engagement, all crucial to informed decision-making processes within our democratic system.

> ***Planning tools*** in this Primer include local government growth management objectives and policies, mapping of potential coastal hazards, risk management and emergency preparedness.
>
> ***Regulatory tools*** include the regulation of subdivision, land use and buildings. These regulatory tools are generally prescribed by legislation and require the approval of a decision-maker or "gatekeeper" responsible for the protection of the public interest.
>
> ***Land use change or restriction tools*** focus on the change or restriction of land use other than through the regulatory functions noted above. Some of these tools are at the disposal of local government and others may be undertaken by private landowners or community groups in order to achieve local government goals.
>
> ***Structural tools*** consist of physical structures on land or in water to protect land and buildings from coastal hazards. A wide range of hard protection and armouring fit in this category.
>
> ***Non-structural or soft armouring measures*** include the creation or restoration of wetlands, building sand dunes, or rehabilitation and beach nourishment. Both sand dunes and beaches are naturally occurring features, created by the interaction of wind, waves and sediment. They serve to dissipate the energy of storm surges and wave action. These natural features can be mimicked or recreated to provide an adaptive buffer to sea level rise.

Several of these tools are interdependent and should be used in combination. While structural and non-structural adaptation tools may appear to represent polar opposites, combining them and creating hybrid shoreline protection systems may result in synergies and cumulative benefits. As one example, living shorelines are hybrid protection systems that use coastal ecosystems to reduce erosion risk and optimize natural shoreline functions.

An analysis of each adaptation tool is provided in this Primer. The analysis includes a description of the tool, a discussion of implementation methods and an identification of the enabling legislation, where applicable. Advantages and disadvantages of the tool are also examined using a 'triple bottom line' approach.

In addition to tools available to local governments, insurance and emergency management are also adaptation tools included in the Primer. Overland flood insurance for residential development, while not a tool available to the public or any level of government in Canada, is discussed as it plays a major role in all other G8 countries. Emergency management is a tool available to communities across Canada, but responsibility for emergency management is shared with senior governments.

Also included in the Primer are appendices consisting of: acronyms; a glossary of terms; a spreadsheet profiling the adaptation tools; legislative matrices in B.C. and Atlantic Canada; and a wide range of municipal policies and bylaws in Atlantic Canada. The Primer concludes with both an annotated bibliography and a bibliography organized into four geographic areas: Canada, Quebec, U.S.A., and other international areas.

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Introduction

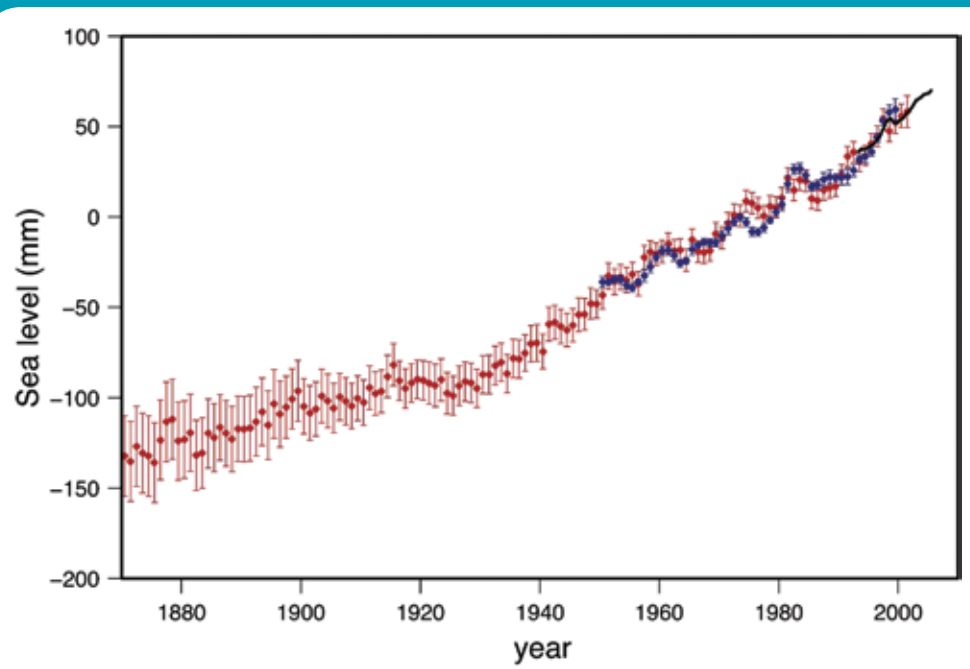
Even if greenhouse gas emissions halt tomorrow, the impacts of climate change will continue into the foreseeable future. One of the recognized impacts of climate change – and potentially the most dramatic for the many coastal communities of Canada – is sea level rise (SLR).[2]

As oceans warm, they expand, raising global sea levels. Melting ice caps, mountain glaciers, and land based ice sheets (e.g. Antarctica and Greenland) also contribute to rising sea levels. In several areas on Canada's coast, geophysical factors, including subsidence and tectonic forces, also play a role. Coastal hazards associated with sea level rise include coastal inundation, erosion, loss of intertidal habitat ('coastal squeeze') and loss of sea ice. Climate change also brings the prospect of more frequent and intense storms and floods – particularly if storms occur during high tides.[3]

Observed Changes in Sea Level

In the latter part of the 19th century and during the 20th century, the global mean sea level rose at a rate of about 1.7 mm/year (17 cm/century).[4] Since 1993, the rate of global sea level rise has increased to around 3 mm/year.

Figure 1 - Global Trends in Mean Sea Level (IPCC, 2007)



The red curve shows reconstructed sea levels from 1870 to 1950. The blue curve shows coastal tide gauge measurements from 1950, and the black curve is based on satellite altimetry. The upper and lower limits in the curves show 90% confidence levels, which have narrowed over time due to the increasing accuracy of data measurement techniques.

[2] (Ausenco Sandwell 2011)
[3] (National Round Table on the Environment and the Economy 2011)
[4] (IPCC Fourth Assessment Report: Climate Change 2007)

Storm surge is one of the more common coastal hazards associated with sea level rise and a significant contributor to coastal flooding. A storm surge refers to a temporary increase in the height of the sea due to extreme meteorological conditions such as low atmospheric pressure and/or strong winds. A storm surge is independent of a high tide, but its impact may be magnified during a high tide. In addition, sea level rise accentuates the risks from storm surge activity as higher water levels advance further inland and affect areas of higher elevation. It is anticipated that climate change will cause more intense and frequent storms in the northern hemisphere and that sea level rise will increase the coastal areas at risk from these events.[5] While a storm surge temporarily raises relative sea level, wave action is a more destructive force associated with storms. Shoreline type and exposure to open water will determine wave intensity and frequency and therefore the effects of increased wave action and height on erosion and flooding. In addition to relative sea level, waves are affected by bathymetry of the near shore (i.e. off-shore depth and topography). Increases in sea level may cause wave impacts to reach further inland or overtop defences that were previously sufficient, causing damage and flooding.

Global factors contributing to sea level rise include thermal expansion, melting of glaciers and ice caps, the melting of the Greenland ice sheet and the melting of the Antarctic ice sheet. From 1961-2003, melting glaciers and ice caps contributed the most to the increase in sea level rise. From 1993 to 2003, the increased global rate was due mainly to thermal expansion.

On the B.C. coast, sea level rise has occurred in most locations but at a lower rate than the global average of 17 cm/century. Tectonic changes are a major factor on the B.C. coast, with structural uplift occurring on the west coast of Vancouver Island and subduction occurring in the Strait of Georgia. Other regional factors include the subsidence of alluvial soils in the Fraser River estuary and postglacial rebound. Historic sea level rise changes along the B.C. coast include the following:[6]

- Prince Rupert 9.8 cm/century
- Vancouver 2.0 cm/50 years
- Victoria 3.1 cm/50 years
- Tofino -16.8 cm/century

In Nova Scotia, the present rate of sea level rise is higher than the global mean; during the 20th century, the increase was about 30 cm. This trend is exemplified at the Fortress of Louisburg National Historic Site (Cape Breton, N.S.) where a 1740s ship's mooring ring is located half a metre below today's high tide level (see following photo).

18th century mooring ring at Fortress of Louisbourg *(Photo: Ambrose MacNeil)*

[5] Stanton, Davis and Fencl 2010)
[6] Marine Environmental Data Service, Fisheries and Oceans Canada

In much of Atlantic Canada, sea level rise has exceeded the global increase due to the additional effect of regional subsidence of the Earth's crust. This subsidence is caused by the gradual collapse and migration of an area of uplift that developed around the margins of the North American ice sheets and by additional water loading on the seabed of the Gulf of St. Lawrence as global mean sea levels have risen. This phenomenon is referred to as "glacial isostatic adjustment."[7] In Nova Scotia, subsidence is estimated to be up to 20 cm/century.[8] In Halifax, approximately half of the relative sea level rise is due to global mean sea level rise, with the remaining half due to regional subsidence.

On the other hand, the north shore of the Gulf of St. Lawrence in Quebec and Labrador is rebounding. Based on long-term harbour records, the following sea level rise trends have been documented:

- Halifax, Nova Scotia — 32 cm/century (records from 1920-2008)
- Yarmouth, Nova Scotia — 30 cm/century (records from 1967-2008)
- North Sydney, Nova Scotia — 30 cm/century (records from 1970-2008)
- Pictou, Nova Scotia — 24 cm/century (records from 1966-1995)
- Charlottetown, Prince Edward Island — 32 cm/century (records from 1911-2008)
- Saint John, New Brunswick — 22 cm/century (records from 1906-2008)

Projected Increases in Sea Level

How will sea level change in the future?

How much sea level rise will occur is subject to uncertainty – and the longer the time frame, the greater the degree of uncertainty.

In its Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) projected global sea level rise using six different scenarios of future greenhouse gas (GHG) emissions. Variables used to determine GHG emissions included population projections, economic growth and the use of technology.

Depending on the IPCC scenario used, the estimated rise in global sea level to the end of this century (i.e. 2100) varies from 18 to 59 cm. Based on the large body of research which has taken place since the IPCC scenarios were prepared in 2007, these projections may be quite conservative. Recent scientific research based on empirical relationships between atmospheric carbon concentrations and sea levels in the paleoclimatological record suggests that the upper bounds of physically plausible sea level rise is larger than once thought, owing to thermal expansion and glacial and ice sheet melt. These "semi-empirical" studies generally project a sea level rise of between 0.47 m and 1.9 m by the year 2100.[9]

Both B.C. and Atlantic Canada recommend planning for sea level rise of approximately 1.0 m by the year 2100. A 2011 study for the Government of B.C. recommended sea level rise planning levels of 0.5 metres (50 cm) to the year 2050, 1.0 metre to the year 2100 and 2.0 metres to the year 2200.[10] This is higher than the 2007 IPCC scenarios but is consistent with sea level rise projections used for planning purposes in Europe and the U.S.A.

Even if drastic measures are undertaken to slow down or even stop carbon emissions, sea levels will continue to rise for many centuries after global temperatures stabilize: a reality which has significant implications for local government planning.[11] Planning for sea level rise presents a challenge for local governments; especially as many communities in Canada are relatively young and growing rapidly. For example, the first local government to be incorporated in B.C. was New Westminster in 1859 and the oldest continuously occupied building in the province is less than 170 years old.

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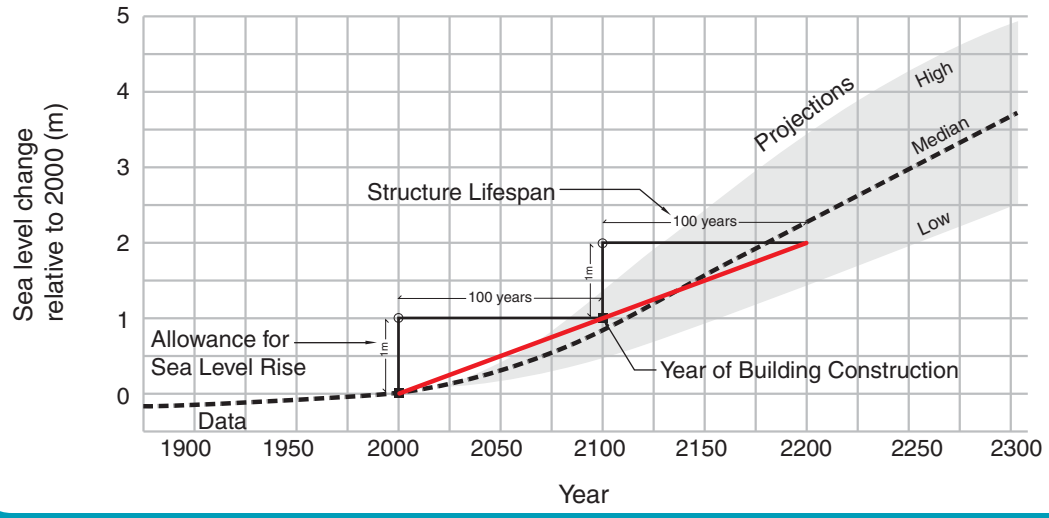
7 (CBCL Limited 2009)
8 (CBCL Limited 2009)
9 (IPCC 2012)
10 (Ausenco Sandwell 2011)
11 (Ausenco Sandwell 2011)

Most buildings and infrastructure have a lifespan much longer than the 20-30 year future time period often used when designing infrastructure and planning communities. Planning for a century of change is a challenge, but is a realistic goal given the implications of projected sea level rise. Figure 2 (below) shows the effect of incremental increases in minimum building elevation planning over time, based on a 100 year lifespan for a structure.

Figure 2 - Sea level rise allowance for structure lifespan *(Ausenco Sandwell, 2011)*



Regardless of the time frame used, observations and predictions of sea level rise will need to be periodically re-evaluated. Predictions of sea level rise will continue to evolve and be refined as the science progresses and more data becomes available.

Vulnerability and Adaptation

The impact of sea level rise on Canada's coastal zones depends largely on the vulnerability of coastal communities. A community's vulnerability is a function of its exposure and sensitivity to a hazard or environmental change and its adaptive capacity or resilience. Adaptive capacity is a function of local context and refers to a community's ability to adapt to potential impacts, as well as cope with specific events, based on its social, economic and institutional resources.[12] Vulnerability can therefore be lowered by adaptation measures which reduce exposure to (or risk from) a hazard or by increasing resilience.[13]

Some of Canada's greatest vulnerabilities to climate change lie in coastal areas, which are home to concentrated populations, economic centres and valuable ecosystems.[14] Although Canada has a vast coastline, the inhabited coastal area represents only 2.6% of the total land area. In 2001, 38.3% of the Canadian population lived within 20 kilometres (km) of a marine or Great Lakes shoreline. Of this total, approximately 4.9 million people, or 23%, lived on the Pacific coast, and 20% lived on the Atlantic coast.[15]

By 2015, it is estimated that a majority of Canadians (50.7%) will be living within 20 km of the coast or the Great Lakes, with the greatest concentration of people living within 5 km of a shoreline.[16]

A proactive approach to sea level rise adaptation is more cost effective and less disruptive than a reactive approach. Adaptation should ideally aim to create resilient communities through a triple bottom line approach that (1) minimizes the unplanned loss of land and physical capital such as infrastructure;

12 (Barron, et al. 2012)
13 (Mason 2005)
14 (Stanton, Davis and Fencl 2010)
15 (Mason 2005)
16 (Mason 2005)

(2) reduces coastal flood risks to acceptable levels in human settlements; and (3) retreats in a planned and efficient way from areas that cannot be protected in a cost-effective manner.[17] Adaptation is more than the simple implementation of a suitable practice or technology. Sea level rise is a progressive and dynamic process and continuous adaptation is required. Adaptation should be viewed by community decision makers as an ongoing process whereby risks and opportunities are prioritized, risk reduction measures are implemented and their effectiveness is tracked and assessed.

Figure 3 - Coastal sensitivity to sea level rise – Natural Resources Canada

Coastal Sensitivity

Natural Resources Canada has mapped the sensitivity of Canada's coastlines to a rise in sea level. Sensitivity here means the degree to which a coastline may experience physical changes such as flooding, erosion, beach migration and coastal dune destabilization. The sensitivity index is a product of seven variables: relief (topography), geology, coastal landform, sea level tendency, shoreline displacement, tidal range and wave height.

Approximately 7,000 kilometres of coastline are considered sensitive to sea level rise.[18] Most of the British Columbia coast has a low sensitivity, mainly due to relief, geology and coastal landforms. However, the areas at greatest risk are home to significant concentrations of population, built infrastructure and economic activity. Major areas of Atlantic Canada (in particular the coasts of Nova Scotia, Prince Edward Island and New Brunswick) are considered to have a high sensitivity to sea level rise. In addition, small areas of high sensitivity occur locally in B.C., Quebec, and Newfoundland and Labrador.

[17] (Hallegate 2011)
[18] (Natural Resources Canada 2007)

Primer Focus Area

Primer Focus Area

This Primer focuses on adaptation tools for Canada's southern coasts, namely the provinces of British Columbia, Quebec, and the Atlantic Provinces of New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador. At 243,000 kilometres, Canada's shoreline is the longest in the world.[19] Although largely undeveloped, coastal areas contain many of Canada's major population and economic centres.

British Columbia

POPULATION 4,400,057 (2011 CENSUS)

The B.C. coastline has a total length of approximately 29,000 km,[20] including the mainland and all islands from Haida Gwaii south to Vancouver Island and the Gulf Islands. Although dominated by rocky high-relief shores, the B.C. coast also has numerous long, twisting, deep fjords and some wide sand beaches. Over 80% of the population of B.C. lives within 5 km of the coast.[21]

In the Lower Mainland, where the majority of the population resides, there are many areas close to sea level which are vulnerable to the potential effects of sea level rise. In most cases these areas are currently protected by structural features such as dikes. Areas currently protected by dikes include the City of Richmond, Ladner and waterfront areas in New Westminster, Port Moody and White Rock as well as all Delta and Surrey farmland. Waterfront areas in Vancouver – including Stanley Park, Southlands, False Creek, West and North Vancouver and the Vancouver International Airport are also protected by dikes. In addition, most Musqueam, Tsawwassen, Semiahmoo, Tsleil Waututh and Squamish First Nations lands, all in the Lower Mainland, are close to sea level. Over 4,600 hectares of farmland and over 15,000 hectares of industrial and urban residential areas in the Lower Mainland are located within 1 metre of sea level.[22] On Vancouver Island, almost all communities have ocean exposure and many have vulnerable coastlines or low-lying areas. Along the northern coast of B.C., critical infrastructure in the Port of Prince Rupert is close to sea level, as are most settlements on Haida Gwaii.

In all, some 59 of 161 municipalities and 14 of 29 regional districts in B.C. consist of coastal communities or have some direct coastline exposure. British Columbia's *Local Government Act* allows local governments to manage land use in coastal areas using a range of tools including official community plans and zoning bylaws. Flood Hazard Area Land Use Management Guidelines released by the province in 2004 recommend a minimum Flood Construction Level of 1.5 m above the natural boundary of the sea and a minimum building setback distance from the sea of 15 m. While local governments are required to consider these guidelines when establishing floodplain bylaws, the manner in which the guidelines are applied varies by municipality.

A 2011 study commissioned by the B.C. government[23] recommended sea level rise planning levels of 0.5 metres (50 cm) to the year 2050, 1.0 metres to the year 2100 and 2.0 metres to the year 2200 (see Figure 2) plus adjustments for local rates of vertical land movement (uplift or subsidence). Sea level rise will not take place uniformly along the B.C. coast. Variations will occur due to the settlement of alluvial soils, aquifer reduction caused by fresh water removal, and tectonic change as the Juan de Fuca plate subducts beneath the North American plate. In addition, because of land subsidence in the Fraser River delta, relative sea level will increase by an additional 1–2 mm per year, primarily affecting Richmond, Delta, Queensborough and the New Westminster Quay. Post-glacial rebound and tectonic uplift partially mitigate global sea level rise

[19] (Natural Resources Canada 2007)
[20] (Marine Planning Office, Province of B.C. n.d.)
[21] (Mason 2005)
[22] (Ausenco Sandwell 2011)
[23] (Ausenco Sandwell 2011)

in some locations[24] of B.C. such as on the west coast of Vancouver Island. In the most sensitive areas, much of today's coastal wetlands, barrier beaches and lagoons will be underwater, and coastal structures will become increasingly vulnerable to flood damage.

Quebec
POPULATION 7,903,001 (2011 CENSUS)

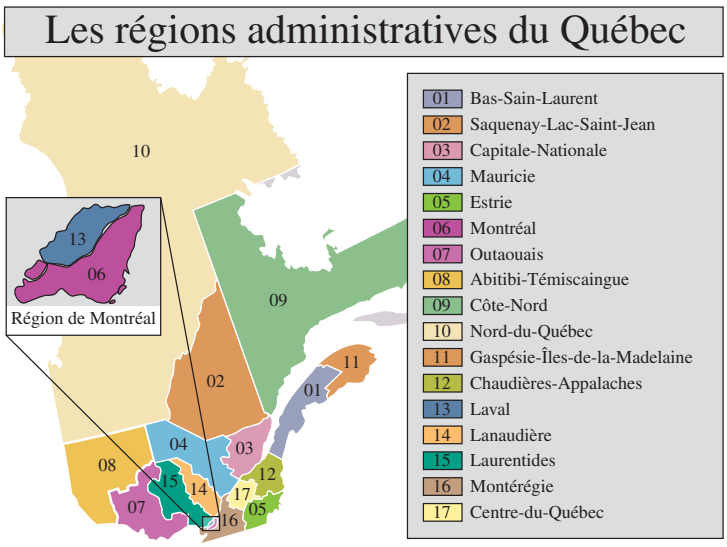
The coastal region of Quebec stretches northeast of Quebec City and around the Gulf of St. Lawrence for 3,500 km. The Gulf of Saint Lawrence is the world's largest estuary covering an area of about 236,000 square kilometres. The Gulf begins in Quebec as the outlet for the Great Lakes which travel along the Saint Lawrence River on their way to the Atlantic Ocean. The north coast (Côte Nord region) has 1,825 km of coastline. Just over a third of this coastline is comprised of primarily rocky cliffs, 38% is rocky cliffs with shallow beach, lagoon or estuary covering over the rock substratum and the remainder of the coastline consists of beaches, lagoons or estuaries. The south coast and islands (Bas-Saint-Laurent and Gaspésie-Iles-de-la-Madeleine regions), are comprised of 1500 km of coastline. Approximately half of the coastline for la Gaspésie consists of rocky cliff escarpments, soft clay cliffs, sandy beaches and marshes.[25] Over two thirds of the Magdalen Islands (Îles-de-la-Madeleine) coastline is sandy beaches, and the rest are soft clay cliffs and lagoons. It is estimated that 40% of the Bas-Saint-Laurent coastline is comprised of sandy beaches and the rest consists of marshes, rocky cliffs and clay cliffs.[26]

The province of Quebec consists of 17 administrative regions under provincial jurisdiction of which the regions of Côte-Nord, Bas-Saint-Laurent, and Gaspésie-Iles-de-la-Madeleine have coastlines exposed to the effects of sea level rise. Within these regions are 121 municipalities, home to a population of over 400,000 people. Most of the 121 municipalities along the coastal areas apply a 10–15 metre setback for the protection of the shorelines. This was established in 1987 by provincial policy. Some municipalities have adopted more stringent regulations based on detailed research on local erosion rates and corresponding government recommendations.

Not all coastal areas of Quebec have been or will continue to experience sea level rise in the same way. Some areas, such as Sandy Hook in Havre-Aubert on the Magdalen Islands, are in fact increasing their coastal reach into the sea through natural processes of erosion and sediment transport. Other communities are extending their coastal land area through dredging. Dramatic erosion during storm events is affecting the Côte-Nord region; and subsidence is affecting parts of the Bas-Saint-Laurent region and Chaleur Bay (Baie-des-Chaleurs) on the east point of the Gaspésie region.[27]

[24] (APEG Professional Engineers and Geoscientists of BC 2012)
[25] (L'erosion littorale en Gaspesie COMPRENDRE - GERER - AGIR 2010)
[26] (Juneau, Bachand and Lelievre 2012)
[27] (Morneau 2012)

Figure 4 - Quebec Administrative Regions *(Source: Banque d'images en Univers Social)*



Atlantic Canada

More than 2.3 million people live in the Atlantic region, most of them in urban areas and smaller communities along the coastline.[28] In 2001 it was estimated that over 60% of the population on the Atlantic Coast (including Quebec) lived within 5 km or less of the shoreline.[29]

The largest region of high sensitivity to sea level rise is in Atlantic Canada and includes large parts of the coasts of Nova Scotia, Prince Edward Island and New Brunswick.[30] In the Atlantic region, unlike other parts of Canada, the predicted effects of climate change, such as sea level rise and the increased occurrence and intensity of extreme weather events, are compounded in many coastal areas by post-glacial crustal subsidence. This increases coastal erosion and flooding, placing dikelands, coastal populations and their infrastructure and industries at risk.[31]

All four provinces have assumed a sea level rise of approximately one metre by the year 2100. This takes into consideration a component for the sinking or rising of the earth's crust as the result of a rebound effect from the last ice age, including consideration of vertical land movement. There is considerable consistency in the analysis and documentation of issues amongst the four provinces. Nevertheless, the legal and policy framework for dealing with coastal zone planning and development varies for each Atlantic province. Newfoundland and Labrador is the only Atlantic jurisdiction which has set a province wide high water design standard for sea level rise, storm surge and wave action in coastal areas; it is set for a 1:100 year return period. The other Atlantic Provinces rely on the generally accepted coastal engineering design standards for the life of structures in coastal areas, which is assumed to be 50 years. One major exception to this standard is the Confederation Bridge between New Brunswick and Prince Edward Island, which was built one metre higher to account for sea level rise over the 100 year design life of the project.

[28] (Environment Canada 2012)
[29] (Mason 2005)
[30] (Shaw, et al. 1998)
[31] (The Sustainable Planning Branch, New Brunswick Department of Environment and Local Government 2002)

New Brunswick
POPULATION 751,171 (2011 CENSUS)

The province of New Brunswick has approximately 5,500 km of salt-water coastline, which extends from the Gaspé Region to the Nova Scotia border and along the Bay of Fundy from The Saint Croix River to the Nova Scotia border. There is great diversity in the coastline from the rugged and grassy dunes along the Acadian Peninsula and Chaleur Bay to the sandy shores of the Northumberland Strait and the rocky cliffs of the Bay of Fundy.[32]

Nearly 60% of the population lives within 50 kilometres of the coast and there has been significant pressure for coastal development in recent years. Between 1990 and 1999, 6,268 new coastal lots were created – an average of 627 new coastal properties per year.[33] A total of 8 provincial counties and 50 municipal areas within them have coastline or areas exposed to the effects of sea level rise. The Gulf of St. Lawrence coast of New Brunswick is considered to have the highest sensitivity to sea level rise and associated storm impacts.[34]

Lameque, N.B. *(Photo from New Brunswick Coastal Areas Protection Policy)*

The New Brunswick Department of Environment and Local Government produced a Coastal Areas Protection Policy for New Brunswick in 2002. The New Brunswick coastal policy is enforced via existing provincial legislation such as environmental impact assessment requirements or watercourse alteration approvals. These provincial requirements also apply within municipalities, and some municipalities have incorporated either elements of or the entire coastal zone policy directly into their bylaws.

Estimates of global sea level rise in conjunction with the best estimates of local vertical motion have been used to predict 0.9 to 1.05 metres of total sea level rise over the next century for the coastlines of New Brunswick.[35]

[32] (The Sustainable Planning Branch, New Brunswick Department of Environment and Local Government 2002)
[33] Ibid
[34] (Daigle 2012)
[35] Ibid

Nova Scotia
POPULATION 921,727 (2011 CENSUS)

The province of Nova Scotia has 13,300 km of jagged coastline that includes some 3,800 coastal islands, bays and estuaries.[36] Development in Nova Scotia tends to be clustered with a high intensity of residences along the coast. The Province of Nova Scotia estimates 70% of the province's population lives on or near the coastline.[37]

Much of Nova Scotia is considered highly sensitive to sea level rise and has been experiencing extensive construction and creation of parcels in scenic coastal locations – many of which will be in hazard zones in a few decades.[38] The south coast and eastern shores of Nova Scotia have been shown to have significant sensitivity to sea level rise and associated storm impacts.

The Province of Nova Scotia includes 55 municipalities, three regional municipalities, 21 rural municipalities and 31 towns – the majority of which are on the coast or in areas potentially subject to coastal hazards associated with sea level rise. The Province has delegated land-use, or zoning powers, to the municipalities through the *Municipal Government Act* and the *Halifax Regional Municipality Charter*. These powers allow municipalities to develop planning strategies and bylaws to regulate land use. In spite of this, only about 45% of provincial land has comprehensive municipal plans or land-use bylaws in place.[39] Development on the shoreline continues with no buffers mandated except for a few designated protected beaches.

Nova Scotia has in place a Coastal Management Framework, which provides a foundation for governments and citizens to work together to ensure the sustainable use and protection of coastal areas and resources. The provincial priority coastal issues include coastal development, coastal access, sea level rise and storm events, working waterfronts, coastal water quality, and coastal ecosystems and habitats. This Framework provides an outline of how the province plans to move forward in protecting and maintaining its valuable coastal resources.

In 2002, the Province of Nova Scotia created a Provincial Oceans Network, which is comprised of representatives from provincial departments and agencies with responsibilities and interests in coastal and ocean management. Chaired by the Department of Fisheries & Aquaculture, the Provincial Oceans Network serves two core functions: 1) to provide advice and expertise in implementation of the Coastal Management Framework, and 2) to facilitate coordination on coastal and ocean management issues and initiatives within the provincial government.[40]

The Government of Nova Scotia has made coastal management a priority with the release of its State of Nova Scotia's Coast Report. This Report provides baseline information on the province's coastal areas and resources which will be used to develop a Coastal Strategy. A draft of the Coastal Strategy was released in 2012 and one of the key objectives is that buildings and infrastructure be located, built and maintained in a manner that minimizes impacts from rising sea levels and storms.

Present rates of relative sea level rise differ all over Nova Scotia due to varying rates of vertical land movement across the province. Estimates of relative SLR for Nova Scotia range between 0.7 to 1.4 m by the end of the century.[41]

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36 (Province of Nova Scotia 2009)
37 Ibid
38 (Shaw, et al. 1998)
39 (Province of Nova Scotia 2009)
40 (Province of Nova Scotia 2009)
41 (Province of Nova Scotia 2009)

Prince Edward Island
POPULATION 140,204 (2011 CENSUS)

The Province of P.E.I. has an ocean-influenced coastline of approximately 3,200 km. The coastline is deeply indented by tidal inlets, estuaries and salt marsh and generally alternates between headlands of steep sandstone bluffs and extensive sandy beaches. The north shore of the Island, facing the Gulf of St Lawrence, features extensive sand-dune formations.[42] The coast of P.E.I. has been identified as one of the areas most sensitive to sea level rise in the entire country. Factors contributing to this sensitivity include soft sandstone bedrock, a sandy and dynamic shore zone which is sediment starved in places, low terrain behind the shore with significant flooding potential and documented high rates of shoreline retreat.[43]

Given P.E.I.'s size and shape – the island is only 224 km long and between 6 km and 64 km wide – a significant proportion of the population lives on or near the coast.

Parts of the North Shore of P.E.I. are rated highly sensitive because this coast is exposed to the open Gulf of St. Lawrence, with potential wave-generating fetches[44] of several hundred kilometres. Decreased sea-ice cover in winter may increase the amount of open water fetch, creating larger waves superimposed on storm surges.[45] Although Charlottetown Harbour is largely protected from the Northumberland Strait and the Gulf of St. Lawrence, relative sea level is rising and storm-surge events are increasingly common.

The provincial government has a major role in land use planning in P.E.I., managing about 90% of the land area in the province. The 31 municipal governments, which practise comprehensive land use planning, have jurisdiction over the remaining 10% of the province's land area. For the most part, municipal land use plans are more restrictive than provincial ones, although in the case of coastal area development, some municipalities are actually less restrictive than provided for in provincial legislation.

Relative sea level estimates for northwest and southwest P.E.I. to year 2100 anticipate a rise of 1.0 to 1.08 m ± 0.48 m. Estimates for the Charlottetown region predict relative sea level rise of 1.06 m ± 0.48 m.[46]

Newfoundland and Labrador
POPULATION 514,536 (2011 CENSUS)

Newfoundland and Labrador has almost 29,000 km of coastline.[47] The province is divided into the mainland territory of Labrador and the southern Island of Newfoundland. The northern coastal region of Labrador is ruggedly mountainous with deep fjords and few settlements. The southern coastal region of Labrador has a rugged barren foreshore and light to moderate settlement. In Newfoundland, the west coast is well-forested coastal plains with several fjord-like bays, the largest of which are the Bay of Islands and Bonne Bay. There are almost continuous settlements in the bays and coves along this coast. The northeast coast, with its numerous bays, islands and headlands fronts on the Atlantic Ocean from the Great Northern Peninsula to the Avalon Peninsula. The shoreline has innumerable bays, coves, islands and fjords – it is also an area blocked on an annual basis by arctic drift ice throughout the winter and early spring. Settlements have developed along the shores of most bays and on some off-shore islands. The south coast has features typical of a submerged shoreline; namely offshore islands, spits, tombolos[48] and bay-mouth bars (barachoix).[49]

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42 (Historica-Dominion Institute 2012)
43 (Shaw, et al. 1998)
44 Fetch refers to the length of water over which wind has blown and is a key factor in creating storm surges.
45 (Shaw, et al. 1998)
46 (Richards and Daigle 2011)
47 (Newfoundland & Labrador Department of Fisheries and Aquaculture 2011)
48 A narrow strip of sand that links one island to another or to the mainland.
49 (Historica-Dominion Institute 2012)

Over 90% of the population is located in coastal communities, including the capital of St. John's which is home to just over a third of total population.[50] Although, sea level rise has been documented throughout the province,[51] most of the coastline of Newfoundland and Labrador is of moderate to low sensitivity to sea level change. In many areas of the province, the presence of relatively steep-sloping bedrock-exposed coastlines means sea level rise will have little impact. Notable exceptions to this include the northwest coast of the Burin Peninsula and St. George's Bay as well as specific communities such as Placentia.[52] With ongoing relative sea level rise, storm surge activity is likely to have a progressively stronger impact on higher areas of the shoreline. Areas at greatest risk are sand dominated beaches, coastal dune complexes, tidal flats, estuaries and salt marshes.[53]

In the Northern Strategic Plan released in 2007, the Government of Newfoundland and Labrador recognized the need for a targeted action plan to address climate change in Northern Labrador. In the 2011 *Climate Change Action Plan* "Charting Our Course", the provincial government committed to preparing a dedicated strategy on climate change adaptation for Northern Labrador.[54] The plan highlights a number of climate change adaptation strategies for the province including integrating adaptation considerations into public and private sector decision-making, and considering climate change implications in the site selection and design of provincial government buildings and infrastructure.

In June of 2011, the Government of Newfoundland and Labrador released a Coastal and Oceans Management Strategy and Policy Framework for public discussion. The need for a provincial coastal land use plan was stated, taking into account the principles of sustainable development, climate change adaptation, hazard prediction and preparedness, and economic development.[55] This document identifies that to be proactive in addressing coastal and ocean issues, the Government of Newfoundland and Labrador must take a leadership role and engage in meaningful integrated coastal and ocean management processes. A key existing provision noted in the document is to maintain a 15 metre shoreline reservation or buffer between the shoreline and the boundary of current land titles issued by the Department of Environment and Conservation.

Available data on recent sea level change indicates relative sea level is currently rising across much of the Island of Newfoundland, is stable or rising in northern Newfoundland and southern Labrador, and is falling in much of central and northern Labrador. For the east coast of Labrador, sea level is estimated to rise by 0.80 m to the year 2099. However, for those areas with the greatest concentration of the provincial population, the Avalon Peninsula and the west coast, a potential sea level rise of 0.80 to 1.0+ m by 2099 is anticipated.[56]

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50 (Government of Newfoundland and Labrador n.d.)
51 (Catto 2010)
52 (Batterson and Liverman 2010)
53 (Catto 2010)
54 Northern Labrador includes the Nunatsiavut Government, a 72,500 km^2 area where limited self-rule was established for the Labrador Innu following a 2005 treaty between the Labrador Inuit Association, the Government of Canada, and the Government of Newfoundland and Labrador.
55 (Newfoundland & Labrador Department of Fisheries and Aquaculture 2011)
56 (Batterson and Liverman 2010)

Framework for Decision-Making

Framework for Decision-Making

Communities need adaptation **strategies** and **tools** to minimize the long-term economic, environmental and social impacts of sea level rise on development in coastal areas.

Adaptation strategies can be grouped into four broad categories:[57]

Protect is a reactive strategy to protect people, property and infrastructure from sea level rise and is typically the first response considered. Protecting the coastline through structural mechanisms such as dikes,[58] seawalls and groynes has been the traditional approach to dealing with sea level rise in many parts of the world.[59] Such measures range from large-scale public projects to small-scale efforts by individual property owners. Protection strategies tend to be expensive and may have limited long-term effectiveness in highly vulnerable locations.[60]

A protect strategy alone creates an expectation that coastal defences will be maintained in perpetuity, which may lead to a false sense of security. It may also compound risk by encouraging further development behind dikes and other structural protection elements, thereby increasing the number of people and amount of property at risk if these fail. Protection strategies are especially attractive if the costs of protection are borne by governments at different levels (i.e., if individual property owners bear little or no risk) and if land use is not managed with a long term perspective by local governments.

Communities may use a protect strategy as an interim measure, providing time to implement a retreat or avoid strategy; however the strategy should be recognized as a temporary solution and not used to encourage further development.

Other forms of protection can take place. There is growing recognition of the benefits of non-structural (soft armouring) protection measures, including beach nourishment and coastal wetland restoration and creation. These measures can be implemented as sea levels rise, and may complement or supplement structural protection. Such non-structural adaptations can enhance the natural resilience of the coastal zone and can be less expensive than structural protection, which can lead to unwanted effects on erosion and sedimentation patterns if not properly implemented.[61]

Accommodate is an adaptive strategy that allows continued occupation of coastal areas while changes are made to human activities and/or infrastructure to adapt to sea level rise. Accommodation can also involve retrofitting a building or making it more resilient to the consequences of sea level rise. Accommodation measures for new construction include the use of structural fill to raise the elevation of habitable space, restricting building areas subject to flooding to garages, crawl space or other nonhabitable uses, and increasing setbacks from watercourses. Strategies such as covenants indemnifying governments from the consequences of coastal hazards may also be used to reduce local government liability.

Retreat (or *Managed Retreat*) refers to any strategic decision to withdraw, relocate or abandon private or public assets at risk due to coastal hazards. Retreat is an adaptive strategy designed to limit the use of structural protections, discourage development in areas subject to sea level rise, and plan for the eventual relocation of buildings and infrastructure to areas with no risk or a lesser risk. Communities in Prince Edward Island have applied this strategy where storms have resulted in significant shoreline loss.

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57 Note: Although these strategies are commonly used, there is considerable variation in their organization and description. Other approaches include Preserve, Business as Usual and Attack (based on Land Reclamation).

58 The spelling of dike and dyke (also dikeland and dykeland) are both commonly used in Canada. The term dike is preferred by the Government of B.C. and has been used throughout this report except where the spelling of dyke is contained in a legislative reference or publication.

59 (Adaptation – Coastal Zone 2007)

60 (Adaptation – Coastal Zone 2007)

61 (Adaptation – Coastal Zone 2007)

Managed retreat is a strategy typically undertaken with a long-term perspective. Small scale managed retreat may include site-specific relocation within a property or relocation to another site. Large scale relocation may include an entire community. As part of a managed retreat strategy, homes, lighthouses, roads and even barns have been moved further inland to protect them from erosion and storm surge. The strategy is often used when property owners have enough room on their parcel or when the ongoing costs of storm repairs and safety concerns outweigh the costs of retreating. The strategy may also be used to provide space for coastal ecosystems to expand or reclaim areas as the sea level rises.[62]

Managed retreat is not currently used as frequently as other strategies. There is often a threshold (e.g. number of coastal residents or value of properties at risk) above which retreat becomes less likely. Retreat from urbanized areas is theoretically possible but politically difficult, and there are few (if any) examples of successful and peaceful retreat in densely populated areas. However, it is anticipated that the use of managed retreat will increase in the future as the rate of sea level rise increases or the cost of a protect or accommodate strategy becomes excessive.

Avoid involves planning so that development does not take place in areas subject to coastal hazards associated with sea level rise or where the risk is low at present but will increase over time. This may involve identifying future "no build" areas within local government planning documents. A wide range of planning tools may be involved in coming to a decision to avoid development in areas subject to moderate to high risk. Regulatory tools may include the designation or zoning of lands for limited development or nonhabitable uses. An avoid strategy may include land acquisition or restriction tools such as a land trust, or the transfer of development potential to areas with low or no risk due to sea level rise.

Business as Usual is not specifically included as a strategy in this Primer but it can be considered as a composite of existing strategies. All four adaptation strategies are currently applied to varying degrees in different local government jurisdictions throughout coastal Canada. It would be inappropriate to call "business as usual" a "do nothing" strategy as there is widespread recognition of coastal risks and the application of various tools to address risk. However, the consequences of "business as usual" are not neutral as sea level rise will lead to increased vulnerability or require the use of new tools, a different mix of tools and higher expenditures. If nothing is done, the consequences of Business as Usual will mean the acceptance of additional risk, whether by intention, omission or lack of resources.

An attack strategy refers to options that reclaim land from the sea through dredging, diking, etc. These are also referred to as land reclamation, land claim, or "advance the line." This strategy has seen some application in other jurisdictions, particularly in the Netherlands, Hong Kong and Singapore. All these locations have small physical coastal land areas and some of the highest population densities in the world. In these jurisdictions, some low-lying land has been diked and/or filled to accommodate agriculture, port and airport development, and for residential purposes. In the Dutch case, the current use of ocean sediment dredged from one location to another represents a form of soft armouring to protect vulnerable areas behind dikes.

An attack strategy refers to measures that reclaim land from the sea through dredging, diking and fill. This strategy is also referred to as land reclamation, or "advancing the line" and has seen some application in other jurisdictions, particularly in the Netherlands, Hong Kong and Singapore. An attack strategy is not considered a viable response to sea level rise in Canada. The economic and environmental costs of land reclamation, wherever implemented, are extremely high. Instances of land reclamation in Canada take the form of soft armouring or hard protection implemented as part of a protect strategy.[63]

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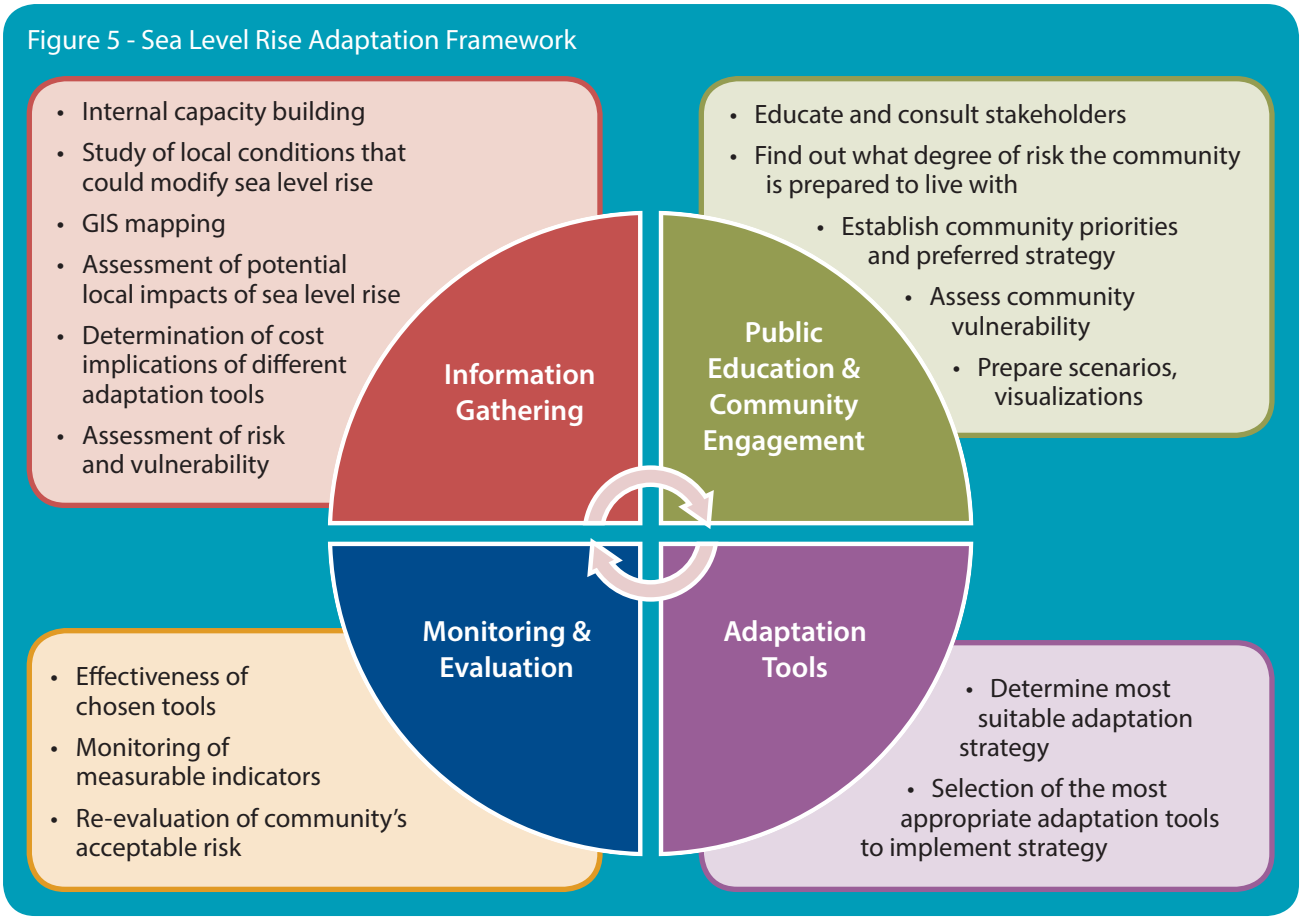
[62] (Abel, et al. 2011)

[63] Local infilling to create or enhance harbours and farmland has historically occurred in Atlantic Canada and in the Lower Mainland of British Columbia but is considered to have minimal applicability for the future due to prohibitive costs and environmental impacts.

Sea Level Rise Adaptation Process

Developing and implementing sea level rise adaptation measures at a local level does not begin with the implementation of an adaptation tool. Prior to the implementation of any of the adaptation tools discussed in this Primer, a process of information gathering, public education and community engagement should be undertaken by local community decision makers.[64]

Figure 5 - Sea Level Rise Adaptation Framework



Through a process of information gathering, including risk and vulnerability assessment, local governments will be able to identify their resource limitations and any knowledge gaps. This process may involve building internal capacity, identifying champions and establishing a cross-departmental steering committee to address sea level rise. After sufficient baseline information has been gathered, public education and community engagement should begin. The inclusion of community input at this early stage can help foster a sense of ownership and provide valuable information that may otherwise be overlooked. While public education and community engagement are shown in Figure 5 as one part of the process, in practice they should be included throughout the adaptation process. Establishing community priorities and a preferred strategic direction will help narrow down the choice of adaptation tools that may be applicable in individual communities.

Many of the adaptation tools identified in this Primer will require ongoing public input and support to be successfully implemented. As the science of estimating sea level rise and its effects evolves, so too will adaptation. In order to incorporate new data into the adaptation process and assess the effectiveness of adaptations tools already implemented, monitoring and evaluation are required to feed back into the process.

The following provides a brief introduction and some examples of information gathering and engagement.

[64] A community may be undertaking other climate change impacts at the same time.

Information Gathering

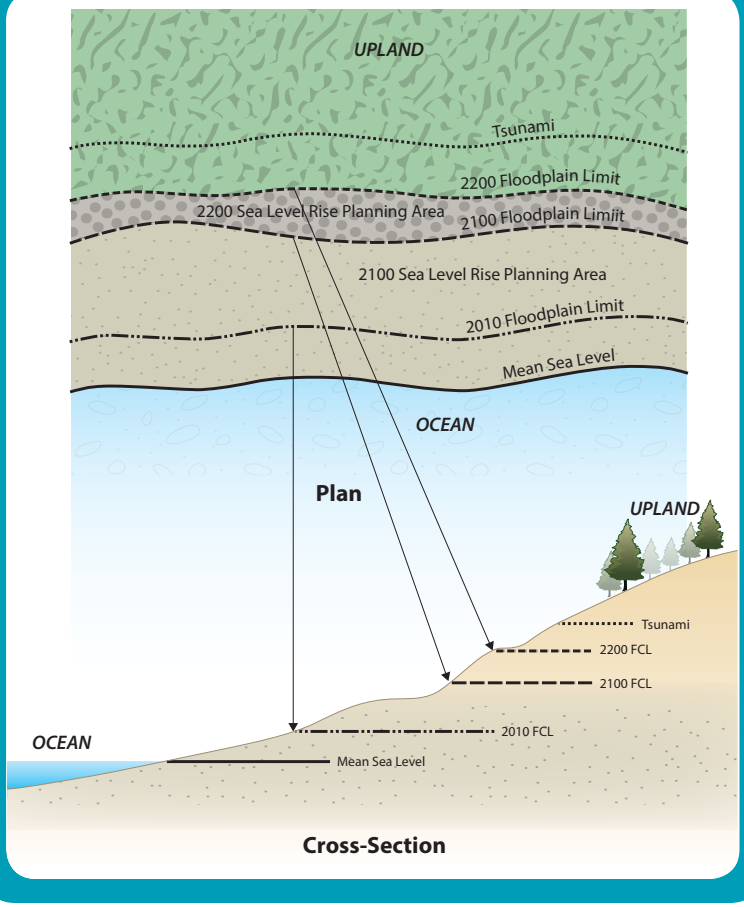
Information gathering in the context of this Primer refers to the identification of the potential effects of sea level rise, the identification of areas at risk from associated coastal hazards and the assessment of vulnerability. This provides a baseline and serves to guide decision makers, stakeholders and the community. Such information can be converted and used to spatially depict "coastal hazard zones" or "sea level rise planning areas" (see Figure 6 – Sketch of Coastal Hazard Mapping Components).

Mapping environmental constraints and opportunities can demonstrate land sensitivity, including: lands vulnerable to sea level rise; increases in tidal surges; changes in low and high tides; increases in coastal and riparian flooding; changes in high and low water tables; and impacts on aquatic and terrestrial habitats.

Before determining possible responses, a discussion of sea level rise should take place. Relevant topics may include the following:

- How will the environment change?
- What impacts can be anticipated?
- What areas are at risk?
- What is the nature and magnitude of the risk?
- What is the value of property and buildings at risk?
- What infrastructure (including transportation links) is at risk?
- What is the overall community vulnerability?

Figure 6 - Sketch of Coastal Hazard Mapping Components[65]



Canadian Examples

In British Columbia the B.C. Ministry of Environment has prepared an online inventory of information resources including a series of maps showing potential coastal flood hazard areas in B.C.. These display potential year 2100 floodplain areas based on approximate flood construction levels (incorporating sea level rise).[66]

The Pacific Climate Impacts Consortium (PCIC) also provides climate services and information to users across British Columbia. PCIC recognized that climate change impacts do not affect every region of the province in the same way and so developed the Plan2Adapt tool. Plan2Adapt generates maps, plots, and data describing projected future climate conditions for regions throughout British Columbia. The impacts can be viewed by sector – agricultural, infrastructure, hydrology and land use planning – or by impact category – sea level rise/storm surge or possible flooding.[67]

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65 (Kerr Wood Leidal Associates Ltd. 2011)

66 Note the presence of dikes or other flood protection work has not been factored into the analysis and the floodplain areas have not been prepared with high-resolution digital elevation models. Information displayed should be considered preliminary and used to highlight areas requiring high resolution coastal floodplain maps.

67 (University of Victoria n.d.)

In Quebec, the Ouranos consortium brings together expertise concerning climate change and adaptation to provide data for decision makers. Since 2000 they have worked in collaboration with various universities to research erosion rates in coastal zones. Additional work identified adaptation strategies for the municipalities most at risk from sea level rise. This collaborative research proved instrumental in the development of subsequent municipal regulations.

The Government of Newfoundland and Labrador has made a three-year commitment to establish a new Coastal Erosion and Mapping Program so that data and reports will be available to all communities for planning and development purposes. The New Brunswick District Planning Commissions manage and plan for development in their areas and provide advice to the province and municipalities with respect to community planning. As an integral part of their mandate, Planning Commissions provide access to building inspectors, GIS technicians and a development officer to communities in their regions. In Halifax, Nova Scotia, the local government has a current project to develop wave modeling for Halifax Harbour as a critical addition to the ongoing development of the Halifax Regional Municipality's overall adaptive land use planning approach.

Fisheries and Oceans Canada – Aquatic Climate Change Adaptation Services Program [68]

In 2011 the Government of Canada committed $16.5 million for implementation of a five-year aquatic climate change program called the Aquatic Climate Change Adaptation Services Program. This program is funding:

- Research projects to expand our understanding of how climate change will impact the delivery of Fisheries and Ocean's Canada programs and policies;
- The development of adaptation tools to enable integration of climate change considerations into the delivery of Fisheries and Oceans Canada programs and policies, including work to:
  - Develop high resolution modelling of changes in extreme sea level and ocean waves;
  - Produce high resolution digital elevation models in intertidal and shallow zones.

Public Education and Community Engagement

Public education and engagement help communities to increase their understanding of how communities may be directly affected by sea level rise now and in the future. Recent adaptation programs suggest a shift towards stakeholder engagement, improved planning tools and governance processes and away from technical solutions and physical measures alone.[69] A collaborative approach to adaptation offers an opportunity to improve public understanding and generate support. Ideally, public education and community engagement should take place throughout the adaptation process to ensure transparency in the decision-making process. Approaches to engagement may include:

- Understanding how communities may be directly affected by sea level rise now and in the future by applying various tools and approaches, such as visualizations, scenarios and mapping;
- Making information available from a wide variety of sources;
- Holding public information seminars, workshops and conferences.

[68] (Fisheries and Oceans Canada 2013)
[69] (Barron, et al. 2012)

Public education and community engagement are vital components of decision making in a democracy and may also be legally required as part of a local planning process. They include addressing key issues such as:

- How much risk is acceptable to a community?
- How should the risk be managed?
- What will the cost be and who will bear it?

Public education may be challenging. While sea level rise has recently gained increasing attention in the public domain, the consequences and the need for adaptation may still be a "hard sell" because the time frame is very long and changes will be incremental. This challenge must be recognized and taken into consideration when designing public education and community engagement processes. Long term residents can play an important role in communicating past extreme events.

Canadian Examples

In British Columbia, the Corporation of Delta partnered with the University of British Columbia's Collaborative for Advanced Landscape Planning (CALP) to develop future sea level rise scenarios using 2D and 3D visualisations. The visual materials generated by this project have been used by staff and a citizens' working group to help them understand the impacts, assess the policy implications and measure the social acceptability of various adaptation strategies.

In Quebec, following the release of coastal erosion research in the Côte-Nord, over 100 information sharing meetings and consultations took place. These meetings played an important role in developing public support for new coastal setbacks.

Scenario-Based Planning

Due to the 'forward looking' nature of climate change planning and its reliance on climate models to estimate future impacts, there is an inherent degree of uncertainty involved in the planning process. One popular community engagement approach for addressing and accounting for uncertainties in climate predictions is scenario-based planning.

Scenario-based planning will typically begin with the creation of a baseline scenario of current land use, management and other stressors. Predicted changes (e.g. expected/proposed development, sea level rise and increased storm surge) and possible elements of interest (e.g. ecological and community infrastructure features) to these stressors are then modelled to create future scenarios. From these scenarios, decision makers can begin to identify thresholds of change – that is, points at which significant impacts will be realized and various management options can be 'tested' to see which maybe most effective.

Several tools have been developed in the United States to help specifically with scenario based planning. These include CommunityViz, NatureServe Vista and SLAMM (Sea Level Affecting Marshes Model).

Adaptation Tools

Adaptation Tools

The following section provides an analysis of a variety of adaptation tools and their applicability in communities on Canada's southern coasts. In each case, a general description of the tool is given, its implementation is discussed, and enabling legislation is noted. In addition, economic, environmental and social criteria are discussed, as are the potential barriers or challenges to implementation.

A total of 21 tools are identified in this Primer. They have been organized into five general categories:

- **Planning tools** identified in this Primer consist of local and regional government planning and management objectives and policies, mapping of potential hazards, risk management and emergency planning.
- **Regulatory tools** include the regulation of subdivision, land use and buildings. These regulatory tools require the approval of a decision maker or "gatekeeper" responsible for the protection of the public interest. The gatekeeper may consist of the municipal council, regional board or other form of local government, building inspector or subdivision approving officer.
- **Land use change or restriction tools** focus on land use change or the restriction of land use other than through the regulatory functions noted above. Some of these tools are at the disposal of local government and others have the potential to achieve local government goals indirectly, for example the acquisition of land through a Land Trust.
- **Structural tools** (flood protection works) consist of physical structures on land or in water to protect land and buildings from coastal hazards. A wide range of hard protection or armouring works fit into this category. This grouping can be further broken down into on-site and off-site works, which are also referred to as property-specific and linear shoreline protection measures.
- **Non-structural or soft armouring measures** include the creation or restoration of wetlands, sand dune building or rehabilitation and beach nourishment. Both sand dunes and beaches are naturally occurring features, created by the interaction of wind and waves, and serve to dissipate the energy of storm surges and wave action.[70]

Structural and non-structural protection methods are frequently used in combinations called hybrid shoreline protection systems. Examples include 'living shorelines', which manage coastal erosion by protecting, restoring, enhancing or creating natural shoreline habitat that includes the use of structural materials in combination with sand, marsh vegetation and other natural planting for shoreline stabilization.

[70] (The Sustainable Planning Branch, New Brunswick Department of Environment and Local Government 2002)

Figure 7 – Summary of Sea Level Rise Adaptation Tools

Planning Tools

1. **Objectives & Policies**
   - Growth management objectives, establishment of policies
   - Coastal management approach based on sensitivity to impact
2. **Coastal Hazard Mapping**
   - Mapping of areas at risk of erosion due to sea level rise
   - Identification of minimum floor elevations (Flood Construction Levels) to reduce risk to buildings in hazard areas
3. **Risk Management**
   - Measurement of the likelihood and consequences of risks to property, buildings and people
   - Cost benefit analysis
   - Vulnerability assessment
   - Resilience assessment
4. **Emergency Planning and Preparedness**
   - Prepare emergency plans for flooding and other disasters

Regulatory Tools

1. **Regulations of Land Use**
   - Zoning Bylaw to regulate land use, density, siting of buildings and servicing standards
   - Designation of land as a floodplain
   - Minimum building elevations & setback for land in floodplain
2. **Subdivision Regulation**
   - Regulation to protect development in areas subject to coastal hazards
   - Regulation where the natural environment would be adversely affected due to sea level rise
3. **Development Permit**
   - Regulation of specific development plans to protect environment or development from hazard
4. **Building Regulation**
   - Restriction of building construction to address safety of land subject to coastal hazards

Land Use Change or Restriction Tools

1. **Land Acquisition**
   - Land purchase or expropriation to prevent development in area at risk due to sea level rise
   - Land purchase to implement non-structural adaptation to sea level rise
2. **Transfer of Development Potential**
   - Transfer of allowable development potential to an alternative location not at risk
   - Creation of 'density bank' to accommodate density transfer
3. **Easments and Covenants**
   - Easement on title to restrict use of land for conservation or other non-development purposes
   - Other restrictions include: statutory right-of-way, covenant or servitude
4. **Land Trusts**
   - Management of land for conservation or other non-development purposes by land trust or other separate environmental organization
5. **Foreshore Tenure**
   - Lease or Licence of Occupation of area from the Crown below the natural boundary to allow integrated management of foreshore

Structural Tools (Flood Protection Works)

1. **Scour Protection**
   - Foundation protection for a new or existing building
   - Protection of a linear structure base
2. **Structural Elevation**
   - Addition of structural fill to raise the land below a building above the flood level risk
   - Raising the habitable areas of a building or the entire building itself
3. **Dikes**
   - Linear shoreline protection structure as a primary defense from flooding
   - Includes accessories such as floodboxes and floodgates
4. **Other Hard Protection**
   - Off-site structural works to protect shorelines from flooding
   - Includes seawall, groyne, revelment and storm surge barrier
   - Secondary protection including roads and back-up dikes
5. **Wet Floodproofing**
   - Installation of building materials that can withstand temporary flood damage
   - Location of electrical and mechanical fixtures above the area subject to flood risk

Non-Structural Tools (Soft Armouring)

1. **Coastal Wetland Creation or Restoration**
   - Creation of a buffer to reduce wave energy
   - Creation or restoration of wetlands to increase adaptive capacity of ecological areas at risk due to coastal squeeze
2. **Dune Building or Rehabilitation**
   - Creation or rehabilitation of dunes to provide a buffer to reduce flood risk
   - Creation of off-shore islands
3. **Beach Nourishment**
   - Addition of sediment on an ongoing basis to satisfy natural erosional forces

Planning Tools

1. Objectives and Policies

Tool Description

Setting objectives and policies is a key tool available to local governments to manage development. Objectives and policies may be included in a wide range of documents, and have different scope and applicability depending on the jurisdiction involved and the planning framework in place. Objectives and policies may be included in comprehensive plans, community plans, neighbourhood plans, strategic plans, and growth management strategies.

Objectives are often general in nature and may aim to accommodate future development, protect residents, manage risk on land subject to hazards, and protect environmentally sensitive areas.

Policies are often more specific and may identify how coastal hazards such as erosion and inundation should be addressed. Policies may include setbacks to avoid coastal areas at risk, environmentally sensitive criteria for development or other measures designed to reduce vulnerability and increase resilience.

Application

Objectives and policies may be used as an adaptation tool in every coastal community in Canada. They may also be added to existing policy frameworks such as Official Community Plans or Regional Development Strategies.

Setting objectives and policies often enables implementation of other tools. Implementation may be achieved through the use of regulatory tools such as a zoning bylaw or development permit. Land acquisition, land trust, structural protection and soft armouring all represent means of implementing objectives and policies and other planning tools.

Enabling Legislation

The *Local Government Act* in B.C. requires all Official Community Plans (OCPs) to identify restrictions on the use of land that is subject to hazardous conditions (e.g. flooding) or is environmentally sensitive. An OCP must include the approximate location and phasing of roads, sewers and water systems. This may identify infrastructure at risk and enable adaptations.

The *Local Government Act* also allows for development of regional growth strategies. Only ten of 29 regional districts have adopted regional growth strategies, however all coastal areas in B.C. with large populations are now covered. Regional growth strategies guide decisions on growth, change, and development. They cover a period of at least 20 years and include a comprehensive statement on the future of the region and social, economic and environmental objectives. Objectives deal with developing settlement patterns that minimize risks associated with natural hazards and protect environmentally sensitive areas.

Québec's policy for the protection of riverbeds, shorelines, coastlines and floodplains sets uniform setbacks based on grade and requires that a permit be obtained for new construction near shorelines. The policy also bans all construction directly on the coastline. Regional County Municipalities (RCMs) were encouraged to integrate measures for coastal protection, as outlined in the policy, within their regional master plans (Schema d'aménagement). As of 2012 all but seven of the 86 RCMs had adopted measures.[71]

New Brunswick's Coastal Areas Protection Policy establishes setbacks for permanent structures. This policy, which came into force in 2002, divided coastal areas into three sensitivity zones:

- Zone A – the areas closest to the water (known as the coastal lands core area) including dunes, beaches, wetlands, dikelands and tidal flats;
- Zone B – a 30 m area landward of Zone A designed to limit activity and provide a development buffer, and
- Zone C – the areas beyond Zone B that form a transition from coastal to inland areas.

This policy is enforced through provincial environmental impact assessment legislation. Provincial legislation also provides municipalities with the ability to incorporate these policies into their own requirements.

New Brunswick also has *Watercourse and Wetland Alteration Regulations*, which limit activities that take place within or close to a watercourse or wetland. A permit is required before certain activities can take place within 30 metres of a watercourse.

Prince Edward Island has adopted shoreline setback regulations for subdivision and development under the *Provincial Planning Act*. The province uses setbacks based on historical data, but is currently updating setbacks using with aerial photos of coastlines. Under the *Environmental Protection Act,* P.E.I. also requires that a watercourse, wetland and buffer zone activity permit be obtained for any temporary or permanent change made to or near a watercourse or wetland. A permit is required for all such alterations made within 15 metres (49.2 feet) of any watercourse (including a coastal water body) or wetland boundary.

In Newfoundland and Labrador, the 1990 *Urban and Rural Planning Act* makes provision for regional and municipal planning including the setting of plan objectives and policies. There are 281 municipalities in the province of Newfoundland and Labrador and about half of these have municipal plans; however many are outdated. The Department of Environment has a "Policy for Development in Shore Water Zones". This policy establishes criteria for issuing permits under the *Water Resources Act*, for all development activities in and affecting shore water zones. In marine situations, the high water level of a water body must allow for maximum waves, wind setup, storm surge and ultimate mean sea levels under global climatic forecasts for a 1:100 year design.

Evaluation and Governance Considerations

Economic – Economic considerations include the cost of developing and setting objectives and policies and the cost of implementing them. The cost to undertake the process is easily measurable while the cost of implementation is much more difficult to assess.

There are also economic costs if no objectives and policies are set. Economic obligations associated with development in hazardous areas may increase (e.g., development in areas at risk of coastal hazards with no protection measures).

Environmental – Development restrictions in environmentally sensitive areas and areas subject to coastal hazards have long been addressed through municipal planning objectives and policies. Incorporating adaptation to sea level rise into these objectives and policies is a logical next step.

[71] (Martel 2012)

Social – Objectives and policies will need to complement other planning measures designed to manage residential growth and other forms of development, recreation and open space needs, community facilities and other infrastructure needs.

The successful implementation of new objectives and policies often depends on a strong public education and consultation process as they are developed.

Implementation Measures and Challenges

Challenges include the time and resources required for public consultation and education. In a regional goal-setting process such as a regional growth strategy, a mediation or arbitration process among the different municipal governments may be required in order to achieve agreement.

In implementing policies and objectives, it is important to differentiate binding and non-binding measures. For example, the City of Vancouver increased Flood Construction Levels by an additional 1.0 m in January 2012 as a recommended but non-binding measure to address increased risk due to sea level rise. This is expected to be followed by a mandatory requirement following further review and technical study.

Advantages	Disadvantages
There is an established history of setting objectives and policies through a co-ordinated and comprehensive approach to land use planning and growth management in response to coastal hazards.	Research and policy development in adapting to sea level rise may be time consuming and require a commitment of staff and financial resources.
The planning process provides opportunities for public involvement and education.	The addition of policies to address sea level rise may add controversy, particularly 'Avoid' or ' Retreat' strategies.
The degree to which objectives are met and policies implemented can be measured and monitored over time.	

2. Coastal Hazard Mapping

Tool Description

Coastal hazard maps identify areas susceptible to coastal hazards and the effects of sea level rise. Mapping provides the technical basis for land use planning in coastal areas and enables the development of floodplain bylaws.

The mapping of coastal areas at risk of flooding or erosion is a vital tool for land use planning. Projected future sea levels can then be superimposed on a topographic map of coastal hazards to identify new areas subject to hazards.

A recent report commissioned by the B.C. government identified four steps to develop coastal floodplain maps. These were:

- Acquisition of detailed floodplain topography
- An engineering analysis of water level components and associated flood construction levels
- Preparation of floodplain maps indicating the areas subject to flood hazards and the magnitude of these hazards, and
- The preparation of a brief documenting the process.

The report also suggested that coastal floodplain maps contain the following elements:

- Flood Construction Levels (FCLs) to the years 2100 and 2200;
- Floodplain limits to 2100 and 2200;
- Sea level rise planning areas for 2100 and 2200; and
- Tsunami evacuation planning areas (if applicable).[72]

Coastal flood hazards are determined by the interaction of storm surges and waves with seabed bathymetry and coastal land cover. To effectively map the extent of coastal hazards, accurate topographic data is required, ideally with a contour interval of 1 m or less. The traditional method is to conduct field surveys of the topography. However, LiDAR (Light Detection and Ranging) data, collected from an aircraft using a laser, is increasingly being used.

LiDAR offers both an accurate and economical means of topographic mapping, particularly where large surface areas are involved. The set of elevation points generated by a LiDAR survey can be brought into a geographical information system (GIS) and used to build surfaces that represent the earth's topography with great precision. This provides an ideal base map which can be used to determine coastal hazard risk.[73]

Ground surveys provide the highest accuracy; however, to cover an entire coastline using this method may be impractical and prohibitively expensive. Ground surveys may be used to supplement or monitor the accuracy of the results received from LiDAR or other technologies.

Ground surveys are still required to establish ground and floodproof elevations at a specific site where the FCL has been derived from a floodplain map. Floodplain map topography should not be relied upon to establish specific building elevations.[74]

An engineering analysis is then used to map areas at risk. A review of long-term water level records is a key resource in assessing historic coastal flood levels and return periods. For coastal areas, these records are collected by tide gauges, operated by the Canadian Hydrographic Service (CHS) of the Department of Fisheries and Oceans (DFO). Coastal water level records are available on the DFO website.[75] Hazard maps typically show the physical boundaries of areas and what the hazard risks are based on risk analysis factors such as a design flood. With sea level rise, hazard mapping will not only need to incorporate the increase in water levels, but the effects of storm surge, wind and tides, in various combinations. These will vary depending on the local climatic conditions**.**

In recent years there has been a lack of sea ice during the winter months in several coastal areas of Atlantic Canada. This lack of sea ice must also be documented as a coastal hazard. The ice has historically provided a buffer for the coastline, but with reduced quantities, wave energy now often reaches the shoreline and hits exposed cliffs, glacial deposits, sand dunes, sand spits, barrier bars, marshes, shoreline protection systems and other coastal features. The P.E.I. National Park has been monitoring "ice foot"[76] in recent years as they have observed significant damage to the park shoreline and dune systems after storm surges during winter months.

[72] (Kerr Wood Leidal Associates Ltd. 2011)
[73] (Birch Hill GeoSolutions 2008)
[74] (Kerr Wood Leidal Associates Ltd. 2011)
[75] www.dfo-mpo.gc.ca
[76] Ice frozen to the shore having a base at or below the low-water mark and formed as a result of the rise and fall of the tides, freezing spray, or stranded ice.

Application

Coastal hazard mapping may be used to identify areas at risk due to the adverse effects of sea level rise, direct new development away from these high risk areas and manage development in areas where the risk is minimal or can be mitigated. Coastal hazard mapping complements and strengthens other adaptation options and increases stakeholder awareness of areas at risk. As such, this tool may be applied to all coastal areas at risk of coastal hazards, irrespective of the other adaptation tools implemented.

In 1975 the federal government of Canada initiated the Flood Damage Reduction Program. Under this program, mapping of floodplain regions was supported through a 50/50 cost shared basis with provinces. Through this program over 700 communities in six provinces undertook flood hazard mapping – of which a majority were in Quebec. At a minimum, maps were required to identify areas subject to 1 in 100 year flood events. B.C. adopted a design flood standard of 1 in 200 years, except on the Fraser River, where the 1948 flood of record was used. Atlantic Canada and Quebec adopted a flood standard of 1 in 100 years. Mapping under this program was completed by 2000.

Since 2000, coastal hazard mapping has progressed sporadically across the country. As part of the Atlantic Regional Adaptation Collaborative, digital elevation mapping was completed for some coastal areas of Nova Scotia, including the Chignecto Isthmus, where an evaluation of flood risk to infrastructure was undertaken.

The Halifax Regional Municipality in collaboration with Natural Resources Canada has conducted flood hazard mapping, including extreme event data. The results are reported in *Halifax Harbour Extreme Water Levels in the Context of Climate Change, Scenarios for a 100-year Planning Horizon* Geological Survey of Canada. This report includes an understanding of present and future sea level rise, vertical land motion, extreme water levels (combined tide and surge), harbour seiche and wave run-up.

The Province of New Brunswick maintains a coastal erosion database, which presents long-term coastline and shoreline migration rates. This data is generated through photogrammetric studies (air photos analyses) conducted by N.B. Department of Natural Resources and collaborators (universities, colleges, NGOs, consultants, etc.). This data is used to determine appropriate setbacks when new developments are being assessed in coastal areas.

In B.C. current federal-provincial flood management programs do not cover updates to hazard mapping or hydraulic analysis, although both have been included as secondary components in some projects.

In Prince Edward Island a 30 cm rise has been observed at the Charlottetown tide gauge since 1900. Climate change scenarios suggest that a sea level rise of 100 cm can be anticipated by 2100 with storm surges likely to become more frequent and more intense. To identify vulnerable infrastructure and guide land use planning, hazard mapping has been undertaken across the province.

Evaluation and Governance Considerations

Economic – Developing hazard maps requires a commitment of both technical resources and funding. This may include resources for:

- Engineering expertise in flood risk modelling;
- Topographic surveys (LiDAR or remote sensing) to provide information on land elevation, which will feed back into the flood risk model;
- Costs of collecting extreme event data such as water levels, wave heights, etc. where this information is available;
- Cost of employing a Geographic Information System (GIS) specialist; and
- Cost of adding a coastal hazard layer or updating hazard information.

The economic impacts of the maps themselves depends on a wide variety of factors, including how they are presented and distributed as well as how they are applied to planning and outreach activities.

Environmental – Coastal hazard mapping may incorporate environmental data such as coastal habitats at risk or sensitive ecosystems and enable better environmental protection for areas at risk.

Social – Hazard maps identify housing, roads, underground services, and community resources subject to coastal hazards, allowing for more informed planning and emergency management decisions. Hazard maps also enable public education and action, however, if a community is unaware of the benefits of coastal hazard mapping, they may prefer to see public money spent on more tangible flood and erosion protection measures.

Implementation Measures and Challenges

Coastal hazard maps have a wide variety of applications. GIS based mapping enables the detailed calculation of land areas at risk, property values and building values as well as the identification of strategic assets. These economic calculations can also provide the basis for better understanding the social and environmental considerations affecting vulnerable areas.

Maps have long been used to support planning and development. In order for coastal hazard maps to effectively reduce future coastal hazard risk and facilitate sustainable development, the consideration of hazard maps must be integrated into planning procedures and periodically updated.

The required expertise and modelling capacity may not be locally available, especially in smaller local governments. In addition, coastal hazards often cross jurisdictional boundaries. To pool limited resources and address trans-boundary impacts, work at a regional scale – with support from various levels of government – is often the most effective approach to hazard mapping.

Advantages	Disadvantages
There is a history of using hazard maps to support planning and development policies by identifying high risk locations and steering development away from these areas.	In itself, new coastal hazard mapping will not cause a reduction in risk nor address sea level rise. The information must be integrated into other regulatory, land use change, and structural and non-structural tools before the full benefits can be realised.
The identification of new or emerging risk areas helps with effective emergency response plans. It is essential that certain infrastructure, such as electricity supplies, sewage treatment, and services, such as the emergency services, continue to function during a hazard event. The creation of hazard maps allows communities to locate these elements in low risk areas. Alternatively, mapping may highlight a requirement to defend these elements from coastal hazards.	To realise the full benefits of coastal hazard mapping, it is important to provide people in the areas at risk with information about emergency procedures and ways of reducing risk. If information on what to do in the event of an emergency is not provided, coastal hazard maps may serve to increase fear and anxiety, as residents are more aware of the risks.
Coastal hazard mapping can quantify what is at risk (e.g. the number of houses or businesses). This can assist in managing risk by helping set priorities and determining the most suitable strategy.	The collection of topographic and bathymetric data to complement extreme water level and wave height information could be expensive.
The creation of coastal hazard mapping promotes greater awareness of the risks of sea level rise. This can be beneficial in encouraging hazard zone residents to prepare for the occurrence of flooding.	Due to the lack of observed extreme event data, more advanced, accurate coastal hazard maps are likely to rely on complex numerical models. This requires a degree of expertise to implement.
By identifying buildings at risk of flooding, awareness raising campaigns can also be targeted at high risk properties.	Coastal hazard maps need to be updated periodically to reflect changing climate and other factors.

3. Risk Management

Tool Description

Risk management is a process widely used to identify and manage the adverse impacts of a change in conditions. The magnitude of a risk is calculated by examining the probability of the occurrence of an event and the severity of its impact.[77] Risk management with respect to sea level rise and associated coastal hazards generally has two components. The first involves the identification, assessment, measurement, and prioritization of risks from sea level rise (risk assessment). The second involves selecting and implementing management measures. The measurement process may be quantitative, such as calculating the probability of a flood in excess of current linear protection, or it may be qualitative, documenting increasing vulnerability and reduced resilience. Coastal hazards due to sea level rise may include the risk of a major disaster such as a dike failure as well as risks from gradual changes such as increasing salinization of groundwater.

A risk assessment may have aspects that affect people, the environment and the economy. Risk management methodologies can also provide a way to explore public attitudes and perceptions of risk – information which can be fed back into the assessment.[78] The setting of priorities reflects the importance of the coastal hazard and leads to a discussion on how those risks should be managed.

[77] (Richardson and Otero 2012)
[78] (Richardson and Otero 2012)

Application

Sea level rise has been identified as a risk in the academic literature for at least two decades. The design of sea level rise risk-management strategies relies on sea level rise projections, which are constantly being revised based on new data and research. Risks due to sea level rise have increased in recent years due to various aspects of climate change, including the more rapid melting of glaciers, higher water and atmospheric temperature readings around the globe and more intense storm activity. As noted previously, considerable regional variation in sea level rise will take place.

With sea level rise, increased protection measures will be required just to maintain the same level of protection (i.e., 1:100 years or 1:200 years) that has been historically provided. When the Canadian Flood Damage Reduction Program was created in 1975, minimum federal standards with respect to acceptable flood risk were set at a 1 in 100 year flood. Should a higher level of protection be called for, additional measures will be required. Whether the standard of protection remains the same or is increased, other approaches to risk management may be required. These may include tools such as land acquisition, land trust, covenant or easement and soft armouring to reduce impact.

Enabling Legislation

A risk assessment does not require specific enabling legislation. It can occur in the preparation of an Official Community Plan or other planning process as authorized by provincial legislation. Risk management may also be undertaken as part of an emergency planning and preparedness initiative. For example, In Québec, the 2001 *Loi sur la sécurité civile* (Law on civil security), Chapter IV, Section III obliges municipal officials to publicly communicate all known major risks and develop regulations for risk management.

Evaluation and Governance Considerations

Economic – Risk management involves a rigorous process of comparing and selecting the most appropriate risk reduction measures. It can also include an analysis of the cost of "doing nothing." A cost-benefit analysis – used to determine how well, or how poorly, a planned action will turn out – can assist the risk management process. A cost benefit analysis is most commonly undertaken where the costs and benefits can be quantified in financial terms, to enable comparability. It relies on the addition of positive factors and the subtraction of negative ones to determine a net result.

The two main applications of a cost-benefit analysis for risk management with respect to coastal hazards are:

- To determine if the proposed action is a sound financial decision. (Can it be justified? Is the proposed action feasible?)
- To provide a basis for comparing possible projects (e.g., dike vs. seawall + beach nourishment). This involves comparing the total expected cost of each option against the total expected benefits, to see if the benefits outweigh the costs, and by how much.

A 'multiple account' cost-benefit analysis recognizes that all values are complex and that not all consequences can be expressed in monetary terms or incorporated into one summary measure of net benefit.

Environmental – Risk management may be used to reduce sea level rise risks to environmental assets and species at risk. The protection of wetlands is of particular importance due to historic losses, as are intertidal areas, due to their high productivity.

Social – Social criteria is embedded into most risk management processes. Assessments identify acceptable risk levels, community assets needing protection, and when or if a different strategy should be adopted to respond to the long-term consequences of sea level rise. The experience of Hurricane Katrina in 2005 demonstrated the extreme vulnerability of persons lacking mobility, particularly those with low income and the residents of nursing homes.

Implementation Measures and Challenges

Implementation of risk management measures depends on the overall strategy adopted and the tool or combination of tools selected to manage identified risk within acceptable levels. Challenges include selecting an acceptable level of risk, selecting the most appropriate tools to manage the risk, and committing the capital and maintenance costs required to implement the risk management plan.

Advantages	Disadvantages
A long-term perspective is often required to manage risks to large scale linear infrastructure. Risk management allows for a phased or cumulative risk management approach.	There may be a significant cost. However, the cost must be measured against the risk.
Risk management may involve a rigorous, defensible analytic approach with reliable information used to support decision making.	The absence of detailed studies may impede some initiatives but should not prevent the use of interim measures to reduce risk (e.g. minimum setback and elevation from the natural boundary or other potential risk).
Risk management can be an essential tool to help determine the most appropriate response to coastal hazards.	

4. Emergency Planning and Preparedness

Tool Description

Emergency planning and preparedness measures are undertaken in advance of a disaster. Coastal flooding may result in property damage, damage to or destruction of property contents, economic losses due to severed transportation links and other damaged infrastructure. It may also result in loss of land due to erosion, business disruption in the affected area, population/community displacement, health and safety hazards and even death. Effective emergency planning and preparedness reduces the damage caused by such events.

Post-disaster management refers to measures undertaken during and after a disaster and are discussed separately following the discussion of adaptation tools.

Application

Emergency planning and preparedness measures may be undertaken in all coastal areas at risk of coastal hazards, irrespective of the other adaptation tools implemented.

Between 1970 and 2013, the federal government administered the Joint Emergency Preparedness Program (JEPP) to support disaster preparedness through funds provided to provincial and territorial governments. This program provided financial assistance of up to 75% of a specific project to a maximum of $3,000,000, and focused specifically on increasing local government emergency response capability.

In B.C., under the *Emergency Program Act*, local authorities have primary responsibility for responding to emergencies and must have an emergency plan in place to address potential flood events and maintain public safety. The Province provides support to local authorities depending on the magnitude of the event.

Local authorities:

- must prepare a local Emergency Plan;
- must establish and maintain an Emergency Management Organization;
- may cause the plan to be implemented;
- may declare a state of local emergency; and
- may do all acts and implement all procedures that it considers necessary to prevent, respond to or alleviate the effects of an emergency or disaster.

The emergency management of floods consists of several phases. This tool covers the first phase – emergency planning and preparedness for a flood. Later phases concern flood response and recovery/ disaster financial assistance. These later phases are critically important but are not considered part of the Primer toolkit.

In 1999, to assist local and diking authorities to prepare a flood response plan, the B.C. Water Management Branch and the Provincial Emergency Program (PEP) published the Flood Planning and Response Guide for British Columbia.[79] This document includes sections on flood prevention, flood damage prevention, the preparation and implementation of a flood response plan and post flood management.

[79] The Guide also provides assistance for preparation of a Flood Response Plan. More detail is available at http://www.env.gov.bc.ca/wsd/public_safety/flood/fhm-2012/flood_emg_response.html.

Emergency Management B.C. stresses the importance of volunteers in dealing with emergencies of various types, including floods. People are encouraged to establish Neighbourhood Emergency Preparedness Programs to help individuals and neighbours prepare to be self-sufficient for an extended period. Volunteers are also important in the implementation of emergency response plans.

In Nova Scotia, under the *Emergency Management Act*, each municipality is required to establish and maintain an emergency measures bylaw, an emergency measures organization with an appointed coordinator, establish an advisory committee consisting of members of the municipal council and prepare and approve an emergency measures plan.[80] Similar provisions are in place in New Brunswick and Prince Edward Island.

In P.E.I. the Office of Public Safety assists communities in upgrading their existing emergency response plans. Their municipal emergency management guide outlines key components and steps to help communities to develop plans, create exercises and ensure resources have been identified before an emergency occurs. A municipal self-assessment tool helps municipalities identify key areas of focus and to ensure hazards are clearly understood. Emergency planning templates are available for municipalities and local businesses to create an emergency plan specific to the community or business requirements and emergency training is offered to individuals and organizations that have a role to play in an emergency.

Evaluation and Governance Considerations

Economic – Economic considerations include the cost and resources of preparing emergency plans, co-ordinating with other agencies and obtaining resources for plan implementation. Input in the form of assistance – technical and monetary – for the preparation of emergency plans or planning may come from higher government departments, agencies, and NGOs.[81]

Environmental – This tool is not intended to address environmental issues.

Social – The primary objective of this tool is the protection of human life, followed by the maintenance of essential services and the protection of infrastructure and buildings. This tool lays the groundwork to prepare for a possible emergency and undertake planning measures including the evacuation of an area to protect human life.

Implementation Measures and Challenges

Challenges include securing adequate resources, updating plans and undertaking disaster simulation exercises. Staff training is essential and "dry runs" are highly desirable to test the plans and response coordination. This requires resources and commitment from dedicated personnel and the coordination of multiple stakeholders.

Advantages	Disadvantages
Local governments have the authority to prepare emergency management plans for a wide range of risks. Sea level rise represents one additional risk to be addressed.	The quality and effectiveness of emergency management plans may vary depending on the level of interest and resources allocated.
The local government has the authority to declare a local emergency, which may be due to sea level rise.	The plans must be updated regularly to remain current.
Emergency planning demonstrates that hazards are real, particularly when public education is included with the planning process.	The monitoring and enforcement of emergency response plans require time and resources.
Emergency management starts from the ground up and involves teamwork with other agencies and the Province.	

[80] (Birch Hill GeoSolutions 2008)
[81] (Birch Hill GeoSolutions 2008)

Regulatory Tools

1. Regulation of Land Use

Tool Description

Land use can be regulated through neighbourhood plans, character guidelines, capital works plans, strategic plans, growth management plans and setback regulations. Land use can also be regulated through the establishment of appropriate zoning within areas subject to or potentially subject to coastal hazards. Zoning can regulate a wide range of activities, including restrictions on land uses, land use densities, setbacks, siting circumstances and servicing standards.

Application

Land use regulation – especially zoning – is a tool available in all provinces, although the specific scope of regulation ranges from jurisdiction to jurisdiction. The three key elements of land use regulation pertaining to sea level rise and coastal hazards consist of minimum building setbacks from coastal hazards or structural protection from coastal hazards, minimum elevation of buildings in relation to flood risk, and restrictions on land use. This tool can also be used to create new composite zones, such as a Sea Level Rise Planning Areas.

Enabling Legislation

In B.C., under Section 903 of the *Local Government Act*, a local government may by bylaw divide the whole or part of the municipality or regional district into zones, name each zone, establish their boundaries and regulate the use of land, siting and density of buildings and other structures within each one. This legislation could be used to create new zones with respect to coastal areas and enable a local government to regulate the use of land.

In B.C., provincial guidelines[82] call for new construction containing habitable space to be located above the historical 1 in 200 year flood event plus an additional safety margin (called freeboard) to deal with uncertainty. The resulting elevation is called the Flood Construction Level (FCL). Section 910 of the *Local Government Act* allows a local government to designate as a flood plain, by bylaw, any area where it considers that flooding may occur on land. When an area is designated as a flood plain, the bylaw may specify setbacks – based on the provincial guidelines – from the water or a dike and what structural support is required to elevate a floor system (or mobile home pad) above the flood level.

Other provinces have similar land use regulations. Zoning restrictions, minimum setbacks, lot grading, minimum building elevations and erosion protection are all commonly used to mitigate hazard risks.

In Quebec, provincial setback lines differ based on regional variations and available data on erosion rates. Most of the coastal areas require a 10–15 metre setback for the protection of the shorelines as established by provincial policy in 1987. From 2000 to 2004 a group of five ministries conducted precise erosion rate research in the Côte-Nord region. From this research setbacks of between 60 and 160 metres were suggested for that region, depending upon the rate of erosion. However, these suggested setbacks were not set as policy and therefore not widely adopted as regulation. In 2011, a uniform 30-metre setback for all other coastal communities was proposed. Many municipalities, however, have requested similar research and detailed erosion maps as were completed for the Côte-Nord to ensure they have irrefutable data in the face of potential legal challenges by coastal property owners. The Province is in the process of commissioning detailed studies on erosion and subsidence rates in order to develop up-to-date precision maps for all the shorelines of Quebec. Studies are being completed one area at a time in order of priority related to vulnerability.[83]

[82] Flood Hazard Area Land Use Management Guidelines (May 2004)
[83] (Désgagnés 2013)

Setbacks in Îles-de-la-Madeleine

Updated maps for the municipality of Îles-de-la-Madeleine were completed in late 2012 by UQAR on commission by the province. Once all the data has been translated into a directive by the province to the municipality, it has 120 days to integrate the new setback rules into its master plans, as per the loi sur l'aménagement et l'urbanisme (Planning and Urban Planning Law), article 56.14.[84]

The municipality of Îles-de-la-Madeleine is one of the most vulnerable areas of Quebec. Zoning regulations adopted in 2010 increased the setback from 15 to 30 metres. Although a provincial directive was not issued, this increase occurred as a result of public consultation and multi-stakeholder research on sea level rise in Îles-de-la-Madeleine, undertaken by the Ouranos Consortium.

In New Brunswick, the *Community Planning Act* has a provision for municipalities and rural communities to enact a flood risk area bylaw with provincial approval. Once such an area has been established, the bylaw can specify engineering standards, designs and techniques for development in flood risk areas. This *Act* also allows for land use planning throughout the province and allows for the creation of District Planning Commissions. These Commissions are responsible for providing building, development and planning services to municipalities and unincorporated areas of the province.

Cap Bimet, Grand Barachois, N.B.

In Nova Scotia, the Province has designated land use or zoning powers to the municipalities through the *Municipal Government Act* and the *Halifax Regional Municipality Charter*. These powers allow municipalities to develop planning strategies and bylaws to regulate land use.[85]

In P.E.I, zoning and development bylaws have been enacted in a number of coastal municipalities, pursuant to the *Planning Act Subdivision and Development Regulations*. These municipalities must follow the provisions of the *Environmental Protection Act Watercourse and Wetland Protection Regulations*, under provincial legislation. Municipalities can alter the setback requirements specified in the *Planning Act Subdivision and Development Regulations* for setbacks from coastal areas and beaches.

[84] (Province of Nova Scotia 2009)
[85] (Province of Nova Scotia 2009)

In Newfoundland and Labrador, responsibility for land use planning is shared by the provincial, federal, municipal, Innu Nation and Nunatsiavut governments. The Department of Municipal Affairs generally focuses on communities, although the *Urban and Rural Planning Act* provides a broader mandate that includes regional planning, the setting of plan objectives and policies, zoning and implementation measures. The Department of Environment and Conservation oversees ownership and use of the seabed within harbours and bays in the province and reviews all applications for land use to ensure compliance with existing regulations and policies.

The Department's *Policy for Development in Shore Water Zones* establishes criteria for issuing permits for all development activities in and affecting shore water zones.[86] This policy does not permit infilling, drainage, dredging, channelization, or removal of surface or underwater vegetation on or along shore water zones which could aggravate flooding problems. Shoreline activities on crown land are covered by provincial rules, though some municipalities do have development guidelines that restrict what can happen in the buffer zone. All individuals applying for unencumbered Crown land in Newfoundland and Labrador must maintain a 15 metre buffer zone between the shoreline and the boundary of the issued title though there is a reduction to 10 metres for residential lots and some older land grants are exempt. As in other provincial jurisdictions, municipalities and regional planning authorities can implement measures under their own plans and bylaws to protect coastal areas from sea level rise, flooding, erosion or other hazards. Newfoundland and Labrador has two regional planning authorities responsible for planning issues in their respective areas. As an example, the regional planning authority for Corner Brook – Humber Valley has included climate change adaptation as an issues to consider in their planning process.[87]

Evaluation and Governance Considerations

Economic – Land use restrictions, by their nature, confer development rights, with different rights for different zones and areas. While these restrictions have significant economic implications, they may be introduced in the public interest, for example, to meet changing community needs and manage competing interests and conflict.

Environmental – Regulation may facilitate identification and protection of environmentally sensitive areas and manage environmental hazards.

Social – Regulation and zoning must be balanced to accommodate future population needs, while protecting infrastructure from hazards and locating essential services in low risk areas.

Implementation Measures and Challenges

Implementation measures include the adoption of a zoning bylaw or other land use regulation by a local government. Challenges include having the information resources or capabilities to identify areas at risk and the degree of risk to be addressed. Related tools include topographic mapping to identify the location of areas at risk, and engineering expertise to address appropriate protection or adaptation measures needed to avoid the risk or reduce the risk to acceptable levels. Technical requirements to address coastal flood risks may be expensive. Public acceptance may also pose a challenge.

There may be challenges in cases where there is conflicting information on appropriate land use restrictions. For example, in Quebec, Côte-Nord established a setback line using the probability of a 1-in-100 year flood event. This conflicted with previous proposal to establish setbacks using the probability of a 1-in-25 year flood event. This situation has resulted in potential grounds for legal challenges.

[86] A shore water zone means the land that is intermittently occupied by water as a result of the naturally fluctuating surface water level in a body of water which can be either a fresh or salt water body and, in either case, the low water mark and high water mark of the water body defining the edges of the shore water zone.

[87] See draft Humber Valley Regional Land Use Plan 2011-12.

Advantages	Disadvantages
Zoning or floodplain related bylaws allow the restriction of land uses based on identified risks within a specified area (e.g., floodplain).	Local government may not be able to impose zoning that will render the land sterile (i.e., unable to be used) but it can restrict the way in which land and buildings are used so that risks can be addressed.
Zoning gives a local government great flexibility in addressing different conditions and needs within its physical boundaries.	Technical supporting documentation to address coastal flood risks may be expensive (e.g., floodplain mapping, design briefs, updated flood risk assessment, implementation measures to adapt to or reduce flood risk).
Zoning is well suited to public education and involvement.	Interim measures may lack technical documentation but can be undertaken at modest cost (e.g. sea level rise study area).

2. Subdivision Regulation

Tool Description

Subdivision regulation can be used to prevent or establish conditions for the subdivision of land at risk from coastal hazards associated with sea level rise. A proposed subdivision must go through a review process, which culminates in the approval (including approval with conditions) or refusal of the proposed subdivision by the Approving Officer or other appointed official. A subdivision refers to establishing a separate title of land. This can include a simple property, bare land strata lot, or strata unit (e.g., townhouse, row house, or condominium unit in an apartment building).

Application

This tool applies to the subdivision of land at risk of coastal hazards due to sea level rise and can be utilized in conjunction with zoning.

Enabling Legislation

In most regions across Canada, subdivision decisions are governed by some form of an approving officer. The nomenclature used to identify this approving officer, their specific role and level of government where the position is located varies in Quebec and Atlantic Canada but their basic "gatekeeper" function is similar.

In B.C., the subdivision of land is an administrative responsibility given to an Approving Officer and is separate from the responsibility of an elected Council or Board. An Approving Officer appointed by a municipality is typically the Municipal Engineer or Chief Planning Officer. For small municipalities, the Approving Officer may be the Chief Administrative Officer or a person contracted to undertake that responsibility. In non-municipal areas of regional districts, the Approving Officer is an employee of the Ministry of Transportation and Infrastructure.

Under Section 86 of the *Land Title Act*, an Approving Officer may refuse to approve a plan for subdivision if the land is subject to, or could reasonably be expected to be subject to, hazards such as flooding and/or erosion. A subdivision can also be refused if the cost to government of providing public utilities or other works and services would be excessive or if the subdivision would adversely affect the natural environment.

Section 86 also allows the Approving Officer to require a report by a qualified professional that the land may be used safely. Under Section 219 of the B.C. *Land Title Act,* the report is included in a covenant and registered as a charge on title and remains on the title of any parcels created by the subdivision, regardless of future ownership.

Variations occur in other provinces. Some but not all Nova Scotia municipalities have Municipal Planning Strategies or bylaws to regulate zoning and subdivision in place. Municipalities or non-incorporated areas must still comply with the provincial *Subdivision Regulations* under the *Municipal Government Act* and the *Environmental Protection Act* in Nova Scotia.

In P.E.I. the *Environmental Protection Act* requires an environmental impact assessment for undertakings which could have a significant effect on the environment including an effect on any unique, rare or endangered feature of the environment, or an effect which causes public concern. This legislation has broad application and includes specific references to the alteration of wetlands, interfering with the movement of sand on a beach or sand dune, and the destruction of natural stabilizing features such as vegetation. As a result, subdivision applications are reviewed through the provincial Environmental Impact Assessment process prior to issuing development permits. N.B., N.S. and N.L. all have similar environmental provisions in place.

Evaluation and Governance Considerations

Economic – Economic considerations include the cost of allowing or avoiding development in an area subject to coastal hazards, the cost of providing flood protection, and the cost of adapting to the risk. In the event of a flood, or if the risk increases and increased structural protection is required (e.g. increased dike height), these costs may be borne by different levels of government.

Environmental – Environmental considerations involve the effect on the natural environment of the subdivision due to sea level rise and coastal hazards. Subdivision regulation can be used to address environmental issues such as suitability of land use and development impact.

Social – Various public stakeholders and potential land owners may be affected by the approval or refusal to approve a subdivision. An Official Community Plan or a similar guiding document may provide a framework for these decisions and provide guidance on the suitability of subdivision development; particularly for residential use.

Implementation Measures and Challenges

This tool relies heavily on accurate information and coastal hazard mapping to provide grounds for the approval or refusal of a subdivision. Implementation requires that an Approving Officer or similar designate exercise their authority to allow or refuse the subdivision of land at risk from coastal hazards. Where the nature and extent of the risk has not been determined, the Approving Officer can withhold subdivision approval pending a report from a qualified professional. A qualified professional (i.e., engineer or geoscientist) can determine mitigation measures that would allow the land use; however the Approving Officer still has the discretion to reject the subdivision.

Advantages	Disadvantages
Most local governments have the legal mandate to establish by bylaw the conditions under which the subdivision of land can proceed.	The loss of potential development value could result in resistance from developers. Reducing subdivision of coastal land should not be undertaken ad hoc or without supporting guiding policy or a strategy in place.
The role of the Approving Officer provides for some degree of separation from political influence. The ability of an Approving Officer to protect the public interest by refusing to approve a subdivision has been well established by case law.	Without the identification of coastal hazard areas at risk of flooding and erosion, it is difficult for the approving body to decline subdivision on the grounds of safety.
This tool allows the conditions of future development to be regulated.	Subdivision approval is discretionary; but is subject to the prescribed scope of authority. The quality of decision making is dependent on the capabilities of those appointed.

3. Development Permit

Tool Description

A Development Permit is a form of land use regulation distinctive to B.C. It is identified separately because it combines policy objectives and guidelines with site specific regulation. A Development Permit can regulate development for a variety of purposes, two of which are applicable to sea level rise:

- protection of the natural environment, its ecosystems and biological diversity; and
- protection of development from hazardous conditions.

In the former case, a Development Permit Area (DPA) may specify areas of land that must remain free of development, except in accordance with any conditions contained in the permit, or require specified natural features or areas to be preserved, protected, restored or enhanced in accordance with the permit. In the latter case, a DPA may specify areas of land that may be subject to flooding, mud flows, or torrents of debris, and specify the guidelines under which the objectives will be addressed. In each case, the purpose of the Development Permit is for the specified objectives to be met prior to a development proceeding.

Application

This tool is used to identify areas where special conditions apply. The objectives of the Development Permit must be established and guidance given for addressing the objectives. While this tool is specific to B.C. legislation, there are other similar processes in Atlantic Canada. For example, Halifax Regional Municipality is managing waterfront development in Halifax Harbour by development agreements in which proponents must account for sea level rise.

Enabling Legislation

In B.C., a local government can establish Development Permit Areas under Section 919.1 of the *Local Government Act*. A DPA and guidelines can be included in an Official Community Plan or a zoning bylaw. Where a DPA has been designated by bylaw, no subdivision, building construction or alteration, or alteration of land can proceed unless a Development Permit has first been issued by the local government. In order to address the hazardous conditions specified in the DPA, the local government may require that the applicant provide a report certified by a professional engineer. When a local government has issued a Development Permit, it must file a notice in the Land Title Office that the land is subject to the conditions specified in the Development Permit. If an OCP designates areas as requiring a Development Permit, this must be issued prior to the subdivision of land within the area and the construction of, addition to or alteration of a building or other structure.

Evaluation and Governance Considerations

Economic – The creation of Development Permit Areas and the granting or refusal of applications with respect to these areas involves an additional step in the development and permitting process. The cost of the independent professional and the cost of meeting the Development Permit conditions can also be considerable. The onus is on the applicant to demonstrate that land that might otherwise not be developed can be done so safely.

Environmental – A DPA is one of the few tools available to a local government where the primary focus can be on protection of the natural environment and biodiversity. Examples could include sand dunes, coastal bluffs, and beaches.

Social – The establishment of a Development Permit Area in an OCP or zoning bylaw requires a public hearing.

Implementation Measures and Challenges

Implementation requires that an Official Community Plan designate a DPA. This includes an amending bylaw and public hearing. Once a DPA is in place, a resolution of approval is required from the local government for a specific development. The main challenge is preparing background studies of hazards and environmentally sensitive areas to justify the DPA.

Advantages	Disadvantages
The use of a Development Permit enables land use planning objectives to be implemented prior to a development proceeding.	Hazardous areas must be documented and identified prior to their designation. Smaller jurisdictions may lack the necessary planning or technical resources.
A DPA can be included in an Official Community Plan with a narrative describing the objectives that justify the designation and specifying the guidelines for addressing the objectives, accompanied by a map.	The use of a Development Permit is an additional procedural requirement for a developer or landowner. However, the additional time by itself can be as little as four weeks and a Development Permit can be processed concurrently with a rezoning or subdivision application.
The scope is very broad, as it includes subdivisions, building construction (whether or not a building permit is required) and alteration of land (e.g. re-grading, soil removal or soil deposition).	Objectives and guidelines need to be well crafted. A Development Permit cannot be turned down by the local government if the specified objectives and guidelines are met. This can be an advantage as well as a disadvantage.
The use of a Development Permit allows for an independent professional to address risk (i.e., professional engineer with relevant expertise) at the applicant's expense.	
No change in existing legislation is needed to create a Sea Level Rise Development Permit Area or Coastal Hazard Development Permit Area.	
Use of this tool requires a notice to be filed in the Land Title Office. As a result, any purchaser is deemed to be notified of hazardous conditions.	

4. Building Regulation

Tool Description

Local communities have a tools which can be used to influence the manner in which buildings are situated and constructed.

Application

This tool is applicable to all building construction or significant retrofits. The use of this tool is the last opportunity to avoid exposure to hazards, including coastal hazards.

Enabling Legislation

Under the terms of the *Constitution Act*, building regulation in Canada is the responsibility of provincial and territorial governments. The Canadian Commission on Building and Fires Codes works with stakeholders and researches to develop a model National Building Code. Most provinces and territories have adopted the National Building Code or adapted it with variations and additions. The National Building Code does not have specific design requirements to protect buildings from coastal hazards but does ensure that buildings are constructed to certain safety and design standards.

Although not all local governments in British Columbia have chosen to enforce the provincial code, technically, the code applies throughout the province. In addition, through powers provided under section 910 of the *Local Government's Act* municipalities may introduce certain construction requirements in a floodplains.

The City of Vancouver is unique among municipalities in B.C. It has its own enabling provincial legislation called the *Vancouver Charter*. Under this charter, Vancouver has developed a building bylaw which is based on the *B.C. Building Code*, with local amendments. This bylaw regulates buildings on lands subject to flooding by establishing minimum flood construction levels (FCLs), specifying construction materials, and service equipment installation, and allowing for covenants on a property title which acknowledge the risk of flood damage.

The *B.C. Community Charter* provides an alternative way that building restrictions may be imposed to address flood hazards. Under section 56 of this *Act*, a municipal building inspector may withhold the issuance of a building permit until satisfied the land can be safely used and can require a geotechnical report by a qualified professional if construction is proposed on land likely to be subject to hazards such as flooding or erosion.

A building permit can be refused until the owner agrees to a covenant on the property title stating that the land will only be used in the manner certified in the report. Regional districts have similar authorities under section 695 of the *Local Government Act*.

In Quebec, adaptation to sea level rise is currently not addressed in provincial regulations governing the authority of local governments to deal with zoning bylaws, home-owner building permits or subdivisions. The province develops planning strategies, then Regional County Municipalities (RCMs) are responsible for integrating the strategies in their Schémas d'aménagement (regional plans), and the municipalities within the RCMs then enact bylaws and regulations to implement the measures in the Schéma. The province develops policies and makes recommendations they hope the local authorities (cities) and regional authorities (RCMs) will adopt, however, there is no forced compliance from one level to the next. In some cases, depending on the type of construction, permits can be issued by regional or provincial authorities.

In Atlantic Canada there is a general provision under provincial planning legislation for the granting of building permits in non-incorporated areas. In Nova Scotia and New Brunswick, regional planning commissions can generate regional plans and bylaws. Most of the larger municipalities in all four Atlantic Provinces have the authority to prepare their own official plan and bylaws. Where official plans and bylaws exist, development officers or building inspectors issue permits. In some cases, there are provisions in place to restrict development in areas vulnerable to coastal hazards. In Prince Edward Island, the *Planning Act*, (Section 8), provides for the regulation of land use activities in non-incorporated areas. The *Planning Act*, *Subdivision and Development Regulations*, provides measures for setbacks in coastal areas of a minimum width of 60 feet (18.3 metres) or 60 times the annual erosion rate for the area (Section 16). In Newfoundland and Labrador, the *Urban and Rural Planning Act* empowers the formation of regional planning commissions in the province, and there are currently two commissions in place.

Evaluation and Governance Considerations

Economic – Building regulation as an adaptation tool has two primary purposes: the protection of property and public safety. The economic costs associated with the use of this tool are not easy to quantify due to the wide variety of circumstances that may apply. Local government review and processing costs and legal costs are likely to be modest to moderate. Similarly, the cost of implementing protective measures vary widely. In some cases a project may have to be abandoned if a qualified professional cannot certify that a building can be safely constructed for the intended use or that the cost for doing so would be excessive.

Environmental – Building restrictions as an adaptation tool only address identified hazards including natural hazards such as erosion and flooding.

This regulatory tool is not intended to address environmental criteria. Other planning tools that typically occur at an earlier stage in the development process should be used to address environmental criteria (e.g., growth management policies, easement, land purchase, subdivision, and zoning).

Social – This tool is designed to address public safety. The intent of this tool is to ensure that the occupants of a building are not subject to excessive risk. If a building cannot safely be constructed in a particular location or if the cost of doing so is economically prohibitive then it will not be constructed, thus reducing the risk to people and property. The use of this tool gives priority to the protection of the public.

Implementation Measures and Challenges

In *B.C. the Community Charter* and *Local Government Act* authorizes the local government building inspectors to withhold the issuance of a Building Permit unless a qualified professional can provide a report certifying the land can be used safely for the intended purpose. Unfortunately, there are a limited number of qualified professionals for this specialized work. One challenge cited mainly by smaller and more remote municipalities is a lack of knowledge as to who is qualified to undertake this specialized work and whether the conclusions arrived at are appropriate. In some smaller communities, local government has chosen not to undertake a building inspection function and so in these areas, this tool cannot be used.

Advantages	Disadvantages
The key advantage of this tool is its ability to place restrictions on building construction until the hazard risk has been addressed.	The application of this tool comes late in the development process. This can be a concern if a property owner is not aware of any potential risk and only finds out when a building permit application is submitted.
This tool enables site specific measures to be incorporated as an integral part of the construction of a building.	Local governments may not have the technical resources to give guidance in determining the minimum elevation for safe building construction (i.e., Flood Construction Level). This is a significant concern for local government officials with limited resources.
An indirect advantage of this tool is its ability to prevent the transfer of risk from one property owner to another unknowing purchaser. Registration of a covenant on title ensures that any future owner or prospective purchaser is aware of the site-specific building requirements. (B.C.)	Reliance on a qualified professional introduces the risk of retaining a person who lacks the necessary skills. In B.C. the Association of Professional Engineers and Geoscientists are addressing this risk by preparing guidelines for qualified professionals working to mitigate flood risks and adapt to sea level rise.
	Where building regulation or enforcement has not been adopted as a local government function, this tool will not be available.

Land Use Change or Restriction Tools

1. Land Acquisition

Tool Description

Local governments can gain ownership of land for the primary purpose of addressing public safety through purchase or expropriation. Land can be acquired for a variety of purposes, including structural protection works (i.e., a dike or other hard protection), vehicular access or setbacks for public safety. Land can also be acquired to prevent the development or to hold it in public ownership for exclusive public use.

Application

Land can be acquired to accommodate a new dike, for the landward expansion of an existing dike or as the land base needed for other forms of structural protection.

Land acquisition can be used to provide public open space, protect rare or endangered habitat or create an ecological reserve. It can also be used to avoid the cost of servicing land at risk due to sea level rise. Land purchase may take place to prevent the development of land subject to hazards, however if land is required for a public purpose, government cannot simply downzone land for exclusive public use without compensating the owner.

Expropriation is perceived as an option of last resort, as an independent third party or the courts are the final determinants of the land value. Expropriation may also be referred to as a compulsory acquisition, compulsory purchase or eminent domain.

Enabling Legislation

A municipality is authorized to expropriate property in accordance with the *Expropriation Act* under Section 31 of the *Community Charter*. Similar provisions to acquire or expropriate land exist in Atlantic Canada.

Evaluation and Governance Considerations

Economic – Land acquisition is potentially expensive and there are ongoing costs and liability associated with ownership. Any tax revenue generated from the land is forgone once it transfers to local government ownership.

Environmental – This tool can be used to protect environmentally sensitive land where development is not advisable or for foreshore protection such as soft armouring. Land acquisition may also be used to provide for public open space purposes subject to restrictions on improvements and the timing and extent of activities.

Social – There are social considerations and impacts associated with the acquisition of private land to protect the public interest. Local governments may have to acquire large sections of land necessary to expand a linear corridor (e.g. dike or seawall). Social benefits may include the acquisition of public open space and public access along a dike. In communities where expropriation is used, there may be negative impacts to local landowners.

Implementation Measures and Challenges

Key challenges in the acquisition of land include obtaining the necessary funds for a land purchase, agreeing on fair market value and obtaining political support for land expropriation. Land expropriation is typically undertaken by a local government but may include a provincial government agency. Strategic or Official Community Plans may identify properties needed for future land acquisition and, if so, make provisions for funding these acquisitions.

Example of Land Acquisition from Bas-Saint-Laurent, Quebec

In 2010 in the Bas-Saint-Laurent of Quebec, 100 homes were destroyed due to a storm event which eroded seven metres of shoreline. In response, the Province of Quebec offered to compensate homeowners for relocation, and the properties were then offered for sale to the municipality for $1.00. The role of the Province in this case allowed the municipality to acquire the land at risk and gain control of it to prevent future development.

Advantages	Disadvantages
An important tool for implementing linear protection measures (e.g. dikes) where existing land ownership boundaries do not allow a cost effective configuration for shoreline management.	This tool is primarily used to protect urban development and may include the high costs of acquiring and demolishing existing building improvements.
Land purchase may be used in combination with other tools to reduce the cost of flood protection (e.g., dike vs. seawall). This will require a comparative analysis of options that includes the cost of land and structural tools.	Land acquisition involves the use of scarce financial resources. Both local and senior governments may be reluctant to set aside funds for land acquisition unless this is part of a capital improvement project.
Where necessary, expropriation enables property acquisition if a voluntary purchase is not possible.	Expropriation has the disadvantage that price is not controlled by the acquiring agency.
Land purchase may also be the preferred outcome of a cost-benefit analysis where other options are more expensive.	Expropriation is typically seen as an option of last resort and is not typically viewed favourably by the general public or land owners.
Land purchase can be a key element in a managed retreat strategy.	The availability of land offered for public acquisition often has a short window of opportunity following the decision of an owner to sell the land or the death of an owner.

2. Transfer of Development Potential

Tool Description

This tool refers to the transfer of a property's development potential under current zoning provisions from one site or property to another. If a parcel is considered at risk, the "as of right" development potential can be relocated to another area of land or parcel not at risk.

Density transfer is primarily a voluntary, market-based concept in which the transfer of development potential offers protection for sensitive coastal resources and removes it from hazard areas. The tool can direct development away from the area at risk by designating the "donor" or "sending" area and allocating it to an appropriate "receiving" area where development or increased density can be safely accommodated.

Application

This tool is utilized in association with zoning where the development potential is measurable (e.g. the number of dwellings units or floor space ratio). Density transfer could apply to any land use but is typically applied to residential uses. The development potential of the "sending" site is reduced and the density of the "receiving" site is increased. An Official Community Plan or other similar policy document is needed to determine both areas at risk and areas where additional density is deemed suitable.

Density transfer may be achieved using a "density bank" in which a specific density is removed from the "sending" site without the need to identify a "receiving" site. Density transfer relies on an administrative process to regulate exchanges and a market to determine value. Density transfer could be applied in any municipality and would be best used in conjunction with a strategic plan where managed retreat is an objective.

Enabling Legislation

The transfer of development potential can occur within the normal powers of zoning. Its application in Canada has mainly been for heritage conservation purposes but it could be used as a tool for adaptation to sea level rise.

Evaluation and Governance Considerations

Economic – This tool essentially assigns an economic value to a property's development potential. The development potential of areas at risk are then restricted and the value transferred to areas suitable for increased density. A market-based mechanism is used to determine the value of the density transfer.

Environmental – The successful implementation of this tool could protect sensitive coastal areas at risk from development activity. Limited development could lead to the expansion of environmentally sensitive habitat, allowing intertidal habitats to expand where otherwise they might be reduced due to coastal squeeze.

Social – The primary use of this tool would be to reduce the development or redevelopment potential of land in areas at risk due to sea level rise.

Implementation Measures and Challenges

Implementation requires both an administrative process and a market that provides an incentive to developers. Although largely a market-based tool, it requires organization and administrative support from the local government.

Transfer of development potential has received considerable interest in planning literature, particularly in the U.S.A. where the concept is referred to as "transfer of development rights." However, the successful implementation of the concept has been very limited, as it poses challenges in terms of equity and administration for owners of both donor and receiving sites and does not have particularly wide appeal to property developers. As an example, the City of Vancouver used a density transfer system for many years to encourage heritage conservation; however, this has resulted in more density "in the bank" than could be used, leading to a moratorium on density banking.

Advantages	Disadvantages
Although not currently widely used, this tool is within a local government's zoning authority.	This tool depends upon the assumption that every parcel of land has development potential that can be quantified and transferred to an alternative location.
This tool is market-based and could be structured so local government requirements are limited to administrative costs.	Density transfer has limited potential for small communities or ones with a static or declining population.
Transfer of density potential could be combined with land acquisition in which the local government acquires ownership of the land and transfers the development potential to the former owner elsewhere in the same municipality.	Owners of coastal properties may resent land use restrictions or "down-zoning" if they perceive no imminent risk.
Density transfer may provide a less costly alternative to land acquisition (whether voluntary or through expropriation).	As a voluntary undertaking, the transfer of development potential may not prevent the development of areas at risk from coastal hazards.

3. Easements and Covenants

Tool Description

An easement is a legal agreement in which one landowner grants the use of some real property rights to another for a specific purpose. It represents an interest in land but not the right of exclusive possession. It can be used to allow access over, use of or other limitation that benefits one piece of land (known as the dominant tenement) and burdens another (known as the servient tenement) without resulting in a change of ownership. In B.C., a statutory right-of-way is similar to an easement. This B.C. variation is used to avoid the need for two properties, one with a dominant and the other with a servient tenement. The use of a statutory right of way is restricted to a government body, Crown Corporation or similar entity. Both covenants and easements "run with the land", meaning they bind current as well as future owners.[88]

A covenant can be used to restrict the use of land for a particular purpose. In B.C. and P.E.I., a covenant can also be of a positive or negative nature requiring an undertaking by a landowner. Examples of positive undertakings would be requirements to plant trees or to maintain privately owned flood protection works. Restrictive or negative requirements would include a limitation on development for flood protection purposes or prevention of the use of fill.

In Quebec, the Civil Code of Quebec makes provision for servitudes. A servitude is a charge on one parcel of land for the benefit of another. A servitude closely corresponds to an easement. Each of these legal instruments can be used to restrict part or all of a property for a particular purpose without the need for a change of ownership.[89]

Application

An easement, covenant, right-of-way or servitude can be registered on the title of any piece of property; however, the agreement of the property owner is required. Easements are commonly used to provide the right of access through a property. A statutory right-of-way is similar but involves a public body. Both typically involve a legal survey or explanatory plan registered as a charge on the property title.

A covenant is a written agreement between two or more parties to limit the use of the land in a particular way or require the land be used in a particular way. For an easement, statutory right-of-way or covenant to be enforceable, a purchaser of property must be given notification of its existence. The purchaser is

[88] (Richardson and Otero 2012)

[89] For a more detailed discussion, see Conservation Easements, Covenants and Servitudes in Canada A Legal Review, Report No. 04-1, North American Wetlands Conservation Council (Canada).

deemed to have notice if the legal instrument is registered on the certificate of title of the property in the applicable provincial land registry. It remains on the land and is automatically transferred from one owner to another if the land is sold.

Enabling Legislation

In common law jurisdictions in Canada (every province but Quebec), easements and covenants are authorized by either common law or statute. In Quebec, the Civil Code of Quebec makes provision for servitudes.[90]

In B.C., an easement, statutory right-of-way and/or covenant may be registered as a charge on the title of land under Division 4 (S.218-223) of the *Land Title Act*. These tools can have broad applications in addressing coastal hazards. For example a covenant can include provisions restricting the use of land or provisions limiting or preventing building on the land, or preventing its subdivision. The *Act* specifies that such a covenant may be of a negative or positive nature and may include a provision that land be protected, preserved, conserved, maintained, enhanced, restored or kept in its natural or existing state in accordance with the covenant and to the extent provided in the covenant.

In Quebec the *Natural Heritage Conservation Act* allows the registration of a nature reserve agreement to be registered against a land title. More specifically, the purpose of this *Act* is to contribute to the objective of safeguarding the character, diversity and integrity of Quebec's natural heritage through measures intended to protect its biological diversity and the life-sustaining elements of natural settings. The *Act* is intended to facilitate the establishment of a network of protected areas representative of biodiversity by introducing protection measures for natural settings that complete existing measures, including the assigning of protection status to certain areas under the responsibility of other government departments or bodies.

In New Brunswick, under the *Conservation Easements Act*, a municipality or any agency of a municipality may hold a conservation easement for a variety of reasons such as: the protection, enhancement or restoration of natural ecosystems; the conservation or protection of soil, air, land or water; the protection or use of land for outdoor recreation; or the use of land for public education.

Nova Scotia follows the 2001 *Conservation Easement Act* which enables a conservation easement to be entered into between an owner and an eligible body for the purpose of protecting, restoring or enhancing land that: contains natural ecosystems or constitutes the habitat of rare, threatened or endangered plant or animal species; provides a haven for concentrations of birds and animals; provides opportunities for scientific or educational programs in aspects of the natural environment; or is representative of the ecosystems, landforms or landscapes of the province.

The *Natural Areas Protection Act of P.E.I.* is intended to preserve natural areas. Under this *Act*, a private landowner may impose a restrictive covenant on his or her land by entering into an agreement with a covenant holder. Such a restrictive covenant may be positive or negative in nature and prohibit specific uses of the land. "Natural areas" are defined by the *Act* and include parcels of land that: provide haven for seasonal concentrations of birds and animals; or provide opportunities for scientific and educational programs in aspects of the natural environment.

Newfoundland and Labrador has no specific conservation easement legislation. However, the *Historic Resources Act* authorizes covenants or easements for the protection of historic resources. The *Act's* definition of "historic resources" is broad enough to cover some lands with conservation values.[91] The *Act* defines "historic resources" as a work of nature or of humans that is primarily of value for its archaeological, prehistoric, historic, cultural, natural, scientific or aesthetic interest, including an archaeological, prehistoric, historic or natural site, structure or object.

[90] (Atkins, Hillyer and Kwasniak 2004)
[91] (Atkins, Hillyer and Kwasniak 2004)

Evaluation and Governance Considerations

Economic – Economic considerations can include the cost of restricting land use to reduce the risk of damage to land or buildings. A Save Harmless provision in a covenant can be used to protect a local government from financial damages in the event of future flooding. The cost of an easement or statutory right-of-way will vary depending on the applicable conditions – an appraisal is frequently used to determine fair market value. Compensation to the owner could be through a lump sum or an annual payment based on a percentage of market value. A local government may be able to issue a tax receipt for a conservation easement if it is classified as a charitable gift by the Canada Revenue Agency.

Environmental – This tool is well suited to conservation purposes. Part or all of the land may be restricted for habitat conservation and a covenant may also be used as means of requiring an undertaking for environment enhancement purposes.

Social – Using this tool provides an alternative to land acquisition that meets the needs both of the landowner and the local government. This could include limited development or no development on land subject to coastal hazards, but not necessarily restriction of the whole parcel. This tool offers flexibility without a change in ownership or subdivision.

Implementation Measures and Challenges

Implementation measures include approval by the local government of the easement or other land use restriction and may include the services of a lawyer, appraiser and legal surveyor. Challenges may include securing an agreement with the land owner as to the nature, value and funding of the restriction.

Advantages	Disadvantages
The easement or other restriction can be limited to a particular part of a site, a particular purpose or a specific time period.	Annual compensation or a lump sum payment may be required to secure the easement or statutory right of way process or servitude.
The owner is able to retain ownership of the property and may be able to use areas not at risk.	
The cost for a covenant or statutory right-of-way is typically much less than fee simple acquisition.	
A covenant may be used in conjunction with other tools such as subdivision, building or land use regulation.	
A conservation easement may be considered a charitable gift by the Canada Revenue Agency.	
A covenant may be negotiated as part of the development approval process with no direct cost to the local government.	

4. Land Trusts

Tool Description

A land trust is a non-profit private organization created for the purpose of environmental conservation or other similar purpose. While there are many land trust organizations in Canada, their general objective is to acquire ecologically significant, often threatened, land through purchase, donation, covenant or lease.

Land trusts consist of nationally or provincially based organizations, typically non-profit societies with the ability to offer tax deductible charitable receipts. National organizations include Ducks Unlimited Canada and the Nature Conservancy of Canada. Provincial organizations include the Nature Conservancy of British

Columbia, Land Trust Alliance of B.C., The Land Conservancy (TLC) of B.C., Nature Action Quebec, the Nature Trust of New Brunswick, the Island Trust in P.E.I, and the Nova Scotia Nature Trust.

Application

Land trusts work with individual donors, foundations, corporations, and all levels of government to acquire and maintain land for environmental conservation purposes. Land trusts may work in a variety of ways to address their individual mandates; these can include accepting gifts of land from private donors, undertaking fundraising to acquire land to prevent the loss of environmentally significant values, and managing land in public ownership to protect and enhance its habitat and other environmental characteristics.

A conservation agreement is central to land trusts. While this does not specifically refer to adaptation to sea level rise, the conservation objectives of existing land trusts can easily accommodate this aspect, particularly with habitat creation or enhancements such as coastal wetland and sand dune creation, or rehabilitation.

Englishman River Estuary on Vancouver Island, B.C. 76.7 Hectare Acquisition by the Nature Trust of B.C. *(Photo: Nature Trust of B.C.)*

Evaluation and Governance Considerations

Economic – The cost of land acquisition as well as the cost of restoration and maintenance would likely be borne by the land trust organization. Local government could facilitate involvement of a land trust without necessarily expending financial resources and achieve the objective of protecting people from coastal hazards.

Environmental – This tool is well suited to acquire and protect environmentally sensitive land without local government having to take on responsibility for the land itself.

Social – This tool can either restrict or enhance public access to environmentally sensitive land or habitat rehabilitation areas. In addition, this tool potentially has wider appeal for application by those wishing to conserve environmentally sensitive areas in perpetuity.

Implementation Measures and Challenges

The implementation of this tool can include acquiring land by a land trust through fundraising, eco-gift, or government transfer, preparing a conservation agreement, and undertaking the necessary restoration and maintenance of the land once an easement, covenant or other restriction is in place. Challenges include obtaining the resources to acquire, restore, and manage environmentally significant lands. Time constraints may also apply.

Advantages	Disadvantages
Land trusts are primarily used for environmental protection and enhancement.	The cost of land acquisition may limit the ability of a land trust to secure and restore environmentally significant land.
Many donors are more receptive to private stewardship of environmentally sensitive land than to donating the land to government.	The appeal of land acquisitions varies greatly depending on the type of environmentally significant land and the cost of maintaining or restoring the land.
Many land trusts have an extensive and exemplary record of environmental stewardship.	
Fundraising for privately managed land acquisition by a land trust offers opportunities that may not be available if government is involved.	
Local governments can work collaboratively with land trusts to identify areas that may be suited to environmental protection and play a facilitation role but leave the negotiation with the land owner up to the trust.	

5. Foreshore Tenure

Tool Description

A foreshore tenure is a legal instrument that authorizes a use or uses over intertidal and subtidal areas. This may include a lease or licence of occupation. In B.C., the foreshore generally refers to the area below the natural boundary.[92] In Atlantic Canada, the foreshore refers to the area below the high water mark. A foreshore tenure by itself will not provide protection from coastal hazards. However, it may, in conjunction with zoning, provide the mechanism to enable a more comprehensive approach to shoreline management.

Application

A foreshore tenure could be applied to almost all of Canada's southern coasts. Foreshore tenure is generally granted by the applicable provincial government, although there are some exceptions, most notably with respect to harbours established under the *Canadian Marine Act*. Foreshore tenure does not affect the underlying Crown ownership of land (including land under water) but it can be used by a local government as part of a comprehensive approach to shoreline management such as beach nourishment, sand dune or coastal wetland creation and/or rehabilitation as well as hard structural protection.

A foreshore lease is one form of tenure. In B.C. foreshore leases require a legal survey to define the tenure area and are typically issued for periods of 10 to 30 years. The term "water lot" is frequently used as an alternative. If the lease is surveyed and has a term of 5 or more years, it can be registered in the Land Title Office. A licence of occupation may be used if the term is short, where minimal improvements are proposed or for remote sites where survey costs may be prohibitive. A statutory right of way may also be used to accommodate a linear corridor within a foreshore area.

The issuance of a foreshore lease is typically by application to the provincial government or another agency with jurisdiction. The interests of riparian owners and First Nations must usually be considered and the lease must be consistent with zoning by local government or other applicable authorities.

In a few instances, a municipality has partnered with the Crown to take over the administration and management of foreshore areas. An example is a head lease. Under this arrangement, the municipality is granted long-term tenure over a foreshore area with a revenue-sharing arrangement with the Crown. In

[92] In B.C., the "natural boundary" is defined in the *Land Act* as, "the visible high water mark of any lake, river, stream or other body of water where the presence and action of the water are so common and usual, and so long continued in all ordinary years, as to mark on the soil of the bed of the body of water a character distinct from that of its banks, in vegetation, as well as in the nature of the soil itself."

return the head lease transfers responsibility for management and environment issues to the municipality. Head leases are not commonly issued to municipalities unless there is demonstrated business case with a high benefit to the Province.

Example of Foreshore Tenure from West Vancouver head lease, B.C.

Since 1974, the District of West Vancouver has held a head lease with the Province of B.C. for the management of land covered by water from the high water mark extending 1,000 m into Burrard Inlet. Only the foreshore areas controlled by the Vancouver Port Authority and the B.C. Ferries Terminal in Horseshoe Bay are excluded. As a result of this partnership, a new 30 year head lease will commence in 2014.

The lease covers any community purposes under the *Community and Institutional Crown land policy*. This includes public access infrastructure such as walkways, seawalls, boat ramps, piers, wharves, and five marinas. Utility works are included, as well as natural enhancements such as groynes, rock reefs and riprap. The lease authorizes subleases and includes a revenue sharing agreement with the Province of B.C., while the District of West Vancouver assumes management responsibility and liability under the head lease. The head lease is subject to the rights of riparian owners or occupiers of adjoining land. The District also has adopted *Official Community Plan* policies to protect the foreshore and a 5 year foreshore protection plan. A number of enhancement works are currently underway with the active support of affected riparian owners.

Enabling Legislation

In B.C. foreshore leases and licences of occupation are typically granted by the Province under the *Land Act*. The *Local Government Act* provides for local government regulation over the surface of the foreshore area through Official Community Plans and zoning authority.

The province of Nova Scotia has a *Beaches and Foreshores Act* which allows for grants or leases of any tidal flat, beach or foreshore. The N.S. Department of Natural Resources issues leases on submerged crown lands for commercial purposes such as wharves, marinas, power generation, utility cables, etc.

In Newfoundland and Labrador, the *Lands Act*, Section 7, provides for a reservation of shoreline on Crown lands that border a lake, pond, river, the seashore or foreshore, and that are granted, leased or licensed to another party, that a 15 metre wide strip of land is maintained as a reserve by the province. The *Lands Act* of Newfoundland and Labrador also gives authority to the provincial government to issue leases on foreshore areas for aquaculture licensing.

On P.E.I., water lots in waterfront areas can be privately owned. The Department of Fisheries and Oceans administers the licensing and leasing of aquaculture operations via the *Fisheries Act*. The infilling of harbours, such as a project in Summerside in 2002, requires federal approval under subsection 35 of the *Federal Fisheries Act*.

New Brunswick has had the authority under *Common Law* to issue foreshore leases or grants for oyster fishing, for up to a 10 year period, since 1866.

West Vancouver, B.C. Seawall

Evaluation and Governance Considerations

Economic – In B.C., the cost of a foreshore lease is set by the Province. The assessed or market value of a lease may be set at a percentage of the land value, for example 8% annually. Nominal rent tenure applies if the lease qualifies under the Community and Institutional Land Use Policy of the Ministry of Forests, Lands, and Natural Resource Operations. This policy applies to eligible public sector organizations, local governments, First Nations and community organizations.

Environmental – A foreshore lease allows the management of the foreshore to be treated as more of a complete system rather than stopping at the traditional jurisdictional boundary of the high tide mark or natural boundary. This can facilitate implementation of innovative soft armoring approaches such as habitat enhancement of intertidal areas, beach nourishment or the creation of wetlands. In B.C. the holder of a foreshore tenure is responsible for clean-up of any contamination that occurs within the tenure boundaries.

Social – Local governance tenure over the foreshore can allow for partnerships with riparian owners and local community groups to provide protection for upland areas or intertidal habitats. This can help foster a sense of ownership and responsibility at the community level for adaptation along the coast. Increased recreational use may provide an additional indirect benefit.

Implementation Measures and Challenges

In British Columbia, foreshore leases have typically been used for marine facilities associated with upland development. One challenge will be to refocus this tool as part of a sea level rise adaptation strategy. In addition, it must be recognized that this tool will have limited suitability due to environmental, bathymetric and other constraints.

The District of West Vancouver provides an excellent model for foreshore management. The District has worked in co-operation with upland owners and has not detrimentally affected fish habitat. In addition, foreshore leases do not affect any federally controlled waterways such as shipping channels for the Port of Vancouver or BC Ferries routes.

Advantages	Disadvantages
Foreshore tenure could enable a local government to undertake a broader range of shoreline management and adaptation measures in response to coastal hazards.	A foreshore lease does not absolve the holder of any responsibility under the *Fisheries Act* or *Navigable Waters Protection Act*.
A foreshore lease (or other form of tenure) could enable environmental enhancement to occur with less reliance on structural protection. Possible applications include beach nourishment or the creation of off-shore islands and sand dunes.	There will be costs associated with a foreshore lease, which could range from a nominal cost to fair market value (prepaid or annual lease payment).
	The applicability of this tool will be limited to areas with suitable shoreline conditions and bathymetry.

Structural (Flood Protection Works)

1. Scour Protection

Tool Description

Scour protection is a property-specific structural tool used to protect shoreline structures or building foundations from being eroded or undermined due to the effects of moving water. Scour protection consists of riprap or structural elements designed to withstand wave action and the force of moving water. It can take different forms depending on the application: a scour apron refers to site-specific protection around the base of a building or structure whereas a scour blanket refers to measures to protect a covered or partially covered asset such as a pipeline, outfall or underground utility from damage by floodwater.

Application

Scour protection is typically applied to the foundation of a building or structure and is often used in conjunction with structural elevation. In this case the scour protection would be implemented around the building or structural element foundation. Other commonly used applications include protecting the base of transmission towers, bridge foundations, seawalls, and along coastal corridors containing a highway, railway or pipeline. Scour protection can be an integral part of a shoreline protection system such as armour rock, gabions, concrete slabs, and similar systems.

Evaluation and Governance Considerations

Economic – There are costs associated with erosion protection measures. A scour apron, typically includes an apron of riprap outside the perimeter wall installed down to the depth of the potential scour around the site. The surface may include a gravel topping or filter fabric as well as topsoil for landscaping. Other scour protection may take the form of pile foundations designed to derive vertical and lateral support below the depth of scour. Pile foundations are more expensive than conventional spread foundations, but they are not common for single storey residential structures.

A scour apron may be used to support retaining walls of linear infrastructure (e.g. dikes) to ensure the toe of the structure is protected. For a submerged structure such as a pipeline, a scour blanket typically consists of an armouring of filter stone around the structure and a cover stone above it.

Environmental – Scour protection primarily addresses the protection of building foundations and linear structure foundations. Environmental impacts will be limited for buildings, but may increase in magnitude where scour protection is introduced along a linear corridor such a seawall, stormwater outfall or a pipeline crossing. Intertidal areas are typically associated with high environmental values, and protective measures may result in some reduction or loss of environmental quality.

Social – This tool is intended to minimize risk to the foundations of buildings and structures. If the risk to a building is reduced, the risk to inhabitants and employees also decreases.

Implementation Measures and Challenges

Implementation typically occurs following an engineering analysis of risk and appropriate mitigation measures. A design drawing is produced, showing the minimum requirements to implement the erosion/scour protection measures. The contractor or other responsible party then constructs the scour protection according to the specifications provided. The tool may be implemented in conjunction with other requirements as determined by a building inspector, approving officer or the terms set within a covenant on title.

Challenges can occur if the extent of the risk increases over time or is not known or identified, with the result that scour protection measures are not requested. If there are no gatekeepers responsible for public protection, the risk to a specific building or infrastructure corridor may be overlooked even if the property owner is conscientious. In the absence of regulatory requirements or regular inspection, information resources can provide general guidelines alerting a property owner to the benefits of scour protection in areas subject to flooding and sea level rise.

Advantages	Disadvantages
Provide a barrier to protect the foundation of a building or other structure from wave action or other form of rapidly moving water. The presence of erosion/scour protection provides two secondary messages: • a vivid and constant public reminder to passers-by that the site is subject to flooding or inundation risks; and • a reminder that adaptation measures have taken place.	Aesthetic disadvantages include the often harsh appearance of the erosion/scour protection. This can often be mitigated by providing an erodible top to cover the scour protection or provide a more gradual grade away from the building. Where services are provided to a building, the erosion/scour protection will only protect services within the scour protection area, not the services beyond. Costs can be significant and include designing, transporting, installing and maintaining erosion/scour protection.

2. Structural Elevation

Tool Description

Structural elevation can be achieved in several ways, including: raising the ground elevation with the placement of structural fill; raising the elevation of habitable areas within a building; or raising the entire building by using stilts, foundation walls or similar elevating structures. This tool is mainly used for new construction but can also apply to a major addition or retrofit. This tool is also sometimes referred to as super elevation or dry floodproofing.

Application

This tool can reduce the risk of damage to buildings and infrastructure by raising their elevation. The increase in elevation above the natural ground level can be determined through a risk assessment by a qualified professional or in accordance with local government requirements, guidelines or policy. In rural areas, this tool typically involves the use of fill to raise the elevation of a house or other buildings above a flood plain or other flood hazard. In urban areas where lot areas are smaller, this tool may involve creating non-habitable space (crawl space or cellar) in areas subject to flooding. A combination of fill and building design changes may be used for new development on a neighbourhood level or for infill redevelopment within an existing area.

In B.C., the authority for structural elevation is most clearly stated in Section 910 of the *Local Government Act*. If a local government considers that flooding may occur on a piece of land, the local government may adopt a bylaw requiring a minimum elevation for the underside of a floor system of a house on that land. Such a bylaw must consider the provincial guidelines, which take sea level rise and related impacts into account.

The standard of protection varies from province to province. In British Columbia, the design standard of protection is for a 1 in 200 year return period. This means the elevation of buildings should be raised to withstand a flood with an annual probability of 0.5% or a 1 in 200 year flood. In B.C. the minimum elevation for habitable construction is called the Flood Construction Level (FCL). This is the minimum elevation of the underside of a wooden floor system or the top of a concrete slab for habitable buildings. The Flood Construction Level typically includes an additional vertical distance (freeboard) of 0.3 metres to 0.6 metres to the calculated flood level to accommodate uncertainties in flood levels. There is a relationship between the standard of protection and resulting risk. If the design standard is reduced to withstand a flood with an annual probability of 1.0%, the cost of protective measures will decrease but the risk increases.

Flood construction requirements in Atlantic Canada may reference a minimum elevation above sea level datum, geodetic datum or protection for a 1 in 100 year return period or a 50 year design standard. In Newfoundland and Labrador, the design standard is based on a flood event with a 1 in 100 year return period. The other Atlantic Provinces rely on generally accepted coastal engineering design standards for the life of structures in coastal areas of 50 years. A notable exception is the Confederation Bridge between New Brunswick and Prince Edward Island, which was built a metre higher to account for sea level rise over the 100 year design life of the project.

Evaluation and Governance Considerations

Economic – The cost of structural elevation depends on a numbers of factors, one of which is the cost of fill. The affected site area will include the building footprint area plus a sloped area for the fill, typically at a 3:1 slope, to return to the natural ground level. Alternatively, a retaining wall or other structure could be used to reduce or eliminate the sloped area. The amount of fill could be substantial. For a 1 metre elevation rise to accommodate a two storey building with 200 m^2 of living area and a building footprint of 10 metres by 10 metres plus a 3:1 slope back to the natural elevation, nearly 200 m^2 of fill would be required. For a 2 metre elevation rise, the amount of fill would increase to over 500 m^2. If a lesser amount of fill is used without reducing the Flood Construction Level, the building could be designed without livable space on the ground level. This often takes the form of a crawl space with a low ceiling height, a garage, an entry foyer, laundry room or a small storage area. Electrical outlets would have to be raised and a furnace located above the Flood Construction Level.

The key economic consideration is the cost of reducing the risk through structural elevation. The cost of providing public infrastructure[93] (roads, bridges) in an area at risk is another economic consideration that will increase over time. The cost of floodproofing can also be compared to the cost of development in an area without risk of coastal flooding or inundation.

Environmental – This tool primarily addresses the protection of buildings and property. Environmental impacts will be more significant where a large area is subject to fill placement, such as previously undeveloped areas, wetlands and other natural areas. The cost of floodproofing can also be compared to the cost of development in an area without risk of coastal flooding or inundation.

[93] Critical infrastructure includes all the services that support development in an area subject to the risk of flooding.

Social – This tool primarily minimises risk to building inhabitants and structures themselves. Social considerations include the visual impact, which increases as the amount of structural elevation increases. For a single family dwelling or townhouse, there is a risk the owner may convert a crawl space or non-habitable space below the Flood Construction Level to a living area after building occupancy has been obtained. This is most likely to occur where the cost of housing is high.

Implementation Measures and Challenges

Structural elevation measures are typically required as a condition of building approval. Structural elevation measures can be implemented after a building is constructed but incur greater costs. The challenges increase depending on the amount of elevation rise required and the site. A large structural elevation rise on a small property may not be feasible. The aesthetics of having elevated and non-elevated structures in the same community may be a drawback if the elevation change is significant.

Providing access for persons with disabilities poses an additional challenge. The structural elevation of heritage buildings also poses a particular challenge.

Advantages	Disadvantages
By raising the habitable floor elevation to a specified design flood event, the risk of flood damage can be measurably reduced.	The cost associated with raising the elevation of a building can be considerable. The cost will vary depending on the size of the building floor plate, the building design and the amount of elevation rise to reach the design requirements. Estimated additional building costs for new construction may range from 3% to 30%. Associated costs may include additional steps or handicapped accessibility provisions.
Structural elevation enhances resilience by providing a secondary means of protection where dikes provide the first line of defence.	There is a limit to the amount of structural elevation which can occur. As structural elevation requirements increase (i.e., become higher), the increase in cost is geometric, not arithmetic.
One indirect impact of structural elevation is greater awareness of sea level rise. Although architectural design can address visual impact to some extent, a major change in elevation for a dwelling or other habitable structure serves as a vivid and constant public reminder that flooding is a risk that must be addressed.	The placement of fill to raise the ground level may not be aesthetically attractive if the elevation change is large. This is particularly evident on small infill lots.
Structural elevation is not a permanent solution, as sea levels will continue to rise, but may last the lifetime of the building.	

3. Dikes

Tool Description

A dike is commonly a linear compacted earthfill structure intended to protect a designated area from inundation caused by high water conditions on an adjacent watercourse or floodplain.[94] Dikes typically form the key defense element in a protect strategy. The primary function of a dike is to prevent the inundation of coastal lowlands from the sea under extreme conditions. Sea dikes typically have a flatter gradient on the seaward side, for the purpose of dissipating wave energy. This is not necessary on the landward side where a steeper gradient is typical to reduce land requirements. In addition, a sea dike will typically have toe scour protection consisting of riprap and an under layer of filter rock or geotextile to prevent it from being undermined.

[94] (APEG Professional Engineers and Geoscientists of BC 2012)

It is important to recognize that, because agricultural land can tolerate some overtopping, the construction elevations and design of earthen dikes to protect agricultural land may be lower than for the protection of life and property. Depending on the province and location, municipalities may have no control over private agricultural dikes within their boundaries. They are not financially responsible for repairs to such dikes but may be affected by the impacts of a dike breach.

Application

Recent research,[95] has resulted in a re-evaluation of the vulnerability of communities to flooding due to storm surges and wave action. In B.C., a 2012 study indicated the need for a higher dike crest elevation for over 250 km of shoreline in the Lower Mainland study area, most of which is protected by dikes. The increased risk is due to a combination of sea level rise as well as an increased provision for storm surges and wave run-up and seismic considerations.

Dikes are typically designed by a qualified professional in accordance with local and provincial regulations and guidelines. In B.C., there are various applicable provincial documents, including the recent Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use,[96] which are divided into three volumes: Draft Policy Discussion Paper, Sea Dike Guidelines and Guidelines for Management of Coastal Flood Hazard Land Use. There are numerous technical publications which provide guidance on engineering design.

Assets protected by dikes can include infrastructure and agricultural lands. Both New Brunswick and Nova Scotia have legislation to protect agricultural land and to create marsh bodies, although not all development that has taken place in low-lying areas is behind a dike or protected by this mandate. In New Brunswick, the legislation is referred to as the *Marshland Reclamation Act* (O.C. 82-14). Nova Scotia has been more progressive, updating the *Marshland Reclamation Act* of 1989 with numerous amendments through the *Agricultural Marshland Conservation Act* (c.22, s.1, amended 2004).

New Brunswick has 37,000 acres of marshland protected from the tidal waters of the Bay of Fundy. Some of this land is protected by a variety of earthen infrastructure (including dikes) constructed over 300 years ago. Much of the earthen infrastructure was constructed in the early 1950s and is currently maintained by the N.B. Department of Agriculture, Fisheries and Aquaculture.

2011 Upgrade to Dike in Fraser River Estuary, Richmond, B.C. *(Photo: City of Richmond)*

[95] (Ausenco Sandwell 2011)
[96] (Ausenco Sandwell 2011)

In British Columbia approval to construct dikes and other hard protection must be obtained from the province under the *Water Act* and the *Dike Maintenance Act* and, where applicable, from the federal government under the *Fisheries Act* and the *Environmental Assessment Act*.

The Nova Scotia Department of Agriculture has a mandate to protect agricultural land behind dikes in the Annapolis Basin, Upper Bay of Fundy and other regions of the province. The Department is currently responsible for tidal dike maintenance, while landowners are responsible for maintenance of internal dike roads and the acquisition of land required for the reconstruction of dikes. Historically, earthen dikes have been used to protect this land. These dikes have been raised to maintain a minimum critical elevation relative to tide levels. Many dikes were originally built by the Acadians 300 years ago and were upgraded in the 1950s. In 2000, the provincial *Agricultural Marshland Conservation Act* was passed to protect these soils for future generations. It is thought that a majority of the diked land is at risk from rising sea levels and storm surge.[97] Under a joint Atlantic Regional Adaptation Collaboration project with New Brunswick, a 2012 GIS assessment of dike vulnerability based on LiDAR data in the Tantramar marshlands area concluded that the region was at immediate risk of flooding.[98] With an average height of 8.9 metres, the vast majority of dikes (89%) would be overtopped with a frequency of 1:10 years (i.e. once in 10 years). This would potentially flood over 20% of Sackville during a storm surge.

Evaluation and Governance Considerations

Economic – Economic considerations include:

- The cost of new dike construction where a dike is not present;
- The cost to accommodate a higher dike due to sea level rise;
- The structural stability of the new dike; and
- The ongoing cost of dike maintenance; and land acquisition to accommodate the land base for the dike and road access for maintenance and emergency management purposes.

Where an increased dike height is involved, the economic, social and environmental implications of a seaward versus a landward expansion must be examined. Hard protection measures tend to be expensive (in the order of thousands of dollars per metre for revetments and dikes). The standard for flood protection measures (i.e., Flood Construction Level for current sea level vs. projections for 2050 or 2100) will have a critical impact on the economic costs. Given the cost implications, it is anticipated that greater use of hybrid techniques such as living shorelines will occur and increased attention will be given to retreat and avoid strategies. The capital and operating costs of dikes may limit their implementation to selected locations, such as densely populated areas, areas with high natural or cultural importance, and high value infrastructure.

Funding for dike upgrades requires a large capital outlay, and requires approval by different levels of government. Intermittent funding programs may not be appropriate where the need for upgrades is ongoing and long-term. It may be difficult to obtain public acceptance depending on the capital costs and the distribution of those costs, especially if property views are impacted.

[97] Refers to an extreme tide which occurs every 18.03 years in the Gulf of Maine-Bay of Fundy region when 3 tidal elements peak at the same time: anomalistic, synodical and tropical monthly cycles.

[98] (Liekse and Bornemann 2012)

Sea dike upgrade costing study, Metro Vancouver, British Columbia[99]

In 2011 the Province of British Columbia published a Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use (Ausenco Sandwell, 2011), which defined sea level rise planning levels and flood protection requirements. The guidelines propose an updated design methodology for coastal flood protection measures, including new design criteria for sea level rise, subsidence, storm surge and wave effects.

To gain a greater understanding of what implications the new guidelines would have on the ground, the B.C. Ministry of Forests, Lands and Natural Resource Operations commissioned a study to develop a 'Class D' estimate of the cost to adapt flood protection to meet the rise in sea level predicted by 2100. The study covered the Metro Vancouver coastal shoreline and the Fraser River shoreline as far east as the Port Mann Bridge, some 250 km of shoreline and dikes in total. Within this area both diked shorelines and low-lying areas that may require protection as sea level rises were considered.

The report calculated the full costs of establishing flood protection for seismic stabilization of the diking system and the sea level rise projected to take place by 2100, including land acquisition, engineering, environmental design, relocation of utilities, and upgrading of pump stations and other associated works. The total estimated cost was $9,470 million, including a 50% contingency factor. The estimated cost for sea level rise alone, including associated infrastructure and property acquisition was $2,810 million.

Environmental – Environmental impacts include the lost intertidal areas from the seaward expansion of a dike, or of agricultural and open space areas where a landward expansion is involved. The presence of dikes impedes natural shoreline migration – an adaptive response of coastal habitats to rising sea levels.

Social – Social implications include the loss of housing due to land acquisition, impacts on views and loss of community amenities in and around dikes.

Dikes provide some assurance of land stability and therefore tend to promote shoreline development. Unless such structures are designed to meet a long-range design standard, they can lead to a false sense of security. If Flood Construction Levels and setbacks are not increased due to sea level rise and other climate change effects, the level of protection provided by a dike will gradually decrease over time.

Hard protection methods have a long history of successful use, although in the rare instance of failure, the consequences can be very severe. Dikes can also provide a secure corridor, such as a road or trail, and often enhance recreation value.

Implementation Measures and Challenges

Apart from the high costs for construction, dike implementation measures require land acquisition for the linear corridor occupied by the dike as well as access for maintenance and emergency measures. The linear corridor may affect numerous landowners and may require the relocation or removal of other structures. There are often environmental and social issues as outlined above.

[99] (Ausenco Sandwell 2011)

Advantages	Disadvantages
Dikes can be engineered to provide a reasonably high level of protection, if adequately maintained.	Dikes are expensive to construct and can be unsightly. They may restrict access to the shore and reduce the recreational value of a shoreline.
Dikes can provide protection for high value development and maintain or enhance property values.	Dikes may cause erosion to adjacent unprotected areas.
Dikes have the secondary effect of containing internal drainage on the land side, requiring it to be discharged through floodbox structures that can be closed at high sea levels, and pumped or opened to release water at low tides. This can also be a disadvantage.	Dikes and revetments tend to absorb wave energy and therefore will be subject to damage and will require ongoing maintenance and investment.
The dike crest may be available for use as a recreation corridor.	Dikes can result in a loss of intertidal areas and impede natural shoreline migration.

4. Other Hard Protection

Tool Description

There are several types of other hard protection structures commonly used within a coastal context.

Groynes are rigid structures typically constructed of riprap or other heavy material extending from the upper foreshore or beach into the water. They are located perpendicular to the shore or at a slightly oblique angle. Groynes are used to dissipate wave energy, trap the movement of sediment along an intertidal area and reduce the seaward transport of sediment (this may cause erosion on one side and accretion on the other). They function by realigning short sections of the shore with respect to the incoming waves.

Breakwaters are rigid structures typically constructed parallel to the coast for the purpose of reducing the amount of wave energy reaching the shore. A perched beach retained by a submerged structure may be considered a subset of this category.

Offshore breakwaters may also be called **bulkheads**. They are designed to reduce the intensity of wave action in inshore waters and thereby reduce coastal erosion or provide safe harborage. Breakwaters may also be small structures placed offshore in relatively shallow water designed to protect a gently sloping beach or a vertical retaining wall designed to hold and prevent soil from sliding seaward.

Seawalls are typically vertical concrete or rock structures constructed to provide protection against erosion and flooding. Seawalls are built parallel to the shore and generally have a deep foundation for stability.

Sea dike and upgraded Oliver Pump Station, Corporation of Delta, B.C. *(Photo: Graham Farstad)*

Revetments are covers or facings which provide erosion resistance to a sloped surface. They can be concrete, timber, armour rock (riprap), gabions and other materials. The terms seawalls and revetments can, on occasion, be used interchangeably.

Floodwalls are vertical structural barriers, typically constructed of concrete, and designed for use in confined areas over short distances to prevent flooding.

Storm Surge and **Tidal Barriers** consist of hard engineered protection with movable or fixed barriers/gates which are closed to prevent flooding when extreme water levels are forecast.

Application

Groynes are typically used to impede the drift of sediment along a beach. Their effectiveness depends upon a supply of sand and the existence of longshore sediment transport. They are often constructed as a series of structures and may be used in combination with beach nourishment.

Breakwaters are used to protect marinas, ports, harbours and other shoreline infrastructure from storm surges and wave action.

Seawalls are most often used to dissipate wave energy, as well as flooding and erosion in constrained coastal areas. This may occur where the land drops off sharply on the seaward side or where the cost of land acquisition for a dike is prohibitive. A seawall provides a firm boundary between the land and the sea and provides protection up to the design height of the seawall. Seawalls are typically in place where available space is constrained due to physical or cost factors.

Floodwalls are typically used in locations where space is limited and where land uses and values are very high. Floodwalls are used where the use of a dike or other lesser cost structure is precluded, due to conflicts with buildings and other land uses.

Storm Surge Barriers are constructed across river estuaries and are equipped with gates that can be closed in the event of a storm surge.[100] They are most commonly used to protect tidal inlets and estuaries. Their primary function is to prevent coastal flooding, but they can shorten the length of defences behind the barrier. Water is discharged through or pumped over the barrier depending on the applicable conditions.

NW Arm Sea wall at Fleming Park under construction June 2012, Halifax, NS

[100] A more detailed discussion of these features can be found in (Linham and Nicholls 2010)

Evaluation and Governance Considerations

Economic – Considerations related to these measures are similar to those of dikes. Groynes, breakwaters and storm surge barriers also involve high construction costs. For all hard protection, an engineering analysis should be undertaken with respect to capital and operating costs as well as risk and impact mitigation.

Environmental – Considerations are similar to those for dikes except for the linear corridor requirements of a dike. Groynes, breakwaters and storm surge barriers may cause negative environmental impacts and transfer risk onto nearby properties.

Social – Criteria are similar to those of dikes.

Implementation Measures and Challenges

Implementation of any form of hard protection will, in most cases, involve large costs and funding. Apart from the construction costs implementation of hard protection measures may require land acquisition and authorized access to undertake maintenance and emergency measures. A particular challenge affecting the implementation of a groyne is the potential to transfer risk from one riparian property to another or create a negative economic, social or environmental impact.

Example: Sept-Îles, QC hard protection challenges

In the municipality of Sept-Îles in Quebec, measures to protect against erosion have primarily involved riprap structures constructed and paid for by the municipality, sometimes with assistance from the Province or private property owners. Property owners require a permit before such measures can be implemented, however, many have built riprap structures without permits over the years.

The result is a patch-work mix of varying quality and integrity. The riprap installed in the bay to protect the downtown core from flooding has held up well over the years and appears to be doing its job. The bay is relatively protected from winds; some waves do not hit the rocks with as much force as in other areas. It has been observed in the areas that extend out from the bay that riprap structures appear to have contributed to increasing erosion particularly in the gap areas where the structures are not as well constructed or are absent.

For this reason, in 2000, municipal officials requested that the province conduct detailed research on erosion in the area. As a result of this research, all structural measures, save for adding sand to the banks, have been prohibited since 2005.

Advantages	Disadvantages
Many forms of hard structural protection can be engineered to provide a reasonably high level of dependability, if adequately maintained.	Structural measures to protect against erosion in one place can increase erosion elsewhere. This situation may occur where incoming waves approach the shoreline at an angle causing sediment to move along the shoreline until blocked by a groyne.
Hard structural protection can provide protection for high value development or natural areas and maintain or increase property values.	A groyne offers limited protection against extreme events and may negatively impact adjacent riparian areas.
A seawall may be available for use as a recreation corridor. The Stanley Park seawall in Vancouver is an example of an outstanding success with major recreation and economic spin-off benefits.	A seawall or floodwall reflects more wave energy, which may cause localized erosion at the toe and require a deep foundation.
	Seawalls and other hard protection structures are expensive to construct and maintain, can be unsightly and restrict shore access.

5. Wet Floodproofing

Tool Description

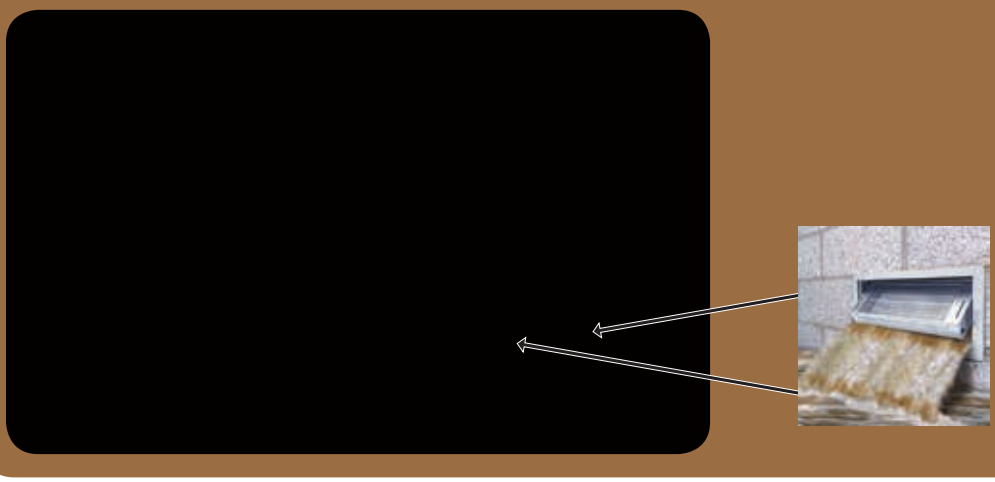
Wet floodproofing consists of measures which allow water to enter and exit a structure with minimal damage. Wet floodproofing involves the use of flood resistant materials, the elevation of electrical and mechanical services and the use of openings for drainage. This tool is distinguished from dry floodproofing which aims to make a building watertight or impermeable to an expected flood.

Application

Wet floodproofing has limited applicability and is not commonly used. It may be used for existing developments with small land parcels built where infrastructure is slightly below the established Flood Construction Level. A commercial storefront abutting a sidewalk that is at an elevation subject to flooding has few alternatives if the building has no setback from the property line. Wet floodproofing may be a viable alternative to elevating an existing residential property on a small lot above the floodplain.

Wet floodproofing may be used where the area subject to flooding is not used for habitable purposes, these may include vehicle parking areas and areas used for the storage of goods not damageable by floodwaters.

Figure 8 - Wet floodproofing design[101] with window openings which allow for passage of flood waters *(Drawing: the Arlington Group Planning + Architecture Inc.)*.



(Photo: Don Jardine)

[101] (Arlington Group Planning + Architecture Inc. 2001)

Evaluation and Governance Considerations

Economic – Economic considerations include the cost of installing or retrofitting flood-resistant materials, and constructing or retrofitting electrical and other services damageable by floodwaters at a higher elevation. Adequately sized openings must be provided to equalize hydrostatic pressure. Owners must be willing to experience a temporary loss of use of areas subject to flooding and must ensure damageable goods are not located in areas subject to flooding.

Environmental – Environmental implications of this tool are minimal.

Social – Wet flood proofing may reduce the risk of flooding to people and buildings. Post-flood recovery time may be rapid compared to flooding of buildings without flood resistant materials.

Implementation Measures and Challenges

Implementation involves the use of flood-resistant materials, as well as the strategic placement and use of building openings and the electrical, mechanical, heating and ventilation equipment. A detailed list of flood-resistant materials and their application has been published by the US Federal Emergency Management Agency based on destructive testing by the US Army Corps of Engineers. Challenges include the cost of implementation and the limited circumstances in which wet floodproofing is applicable for long-term adaptation to Sea Level Rise.

Advantages
Can reduce the time and cost of cleanup after a flood.
Wet floodproofing can be less costly than other retrofits as no additional land is required and the appearance of the building is minimally affected.
Allowing water to enter and exit a building may be a cost-effective alternative to dry floodproofing.
A wide range of water resistant materials can be used at a reasonable cost.

Disadvantages
Wet floodproofing has limited applicability and appeal for sea level rise.
Clean-up is still required post-flood.
A residential building will be uninhabitable during a flood; other accommodation has to be provided.
Goods may be damaged by floodwaters if they cannot be moved to higher ground.

Non-Structural (Soft Armouring)

1. Coastal Wetland Creation or Restoration

Tool Description

Wetlands are some of the most ecologically important and vulnerable coastal habitats. Coastal wetlands are found in the "transition zone" between land and sea, and have both upland and aquatic characteristics. As a result, they are extremely productive ecosystems and often have a richer flora and fauna than other environments.[102] Functionally, coastal wetlands assist with wave and tidal dissipation, and their vegetation and root systems act as a trap for sediments, facilitating accretion and reducing erosion. In the absence of a barrier to migration, if a wetland or salt marsh is losing area on its seaward side, it is likely claiming area on its landward side. This adaptive ability contrasts sharply with traditional human-made coastal defences that are static and typically require the continuous input of resources.[103] The most commonly restored coastal wetland ecosystems are salt marshes.

Application

On the seaward side, this tool can be used as part of a protect or accommodate strategy. On the landward side, wetland creation can be part of an avoid strategy or provide a transitional land use as part of a long-term strategy of managed retreat. This tool does not apply to rocky coastlines or where the ocean depth drops rapidly.

Enabling Legislation

There is no specific legislation governing wetland restoration although the Federal *Species at Risk Act* may apply. Wetland creation may be facilitated through Environment Canada's Ecological Gifts Program.

To effectively manage and conserve wetlands, the New Brunswick Provincial Government developed a Wetlands Conservation Policy. The policy, approved in 2002, had two main objectives: (1) the maintenance of wetland function and (2) the securement, stewardship, education and awareness of wetlands. Subsequently, parts of the policy were dropped after complaints from some businesses and landowners that it was too restrictive.

Evaluation and Governance Considerations

Economic – Considerations include the economic benefit of reduced flood risk to people and property, the cost of securing the land (which includes land covered by water) through a foreshore lease or other means, the cost of creating or restoring the land and the cost for long-term management. Environment Canada's Ecological Gifts Program, through which a landowner donates ecological sensitive land and receives a tax benefit, may be of assistance, although this program does not apply to existing intertidal areas, which are owned by the Crown throughout Canada.

[102] (Ecology Action Centre n.d.)
[103] (Singh, Walters and Ollerhead 2007)

Fraser River Park
Vancouver, B.C.
(Photo: Hay & Company Consultants Inc.)

Environmental – Environmental considerations include the environmental benefit of the wetland creation or restoration such as new or enhanced habitat for fish and shellfish and improved water quality.

Social – Passive recreational activities, such as bird watching and interpretive opportunities, may complement the creation of coastal wetlands. Passive recreational features include elevated walkways, at grade walkways subject to periodic flooding, blinds and waterfowl observation towers for naturalists. In conjunction with other tools, wetland creation may reduce the land requirements for linear protection.

Implementation Measures and Challenges

Like any tool, the appropriateness of wetland or salt marsh restoration must be evaluated on a site-by-site basis. Understanding the biophysical conditions under which restoration is being considered is particularly important as these may ultimately determine the long-term sustainability of a restored wetland or marsh.[104] Implementation measures include land acquisition, foreshore lease, covenant or other form of protection. An assessment of the area by a Registered Professional Biologist or other qualified professional should take place. Financial resources are required to undertake the necessary investment to create or restore the wetland; and an organization such as a land trust may be required to manage the wetland. Challenges include acquiring the wetland area (i.e., tenure from a private land owner), securing the necessary funds and undertaking long-term maintenance.

[104] (Singh, Walters and Ollerhead 2007)

Advantages	Disadvantages
The main benefit is the reduction of incoming wave and tidal energy through dissipation in the intertidal zone.	For a protect strategy, space requirements in areas with existing development or high development potential may have attendant high acquisition costs.
Coastal wetlands or salt marshes are cost effective relative to static man-made coastal defence structures.[108]	A lack of public awareness of the flood and erosion protection benefits offered by these environments can be a potential barrier to implementation.
Wetlands can help reduce coastal flooding and stabilize shorelines.	Wetland creation is not feasible in many areas due to unsuitable bathymetric conditions or excessive erosion.
Wetlands can provide highly productive new habitat and environmental benefits.	
Coastal wetlands have capacity to improve water quality and fishing in coastal waters by providing vital breeding and nursery grounds for fish and shellfish.	
Provided wetlands are not subjected to coastal squeeze and that the rate of sea level rise is not too rapid to keep pace, wetlands are capable of adapting to sea level rise without further intervention or investment.	

2. Dune Building or Rehabilitation

Tool Description

Naturally occurring dunes are wind-formed sand deposits representing a store of sediment in the zone just landward of normal high tides. They typically occur along wide sandy coastlines, and are dynamic and constantly moving. Natural sand dunes provide an effective defence against coastal erosion and flooding by dissipating incoming wave energy from a storm surge, wave run-up or extreme high tide. Dunes form a barrier similar in function to a seawall but are more dynamic, as they have the ability to adjust in response to changes in wind and wave climate or sea level.

Artificial dunes are engineered structures created to mimic the function of natural dunes. At its simplest, artificial dune construction involves placing sediment from dredged sources and shaping them to form dunes.[106] Dune rehabilitation refers to the restoration of natural or artificial dunes in order to gain the greatest coastal protection. Both natural and artificial dunes can be stabilized through vegetation planting; vegetation roots help stabilize the dune. Historically, sand dunes have often been removed or altered, either because they represent an economical source of construction materials or are a barrier to coastal access or views. Naturally occurring dunes have often been seen as conflicting with human settlement as these same coastlines are often the most desirable places for development.

Application

Dunes occur very infrequently along the west coast of B.C. but are more common on the east coast of Vancouver Island and the east side of Graham Island in Haida Gwaii. They occur more frequently in Quebec and Atlantic Canada, particularly in P.E.I. They are found most frequently along wide sandy coastlines and may be used in combination with beach nourishment.

Dune creation or restoration requires compatible sediment. Vegetative planting or fences may be used to stabilize an artificial dune. A 2011 project by the Souris Wildlife Federation on the causeway at Souris, P.E.I. has installed snow fencing and spruce boughs in an effort to trap sand to build up the dunes to help protect against future storm surges.

[105] (Singh, Walters and Ollerhead 2007)
[106] (Linham and Nicholls 2010)

Dune protection consisting of sand fence with spruce boughs, Souris Causeway, P.E.I. *(Photo: D. Jardine)*

Evaluation and Governance Considerations

Economic – Economic considerations include the availability and cost of sand, the cost of equipment, the frequency with which dunes need to be replenished and the cost of the land or foreshore lease required to accommodate dune building.

Environmental – Dune creation and protection is one of the limited number of tools likely to have a positive environmental impact (e.g., increased habitat in limited supply, tool that works with nature).

Social – On one hand, creating dunes on the landward side may result in a loss of land for existing residents and property owners. Loss of views and direct access to coastal areas may affect existing residents. On the other hand, opportunities for passive recreation could increase. Implementation could serve as a community education process about non-structural measures used in adapting to sea level rise. Creating dunes on the ocean side may not be feasible.

Implementation Measures and Challenges

Implementation requires an area (land or foreshore) to be set aside, a source of sand to create or rehabilitate dunes, equipment to move and shape sand into a dune, and funding sources for capital and ongoing maintenance. Key challenges include the availability of suitable material, the cost of implementation and maintenance, the equitable allocation of project costs between benefiting property owners and society as a whole, and obtaining public support.

As an example of potential challenges, Sept-Îles in Quebec has a regulation[107] banning all structural protection for private property owners, except for sandbanks. Construction of these banks requires a provincial permit which the Province will not presently issue to individuals, a challenge to the cohesive use of this tool.

[107] Règlement No. 02-2005, Règlement do contrôle intérimaire relatif aux zones de risque d'érosion littorale en bordure du fleuve Saint-Laurent et de l'estuaire de certaines rivières du territoire de la MRC de Sept-Rivières (Regulation number 02-2005, Interim regulation related to erosion risk zones along the St. Lawrence and for certain river estuaries in the RCM of Sept-Rivières). Adopted in 2005, dated in 2010.

Advantages	Disadvantages
Dunes can be used to provide an effective defence against coastal flooding and erosion by maintaining wide sandy beaches, which dissipate wave energy, and can serve as a store of sediment, which can be accessed in order to satisfy erosional forces.	Dunes, especially artificial dunes, can be perceived as a barrier to beach access, and a dune creation proposal may run into community opposition. While providing protection from erosion, dunes may conflict with residential or tourism purposes where the concern is maintaining "sea views". Dune development may be seen as an opportunity to encourage additional coastal development at risk from sea level rise.
Dune protection can meet multiple objectives, including environmental enhancement and protection, public and recreational access, and hazard reduction.	Dunes are not static like hard forms of protection. They are dynamic and constantly evolving, and therefore require careful long-term management.
Dunes can be created in a sensitive manner by taking into account the environment in which they are placed. Dunes and the vegetation of dunes can provide an important environmental benefit by creating or increasing valuable coastal habitat for species at risk.	Dunes as an sea level rise adaptation tool have limited applicability since sandy shorelines and suitable material are not present in many areas. As well, the bathymetry near the shoreline may not be suitable for the use of this tool. Dunes may require a large footprint, which may have significant cost implications.

3. Beach Nourishment

Tool Description

Beach nourishment refers to the addition of sand or other similar beach sediment material to satisfy the erosional forces of natural wave action and prevent shoreline erosion. As waves run up on a beach, they lose energy and are dissipated; the more beach (or similar surface), the more energy is dissipated. By adding a sediment supply, the beach is maintained at a width that provides storm protection and acts as a buffer. The cross-sectional shape of a beach affects its ability to dissipate wave energy: a wide and shallow beach will attenuate wave energy more effectively than a steep and narrow beach.

Beach nourishment reduces the detrimental effects of coastal erosion by providing additional sediment to satisfy the natural forces of erosion. Beach nourishment will not stop erosion; however, it will provide a sacrificial element against coastal erosion, rather than a hard barrier. Beach nourishment will likely be required on an ongoing basis as long as the forces of erosion are present.[108]

Application

Beach nourishment can use sediment material dredged from the ocean, or material barged, trucked, moved by heavy equipment or by a conveyor belt from a land-based source. The rate of erosion needs to be monitored on a regular basis, typically by a cross-sectional analysis. If the available beach material drops below to a critical level, re-nourishment will be required to avoid further erosion and damage to coastal infrastructure. A sediment budget is used to describe the measurement of migrating and eroding sediment in a manner similar to the measurement of river bed aggradation.

Because of annual sand erosion from the dunes and beaches in the area, a beach nourishment program has been in place at Parlee Beach (near Shediac, N.B.) since 2009. It is expected that this will become an annual program with a portion of the park entrance fee ($3) used to help pay for the program.

[108] (Linham and Nicholls 2010)

Evaluation and Governance Considerations

Economic – Economic considerations include the availability and cost of acquiring, moving and placing sand or other suitable beach material on an eroded shoreline. The allocation of costs between individual benefiting property owners and the community as a whole may need to be addressed.

Beach nourishment may offer economic benefits as an alternative to or in combination with other forms of structural protection.

Environmental – Beach nourishment may enhance intertidal areas. However, negative effects could occur if the material deposited does not match the size and composition of native beach material, if the deposited material provides excessive turbidity or if the depth of material deposited buries existing marine organisms.

Social – Social benefits include reduced risk and enhanced property values for waterfront properties, and increased use of beach nourishment areas by the public for recreational purposes.

Implementation Measures and Challenges

Engineering studies over an extended time period are required to determine the rate and extent of shoreline erosion and the volume of beach nourishment required to address the sediment deficit. For large-scale beach nourishment applications specialized equipment must be used. Ongoing monitoring will be required to evaluate the success of the beach nourishment and when additional beach nourishment is required.

Challenges include the cost of implementation, supply limitations, lack of specialized equipment and expertise, the need for public education and recognition that the job is never finished.

Advantages	Disadvantages
Beach nourishment provides sacrificial material to be eroded, effectively protecting landward areas from wave action.	The use of beach nourishment is subject to a number of widespread limitations, including a consistent supply of correctly sized sediment for the long-term and a suitable foreshore profile.
This tool may provide an alternative to the use of hard protection such as groynes which can disrupt natural processes of sediment supply to a beach.	Beach nourishment can become prohibitively expensive if a supply of sediment is not readily available.
Beach nourishment can enhance the value of beaches by providing a more aesthetically appealing environment.	The value of aggregate resources including sand is highly dependent on the proximity of supply sources to the locations in which they are needed.
As sediment is redistributed by the natural forces or erosion, it may also have a positive effect on adjacent areas not directly nourished.	Beach nourishment is not a permanent solution to shoreline erosion. It will require regular monitoring and periodic re-nourishment depending on the rate of erosion that takes place.
Beach nourishment may address multiple objectives, including environmental enhancement and protection, public and recreational access, and hazard reduction.	Beach nourishment may affect the productivity of intertidal areas.

Combinations & Compatibility

Combinations & Compatibility

The 21 tools in this primer have been organized into five broad categories: planning, regulatory, land use change or restriction, structural and non-structural. These five categories are intended to assist decision makers in the selection, application and combination of these tools.

Several of the tools are interdependent and should be used in combination, producing hybrid shoreline protection systems. At first glance, structural and non-structural adaptation tools may appear to represent opposing approaches; however, they are often used in combination. Non-structural tools, sometimes referred to as soft armouring or soft engineering, offer flexibility and can reduce the costs of construction and negative environmental effects incurred by using structural tools alone.

Dunes at Hole 16 Crowbush Cove Golf Course *(Photo: D. Jardine)*

Hybrid techniques from P.E.I.

Hybrid techniques were implemented at the Crowbush Golf Course on P.E.I. after a major storm surge in December, 2004. At Crowbush Cove, a low-lying armour stone base, known as a revetment, was installed parallel to the shoreline. Sand was placed on top of the revetment to re-establish the dune in the area, and marram grass was re-seeded on the dune to help with stabilization. After storm events, removed sand must be replaced. The same type of system was installed on the Panmure Island Causeway.

The tools in this primer, individually or in combination, may be used to meet the four overall strategies for adaptation to sea level rise. These strategies are not "pure" approaches or mutually exclusive; in fact, a local government may undertake different strategies for different areas following an analysis of the varying conditions. A protect strategy may be suitable for an historic area where all buildings and infrastructure would be frequently inundated without the installation of linear structural protection such as a dike. An accommodate strategy may apply to a new development at the margins of an area at risk of coastal flooding. An avoid strategy may be applied to prevent a proposed new residential development or a large commercial or institutional development in a previously undeveloped area at risk of flooding. Finally, a retreat strategy may be suitable for a rural area where the Flood Construction Level is an entire floor above the ground elevation.

Over time, the choice of strategy for the same area may change due to changing circumstances, risk assessment or availability of resources. For example, a protect strategy relying on dikes alone may represent the historic approach in a particular area. With a new risk analysis, an accommodate strategy might evolve in which all new development is required to provide scour protection and floodproofing of buildings.

The following **Compatibility Matrix** shows the 21 different adaptation tools and how they relate to the four overall adaptation strategies. Some tools are recommended for all strategies, while other tools may or may not be appropriate to a particular strategy. For instance, a land trust would not be applicable to a protect strategy, but would be compatible with all other strategies.

Table 1 – Compatibility Matrix

Tool		Protect	Accommodate	Managed retreat	Avoid
Planning	Objectives & Policies	Recommended	Recommended	Recommended	Recommended
	Coastal Hazard Mapping	Recommended	Recommended	Recommended	Recommended
	Risk Management	Recommended	Recommended	Recommended	Recommended
	Emergency Planning & Preparedness	Recommended	Recommended	Recommended	Recommended
Regulatory	Regulation of Land Use	Recommended	Recommended	Recommended	Recommended
	Subdivision Regulation	Recommended	Recommended	Applicable	Not applicable
	Development Permit	Applicable	Applicable	Applicable	Not applicable
	Building Regulation	Recommended	Recommended	Not applicable	Not applicable
Land Use Change or Restriction	Land Acquisition	Not applicable	Applicable	Applicable	Applicable
	Transfer of Development Potential	Not applicable	Applicable	Applicable	Applicable
	Easement, Covenant/Other Restriction	Applicable	Applicable	Applicable	Applicable
	Land Trusts	Not applicable	Applicable	Applicable	Applicable
	Foreshore Tenure	Applicable	Applicable	Applicable	Not applicable
Structural (flood protection works)	Scour Protection	Applicable	Applicable	Not applicable	Not applicable
	Structural Elevation	Applicable	Recommended	Applicable	Not applicable
	Dikes	Applicable	Not applicable	Not applicable	Not applicable
	Other Hard Protection	Applicable	Not applicable	Not applicable	Not applicable
	Wet Floodproofing	Not applicable	Applicable	Applicable	Not applicable
Non-Structural (soft armouring)	Coastal Wetland Creation/ Restoration	Applicable	Applicable	Applicable	Not applicable
	Dune Building/ Rehabilitation	Applicable	Applicable	Applicable	Not applicable
	Beach Nourishment	Applicable	Applicable	Applicable	Not applicable

Living Shorelines

Living shorelines, also termed soft stabilization shoreline alternatives, refer to the management of coastal areas in ways that protect, restore, enhance or create natural shoreline habitat. Living shorelines employ a suite of techniques to minimize coastal erosion and maintain coastal processes. These include the use of sills, groynes or breakwaters used in combination with sand, marsh plantings, or other natural materials.

The benefits of living shorelines include engineering benefits such as cost effective absorption of wave energy and storm surges as well as the maintenance of natural shoreline dynamics. Environmental benefits include improved water quality (by settling sediments and filtering pollution), greater abundance and diversity of aquatic species and a linkage between aquatic and upland habitats.

Living shorelines have typically been designed and implemented using a collaborative approach; working with several levels of government, riparian property owners, nature trust organizations and other stakeholders.

One of the leading proponents of living shorelines is the State of Maryland. Maryland has over 11,000 kilometres (7,000 miles) of tidal shoreline along Chesapeake Bay and other coastal watersheds. The state faced an annual loss of over 235 hectares (580 acres) of coastal shoreline and a permitting issue wherein soft armouring was at a major disadvantage compared to structural protection. Under the *Living Shoreline Protection Act* of 2008, the State of Maryland adopted non-structural "living shorelines" erosion control measures as the preferred method to address the impacts of shore erosion induced by sea level rise wherever technologically and ecologically appropriate. This legislation does not prevent the implementation of hard structural measures, but requires soft or non-structural measures be considered first. Adoption of the *Living Shoreline Protection Act* followed more than 20 years of research on the effectiveness of non-structural erosion control in Chesapeake Bay and other sheltered areas.[109]

In Atlantic Canada, Nova Scotia and P.E.I. now employ living shorelines approaches. In B.C., communities on Vancouver Island and on the Sunshine Coast have used living shoreline approaches; on the west coast, living shores approaches are also known as "Green Shores" projects.

Green Shores Examples from B.C.[110]

Green Shores is a trademarked program of the Stewardship Centre for British Columbia. The Green Shores program consists of hybrid techniques that promote the sustainable use of coastal ecosystems through planning and design that recognizes their ecological features and functions. Their four principles consist of preserving the integrity of coastal processes, maintaining habitat diversity and function, minimizing marine pollutants to the environment, and reducing cumulative impacts to the coastal environment. A key program component is a Coastal Development Rating System intended for use by designers, builders and owners to guide Green Shores design and assess design performance.

[109] (Management, Policy, Science, and Engineering of Nonstructural Erosion Control in the Chesapeake Bay 2006)
[110] (Stewardship Centre for British Columbia 2012)

Non-Local Government Adaptation Tools

Non-Local Government Adaptation Tools

Insurance and emergency management are also essential adaptation tools. Insurance plays almost no role in Canada, but is widely used in other developed countries. Emergency management is present in all provinces, but responsibility is shared with senior governments.

1. Insurance

Insurance is widely used to encourage sea level rise adaptation in other developed countries with extensive shorelines and coastal areas at risk. However, it is not currently a tool available to local governments, and its availability in Canada is very limited.[111]

Insurance premiums are commonly based on estimates of previous losses incurred. While this approach can discourage asset investment within high-risk hazard areas, it also puts pressure on local, provincial and federal government to provide "protection" against the hazard. Flood insurance due to overland flows (such as storm surge or high river levels,) surface water flooding or flooding caused by groundwater is not available to homeowners in any province in Canada, though it is available for commercial development. A 2004 survey of 2,100 homeowners by the Institute for Catastrophic Loss Reduction reported that close to 70% believed they were insured for flood damages.[112]

In Canada, provincial and federal governments provide financial support when uninsurable disaster-related property damage occurs. A drawback to such government relief in contrast to private insurance is that it tends to create distance between a household's actual exposure to risk and the household's perception of risk.[113] This distance between actual and perceived risk can encourage people to reside in flood-prone areas with the understanding that government will bear the cost of some flood-related damages.[114]

According to the insurance industry, certain conditions must be in place in order for insurance to be a viable tool; these conditions include:

1. Mutuality – a large number of people must combine to form a risk pool or community.
2. Need – there must be a need for insurance to cover an anticipated risk such as flooding or erosion.
3. Ability to be assessed – the peril must be measurable and quantified in terms of possible losses of economic value.
4. Randomness – the risk must be independent of the will of the insured and the event must not be predictable, except in a general way.
5. Economic viability – the risk community must be able to cover the anticipated losses.
6. Similarity of threat – the risk community must be exposed to the same threat and the occurrence of anticipated damages must result in the need for funds in the same way for each member of the risk community.

The success of insurance depends on how these six conditions are addressed.

Not all of these conditions are present for flood insurance in Canada. The biggest challenge to the introduction of flood insurance in Canada is mutuality. The risk of flooding does not apply equally throughout a province or throughout most communities; it is limited to specific areas. Property owners most exposed to a flood risk will be motivated to purchase flood insurance. Demand for flood insurance

[111] (National Round Table on the Environment and the Economy 2011)
[112] (Sandink, et al. 2010)
[113] (National Round Table on the Environment and the Economy 2011)
[114] (Hallegatte 2006)

will be low outside of risk areas. For example, flood insurance would generate minimal demand in Regina, Saskatchewan compared to Ladner, B.C.

Economic viability is another challenge. Economic viability is threatened when large losses affect an area with a large concentration of policy holders. Flood insurance rates would be prohibitively expensive for those concentrated in high-risk areas. Some, but not all, of this risk can be addressed through reinsurance (i.e., spreading the risk among insurance companies to other areas with different risks).

Both of these challenges are related to a problem called adverse-selection. Demand for flood insurance is concentrated in areas with a high risk of flooding; few people would voluntarily purchase insurance specifically to protect against flooding if they did not live in a flood risk area. Adverse selection violates a basic principle of insurance, which is to spread the risk. Adverse selection results in insurance rates that are prohibitively high for homeowners.

There are several ways to address these challenges of flood insurance. By bundling flood insurance with other forms of insurance, such as fire and theft, insured risks are spread over a larger pool of properties, across different perils and different rating areas. Bundling broadens the risk pool and is used to lower costs and increase insurance penetration rates. Bundling insurance to include flood or erosion coverage can make it unavoidable, or effectively compulsory.

The United Kingdom uses this approach to overcome the challenges of flood insurance. There, flood insurance, whether inland or coastal, is included with other insured risks and is required by mortgage companies. Bundled coverage is also in place in Japan, Spain, Portugal, Switzerland and Israel.

Another approach is to subsidize the cost of flood insurance. In the U.S.A., flood insurance is partially subsidized by the federal government. Flood insurance is intentionally kept affordable in order to enhance participation rates. Insurance premiums cover administration costs and operating costs in most years, but not the full cost of major disasters.

Flood insurance is widely used in developed countries with extensive coastal lowlands. The following provides a summary of how flood insurance is used in the U.S.A., Germany and the United Kingdom.

United States of America

The National Flood Insurance Program is administered through the Federal Emergency Management Agency (FEMA) in cooperation with private insurance agencies. The National Flood Insurance Program was created by the U.S. Congress in 1968 to help provide a means for property owners to financially protect themselves. Prior to that, private flood coverage was excluded from standard homeowner policies and the primary recourse of flood victims was government disaster assistance. In its early years, even subsidized rates did not provide a sufficient incentive for homeowners to purchase flood insurance or for communities to join the National Flood Insurance Program. Subsequent legislative changes in 1974 and 1994 required federally insured or regulated lenders to require flood insurance as a condition of granting or continuing a loan for a building located in the Special Flood Hazard Area of a participating community. The federal government, through FEMA, sets flood insurance premium rates, identifies flood zones and risks and sets the standard for construction in floodplains. Local governments are responsible for adopting development regulations that meet National Flood Insurance Program standards. Close to 90 private insurers sell flood insurance policies and collect flood insurance premiums on behalf of the government but do not assume any risk.

Currently over 20,000 U.S. communities participate in the National Flood Insurance Program. This program offers flood insurance to homeowners, renters, and business owners. The incentive is affordable rates of flood insurance and coverage up to USD$250,000 for a residential building and up to USD$100,000 for personal property (i.e., contents). In return, participating communities agree to adopt and enforce bylaws (referred to as ordinances in the U.S.A.) that meet or exceed FEMA requirements designed to reduce the risk

of flooding. Flood management measures include many of the tools documented in this report. Applicable tools include zoning, subdivision, scour protection, structural elevation, wet floodproofing, easements, land trust agreements and land acquisition. Mapping plays a multipurpose role. Flood Rate Insurance Maps are used to identify communities at risk (i.e., areas subject to a 100 year flood), set insurance premiums and regulate development in floodplains. In the 30 years since the inception of the National Flood Insurance Program, buildings constructed to federal standards have sustained 77% lower losses than buildings without such protection.

Flood insurance premiums vary according to several factors, including the deductible chosen by the homeowner, the amount of protection provided, either structural elevation (dry floodproofing) or wet flood proofing, the date of construction and the potential and probability of a hazard. Low elevation properties located near the ocean are considered high risk due to storm surge flooding and hurricane risks. The cost for the maximum available building (USD$250,000) and contents (USD$100,000) insurance in a coastal high risk zone is up to USD$6,410 annually. This compares to similar coverage of USD$1,717 per year in a moderate to low risk area and as low as USD$365 per year in a preferred risk (i.e., low) area.

In 2011, under the *National Flood Insurance Program*, 5.5 million flood insurance policies were written, USD$3.4 billion collected in premiums and USD$1.43 billion paid out in flood claims. Expenditures for flood hazard mapping and risk analysis exceeded USD$97.7 million.[115] In addition to managing the *National Flood Insurance Program*, FEMA has a broad mandate to lead and support the nation in a risk-based comprehensive emergency management system of preparedness, protection, response, recovery and mitigation. In an attempt to reduce a deficit of over $25 billion in the *National Flood Insurance Program*, the *Biggert-Waters Flood Insurance Reform and Modernization Act* of 2012 mandated that some subsidies be phased out, resulting in a large rate increase for some property owners. The resulting backlash led to a proposed four year delay in its implementation.

Germany

Private insurance companies in Germany have offered insurance for natural hazards as a supplement to building and contents insurance since 1991.[116] This supplemental policy is optional for property owners and covers losses due to flooding. However, storm surge is an uninsurable risk and is excluded from supplemental policies. The market penetration for building insurance is approximately 90%, as banks require this as a condition for obtaining loans; market penetration for supplemental hazard insurance is much lower (26% in 2010).

Germany does not have a national system of flood hazard mapping. As a result, the German insurance industry developed an online risk assessment tool called ZURS Geo. This geo-based data system uses property addresses to identify the risk of flooding in any geographical area and offers a risk-based insurance premium. This tool uses a four zone system, with the lowest risk being less than a 1 in 200 year event and the highest being more than a 1 in 10 year event.

Following a major flooding of the Elbe River in 2002, the most expensive in German history, a widespread evaluation of the state of flood insurance took place. Most private sector losses were not covered by private insurance. This led to the consideration of mandatory natural hazard insurance. The compulsory insurance option was rejected, largely due to a major concern that buyers would experience premium shock due to much higher reinsurance requirements. Other options were pursued, including 2004 legislation passed by the German Parliament prohibiting development on flood prone land. As a result, it has been estimated that 10% of the land area cannot feasibly be insured, although only 1.5% of the buildings are uninsurable. The German model has been criticized for lacking incentives to strengthen private loss mitigation and insurance companies for doing little to encourage precautionary measures.

[115] (U.S. Department of Homeland Security; and FEMA 2012)
[116] (Sandink, et al. 2010)

United Kingdom

The United Kingdom has approximately 2.2 million homes at risk due to coastal or inland flooding. Approximately 330,000 homes have a flood risk greater than 1 in 75 years. Insurers have agreed to provide insurance in all areas where the flood probability is less than the highest risk threshold. Where the flood probability is greater than 1 in 75 years and improved flood defenses are provided, flood insurance for households and small businesses will be maintained. Where the flood probability is greater than 1 in 75 years and no flood defenses are planned, flood insurance for households and small businesses is considered on a case by case basis.[117]

Flood risk has been grouped according to three classes. The low probability Zone 1 consists of lands with a less than 1 in 1,000 year flood risk. The medium probability Zone 2 consists of lands with a probability of flooding from the sea of between 1 in 200 and 1 in 1,000 years. The high probability Zone 3 contains land with a greater than 1 in 200 year probability of sea flooding (or greater than 1 in 100 probability of riverine flooding). Under the policy, development should be steered away from Zones 2 and 3 and toward Zone 1. This policy statement includes flood risk changes resulting from climate change, particularly those associated with sea level rise.[118]

Building insurance is not compulsory in the United Kingdom, but such insurance is generally required to obtain mortgage financing. Flood insurance is bundled as part of standard home insurance and is included in the building and contents policy. Insurers generally do not refuse flood coverage for residential property, regardless of flood risk, and as a result, the vast majority of households have flood insurance coverage.[119]

Key features of the U.K. approach to flood management include a bundled approach to flood insurance, a very high penetration rate of 95% for flood insurance, the option for insurers to exclude very high risk homeowners in order to avoid the problem of adverse-selection, risk-based flood insurance pricing, partial risk assumption by private homeowners through a system of deductibles, variable premiums and on-site risk mitigation. Government responsibilities consist of land use planning, risk assessment through the development of flood hazard maps and off-site structural protection measures. The Association of British Insurers indicated in 2007 that annual flood defense spending needed to increase from £500 million to a minimum of £750 million in order to maintain design-specification levels of protection.[120]

The national government does not have statutory authority for the management of development in flood-prone areas. These responsibilities have been delegated to regional and local planning authorities although they are permissive, not mandatory. Regional and local planning authorities have the authority to develop strategies to appraise and manage flood risk through policy development in areas subject to flood hazards.

Until very recently the national government's perspective was reflected in a series of Planning Policy Statements concerning town planning. *Planning Policy Statement 25* concerned national policy on development and flood risk in England. This policy ensured that flood risk was taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from the areas of highest risk. These P*lanning Policy Statements* were replaced by a single document called the *National Planning Policy Framework* finalized in March 2012. This document retains many of the previous risk management policies, although in an edited form.

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117 (Sandink, et al. 2010)
118 (Department for Communities and Local Government, UK Government 2010)
119 (Sandink, et al. 2010)
120 (Institution of Civil Engineers (ICE) 2010)

Of particular interest is a policy calling on local planning authorities to "reduce risk from coastal change by avoiding inappropriate development in vulnerable areas or adding to the impacts of physical changes on the coast." Local planning authorities are called on to identify as a Coastal Change Management Area any area likely to be affected by physical changes on the coast and make clear what development will be appropriate in such areas and in what circumstances, as well as to make provision for the relocation of development and infrastructure where this is needed. Another policy sets out recommended contingency allowances for net sea level rise that increase from 4.0 mm/year at present, to 8.5 mm/year after 2025, to 12.0 mm/year after 2055 and to 15.0 mm/year after 2085 for London, East England and Southeast England.

The Potential Role of Insurance in Adaptation

There are several reasons why insurance may receive increasing attention in the future. One is that the areas at risk of coastal flooding and subsequent damages are anticipated to increase exponentially over time. The current cost of flood damage to private property is largely met by the provincial government and, for major events, the federal government through Disaster Relief assistance. The expectation of guaranteed disaster relief also reduces the incentive to take precautions in the way of flood-proofing or hazard avoidance measures.[121] Senior governments are aware of the rising risk and cost implications they will increasingly have to absorb under current provisions.

Second, the current approach involves a considerable degree of moral hazard. This refers to the tendency to take undue risks because the costs are not borne by the party taking the risk. If an area is subject to flood hazard, the property owner will suffer inconvenience in the event of a flood but little economic risk. The current deductible is nominal and there is no economic incentive for a property owner to undertake proactive preventative action. Local governments have a wide array of tools to address new development. Except in the limited cases of improvement areas in rural areas, any off-site structural protection will likely be funded through the general tax base of a local government in association with senior governments.

Third, the nature of flood risk due to sea level rise varies considerably from one area to another. Little of that risk is borne by property owners in the areas at risk.

Flood insurance can address all of these concerns to some degree, because it will transfer some of the risk away from senior governments and onto private property owners through insurance premiums. With variable premiums, flood insurance provides an incentive for a private property owner to undertake proactive action to reduce on-site risk. Flood insurance also provides an incentive for an avoid strategy by encouraging development in areas not at risk from coastal flooding and penalizing development in areas at risk (without including land use policy and *Official Community Planning* considerations).

From the case studies discussed above, two conditions are essential to the success of flood insurance. One is that the use of flood insurance must have broad application to properties at risk, whether it follows the U.S.A. or the U.K. model. Second, the utility and success of flood insurance is much higher if it complements other forms of risk reduction undertaken by property owners and local governments.

[121] (National Round Table on the Environment and the Economy 2011)

Advantages and Disadvantages of Potential Insurance Tool for Adaptation to Sea Level Rise

Advantages	Disadvantages
Would better align risk management objectives. Homeowners who choose to purchase in areas at risk would pay for the additional risk and those in low risk areas would benefit from risk avoidance. Flood insurance provides an incentive for an avoid strategy.	There is an expectation that government will provide protection against the consequences of natural disasters.
Flood insurance premiums will spread risk with other geographical areas also subject to flood risk.	The consequences of sea level rise are not intentional and residents of areas subject to disasters would not feel personal responsibility for flooding.
Owners of residential dwellings would be able to obtain insurance for the actual value of improvements (current Disaster Financial Assistance limit in B.C. is $300,000).	Administration of flood insurance claims in other jurisdictions is not without controversy.
Flood insurance could be linked with other forms of insurance commonly used in Canada (e.g. house and mortgage insurance)	
Homeowners in high risk areas incur minimal risk at present.	

2. Emergency Management

Emergency and post disaster management refer to measures undertaken during and after a disaster. Emergency Planning and Preparedness refer to measures undertaken in advance of a disaster and is discussed in the section on Planning Tools. Emergency management is distinguished from the Emergency Planning and Preparedness for two reasons. First, some emergency management functions are provincial or federal responsibilities (i.e., disaster financial assistance and declaration of provincial disaster) whereas emergency planning and preparedness is primarily a local government responsibility. This Primer is intended to focus on tools available to local government. Second, emergency management takes place during and after a disaster, and so cannot be considered a proactive adaptation tool like the utility tools in this Primer.

Emergency activities can be structured in four components: (1) preparedness; (2) response; (3) recovery; and (4) mitigation[122] or adaptation. The first is discussed under the Emergency Planning and Preparedness tool while the following two are discussed in this section. Response refers to warning and evacuation measures. Recovery refers to clean-up and compensation for losses. The final component may include any of the tools in this Primer and demonstrates that the process is iterative.

Enabling Legislation

In an emergency situation, federal responsibility (all departments and agencies), where applicable, is governed by the *Emergency Management Act*. The *Act* also allows for the development of programs to deal with emergency events. The federal government has exclusive responsibility for emergencies related to war, armed conflict and counter-terrorism. The federal government also has responsibility for First Nations reserves through Aboriginal Affairs and Northern Development Canada. This *Act* recognizes the interests of the provinces, territories and local authorities in relation to federal assistance provided during a provincial emergency.[123]

The *Emergency Program Act* is the applicable legislation in B.C. Further information about this *Act* is provided under the Emergency Planning and Preparedness tool. The provincial emergency flood response is detailed in the *British Columbia Flood Response Plan*, adopted in April 2012.

The B.C. *Dike Maintenance Act* of 1996 describes the powers and duties of the Inspector of Dikes, orders that may be issued, consequences of failure to carry out an order, offences and appeals. Diking

[122] (Birch Hill GeoSolutions 2008)
[123] (Birch Hill GeoSolutions 2008)

Authorities own and operate the public diking systems in B.C. and they are obliged to have a flood response plan, which should be integrated with the *Local Authority Emergency Response Plan*, and provide emergency response.

The B*ritish Columbia Flood Response Plan* describes the methodology the Province will utilize for coordinating activities to manage response to a flood event, depending on its magnitude. This includes the roles and responsibilities of other levels of government, provincial ministries and agencies and other stakeholder groups.

Other provinces also have emergency management provisions. For example, in Nova Scotia, the *Emergency Management Act* is the governing legislation dealing with emergency management and emergency powers legislation. The *Act* creates and gives powers to the Emergency Management Officer (EMO) to act on government's behalf in an emergency.[124]

In Quebec, disaster relief funds from the Ministry of Public Security currently include support for damage incurred by major storm events, both for public infrastructure and for private property. For private properties damaged or destroyed in coastal areas from storm surges, up to $150,000 in compensation can be paid out to those willing to relocate, under the following conditions:

- The property in question is the primary residence (secondary residences are not covered)
- The lot and remaining structure is sold to the municipality for $1
- The municipality cannot erect any new construction, but can create a recreational area on such lands
- The home relocated to must fall outside the setback established by the provincial government for the region

For the time being this mechanism is ad hoc, activated on a case-by-case evaluation of storm events undertaken between the Province and the impacted municipalities.

Application

Local authorities (i.e., municipalities and regional districts) have the primary responsibility for emergency management within their jurisdiction. As noted in the section on the Emergency Planning and Preparedness tool, this includes the preparation of local emergency plans. Should flooding occur, the local government is responsible for activating emergency plans and their emergency operations centre, notifying the provincial authority of local emergency response activities, issuing evacuation notices, as required, establishing local centres for public inquiries and providing post-flood information. If the local government requires emergency powers within the *Emergency Program Act*, including the evacuation of residents, a state of local emergency should be declared.

The *British Columbia Flood Response Plan* details that province's approach in co-ordinating the ministries involved in flood management during an integrated provincial response event. Emergency Management British Columbia has the primary responsibility for co-ordinating the provincial management structure. The Provincial Emergency Program (PEP), a division of the Ministry of Public Safety and Solicitor General, Emergency Management B.C., works with local governments year-round, providing training and support before, during and after emergencies.

Other provincial agencies and responsibilities include the following:

- Ministry of Transportation and Infrastructure – safety of provincial highways and bridges
- Ministry of Health – monitoring and managing public health impacts including sewage disposal and drinking water expertise
- Ministry of Environment – hazardous material, flood debris management and other threats to the environment

[124] (Birch Hill GeoSolutions 2008)

- Water Management Branch, Ministry of Forests, Lands and Natural Resource Operations – provide flood forecasts and bulletins, liaise with Environment Canada regarding weather forecasts, provide oversight to dam and dike owners, and modeling to support flood level efforts
- Ministry of Community, Sport and Cultural Development – guidance and assistance to local government regarding infrastructure including emergency funding, as required

The following regulations under the *Emergency Program Act* further describe the program:

- Emergency Program Management Regulation, 1994

This regulation defines the obligations of the Provincial Emergency Program, emergency plans and procedures of ministers and government corporations, the Inter-Agency Emergency Preparedness Council, the role of ministers in relation to hazards, the role of ministers and government corporations in emergency or disaster.

- Compensation and Disaster Financial Assistance Regulation, 1995

This regulation describes compensation and disaster financial assistance, eligibility for assistance and what is covered. Disaster financial assistance may be claimed for eligible personal expenses (i.e., the principal residence of the owner of a structure damaged or destroyed in a disaster and "the necessities of life" of a tenant, small business expenses, farm operation expenses, charitable or volunteer expenses and local government body expenses). Assistance is limited to 80% of an accepted claim over a deductible of $1,000 up to a maximum of $300,000. Financial assistance to repair or rebuild a structure may be denied if assistance has been provided on two previous occasions.

- Local Authority Emergency Management Regulation, 1995

This regulation outlines the required contents of Local Emergency Plans and defines the powers and duties of a local authority under the *Act*.

As previously noted, Quebec provides for up to $150,000 in compensation for those willing to relocate. Where the market value of the damaged property is less than $150,000, disaster relief has served its intended purposes of providing compensation for private losses and acquiring high risk property to ensure the Province is not subject to repeat claims for compensation. A key challenge is where the value exceeds $150,000, since property owners lack a financial incentive to relocate or undertake additional protective measures; this leads to continued or increased vulnerability on the same site.

Disaster Financial Assistance Arrangements

Disaster Financial Assistance Arrangements are designed to provide financial assistance from the federal government on a sliding scale where disaster damages exceed $1.00 per capita of provincial population. For disasters below this threshold, no federal assistance is provided. The federal contribution increases to 50% where damages are between $1.00 and $3.00 per capita of provincial population. The federal contribution increases to 75% if the damages are between $3.00 and $5.00 per capita of provincial population and to 90% if they exceed $5.00 per capita of provincial population. Examples of federal government assistance include the 1997 flooding in Manitoba's Red River Valley, the 2003 wildfires in B.C.'s Okanagan Valley, and the 2013 floods in Calgary and High River, Alberta.

Each province is responsible for the development and implementation of disaster recovery assistance programs, for deciding when disaster payments are provided, and for determining the amount that will be provided in their jurisdiction. A 2008 revision allowed for a 15% supplement of total disaster recovery payouts to provinces in order to mitigate the impacts of future hazard events. The key objective of the revised program is to reduce or prevent the recurrence of damages.

The Cost of Sea Level Rise and Adaptation

The Cost of Sea Level Rise and Adaptation

The cost of coastal adaptation is considered to be the sum of all investments (and maintenance costs) necessary to protect coastline and human settlements located in at-risk areas. The estimated annualized cost for optimal levels of protection can be modest, frequently less than 0.1% of national Gross Domestic Product (GDP). However, adaptation costs may be high relative to the GDP of coastal areas, as there is no guarantee protection costs will be absorbed fully at the national level.[125]

The National Round Table on the Environment and the Economy released a report, "Paying the Price: The Economic Costs of Climate Change for Canada" in September 2011. The study noted that Prince Edward Island has the largest proportion of its land area at risk due to flooding by 2050 as a result of climate change. B.C., on the other hand, has the lowest proportion of its land area at risk but the majority of dwellings at risk, due to the high housing density in the Lower Mainland, much of which is low lying. The Lower Mainland, consisting of Metro Vancouver and the lower Fraser River Valley, is very vulnerable to sea level rise because of a 127 kilometre system of dikes, which were not built with sea level rise factored into the design. This area also has very expensive real estate subject to flood risks.

The report examined coastal lands that would be at risk without sea level rise (baseline case) and the additional lands at risk due to climate change. The report evaluated two adaptation strategies for coastal areas: climate related development planning and strategic retreat. The first strategy prohibited future construction in areas expected to be at risk of flooding by 2050 in a high climate change scenario. No additional growth would be permitted, but existing dwellings could be rebuilt following a storm surge. The second strategy involves a gradual abandonment of newly flooded areas. The National Round Table found that both strategies reduce the overall cost of climate change, but that strategic retreat produced benefits one order of magnitude higher than climate-wise development planning. When pursued in combination, the two strategies could lower the cumulative cost by $1 to $6 billion over the next century.

Funding Projects Related to Sea Level Rise in Canada

There is currently no national program for funding shoreline protection or for combating the impacts of sea level rise along the 243,000 kilometres of coastline in Canada. Some funding for shoreline protection is provided via programs such as the Building Canada Fund, Gas Tax Fund, Disaster Financial Assistance Program, Small Crafts Harbour Program, Infrastructure projects, Highway funding programs, St. Lawrence Plan, Green Municipal Fund and other federal initiatives.

Funding is also available from Environment Canada, Environmental Damages Fund for the protection of and restoration of wildlife habitats in coastal areas. Natural Resources Canada has also made funding available to help assess the impacts of climate change and how to mitigate and adapt to them. The Regional Adaptation Collaborative program has contributed valuable funding to help provinces, local governments and individuals improve their decision-making in regard to adapting to sea level rise, storm surges, heavy to intense precipitation events, flooding and other events related to climate change.

[125] (Hallegate 2011)

Major damage from the December 2010 storm in the Bas-Saint-Laurent Region, QC

In December 2010, a major storm event in the Bas-Saint-Laurent Region, QC eroded seven metres of the shoreline and destroyed nearly 100 homes in the region. In the absence of a regulatory framework for dealing with such natural disasters, the Minister of Public Security announced that the province would compensate property owners up to $150,000 toward rebuilding elsewhere on safer grounds.

The agreement required owners to sell their property to the municipality for $1. The municipality, as owner of the land, was not able to build on the land but could use it for recreational purposes. Eighty compensation packages were issued once evaluations were conducted by the provincial government. Many owners refused the packages, as $150,000 was not enough money for relocation. In some cases, residents unable to supplement the compensation were forced to remain in damaged homes in high-risk areas. Given the lack of regulation on erosion in the area, construction and reconstruction permits are still being issued in high risk areas.

Recognizing that it would not be able to offer similar compensation in the future, in 2011 the province suggested the region adopt a 30m standard setback. Neither the region nor any of its municipalities adopted this standard, and requested more detailed research be completed in order to establish setback lines per coastal zone based on regionally specific science (J.-p. Savard 2012).

Quebec is a province with significant funds available for adapting to seal level rise. The financing available to municipalities for adapting to sea level rise comes via the Framework for Natural Disaster Risk Prevention Funds from the Ministry of Public Security. In November 2006, the province designated $55 million to support municipal adaptation projects to climate change, with $26.6 million specifically earmarked for adaptation to coastal erosion. Municipalities apply to the fund and contribute a portion of the total initial budget. The provincial money represents a one-time investment – the municipality is responsible for the cost of maintenance over time. This fund is expected to be renewed under the 2013-2020 Climate Change Action Plan.

Under this program, Sept-Îles was approved for a $6 million project to rebuild the sandbank on the east end of the city. The municipality would have to contribute $2 million of the total budget, and would be responsible for all maintenance costs over time. The local government had difficulty obtaining public support for the levy needed to raise funds, as it would have been applied to all residents while only the ocean-front property owners would benefit. In the end, Sept-Îles declined the grant, as it could not find a realistic means of coming up with their portion of the contribution required.

Municipalities in Atlantic Canada that own property or infrastructure along the coastline have taken action to protect their capital assets from sea level rise, storm surges and other climate events. This includes installing shoreline protection systems at facilities such as waste water treatment facilities, streets, parks, recreational facilities, and other municipal infrastructure. In 2011, Nova Scotia implemented a new requirement for Federal Gas Tax Reporting for the period 2010- 2014. Nova Scotia municipalities must now prepare Municipal Climate Change Action Plans (CCAP) to access the Gas Tax funds. These plans must be submitted by December 31, 2013.

Municipalities in British Columbia have also taken proactive action. Responses vary considerably, but measures include updated Official Community Plans, updated floodplain mapping, increasing Flood Construction Levels, raising dike elevations and appurtenant flood protection structures, installing artificial reefs and public education measures. Federal-provincial cost sharing programs in B.C. have played an essential role in the implementation of structural protection measures.

Funding Programs in Other Countries

New Jersey Shore Protection Program
The State of New Jersey provides an excellent example of innovative funding. The New Jersey Department of Environmental Protection has a Shore Protection Fund which dedicates USD$25 million annually "to protect existing development and infrastructure from storm surges, sea level rise and shoreline migration through dune creation and maintenance, beach nourishment projects, and construction and repair of shore protection structures." The monies for this fund are generated from a realty transfer fee imposed on the recording of deeds transferring real property, calculated based on the amount paid in the deed.

Western Australia Coastal Protection Policy and Grant Program
Western Australia's Department of Transport provides up to 50% of the cost of planning, investigation, design and construction of emergency coastal protection works, public coastal protection works, necessary data collection and the maintenance of marine structures for permanent coastal protection.

Once structures are built, the local coastal managers have ownership of the structures and are responsible for ongoing repair and maintenance.

England – Flood and Coastal Resilience Partnership Funding
The United Kingdom allocates £2.1 billion of partnership funding annually for flood and coastal erosion risk management projects in England. Funding levels are related to the number of households protected, the damages being prevented and any other benefits. The United Kingdom Environment Agency, local authorities and internal drainage boards carry out the flood and coastal risk management schemes using the grant funding allocated. The schemes approved are intended to reduce the risk of flooding from rivers, seas, groundwater and surface water, and to reduce the risks from coastal erosion.

Netherlands – Coastal Flood Risk Management
In the Netherlands all funding for strengthening flood defences or nourishment comes from the national government, and from 2000-2006 averaged €550 million per year. This amount includes funding from water boards, which fund maintenance costs via water board taxes. In the Netherlands, a storm surge warning system has been developed for exposed areas, as forecasting times for coastal flooding from storm surges tend to be shorter than for river flooding. Dunes and dikes protect parts of the Netherlands situated below sea level.

The design of these flood defence structures are related to extreme storm surge levels. For instance, in the provinces of Noord-Holland and Zuid-Holland, the structures are designed to withstand the effects of a storm with a probability of occurrence once in 10,000 years, which corresponds to a storm surge level of 5 m+ Dutch Ordinance Level (NAP). The Dutch government has also made a policy decision to maintain the coastline at its 1990 position. In the National Spatial Strategy of 2004, the Netherlands guarantee safety against flooding and the preservation of the spatial quality of the coastal zone.

Appendices

Appendix A – Glossary

ADAPTATION means an adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects. With respect to sea level rise, adaptation refers to action taken to prepare for its occurrence.

ADAPTATION PLANNING refers to the process of how a community identifies ways in which it may be impacted by climate change, and how it develops a plan to address the negative consequences.

APPROVING OFFICER* is a person appointed under the *B.C. Land Title Act* with responsibility for the approval of subdivision plans. This involves a municipal engineer or planner for a municipality or the Nisga'a Lisims Government under the Nisga'a Treaty, or a Ministry of Transportation employee for a rural area within a regional district.

ARMOURING usually refers to a hard engineering approach to shoreline protection such as a dike, seawall or riprap. Soft armouring refers to shoreline protection measures without the use of concrete, rocks or other rigid barriers.

BANK PROTECTION refers to the treatment of slopes of Dikes and stream banks, lakes and other water bodies by the placement of riprap or other forms of protection to prevent Erosion by surface runoff, stream flows and/or wave action.

BATHYMETRY is the study of the underwater depth of the ocean floor or other water body. A bathymetric map measures the ocean floor and is the underwater equivalent of a topographic map.

BEACH NOURISHMENT refers to the addition of sand or gravel to a shoreline to offset the forces of erosion. To be effective, beach nourishment is typically required on an ongoing basis.

CHART DATUM is the plane of vertical reference to which all charted depths and drying heights (i.e., vertical distance of the seabed exposed by the tide) are related. Chart Datum is generally a tidal datum and represents the least depth of water found in any place under "normal" meteorological conditions. It forms a plane so low that the water level will seldom fall below it and may also be referred to as the lowest astronomical tide and lowest low water.

CLIMATE CHANGE refers to the process by which the average weather becomes different over time. Climate has changed due to natural forces over the course of history (e.g., volcanoes, ocean currents) but human activity (e.g., industry, transportation) is now considered the cause of rapid and severe climate change. These changes include sea level rise, more intense and more frequent extreme weather events (e.g., storms, hurricanes, storm surge) and in Atlantic Canada, warmer and wetter summers and winters.

CLIMATE refers to the "average" weather over a long period of time. Aspects of climate include temperature, precipitation, wind speed and direction, sunshine, fog and frequency of extreme events.

COASTAL EROSION is the wearing away or reduction of coastal land resulting primarily from wave action along the shore. Coastal erosion causes the shoreline to move further inland.

COASTAL HAZARDS are naturally occurring events that can pose a threat to the health or life of people, property and/or the environment in coastal areas. Types of coastal hazards include storm surges, coastal flooding and erosion.

COASTAL SQUEEZE refers to the effect of shoreline retreat located between rising sea levels and hard structural protection such as dikes. Coastal habitats that are unable to migrate landward are squeezed between the rising sea and hard defences. This reduces the adaptive capability and the extent of intertidal and sub-tidal habitats including saltwater marshes.

DATUM refers to any numerical or geometrical quantity or set of such quantities that may serve as a reference or base for other quantities. A horizontal datum forms the basis for computations of horizontal control surveys in which the curvature of the Earth is considered. A vertical datum refers to elevations.

DESIGN FLOOD LEVEL* is the calculated water surface elevation of the Design Flood.

DESIGN FLOOD* is a flood, which may occur in any given year, with a 200 year recurrence interval, based on a frequency analysis of unregulated historic flood records or on regional analysis where there is inadequate data available.

DIKE (or **DYKE)** is an embankment, berm, wall piling or fill constructed to prevent the flooding of land or to provide protection from a high tide plus a storm surge, possibly in combination with wind setup and wave run-up. The term levee is used in the U.S.A.

EROSION refers to the loss of land or bed materials due to the action of flowing water, which can be regular or highly episodic.

ESTUARY is a partly closed coastal or tidal body of water with one or more streams or rivers flowing into it and a free connection to the ocean.

FLOOD CONSTRUCTION LEVEL (FCL)* is the Design Flood Level plus the allowance for Freeboard used to establish the minimum elevation of the underside of a wooden floor system or top of a concrete slab for habitable buildings. In the case of a manufactured home, the ground level or the top of the concrete or asphalt pad, on which it is located, shall be equal to or higher than the above-described elevation. It also establishes the minimum crest level of a Standard Dike. Where the Design Flood Level cannot be determined or where there are overriding factors, an assessed height above the Natural Boundary of the water body or above the natural ground elevation is typically used.

FLOODBOX is a drainage culvert through a dike that conveys the internal drainage from a watercourse from inside the dike to the body of water (i.e., river or ocean) outside the dike. A gate is installed at the outlet end of the floodbox to prevent backflow from the body of water to the inside and to allow gravity flow from inside to the outside.

FLOODING refers to the overflowing of water onto land. Inland flooding usually results from faulty infrastructure or sudden and/or heavy precipitation that exceeds the design capacity of infrastructure. Coastal flooding usually results from high tides and storm events also called storm surges.

FLOODPLAIN is a lowland area, whether diked, floodproofed, or unprotected, which is at an elevation susceptible to flooding from an adjoining watercourse, lake, ocean or other body of water based on the area submerged by the Designated Flood plus freeboard.

FLOODPROOFING refers to the alteration of land or buildings to reduce flood damages. Floodproofing may include adding fill to raise the elevation of a building site, structural measures such as foundation walls or columns to raise a building, or combinations of fill and structural measures. Floodproofing also includes wet floodproofing, in which water-resistant building materials are used to reduce damage.

FREEBOARD is the vertical distance (typically 0.6 m) added to the calculated elevation of the Design Flood level to accommodate uncertainties. Such uncertainties include hydraulic and hydrological variables, potential for wave run-up, storm surges and other natural phenomena.

GABIAN BASKET OR WALL is a form of rip-rap consisting of a cage or basket of heavy wire containing rocks designed to protect shorelines from erosion.

GEODETIC DATUM means a set of constants specifying the coordinate system used for geodetic control (i.e., for calculating the coordinates of points on the Earth). The Canadian Geodetic Vertical Datum is the current orthometric height reference in Canada.

GROYNE (or GROIN) is a rigid structure built from an ocean shore or a river bank that interrupts the flow of water and limits the movement of sediment. An ocean groyne is typically constructed of rip rap or other heavy material perpendicular to the shore, extending from the upper foreshore or beach into the water.

HABITABLE AREA means any room or space within a building or structure that is or can be used for human occupancy, commercial sales, or the storage of goods, possessions or equipment (including furnaces) which would be subject to damage if flooded.

HIGH WATER MARK means that part of the ocean shore to which the waves normally reach when the tide is at its highest point. It is often marked by a debris or wrack line along the shore. The term strandline may also be used.

INSPECTOR OF DIKES (IOD)* is an official of the B.C. Ministry of Environment as defined under the *Dike Maintenance Act* RSBC 1996, chapter 95.

LONGSHORE DRIFT means the movement of beach-grade sediments along a coast parallel to the shoreline. It is caused by waves obliquely hitting the shoreline.

MITIGATION means a human intervention to reduce the occurrence or impact of an activity or to enhance the ability to cope with those impacts.

NATURAL BOUNDARY means the visible high water mark of any lake, river, stream or other body of water where the presence and action of the water are so common and usual and so long continued in all ordinary years as to mark upon the soil of the bed of the lake, river, stream or other body of water a character distinct from that of the banks thereof, in respect to vegetation, as well as in respect to the nature of the soil itself. For coastal areas, the Natural Boundary shall include the natural limit of permanent terrestrial vegetation. In addition, the Natural Boundary includes the best estimate of the edge of dormant or old side channels and marsh areas.*

PRECIPITATION refers to rain, snow, and hail that fall from the atmosphere.

PUMP STATION is a flood protection structure used to discharge water across a dike to a body of water when floodboxes are closed by a high tide or high river elevation. A pump station is generally built in conjunction with floodboxes as a combined structure.

RESILIENCE means the capacity to anticipate, prepare for, respond to, and recover from the effects of sea level rise with minimum damage to social well-being, the economy and the environment.

REVETMENT is a sloping structure designed as a cover or facing to absorb the energy of incoming water and protect existing shoreline uses as a defence against erosion.

RIPARIAN RIGHTS refer to common law rights that occur to property ownership along the shore of the ocean, a river or lake. They typically include access to and from the water, limited rights to use the water in its natural state, and protection of the property from erosion.

RIPRAP is an engineered layer of graded broken rock or other heavy material, which serves as the primary protection against shear stress or Erosion from flowing water. Riprap protects shorelines and shoreline structures by absorbing and deflecting the energy of waves before they reach the areas to be protected.

RISK means the likelihood of a negative event occurring (e.g., flooding due to sea level rise) combined with the magnitude of the potential consequences.

SALT MARSH is a coastal wetland on the edge of a shoreline or estuary where fresh water mixes with sea water. A salt marsh is the result of interaction between living organisms and natural forces of wind, currents, storms, tides and salt.

SAND DUNE is a ridge of sand created by the wind. Naturally occurring sand dunes represent a store of sediment just landward of normal high tides. Artificial sand dunes and dune rehabilitation represent a form of soft armouring engineered to mimic the functioning of natural dunes and reduce coastal erosion.

SETBACK is a horizontal distance which a building or landfill must be set back from a Natural Boundary or other reference line to maintain a Floodway and allow for potential land Erosion.

SPECIAL FLOOD HAZARD AREA refers to the land area covered by a base flood on National Flood Insurance Programs maps in the U.S.A. A base flood means a flood with a 1% chance of being equalled or exceeded in any given year. A base flood is also known as the 100-year flood and is the national standard used by the National Flood Insurance Program and all federal agencies for the purposes of requiring the purchase of flood insurance and regulating new development.

STORM SURGE refers to strong coastal waves pushed ashore by high winds during a storm. On the coast this represents the difference between the observed water level and the predicted astronomical tide.

SUBSIDENCE refers to the sinking of the Earth's surface in response to geologic or human-induced factors and may occur through gradual settlement or sudden collapse.

VULNERABILITY refers to the degree to which a system is susceptible to, or unable to cope with the adverse effects of climate change, including variability and extremes. Climate change impacts include inland flooding or coastal hazards (e.g., coastal storms, coastal flooding, coastal erosion).

WEATHER is the state of the atmosphere (e.g., temperature, precipitation, wind) at a specific time and location.

WETLAND refers to a land area that is saturated with water, either permanently or seasonally. Wetland areas have characteristic aquatic plants adapted to their unique soil conditions and are considered a distinct ecosystem. Wetland water may be saltwater, freshwater or brackish. Wetland areas provide important environmental functions, principally water purification, flood control, and shoreline stability. Wetland areas are considered the most biological diverse of all ecosystems.

*definition has specific application to B.C. legislation

Acronyms

CRE Committee of regional elected officials (In French: *CRE – Comité régional des élus*)

Defra United Kingdom Department for Environment Food and Rural Affairs

DPA Development Permit Area (specific to B.C.)

FCL Flood Construction Level (specific to B.C.)

IPCC Intergovernmental Panel on Climate Change

GDP Gross Domestic Product

GHG Greenhouse gases

NGO Non-governmental organization

PEP Provincial Emergency Program

RCMs Regional county municipalities (In French: *MRC – Municipalité régionale de comté*)

RAC Regional Adaptation Collaborative

SLR Sea level rise

TE Equivalent Territory

Type of Tool	Tool	Description of Tool	Examples	Authority	Legislation (if applicable)	Means of Implementation/ Responsible Party	Implementation Mechanisms	Means of Enforcement
1. Planning	Objectives and Policies	Growth management objectives, establishment of policies and setting of priorities	Management of growth at a level broader than a local government (e.g., Regional Growth Strategy)	Regional District	*Local Government Act* (LGA)	Regional government bylaw	Establish goals and policies to regulate or restrict development in areas subject to sea level rise (e.g., avoid development or limit type and intensity of development in areas subject to specified risk criteria)	Do not allow zoning or service extensions in areas subject to specified coastal hazard risks
			Management of growth at a local government level (Official Community Plan, Comprehensive Plan)	Local government (Municipality and Regional District)	LGA	Local government bylaw		
			Management of growth within a local government (detailed planning for a new neighbourhood or redevelopment of an existing neighbourhood)	Local government	LGA	Local government bylaw		
		Coastal management approach based on sensitivity to impact	Coastal Areas Protection Policy	Provincial government	Policy set by provincial government (i.e., New Brunswick)	Provincial government regulation Environmental Assessment Approvals Local government bylaws	Limiting of activities in three separate zones depending on the sensitivity for those zones.	Provincial government enforcement authorities or municipal gov't enforcement authorities.
	Coastal Flood Hazard Mapping	Spatially determine areas at risk from coastal hazards	Mapping of floodway and flood fringe areas with flood level isograms showing required building elevations to protect from design flood	Provincial government Local government	LGA *Emergency Program Act*	Federal/provincial agreement Local government	Zoning bylaw Floodplain bylaw	See subdivision, building and land use regulation tools
	Risk Management	The identification, assessment, measurement and prioritization of risks as a tool to assist in the coordinated and economical application of resources to monitor or minimize the probability and/or impact of flooding due to sea level rise	Setting of risk management standards to protect the public, buildings and land Cost benefit analysis Transfer of risk Covenant Flood damage curves	Any level of government or private land owner	LGA *Emergency Program Act*	Provincial government Local government Property owner	Building, land use and subdivision regulation	Through regulatory tools

Type of Tool	Tool	Description of Tool	Examples	Authority	Legislation (if applicable)	Means of Implementation/ Responsible Party	Implementation Mechanisms	Means of Enforcement
	Emergency Planning and Preparedness	Emergency planning to prepare for and mitigate the risk of flooding and undertake post disaster planning	Emergency preparedness plans Flood advisory warning Early warning system Recovery plans	Local government Aboriginal Affairs & Northern Development Canada	*Emergency Program Act* *Indian Act*	Local government First Nations Emergency Services Society Public Safety Canada Provincial Government	Preparation of an emergency plan for each local government Preparation of a provincial emergency plan	Provincial Emergency Plan requires local governments to prepare emergency plans and establish an emergency management organization Local government may declare a local state of emergency Provincial Minister or LGC may declare a state of emergency
2. Regulatory	Regulation of Land Use	Zoning of land to address safety	Restriction of land uses, establishment of minimum setbacks and building elevations for habitable use of buildings and other structures	Local government	*Local Government Act*	Local government bylaw	Rezoning to regulate land use, density, setbacks, minimal building elevations	No rezoning unless applicant agrees to flood mitigation requirements
		Establish minimum building elevations and setbacks for land designated as a flood plain	Flood Plain Bylaw includes minimum construction requirements for habitable dwellings in flood plain areas*	Local government	*Local Government Act*	Local government bylaw	Local government designation of land as a flood plain and consider Provincial Guidelines when adopting flood construction levels for dwellings, business and storage of goods; minimum building setbacks from a dike or body of water; siting circumstances; and works & services	Ensure Building Permit complies with bylaw requirements in a designated flood plain
	Subdivision Regulation	Regulation of subdivision by the Approving Officer to address safety of proposed use	Regulation of the subdivision of land to ensure the safety of proposed uses through a combination of structural protection, setbacks, minimum flood construction levels and restriction or prohibition of uses	Approving Officer	*Land Title Act,* *Highway Act*	Refusal of subdivision or withholding of approval until safety of proposed land use is provided to Approving Officer	Engineering report, covenant on title	Requirement of engineering or geotechnical report, covenant on land title

Type of Tool	Tool	Description of Tool	Examples	Authority	Legislation (if applicable)	Means of Implementation/ Responsible Party	Implementation Mechanisms	Means of Enforcement
	Development Permit	Regulation of specific development plans to protect the natural environment or to protect development from hazards	Regulation of specific development to ensure compliance with objectives for a particular area or type of land use	Local government	*Local Government Act*	Local government approval	Vetting of specific land use proposal in accordance with specified criteria such as goals and policies	Subdivision, building permit or alteration of land cannot take place without approval of development permit
	Building Regulation	Regulation of building construction by the Building Inspector to address safety, including flood risk	Regulation of a building according to the provincial Building Code and any local additions Withhold building permit until qualified professional can provide assurance of safe use	Building Inspector	*Community Charter*	Withhold building permit unless a qualified professional certifies that the land may be used safely for the intended purposes	Report by qualified professional to certify that the land may be used safely in accordance with the specified conditions Register covenant on title with report of qualified professional	Withhold building permit unless report by qualified professional is received Legal action if covenant conditions breached
3. Land Use Change or Restriction	Land Acquisition	Acquisition of land where private development is not suitable, for environmental protection purposes or exclusive open space use	Park or open space Environmental protection Ecological reserve	Government at any level	*Community Charter* *Expropriation Act*	Acquisition of land at fair market value through purchase or expropriation	Negotiated acquisition or expropriation	N.A. as acquisition requires willing buyer and seller. Expropriation is not generally subject to appeal.
	Transfer of Development Potential	Transfer of allowable density to an alternative location not at risk	Sale or exchange of allowable density Creation of a "density bank"	Local government	*Vancouver Charter* *LGA*	Local government	Zoning bylaw Establishment of "density bank"	N.A. as concept is market-based with willing buyer and seller
	Easement, Covenant or Other Restriction	Registration of easement, covenant or servitude on land title to restrict use of land	Covenant to run with land to prevent habitable uses Protection of marshland area Access to dike for maintenance Prevent or require deposit of fill on part or all of site	Local government	*Land Title Act*	Legal agreement to ensure permanent land use protection	Covenant on title	N.A.
	Land Trusts	Management of land by organization established for environmental, conservation and climate change adaptation purposes	Transfer of title or long-term management of land by land trust or other qualified organization for specified public purpose	N.A.	*Society Act* or specific enabling legislation	Legal agreement with land trust organization	Conveyance of land to organization responsible for its protection for specified purpose	N.A.

Type of Tool	Tool	Description of Tool	Examples	Authority	Legislation (if applicable)	Means of Implementation/ Responsible Party	Implementation Mechanisms	Means of Enforcement
	Foreshore Tenure	Acquisition of area below the natural boundary in order to undertake measures to mitigate the impact of tidal surges or other flood impact before it reaches land	Creation of an artificial island or reef to reduce the impact of storm surges Beach nourishment Dune building Wetlands restoration Breakwater	Provincial government Port Authority	*Canada Marine Act* *Land Act*	Port Authority Provincial government	Lease	Lease conditions Civil action
4. Structural (Flood Protection Works)	Scour Protection	Property-specific (on-site) protection of the foundation of an existing or new structure or the surrounding site to prevent erosion or undermining of the foundation due to rapidly moving water	Installation of riprap or other structural protection around building site Reinforcement of a building foundation and building materials to reduce risk Use of scour blanket to protect underwater infrastructure (electrical cable, water line, sewage outfall, pipeline)	Local government Approving Officer	*Local Government Act* *Community Charter* *Land Title Act*	Council approval of rezoning Approving Officer approval of subdivision Building Inspector approval of Building Permit	Subdivision, rezoning or building permit approval subject to provision of required protective measures Covenant on title	Withhold rezoning bylaw, Building Permit issuance or subdivision approval unless report received from a geoscientist or professional engineer that the land can be used safely with such report included in a covenant on title Legal action of covenant conditions breached
	Structural Elevation	Raising the elevation of flood prone lands to allow development, or raising the elevation of the development itself to be out of harm's way (also known as dry floodproofing)	Property-specific protection to raise and reinforce a building at a higher elevation Relocation of a building to a new location at a higher elevation further removed from the shore	Federal, provincial or municipal government	Federal or Provincial Environmental Assessment process or Water course alteration process.		Local government approval Covenant on title	Withhold rezoning bylaw, Building Permit issuance or subdivision approval unless a report is received from a geoscientist or professional engineer that the land can be used safely, with such report included in a covenant on title Legal action of covenant if conditions breached

Type of Tool	Tool	Description of Tool	Examples	Authority	Legislation (if applicable)	Means of Implementation/ Responsible Party	Implementation Mechanisms	Means of Enforcement
	Dikes	Linear shoreline structural protection designed to provide protection from a designated flood including storm surges (e.g.,1:100 or 1:200 year event)	Construction of a dike to provide protection from flood waters including storm surges Removal of a dike and its reconstruction further removed from the shore Reinforcement of a dike to provide enhanced protection due to sea level rise Appurtenant structures such as floodboxes and pumping stations undertaken in conjunction with a dike Secondary dike construction behind linear shoreline projection in order to confine or compartmentalize areas at risk	Local government Local Improvement District Inspector of Dikes	*Dike Maintenance Act* *Drainage, Ditch & Dike Act*	Local government Provincial government First Nation Cost sharing, including Government of Canada	Dike must be designed and certified by a Professional Engineer in accordance with Best Management Practices specified by the Ministry of Environment (July 2003)	Flood protection dikes are subject to the written approval of the provincial Inspector of Dikes
	Other Hard Protection	Off-site structural works designed to protect shorelines and shoreline structures from erosion resulting from the energy of waves. These are often placed to maintain the position of the shoreline, slow or stop the further erosion of the shoreline.	Hard protection or breakwater techniques include riprap, floodwall, coastal revetment, gabian baskets, groynes, sea wall, armour rock, steel piles and wooden structures				Structural elements noted may be included as an integral part of a dike infrastructure design or as an ancillary feature	Covenant on title Lease Zoning

Type of Tool	Tool	Description of Tool	Examples	Authority	Legislation (if applicable)	Means of Implementation/ Responsible Party	Implementation Mechanisms	Means of Enforcement
	"Wet Floodproofing"	Installation of building materials that can withstand flood damage for a limited time period	Require flood resistant building materials on the ground floor of a building within a designated flood plain Ensure building opening to basement or other area below a Flood Construction Level to prevent structural uplift	Local government Approving Officer Qualified professional	*Local Government Act* *Land Title Act*	Local government Report by qualified professional Initiative by builder	Selection of flood resistant building materials (e.g., FEMA specifications are based on destructive testing by the U.S. Army Corps of Engineers)	Covenant on title
5. Non-Structural Tools	Coastal Wetland Creation or Restoration	Coastal wetlands dissipate wave and tidal energy, and their vegetation and root systems act as a trap for sediments, facilitating accretion and reducing erosion.	Salt Marshes	Local government Provincial government First Nation Cost sharing including Government of Canada	None to date	Local government Provincial government First Nation Cost sharing including Government of Canada through programs	Implementation measures include land acquisition, foreshore lease, covenant or other form of protection. Land trust agreement may apply.	Local government management
	Dune Building or Rehabilitation	Naturally occurring dunes are wind-formed or artificial sand deposits representing a store of sediment in the zone just landward of normal high tides. They typically occur along wide sandy coastlines, and are dynamic and constantly moving.	Dunes occur very infrequently along the west coast of B.C. but are more common on the east coast of Vancouver Island and the east side of Graham Island in Haida Gwaii. They occur more frequently in Quebec and Atlantic Canada, particularly in P.E.I.	Local government Provincial government First Nation Cost sharing including Government of Canada	None to date	Local government Provincial government First Nation Cost sharing including Government of Canada through programs	Implementation requires an area (land or foreshore) to be set aside, a source of sand to create or rehabilitate dunes, equipment to move and shape sand into a dune, and funding sources for capital and ongoing maintenance.	Local government management

Type of Tool	Tool	Description of Tool	Examples	Authority	Legislation (if applicable)	Means of Implementation/ Responsible Party	Implementation Mechanisms	Means of Enforcement
	Beach Nourishment	The addition of sand or other similar sediment material to satisfy the erosional forces of natural wave action and prevent shoreline erosion.	Parlee Beach, N.B.	Local government Provincial government First Nation Cost sharing including Government of Canada	None to date	Local government Provincial government First Nation Cost sharing including Government of Canada through programs.	Engineering studies over an extended time period are required to determine the rate and extent of shoreline erosion and the volume of beach nourishment required to address the sediment deficit. For large-scale beach nourishment applications specialized equipment must be used. Ongoing monitoring will be required to evaluate the success of the beach nourishment and when additional beach nourishment is required.	Local government management
6. Hybrid Techniques	Living Shorelines Approach	Represents a hybrid technique with a focus on managing coastal areas that protect, restore, enhance or create natural shoreline habitat.	Cariboo Island, N.S. Point Ellice Park Shoreline Restoration, Victoria, B.C.	Local government Provincial government First Nation Cost sharing including Government of Canada	None specific to hybrid techniques	Local government Provincial government First Nation Cost sharing including Government of Canada through programs Ecology Action Centre, N.S. Green Shores Stewardship Centre, B.C.		Local government management

Appendix C – Legislative Matrices

British Columbia

B.C. Legislation	Key Elements	Key Provisions	Responsible Party
Local Government Act, RSBC 1996	Regional Growth Strategy	Under S. 849, regional growth strategy objectives can include protecting environmentally sensitive areas and achieving settlement patterns that minimize the risk associated with natural hazards.	Regional Districts
		Under S. 850, the purpose of a regional growth strategy is to guide decisions of social, economic and environmental growth for a period of at least 20 years.	Regional Districts
		Under S. 852, a regional growth strategy can be mandated by the provincial Minister of Community, Sport and Cultural Development.	Minister of Community, Sport and Cultural Development. This provision was exercised once - for the Comox Valley Regional District
	Official Community Plan	S. 875 includes statement of objectives and policies to guide land use planning, S. 876 covers bylaw process, S. 877 covers content including land use restrictions due to hazards or environmental sensitivity, S.878 addresses regional context statement.	Local governments (municipalities and regional districts)
	Zoning bylaw	S. 903 provides authority for local government to regulate land use. Regulation includes siting, location of uses on land, different uses, servicing standards, minimum areas and regulation of density. Also included is the power to prohibit any use in a zone.	Local governments (municipalities and regional districts)
	Floodplain bylaw	S. 910 addresses designation of a floodplain by local government bylaw, role of Provincial Guidelines, and construction requirements in a flood plain including setbacks and minimum building elevations.	Local governments (municipalities and regional districts)
Land Title Act, RSBC 1996	Subdivision approval	S. 85(3) allows Approving Officer to refuse subdivision approval if he considers it to be against the public interest. S. 86 allow a subdivision to be refused if the land is subject to flooding and other hazards. The Approving Officer may require a report by a professional engineer or geoscientist concerning how the land can safely be used as a condition of subdivision approval with the report included in a restrictive covenant on the land title. The conditions under which a subdivision is approved are also included in the Land Title Act.	Approving Officer - typically municipal planner or engineer appointed by Council but with independent role due to statutory powers. Approving Officer is Ministry of Transportation and Infrastructure employee in non-municipal areas (i.e., electoral areas) and smaller municipalities.
	Registration of covenant	S. 219 can include limiting conditions necessary for the safe use of land as required by a Building Inspector, Approving Officer or local government. A covenant can also be used for a save harmless provision where the owner accepts the risks of development and indemnifies government.	
Community Charter, SBC 2003	Building Inspector	S.55-56 gives authority to the Building Inspector to require a qualified professional to provide a report specifying the means by which the land can be safely used for the use intended prior to a building permit being issued. The covenant must be registered on title with the report concerning safe use provisions.	Building inspector for local government
Dike Maintenance Act, RSBC 1996	Regulation of Dikes	S. 2 provides for flood protection dikes to be subject to the written approval of the Inspector of Dikes. This includes changes in elevation or any other works. A technical review is undertaken to ensure Provincial Guidelines are met.	Inspector of Dikes (provincial government employee)
Emergency Program Act, RSBC 1996		Covers emergency planning for the provincial government and for local governments. Disaster Financial Assistance is administered through the Provincial Emergency Program.	Provincial government and local governments

Quebec Legislation

Quebec Legislation	Key Elements	Key Provisions	Responsible Party
La loi sur la sécurité civile (*Law on civil security*) Adopted in 2001, last updated in 2012	There is nothing in this legislation that deals specifically with adaptation to sea level rise, though one article is indirectly related	Chapter IV, Section III of this law obliges municipal officials to publicly communicate all known major risks and development regulation for risk management	Provincial government
La loi sur la qualité de l'environnement (*Law on the quality of the environment*) Adopted in 1972, last updated in 2012	There is nothing in this legislation that deals specifically with adaptation to sea level rise, though two articles are indirectly related	Article 22 which obliges authorisation for all construction via permits; and Article 31.1 outlining Environmental Impact Assessment procedures, including public consultations, in specially designated areas	Provincial government
La loi sur l'aménagement et l'urbanisme (*Law on planning*). Adopted in 1979, last updated in 2012.	There is nothing in this legislation that deals specifically with adaptation to sea level rise, though one article is indirectly related	Article 5 of this law requires compliance by municipalities with provincial directives	Provincial government
Quebec Policies	**Key Elements**	**Key Provisions**	**Responsible Party**
Politique gouvernementale en matière de protection des rives, du littoral et des plaines inondables (*Governmental policy for the protection of riverbanks, shorelines, coastlines and floodplains*) Adopted in 1987, last updated in 2005	Originally intended to be legislation, this policy outlines coastal protection measures that were encouraged to be included in regional master plans (schemas d'amènagement)	Section 2.2 of the policy outlines a uniform setback of 10 m if the land grade is less than 30 degrees from the shore and 15 metres if the land grade is greater than 30 degrees from the shore. Section 3.1 of the policy mandates a special permit for new construction on all shorelines, to ensure compliance with the measures outlined in the policy. Permits are issued by the relevant authority, which depending on the location will vary from the municipality, the region or the Province. Section 3.3 of the policy bans all construction directly on the coastline, with some exceptions such as piers, small bridges, water intakes, etc.	Provincial government
Quebec Plans and Strategies	**Key Elements**	**Key Provisions**	**Responsible Party**
Plan d'action aux changements climatiques, 2006-2012 (*Climate Change Action Plan*, 2006-2012)	The QC government released its first *Climate Change Action Plan* in 2008. In addition to mitigation objectives (the goal is to reduce total GHG emissions by 20% below 1990 levels), objectives related to sea level rise adaptation are also included.	Section 2.3 entitled "Les actions visant l'adaptation du Québec aux changements climatiques" (Actions related to Quebec's adaptation to climate change), sub point 2.3.2, measure 23 of the plan includes conducting more detailed research into the impact of climate change on coastal zones in order to develop plans for better protecting sensitive ecological zones as well as infrastructure.	Provincial government
Stratégie gouvernementale d'adaptation aux changements climatiques, 2013-2020 (*Government strategy for adapting to climate change*, 2013-2020)	The provincial government released its strategy for its second climate change action plan in February 2012, for public consultation. Once feedback on the proposed strategy has been integrated, the *Climate Change Action Plan 2013-2020* will be published.	Section 3 deals specifically with adaptation tools and outlines the need for: solid research in order to prioritise issues; increasing awareness on these issues; analysing the vulnerability of communities and ecosystems; communicating the data to the impacted communities; developing and implementing appropriate technologies; and adapting legal instruments and governance structures according to adaptation needs. Objectives are elaborated for achieving these needs.	Provincial government

Quebec Regional & Supralocal Regulation	Key Elements	Key Provisions	Responsible Party
Règlement No. 02-2005, Règlement de contrôle intérimaire relatif aux zones de risque d'erosion littorale en bordure du fleuve Saint-Laurent et de l'estuaire de certaines rivières du territoire de la MRC de Sept-Rivières (*Regulation number 02-2005*, Interim regulation related to erosion risk zones along the St. Lawrence and for certain river estuaries in the RCM of Sept-Rivières) Adopted in 2005, last updated in 2010	In 2005, after extensive consultations with its municipalities, the RCM of Sept-Rivières adopted this interim regulation for high erosion rate areas, based on the inter-ministerial report findings.	Article 7 on construction indicates that within the non-construction zone, as defined in Appendix 1 and 2 of the regulation, as per the research findings of the inter-ministerial research on erosion rates: • no new construction; • no extension of habitable surface to existing buildings; • no re-construction permits for buildings that have been destroyed or damaged in an amount equal or greater than half the value of the building, for whatever cause; Some exception provisions apply and are stipulated. Article 8 on permissible work stipulates that individuals are only allowed to protect their properties from erosion through rebuilding sandbanks. All other structural measures (riprap, dikes, etc.) are prohibited, unless allowed for by special provision. Appendices 1 & 2 establish setback lines for a 25 year protection period, according to the inter-ministerial report recommendations. Appendix 1 includes the maps and Appendix 2 includes the charts with approximately 240 different setback lines per land sector. Setbacks range from 30 to 180 metres, with some zones declared non constructible.	Regional County Municipality

Atlantic Canada Legislation

New Brunswick Legislation	Key Elements	Key Provisions	Responsible Party
Coastal Areas Protection Policy	Divides the coastal areas of the province into 3 sensitivity zones: A) areas closest to the water known as the coastal lands core; B) areas beyond Zone A which provide a further buffer zone; C) areas beyond Zone B that form a transition from coastal to inland areas	Enforced via Environmental Impact Assessment requirements or Watercourse Alterations Approvals or incorporated into municipal bylaws	Provincial government; Municipal government
Watercourse and Wetland Alteration Regulations, 1990	Limits activities that take place within or close to a watercourse or wetland	A permit is required before certain activities take place within 30 metres of a watercourse: Erosion protection works Depositing or removing rocks, sand, gravel, earth or any other material Drainage systems Tree or undergrowth clearing	Provincial government (Department of Environment)
The Community Planning Act, RSNB 1973	Provides a mandate for land use planning throughout the province and allows for the creation of District Planning Commissions	District Planning Commissions are responsible for providing building, development and planning services to municipalities and unincorporated areas of the province	Provincial government (Department of Environment)
	Provision for municipalities and rural communities to enact a flood risk area bylaw with provincial approval	Once such an area has been established the bylaw can specify engineering standards, designs and techniques for development in flood risk areas	

New Brunswick Legislation	Key Elements	Key Provisions	Responsible Party
Federal Maritime Marshland Rehabilitation Act, 1948	Enabled federal assistance for the preservation and extension of the dryland area	Was used to upgrade dykes in the 1950's and 1960's originally built by the Acadians 300 years ago but without any consideration for rising sea levels and climate change.	Currently maintained by the New Brunswick Department of Agriculture, Fisheries and Aquaculture

Nova Scotia Legislation	Key Elements	Key Provisions	Responsible Party
Statements of Provincial Interest	Statement of Provincial Interest on Flood Risk	Goal: to protect public safety and property and to reduce the requirement for flood control works and flood damage restoration in floodplains. This statement applies to all flood Risk Areas that are designated under the Canada-Nova Scotia Flood Damage Reduction Program. No coastal areas have been identified under this program	Provincial government
Municipal Government Act Adopted 1998, last updated 2010	Municipal authority to develop Municipal Planning Strategies (MPS) and Zoning Bylaws	Under PART VIII, Section 220 of the Act can regulate land use through an MPS and Zoning Bylaw	Municipal government
Halifax Regional Municipality Charter Adopted 2008, last updated 2011		Section 2 The purpose of this Act is to (a) give broad authority to the Council, including broad authority to pass bylaws, and respect its right to govern the Municipality in whatever ways the Council considers appropriate within the jurisdiction given to it; (b) enhance the ability of the Council to respond to present and future issues in the Municipality; and (c) recognize that the functions of the Municipality are to (i) provide good government, (ii) provide services, facilities and other things that, in the opinion of the Council, are necessary or desirable for all or part of the Municipality, and (iii) develop and maintain safe and viable communities.	
Environment Act, 1994-5	Environmental Impact Assessment	Environmental Assessment Regulations	Provincial government

Prince Edward Island Legislation	Key Elements	Key Provisions	Responsible Party
The Planning Act Adopted 1988, last updated 2010	Subdivision and Development Regulations	Section 16 requires that, where development is adjacent to a beach, a buffer having a minimum width of 18.3 metres or 60 times the annual erosion rate for the area (whichever is greater), measured from the top of the bank, be provided	Provincial government; Municipalities can alter the setback requirements from coastal areas and beaches

Prince Edward Island Legislation	Key Elements	Key Provisions	Responsible Party
	Municipal Planning Bylaws	Prince Edward Island municipalities can assume responsibility for land use planning through the development and adoption of official plans and land use bylaws. Thirty-one municipalities have opted to take on responsibility for planning (see Appendix F, Table 2).	Municipal government; If no OCP or bylaws in place, the land comes under the jurisdiction of the Province and is governed by a general set of subdivision and development regulations.
The Environmental Protection Act Adopted 1988, last updated 2010	Environmental Impact Assessment	Section 9 requires written permission from the Minister for any undertaking proposed in the province (including coastal areas)	Provincial government
	Sand Dunes and Beaches	Section 22 (1) No person shall, without written permission of the Minister, (b) carry out any activity that will or may (i) interfere with the natural supply or movement of sand to or within a beach or a sand dune, (ii) alter, remove, or destroy natural stabilizing features, including vegetation, of a beach or a sand dune.	Provincial government; Municipalities must follow the provisions.
The Watercourse and Wetland Protection Regulations Adopted 1988, last updated 2009		Requires a Watercourse, Wetland and Buffer Zone Activity Permit for alterations or activities in watercourse or wetland areas, tidal estuaries or coastal bodies. These are included in the definition of a watercourse.	Provincial government; Municipalities must follow the provisions.

Newfoundland and Labrador Legislation	Key Elements	Key Provisions	Responsible Party
Water Resources Act, SNL 2002	Newfoundland Department of Environment and Conservation Policy for Development in Shore Water Zones establishes criteria for issuing permits under the Water Resources Act		
Urban and Rural Planning Act, SNL 2000	Enabling legislation which: - establishes the province's land use planning system; - allows the preparation of a range of planning documents; and - enables the creation of regional planning areas		
Lands Act, SNL 1991	Enabling legislation which provides rights to parcels of land	Section 7 – Reservation of Coastline	Provincial government
Environmental Protection Act, SNL 2002	Provides regime for environmental assessment in the province	Part X – Environmental Assessment and Control of Undertakings	Provincial government, Minister

Prince Edward Island Municipalities					
Municipality	**Title of Instrument**	**Section of the document**	**Title**	**Prohibition**	**Other**
City of Charlottetown	Zoning and Development Bylaw	4.73	Viewscapes and development along shorelines, watercourses and wetlands	No permits within 23 m of a wetland or watercourse as per provincial requirements under the Environmental Protection Act.	Some exemptions apply. The City uses a design storm water height of 3.25 m geodetic for structures in coastal areas as per the Lot Grading Guidelines, which are subject to review.
	Lot Grading Guidelines	Enforced via S 4.63A of the Zoning and Subdivision Development Bylaw	Surface Drainage Problem Lands and Flood Risk Areas	The City requires that habitable space in new buildings be located above 4.93 m above sea level Chart Datum (3.25 m geodetic or contour level). The building design must consider access to the building and parking in the event of flooding or natural sea level rise over the life expectancy of the building. Basements below the projected sea level rise must not be used for habitable space or for the storage of immovable objects, flammable, explosive, toxic or otherwise toxic material. Electric and mechanical rooms must also be located above 4.93 m (3.25 m Geodetic) elevation or protected or movable as normal water levels rise over the years.	
City of Summerside	Zoning Bylaw SS-15-2007	11.3	Fencing, screening, landscaping and setbacks	No permits for any use within 10 m buffer zone of a watercourse plus an extra 13 m for main building, 9 m for accessory building and 5 m for a street.	
Town of Stratford	Zoning and Subdivision Control (Development) Part 1 Bylaw 29	22.1(2)	Environmental Reserve Zone		The Town has a climate change adaptation plan via a Canadian Institute of Planners project with funding from Natural Resources Canada.
		S. 18 Appendix B	Sustainable Development Overlay Zone	Scoring system used to determine if site is sustainable.	If any part of the site is located in coastal zone or inland areas within a high- or moderate-risk floodplain, as identified by local authorities based on hydrological trends and the Climate Change studies demonstrating the projected impacts, develop only portions of the site that are not in the floodplain.
Town of Cornwall	Zoning and Subdivision Control (Development) Bylaw	21, 21.2	Environmental Reserve Zone	No building or part allowed within 23 m of any watercourses or wetlands (includes coast line)	Recreational or conservation activities are allowed.
Town of Souris	Zoning & Subdivision Control (Development) Bylaw	18.7	Setbacks – Erosion Factors	On those lots adjacent to the shore not having a shoreline buffer, or to which the applicant of a shoreline buffer requirement is impractical, no buildings or structures shall be constructed closer than: (a) the distance determined by multiplying the annual erosion rate for that shoreline by sixty (60'); or (b) seventy-five feet (75'), whichever is greater, measured from the top of the bank to the nearest exterior part of the proposed building or structure.	Some exceptions apply for certain buildings or structures or under certain situations. Where there is no embankment, the phrase "top of the bank" means the ordinary high water mark.
		S. 22.3	Permission to Subdivide	No person shall subdivide land within the Town unless the subdivision: (iii) will not cause undue flooding or erosion.	

Prince Edward Island Municipalities

Municipality	Title of Instrument	Section of the document	Title	Prohibition	Other
Town of Alberton	Zoning and Subdivision Control (Development) Bylaw	4.39	Watercourses and Wetlands	Cannot alter or remove any natural vegetation or deposit or remove fill with 75ft of a watercourse. Cannot erect any structure with 75 feet of a watercourse or wetland.	Council can approve development in 75 ft. zone when it deems there would be no significant damage to the natural environment
Community of Eastern Kings	Zoning & Development Bylaw	5.19	Setbacks from Beach, Sand Dune, Wetland or Watercourse	No person shall construct within 22.9 m or 60 times the annual erosion rate, whichever is greater from a beach measured from the top of a bank. Also includes primary or secondary sand dunes.	
Community of Borden-Carleton	Zoning & Development Bylaw	2.31	Watercourses – Separation Distances	To protect wetland and shoreland areas: no development shall take place within 20 m and no structure shall be located with 30 m of any watercourse including Northumberland Strait.	
Village of Victoria	Zoning & Subdivision Control Bylaw	5.17		No development within 75 ft. of streams, watercourses or river embankments.	
Community of North Rustico	Zoning Laws	Zoning section 4-3 Section 51	Watercourses-Separation Distances	No structure shall be located within 50ft of any watercourse (includes shoreline).	Less than Provincial Planning Act Requirement
Resort Municipality of Stanley Bridge, Hope River, Bayview, Cavendish and North Rustico	Zoning and Subdivision Control (Development) Bylaw 2004	Sections 2.88, 2.89, 4.13, 4.46	Definitions, Development Approval, Other Information, Watercourses and Wetlands	No person shall remove vegetation, remove or deposit fill or erect or place any structure within 75 feet of any watercourse or wetland.	Watercourse includes tidal water bodies, beds, and shores, below the high water mark. Wetlands include all tidal areas that are or may be submerged under fresh or salt water.

Nova Scotia Municipalities

Municipality	Title of Instrument	Section of the document	Title	Prohibition	Other
The Municipality of the County of Kings	Bylaw #75-County of Kings Land Use Bylaw	S. 14.6.6	Special Requirements: Development within the Coastal Shoreland (CS) Zone in Grand Pré and Area	14.6-2 – a minimum setback of 50 feet from the top of the bank. Property owners shall provide written confirmation to the development officer stating they are aware their property is prone to erosion and that they understand the risks associated with development.	Applicants for development permits with water frontage on the Bay of Fundy and Minas Basin are reminded to take into consideration the hazards of erosion and slope failure in the placement of dwellings and accessory structures and driveways. Seeking professional assistance may be prudent in making decisions related to development in proximity of tidal zones, beaches and cliffs.

Nova Scotia Municipalities					
Municipality	**Title of Instrument**	**Section of the document**	**Title**	**Prohibition**	**Other**
Halifax Regional Municipality	Land Use Bylaw for Eastern Passage / Cow Bay;	4.18A	Coastal Areas	No development permit shall be issued for any lot abutting the coast of the Atlantic Ocean, including its inlets, bays and harbours, within a 2.5 m elevation above the ordinary high water mark.	Some exceptions apply.
	Land Use Bylaw for Halifax Peninsula	16 K			
	Land Use By-Law for Planning District 5 (Chebucto Peninsula)	4.20A			
	Land Use By-Law for Downtown Halifax	S. 7 (12)	Residential Uses : Storm Surge Protection	No portion of a building of a lot within schedule W shall be less than a 2.5 metre elevation above the ordinary high water mark.	
Cape Breton Regional Municipality	Land Use Bylaw of the CBRM.	Section 2	LP2 Lot Parcel development requirements	Minimum building setback from a body of water is 100 feet.	Louisburg Parkway area
Village of Pugwash	Pugwash Community Master Plan	Rural Area and Coastline		No mandatory requirements. (See Municipality of Cumberland County Bylaws).	Climate change and sea level rise identified as issues for those living or vacationing along the coast.
	Municipal Planning Strategy	S 3.5.1.1		To require the establishment, retention or restoration of a 30.5 m shoreline buffer along all coastlines and wetlands and areas prone to seasonal flooding or flooding due to high tides or storm surges … the Bylaw shall generally prohibit all development within the shoreline buffer, except for coastal stabilization works. To prohibit development intended for human occupancy below a 2.5 m. elevation above the ordinary high water mark.	
The Municipality of the County of Cumberland (Central, Joggins and Pugwash areas)	Land Use Bylaw	S 3.13	Shoreline Buffer	Shoreline buffers of 30.5 m in depth shall be established, retained or restored along all coastlines and wetlands and areas prone to seasonal flooding or flooding due to high tides or storm surges. Within shoreline buffers, all development and outdoor storage shall be prohibited.	Exceptions shall include, necessary "hard" shoreline stabilization works, one accessory building or structure or… In S 6.5 an exception is made for existing lots for single detached dwelling of at least 929 square metres for a minimum shoreline buffer of 8 m.
Glace Bay (within Cape Breton Regional Municipality)					The Town has a climate change adaptation plan via a Canadian Institute of Planners project with funding from Natural Resources Canada.

Nova Scotia Municipalities

Municipality	Title of Instrument	Section of the document	Title	Prohibition	Other
The Town of Yarmouth	Municipal Planning Strategy	Policy 8.49	It shall be the intention of Council to undertake a Climate Change Adaptation Study to identify potential impacts from sea level rise and storm surges through a risk assessment and to implement safeguards to minimize the effects of climate change along Yarmouth's waterfront.	See also - Statements of Provincial Interest	The Integrated Community Sustainability Plan recognizes that climate change will have an effect on coastal areas. In light of increased storm surges due to climate change, Council intends to undertake a risk assessment to develop regulations to minimize potential adverse effects of climate change.
		Policy 8.76 (3)	A collaborative regional approach to enhance the region's capabilities to adapt to climate change through the use of shared knowledge and mapping/modelling resources to help anticipate climate change impacts and coordinated planning and development of appropriate emergency measures.		

New Brunswick Municipalities

Municipality	Title of Instrument	Section of the document	Title	Prohibition	Other
Village of Le Goulet	Le Goulet's Climate Change Adaptation Plan; Draft Zoning bylaw			The regional planning commission identified a zone where climate change impacts are considered a major risk that developers must consider in their plans. The draft zoning bylaw provides an opportunity to educate developers about the climate change related risks to people and infrastructure, and ensures that appropriate, but not prescriptive, measures are taken to accommodate those risks.	www.nrcan.gc.ca/earthsciences/climate-change/community-adaptation/municipalities/709 Planned retreat is one option to responding to sea level rise. No legal requirement is in place as of Jan. 20, 2012.
Village of Grand Manan	Municipal Bylaws, Rural Plan, 32-01	2.2 (1)	Powers of the Planning Advisory Committee	No building or structure may be erected on and site … if in the opinion of the Planning Advisory Committee… if the site is marshy, subject to flooding, excessively steep or …	Section could be used to restrict development based on flooding from storm surge or sea level rise.
Pointe-du-Chêne	Community Plan for Adaptation in Pointe-du-Chêne, N.B.			No bylaw in place	Buildings moved away from the shore (retreat).
Beaubassin-est Rural Community	Rural Community Rural Plan By-Law 09-1B – Modifying the By-Law adopting the rural plan (sea level rise risk zone)	7.2 (2) d)	Protection Zone	Allows only developments that demonstrate an adaptation to the effects of the rise of sea levels and storm surges in flood-risk zones.	An sea level rise zone or sea level rise risk-zone is created and is shown on the zoning map in Appendix B-1 of the bylaw. Some exceptions to the requirements apply.

New Brunswick Municipalities					
Municipality	**Title of Instrument**	**Section of the document**	**Title**	**Prohibition**	**Other**
		7.2 (4) a)		In the case of a new building: i. The minimal elevation of the habitable part must be 4.3 m (CGVD28), and ii any permit request must be accompanied by: a. A plan demonstrating the elevation of the habitable part of the building, and; b. A drainage plan – if the adaptation method includes more than one metre of land filling for properties of < one acre	
Beaubassin West Planning Area	Rural Community Rural Plan	8.2	Open Space Zones	For buildings 279 m or less in size, a 30 m setback required from watercourses, lakes, ponds, sea shores.	www.cabbpc.ca Beaubassin Planning Commission
Richibucto	BY-LAW No. 04-11	6(1)	Powers of commission	No building or structure may be erected on any site which is marshy, subject to flooding.	
City of Saint John	Municipal Plan 2011	S. 1.4.1 #6	Plan Directions	Last bullet –"develops effective policy on climate change and integrates mitigation and adaptation options that can be influenced through land use policy." Encourage new waterfront development to actively promote environmental sustainability, taking into account changes in sea level caused by climate change.	The Saint John Municipal Plan was adopted by City Council on Jan. 30, 2012
		S. 4.3.4 Policy UD-14	Natural Environment & Energy	7.9. "The City's location on the Bay of Fundy, the Saint John River, and the Kennebecasis River makes the community particularly susceptible to the effects of climate change and rising water levels."	
		Chapter 7	Natural Environment and Energy		See policies NE-42, NE-43 and NE-44
Town of St. Andrew's	Municipal Plan By-Law No. 07-02	2.1.2 Policies	The Waterfront, Tidal and Marsh Areas, and Parks	Council shall, where necessary, introduce new standards and operational approaches to reduce potential climate change impacts.	This may include flood control measures, vegetation retention and shoreline erosion control.
Town of Sackville	By-Law to Adopt a Municipal Plan- By-Law No. 211	3.2.5.1	Agricultural / Conservation Zone	Any agricultural lands, waterways, marshes and floodplains are protected in this designation.	Floodplains would include areas impacted by storm surge. No new development is permitted in these areas with the exception of agriculture, wildlife conservation, ecotourism, and renewable energy
Town of Shediac	Zoning By-Law Z-11-44	S 66(2) S 66(4)	Sea Level Rise Zone (areas at risk to sea level rise)	b) Anticipate, prevent and attack the causes of coastal environmental degradation; d) Only allow developments that will be able to adapt to sea level rise and severe storm surges in zones that risk flooding	For a new building the minimum elevation must be 4.3 m (CGVD28) S. 66(4) a) i. One of the objectives is to use the precautionary principle.
Village of Clair					The Town has a climate change adaptation plan via a CIP project with funding from NRCan.

Newfoundland and Labrador Municipalities					
Municipality	**Title of Instrument**	**Section of the document**	**Title**	**Prohibition**	**Other**
Town of Placentia	PIEVC Infrastructure Vulnerability Assessment	No bylaw in place			A Water Resources Public Infrastructure Vulnerability Assessment was conducted for the Town in 2009 by Engineers Canada.
City of Corner Brook	City of Corner Brook Municipal Plan 1994-2004 Part I	Chapter II (b) (ii)	Environment	To prevent development from occurring on lands having inherent natural environmental hazards such as poor drainage, flood susceptibility, erosion, steep slopes, or any other physical conditions which could damage human life and property.	General policy statement
Humber Valley Regional Planning Area	Draft Land Use Plan	S. 1.1	Climate Change Policies	1.1.2 "Establish adaptation strategies to minimize vulnerability to riverine flooding, storm tide or sea level inundation, coastal erosion, forest fires and landslides, severe winds, storm and rainfall events."	See policies 1.1.1 to 1.1.7
City of St. John's	St. John's Municipal Plan	S. 8.2.4	Lands Adjoining Bodies of Water and Flood Hazard Areas	Land within a 15 m buffer of the 100-year high water mark of ponds, wetlands, rivers or major tributaries of rivers designated under this plan (see S 8.2.1) shall not normally be developed. Nor shall any lands within Flood Hazard Areas or any Flood Risk Areas, as identified by the Dept. of Environment, normally be developed.	Some exceptions apply.
Town of Norris Point	Municipal Sustainability Plan 2009- 2019	S 2.2	Planning for Environmental Sustainability		As a coastal community, there is growing concern over coastal erosion and rising sea levels. Residents will have to consider how land development practises need to be adapted within the context of climate change.
		S 3.4 Policy G-9 – See also S 3.9.2 Policy EP-1	General Land Use Policies - Planning for Climate Change Environmental Protection Policies	It shall be the intention of Council to be aware of changes in climate and seek information and professional advice about the effects of climate change on the community. Engineering studies will be required to assess coastal erosion and recommend appropriate setbacks for development proposals within 200 m of the high water mark of the coastal shoreline. Measures proposed to protect the shoreline from erosion will be evaluated for their effectiveness and visual impact on the community. Council shall prohibit development in areas exposed to ocean surges, flooding or other environmental danger.	
	See also Town of Norris Point Development Regulations 2009-2019	S 59	Watercourse Protection Buffers	100 m setback required from the top of bank or high water mark, whichever is greater.	
		S 59. 1.)	High Water Level	For the purposes of interpretation, the high water level of a water body is taken to be the 1:100 year return period water level. In marine situations, the level must include maximum waves, wind setup, storm surge, and ultimate sea levels under current global climatic forecasts for a 1:100 year design.	

Newfoundland and Labrador Municipalities					
Municipality	**Title of Instrument**	**Section of the document**	**Title**	**Prohibition**	**Other**
The Town of Glenburnie-Birchy Head-Shoal Brook	Municipal Plan, Strategic Plan, Emergency Plan				The Town has a climate change adaptation plan (2010) via a Canadian Institute of Planners (CIP) project with funding from NRCan. The Town has officially incorporated the report in the Municipal Plan, the Strategic Plan, the Emergency Plan and the ICSPlan. All these plans come under the Municipal Plan for effectiveness and implementation.
Town of Conception Bay South	Policies				The Town is using hazard maps, which denote a range of natural geological hazards such as sea level rise, floodplains and slopes to assign a hazard level. Most of the shoreline is within the high or moderate level risk and there are policies which specify uses and development conditions within the risk areas.
Town of Torbay	Municipal Plan 2007 -2017	S 3.1.1 xvii)	General Policies – Coastal Reservation	To ensure that development is setback sufficiently to protect both the developer / user of the land and the environment, no building development shall be permitted within 30 metres from the top of the steep coastlines along the shorelines of the Town.	

Appendix E – Annotated Bibliography

Arlington Group Planning + Architecture Inc. *Flood Protection Strategies in British Columbia.* Report for the British Columbia Real Estate Association (BCREA), Vancouver: BCREA, 2010. Available at: http://www.bcrea.bc.ca/docs/government-relations/2010-11flood-protection-strategies-report-in-bc---final.pdf?sfvrsn=2

This study reviews the legislative provisions available in British Columbia to address flood hazards. This included a detailed documentation of key provincial statutes, policies, information sources and the tools they provide for mitigating flood hazards. Potential funding sources were also identified. The effectiveness of current flood protection strategies is discussed in light of major changes in provincial legislation in 2003 and 2004 including a detailed survey of flood hazard practitioners. Although it is not the primary focus of the report, sea level rise is discussed in the context of highly variable coastal conditions, the need for updated floodplain mapping and analysis and public education.

Arlington Group Planning + Architecture Inc. *Floodproofing Options for Historic Settlements.* Commissioned by Fraser Basin Council, Vancouver: Fraser Basin Council, 2001. Available at: http://www.fraserbasin.bc.ca/publications/documents/floodproofing.pdf

This report includes practical and cost-effective design options for floodproofing new residential and commercial construction within historical settlement areas. These settlement areas consisted of communities in the lower Fraser Valley where flood protection from the Fraser River or the sea took the form of dikes or other off-site structural protection. The report addresses a series of on-site mitigation measures that could alter the current total reliance on off-site structural protection. Design options were to limit flood damages, maintain or increase public safety, minimize adverse visual impacts, minimize adverse drainage and soil displacement impacts, minimize cleanup and repair costs, and comply with current statutory and regulatory requirements. Ten design scenarios were prepared; these included single family residences, townhouses and small commercial lots. Three lot frontages were considered (9.1 m, 12.2 m and 15.2 m) and two FCL increases above grade (1.7 m and 2.5 m). Geotechnical considerations for development in organic soils and compressible silts were also addressed. Designs for each scenario were prepared, illustrating conventional building areas needed for market acceptability while addressing on-site floodproofing requirements. Cost implications for each scenario as well as their advantages and disadvantages are also documented.

Atkins, Judy, Ann Hillyer, and Arlene Kwasniak. *Conservation Easements, Covenants and Servitudes in Canada - A Legal Review.* Report No. 04-1, Ottawa, Ontario: North American Wetlands Conservation Council (Canada), 2004. Available at: http://www.wetlandscanada.org/conseasecov04-1.pdf

This report is an update to a 1995 publication which reviewed the state of conservation easement, covenant and servitude legislation at the time. Since the original publication there has been an increase in the use of statutorily-based easements and covenants for conservation purposes across Canada. More jurisdictions have introduced legislation enabling the use of such instruments specifically for conservation purposes and more covenants and easements have been placed on private land to conserve and protect open space and important ecological values on the land. During this same time, the federal and provincial governments have improved income tax benefits associated with private land protection, which has enhanced the attractiveness of the use of these tools. This report lists the primary statutes or portions of statutes enabling the use of conservation easements, covenants and servitudes in Canada.

Ausenco Sandwell. "Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use." Draft Policy Discussion Paper, 2011. Available at: http://www.env.gov.bc.ca/wsd/public_safety/flood/fhm-2012/draw_report.html#2

This guideline document describes the principles for determining the exposure of low lying lands to a flooding hazard due to their exposure to the sea and provides guidelines and direction for their management. It also provides guidelines intended to help local governments, land use managers and approving officers develop and implement land-use management plans and make subdivision approval decisions for lands exposed to coastal flooding hazards and sea level rise.

Barron, Sara, et al. "A Climate Change Adaptation Planning Process for Low-Lying, Communities Vulnerable to Sea Level Rise." *Sustainability*, 2012: 2176-2208.

This research demonstrates a process to model, visualize and evaluate potential flood impacts and adaptation options. The study focus is on South Delta and Ladner and includes economic, social and environmental perspectives. The results of the scenario development, mapping and visualization imagery and assessment of indicators provided the community and decision-makers with a structured set of options and holistic listing of relative impacts and implications of flooding associated with sea level rise. The authors note a major success of this methodology is the ability for the visioning packages to engage in more meaningful conversations about specific adaptation strategies, their implications, phasing, implementation, acceptability and how they may be refined into coherent policy pathways.

Batterson, M., and D. Liverman. "Past and Future Sea-Level Change in Newfoundland and Labrador: Guidelines for Policy and Planning." *Newfoundland and Labrador, Dept of Natural Resources, Geologic Survey Report*, 2010: 129-141. Available at: http://www.nr.gov.nl.ca/mines&en/geosurvey/publications/CR2010/2010_Batterson-Liverman.pdf

This report aims to promote understanding of the direction and magnitude of future sea level change, which is important in creating policy and planning measures for development in the coastal zone. To determine guidelines for the province, local trends in sea level are examined by using tide gauge records, salt marsh research and other indicators of past sea level changes. These local trends are combined with estimates of future global sea level change to provide predictions of likely changes in sea level for the province. Estimates of sea level change leading up to 2050 and 2100 are provided for four zones covering the province.

Birch Hill GeoSolutions. *Climate Change Adaptations for Land Use Planners.* Project A1209, Natural Resources Canada, 2008. Available at: http://www.cakex.org/sites/default/files/Birch_Hill_Geosolutions.pdf

The purpose of this project was to develop a toolkit for use by community Land Use Planners, with assistance from municipal and consulting engineers, for assessing climate change impacts on their community and adapting to them. An underlying theme was that more science and engineering input is already needed in sustainable community Land Use Planning, and climate change may increase that need, since it could exacerbate existing environmental impacts on development, and vice versa. The focus was climate change impacts in rural areas of Atlantic Canada, with test sites in Annapolis Royal and the Pereau River watershed in southwestern Nova Scotia. This study reviewed implementation tools for their applicability to climate change, including: 1) Engineering Codes of Practice; 2) Regulations and Administrative Practices Related to Land Use Planning; 3) Building Codes; 4) Sustainable Building Adaptations; and 5) Emergency Management.

Bowron, Beate, and Gary Davidson. *Climate Change Adaptation Planning: A Handbook for Small Canadian Communities.* Mainstreaming Climate Change Tools for the Professional Planning Community, Canadian Institute of Planners, 2011. Available at: http://www.fcm.ca/Documents/tools/PCP/climate_change_adaptation_planning_handbook_for_small_canadian_communities_EN.pdf

This handbook helps small Canadian communities to prepare a Climate Change Adaptation Plan. The handbook helps community planners take the key steps required to plan for climate change adaptation, and decision-makers to determine what strategic actions need to be taken. It is especially useful for small communities without "in house" planning resources.

Bowron, Beate, and Gary Davidson. *Climate Change Adaptation Planning: A Nunavut Toolkit.* Atuliqtuq: Action and Adaptation in Nunavut, Canadian Institute of Planners, 2011. Available at: http://www.planningforclimatechange.ca/wwwroot/Docs/Library/CIPReports/NUNAVUT%20TOOLKIT%20FINAL.PDF

The toolkit focuses on a community development process for small settlements in Nunavut. The toolkit reflects the themes identified in the 2008 Nunavut Climate Change Partnership document entitled "Atuliqtuq: Action and Adaptation in Nunavut," which are:

- To build capacity for climate change adaptation planning within the Government of Nunavut and communities
- To develop tools to collect, publish, share and communicate climate change adaptation knowledge across the communities of Nunavut and beyond and
- To create scientific information that is regionally and locally targeted to help communities adapt to climate change and transfer this capability into Nunavut

Bowron, Beate, and Gary Davidson. *Climate Change Planning: Case Studies from Canadian Communities.* Prepared for the Canadian Institute of Planners, Ottawa, ON: Canadian Institute of Planners, 2012. Available at: http://www.planningforclimatechange.ca/wwwroot/Docs/Library/CIPReports/CASE%20STUDIES%20FROM%20CANADIAN%20COMMMUNITIES%20FINAL.PDF

Ten case studies are included in this document as part of the Canadian Institute of Planners' initiative to develop and disseminate best practices recommendations for climate change mitigation and adaptation planning. Three of the studies concern sea level rise adaptation measures.

- Tantramar Dykelands Infrastructure at Risk Study concerns the marshland between New Brunswick and Nova Scotia. The natural floodplain has been modified over several centuries to transform the salt marsh into arable land interspersed with freshwater creeks and wetlands. Although the system has worked relatively well to date, the future projection is that 90% of the dikes will be overtopped, flooding 20% of the Town of Sackville once a decade.
- Interim Flood Construction Levels (FCLs) were established in Vancouver B.C. following the May 2011 release of new provincial climate change adaptation guidelines for sea dikes and coastal flood hazard land use. Implementation is taking place in stages starting with public education followed by advisory standards with developers given the flexibility to select adaptation options provided the risk of flooding is mitigated to meet the new Provincial Guidelines.
- Flood management planning was undertaken in Delta, B.C. using a visioning process undertaken by the Collaborative for Advanced Landscape Planning (CALP) at the University of B.C. in co-operation with the Corporation of Delta. With a population of 100,000, the community has a large farmland base and significant urban area (Ladner) protected from flooding by sea and river dikes. The process involved the establishment of a Citizen's Working Group, the definition of climate change scenarios and early exploration of adaptation options. Scenarios included Reinforce and Reclaim, Hold the Line, and Retreat.

Catto, N. *Coastal Erosion in Newfoundland.* St Johns, Newfoundland: Dept. of Geography, Memorial University, 2011. Available at: http://atlanticadaptation.ca/sites/discoveryspace.upei.ca.acasa/files/Coastal%20Erosion%20in%20Newfoundland.pdf

This report classifies the coastline of the island of Newfoundland, focusing on the sensitivity of the coastline to erosion and petroleum contamination. It forms the first phase of a detailed study of the Newfoundland coastline. A subsequent report will discuss individual locations along the coast, based on field, office, and laboratory research conducted throughout the period from May 2010 through 2011, building upon research conducted since July 1989.

Coldwater Consulting. *Geomorphic Shoreline Classification of Prince Edward Island.* Report for P.E.I. Dept. of Environment, Energy and Forestry, Charlottetown, P.E.I.: Government of P.E.I, 2011. Available at: http://atlanticadaptation.ca/sites/discoveryspace.upei.ca.acasa/files/ACASA%20PEI%20Shoreline%20Classification.pdf

This report summarizes work undertaken by Coldwater Consulting Ltd. to develop shoreline classification and sensitivity mapping for the entire P.E.I. shoreline. The development of a shoreline classification system is a key step in being able to assess the effects of coastal hazards on the Island's shorelines. Coastal hazards include: coastal flooding, coastal erosion, and damage to coastal ecosystems. All of these hazards are influenced by the combined actions of sea level rise, tides, storm surge and wave action.

Daigle, Réal. *Sea-Level Rise and Flooding Estimates for New Brunswick Coastal Sections*. Fredericton: Climate Change Secretariat, New Brunswick Department of Environment, 2012.

This report provides estimates of relative sea level rise over the coming century, including the storm surge component for return periods of 1, 2, 5, 10, 25, 50 and 100 years, for the coastline of New Brunswick, based on the availability of tidal data information. The estimates of global sea level rise were used, in conjunction with the best estimates of local vertical motion (crustal subsidence) to calculate total sea level rise estimates over the next century for the coastlines of New Brunswick of 0.9 to 1.05 metres.

Dalton, Shawn, Michael D. Riley, William Richards, and Réal Daigle. *Climate Change Scenarios New Brunswick Municipalities.* ETF Project Number 080185 - Final Report, Environment and Sustainable Development Research Centre (ESDRC), 2009. Available at: http://atlanticadaptation.ca/sites/discoveryspace.upei.ca.acasa/files/Climate%20Change%20Scenarios%20NB%20Munic-2009.pdf

This report provides climate scenarios for 11 New Brunswick municipalities. The future periods used in this report are the 2020s (2011-2040), 2050s (2041-2070), and the 2080s (2071-2100). In the context of sea level parameters, the mid-point of the three future periods (2025, 2055 and 2085) was adopted as the representative year for each scenario period.

Danard, M., A. Munro, and T. Murty. "Storm Surge Hazard in Canada." *Natural Hazards*, 2003: 407-431.

This report identifies hazards from storm surge across Canada. Storm surges occur frequently in Canada mainly due to extra-tropical cyclones, also referred to as winter storms. Storm surges have occurred both on the Atlantic and Pacific coasts, in the Gulf of St. Lawrence, St. Lawrence Estuary, Bay of Fundy, Hudson Bay, James Bay, Northwest Passage, Beaufort Sea, the Great Lakes and other large lakes such as Lake Winnipeg. The report notes that a high priority for proper assessment of storm surge hazard is the production of maps showing inundation zones for storm surges that might occur in populated coastal areas.

Delcan. *Cost of Adaptation - Sea Dikes & Alternative Strategies*. Final Report, Victoria: Province of British Columbia - Forests Lands and Natural Resource Operations, 2012.

The purpose of this study, commissioned By the Ministry of Forests Lands and Natural Resources, was to develop a 'Class D' estimate of the cost to adapt flood protection measures in the Lower Mainland to meet the rise in sea level predicted by 2100. The study area covered the Metro Vancouver coastal shoreline and the Fraser River shoreline as far east as the Port Mann Bridge, totaling over 250 km.

The estimated cost of adaptation to sea level rise by 2100 from the study totalled $9,470 million. Of this $880 million was for structural flood protection; $350 million was estimated for utility impacts, pump stations and flood boxes; and $1,580 million was for property acquisition. The estimate also included costs for seismic upgrading which were estimated at $3,250 million. In addition to this, the estimate included monies for environmental requirements ($90 million) and site investigation, project management and engineering costs of $190 million. Finally, the estimate included a 50% contingency of $3,160 million to address the high-level uncertainty.

Forbes, D., G. Manson, J. Charles, K. Thompson, and R. Taylor. *Halifax Harbour Extreme Water Levels in the Context of Climate Change - Scenarios for a 100-year Planning Horizon.* Geological Survey of Canada Open File 6346, Ottawa, Ontario: Geological Survey of Canada, 2009. Available at: http://www.halifax.ca/regionalplanning/documents/HRM-OF_v5.pdf

This study provides the scientific basis for a set of plausible scenarios for a 100-year planning horizon for coastal areas in Halifax, Nova Scotia.

The HRM Regional Municipal Planning Strategy (RMPS), adopted by Council in August 2006, included policies to address climate change. The RMPS recognized the effects of climate change, including sea level rise and storm surges, on Halifax Harbour and other coastal areas in HRM and endorsed the precautionary principle as an important policy consideration.

Forbes, D., G. Parkes, G. Manson, and L. Ketch. "Storms and shoreline retreat in the southern Gulf of St. Lawrence." *Marine Geology*, 2004: 169-204.

This article summarizes storm related shoreline retreat in southeastern Canada. Storms play a major role in shoreline recession on transgressive coasts (i.e., sea level rise relative to the land, with the shoreline moving toward higher ground). In the southern Gulf of St. Lawrence (GSL), southeastern Canada, long-term relative sea level rise off the North Shore of Prince Edward Island has averaged 0.3 metres/century over the past 6,000 years (>0.2 metres/century over 2,000 years). This has driven long-term coastal retreat at mean rates >0.5 mm/annum but the variance and details of coastal profile response remain poorly understood. As one example, Charlottetown tide-gauge records show mean relative sea level rise of 3.2 mm/annum (0.32 m/century) since 1911. A further rise of 0.7 metres ±0.4 metres is projected over the next 100 years.

Frail, J. *Community Sea-Level Rise Resource Requirements.* Clean Nova Scotia and N.S. Climate Change Centre, 2009.

The goal of this project was to identify and create an inventory of sea level rise adaptation resource needs from a sample of Nova Scotia's coastal communities. The intent of this study was to gain a general perspective from a varied sample of coastal communities on what is needed to move forward with sea level rise adaptation. This information was gathered through a series of qualitative interviews.

Greene, Kate, and Armand G. Robichaud. *Climate Change Adaptation Action Plan for Stratford, P.E.I.* Mainstreaming Climate Change Tools for the Professional Planning Community, Canadian Institute of Planners, 2010. Available at: http://www.planningforclimatechange.ca/wwwroot/Docs/Library/CIPReports/CCMAP%20TOWN%20OF%20STRATFORD%20COMPLETE.PDF

This report aimed to integrate relevant existing scientific climate change data and adaptation processes with community knowledge of climate change, to develop new tools that incorporate climate change concerns in community planning initiatives. The major issues identified during this study were coastal erosion, increased potential for more flooding from storm surge and more intense rainfall events,The report outlines some suggestions for Official Plan Policy such as monitoring the progress of climate change impacts; providing setbacks from coastal and low lying areas;allowing for construction and maintenance of sea walls to protect infrastructure; and not approving subdivisions which could be negatively affected by climate change impacts.;

Keenan, Eileen, and Andrew Yan. *The Local Effects of Global Climate Change in the City of Vancouver: A Community Toolkit and Atlas*. Vancouver: BTAworks, 2011. Available at: http://www.btaworks.com/wp-content/uploads/2011/07/BTAworks_Local-Effects-of-Global-Climate-Change-Community-Toolkit-and-Atlas_FINAL.pdf

This toolkit and atlas outline the impacts of climate change on Vancouver, British Columbia. It notes that a sea level rise of 1 m would affect 3% of the City's land area but if an additional 2 metres is added above the high tide line to buffer any effects such as wave spray, overtopping, or abnormally high tides, the impacted area would increase to 8% of Vancouver's 144 km^2 landmass. Maps showing the location of areas affected by 1 m, 2 m, 3 m, 4 m 5 m and 6 m rise in sea level are shown. A spreadsheet and graph of the relative impact of these changes in sea level rise on different land use are also shown, as well as cross sections of Granville Island now and with sea level change. A brief discussion of the mitigation costs is included; these are $5,000/lineal metre for an earth dike and $10,000/lineal metre for a seawall; however, these estimates exclude the costs for waterfront property acquisitions and the new provincial seismic construction standards for dyke infrastructure published in 2012.

Kerr Wood Leidal Associates Ltd. *Coastal Floodplain Mapping – Guidelines and Specifications.* Final Report for Ministry of Forests, Lands and Natural Resource Operations (MFLNRO), Victoria, Canada: MFLNRO, 2011. Available at: http://www.env.gov.bc.ca/wsd/public_safety/flood/fhm-2012/draw_report.html#3.

The purpose of coastal floodplain maps is to identify the coastal flood hazard(s) and to provide the technical basis for land use planning and developing floodplain bylaws. Floodplain mapping is an important first step in developing a flood hazard management plan, as floodplain maps identify the flood hazard(s) and provide information on the spatial distribution of Flood Construction Levels (FCLs).

This report contains guidance on estimating of some of the Flood Construction Level components, as well as a scope of work for more detailed site-specific engineering studies that also must be undertaken in order to derive the FCL. In addition, the report summarizes recommended standards for topographic mapping that also will be required in the production of coastal floodplain maps. A sample coastal floodplain map and Design Brief as an illustration of the coastal floodplain mapping process prepared for the City of Campbell River is provided in the report. In conjunction with this project, a series of maps showing potential coastal flood hazard areas for the year 2100 was developed for coastal B.C. based on approximate FCL's.

This report is intended to provide a technically sound basis for local governments to develop coastal floodplain maps, including an estimation of Flood Construction Levels based upon best mapping and engineering practices. In light of rising sea levels, coastal floodplain maps will also allow local governments to define sea level rise planning areas which will facilitate land use planning and development decisions.

Marlin, Amanda, Jeff Ollerhead, and David Bruce. *New Brunswick Dyke Assessment Framework: Taking the First Steps.* St John, N.B.: New Brunswick Trust Fund, 2007. Available at: http://www.mta.ca/research/rstp/NB_Dyke_Assessment_Framework_ETF_Final_Report_c.pdf

Many salt marshes in New Brunswick have been diked and drained, but as sea level continues to rise, it will become more and more costly to maintain dikes. This report identifies 3 options: reinforce, realign or remove the dikes and allow the salt marshes to return. Salt marshes act as buffer areas which naturally absorb the impact of wave action and flooding. The removal of certain dikes, allowing the return of salt marshes, is one adaptive response to sea level rise; however, it is not an easy or obvious choice. In some regions of New Brunswick, such as the Tantramar Marshes, reinforcement or realignment of dikes will likely be preferred due to the vital infrastructure they protect.

In order to discuss the future of a given dike, a systematic method is needed to evaluate the dike and the land uses it may protect. The goal of this project was to develop a tool that communities can use to assess a local dike for possible salt marsh restoration. Criteria for the assessment of dike infrastructure, ways to measure each criterion, and the degree of difficulty or cost are identified.

Marlin, Amanda, et al. *Examining Community Adaptive Capacity to Address Climate Change, Sea Level Rise and Salt Marsh Restoration in Atlantic Canada.* Submitted to the Climate Change Impacts and Adaptation Program, Sackville, N.B.: Coastal Wetlands Institute, 2007. Available at: http://www.mta.ca/research/rstp/CCIAP_Project_A1106_Final_Report1.pdf

This report focuses on the ecologic, economic, social and policy conditions under which a community might employ dyke removal and salt marsh restoration in the Bay of Fundy region as an adaptive response to future climate change and sea level rise. It is a multidimensional study involving six separate but linked research activities including the monitoring of a restored marsh at Musquash, N.B. as well as looking at some of the main planned salt marsh restoration projects in the Maritime provinces. The importance of community consultation is discussed and a brief discussion on the policy environment for salt marsh restoration in N.B. and N.S. is presented.

Mason, G. K. "On the Coastal Populations of Canada and the World." *Canadian Coastal Conference 2005*. Dartmouth, N.S.: Geological Survey of Canada-Atlantic, 2005.

This paper provides a national assessment of the vulnerability of Canadians to coastal processes, hazards and changing climate requires. The paper concludes that relative to the rest of the world, the percentage of Canadians living in the coastal zone is higher and growth is occurring at a higher rate, though mean population density is much lower. Compared to the global coastal population, the Canadian coastal population is very small, and the contribution of Canada's coastal population growth to that of the global coastal population is barely significant.

National Round Table on the Environment and the Economy. *Paying the Price: The Economic Impacts of Climate Change for Canada.* Climate Prosperity Series Report 04, Canada, 2011. Available at: http://nrtee-trnee.ca/climate/climate-prosperity/the-economic-impacts-of-climate-change-for-canada/paying-the-price

This report provides the results of the first national study to estimate the economic consequences of climate change to Canada under four separate scenarios involving two factors: global GHG emissions and Canadian economic and population growth. The focus is on the economic impacts and cost-effectiveness of adaptation strategies for three representative areas: timber supply, coastal areas and human health. The report finds that flooding damages to coastal dwellings, resulting from climate change induced sea level rise and storm surges could cost between $1 billion to $8 billion per year with higher-than-average cost impacts in Atlantic Canada.

Natural Resources Canada and Environment Canada. *From Impacts to Adaptation: Canada in a Changing Climate 2007*. Government of Canada, 2008. Available at: http://www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/assessments/132

This national assessment, produced by the Canadian government, finds that adaptive capacity in Canada is generally high but is unevenly distributed between and within regions and populations. Some adaptation is occurring in Canada, both in response to and in anticipation of, climate change impacts. The assessment concludes that integrating climate change into existing planning processes, often using risk management methods, is an effective approach to adaptation. The assessment also recognizes that barriers to adaptation action need to be addressed, including limitations in awareness and availability of information and decision-support tools.

New Brunswick Department of Environment. *Impacts of Sea-Level Rise and Climate Change on the Coastal Zone of Southeastern New Brunswick*. Executive Summary, St John, N.B.: Environment Canada, 2006. Available at: http://www.ec.gc.ca/Publications/default.asp?lang=En&xml=297D1933-034A-4BD2-996E-C83FAA1C8016

The objective of this three-year (2003-2006) multidisciplinary research project was to quantify the impacts of climate change — specifically, sea level rise, storm surge and coastal erosion — on the Gulf of St. Lawrence coastal zone of southeastern New Brunswick. The results of the study support sustainable management, community resilience and the development of adaptation strategies.

Newfoundland & Labrador Department of Fisheries and Aquaculture. *Coastal and Ocean Management Strategy and Policy Framework*. St. John's : Government of Newfoundland and Labrador, 2011.

This framework provides long-term strategic direction on sustainable use of coastal and ocean resources in Newfoundland and Labrador. It provides a long-term vision for planning and management, and conservation and sustainable use of the province's coastal and ocean areas and resources. The strategic direction outlines the actions needed to achieve overarching goals and address priority issues. Within this document is the policy framework, intended to guide the coordination of provincial coastal and ocean policy in relation to priority issues identified for the province, with increased collaboration between governments, stakeholders, and communities.

Parewick, K., R. Keenan, Dr. K. Vodden, and Dr. N. Catto. *Climate Change Adaptation Tool Development: Community Consultations*. Final Report, Municipalities of Newfoundland and Labrador, n.d. Available at: http://www.municipalnl.ca/userfiles/files/CLIMATE%20CHANGE%20TOOLKIT%20CONSULTATION%20FINAL%20REPORT.doc

This paper is a summary of consultation undertaken by the Municipalities of Newfoundland and Labrador and is one step on the way towards developing a climate change adaptation toolkit. While this paper discusses climate change in a more general way, its focus is the way in which adaptation will take place at the municipal level and how the toolkit can best address and support small economically challenged communities at risk. This paper includes a discussion of what modifications might be necessary to make existing tools applicable to each participating community.

Partners for Climate Protection. *Municipal Resources for Adapting to Climate Change.* Ottawa, Ontario: Federation of Canadian Municipalities, 2009. Available at: http://www.fcm.ca/Documents/reports/PCP/Municipal_Resources_for_Adapting_to_Climate_Change_EN.pdf

The purpose of this resource is to provide information to Partners for Climate Protection (PCP) members and other municipal officials about municipal adaptation initiatives and to provide resources for municipal officials who wish to undertake adaptation planning. Emphasis is placed on different climate change impacts within regions and the importance for municipalities to take some time to investigate the specific risks for their communities. The document discusses the difference between mitigation and adaptation. The types of assessment and the preventative actions required for adaptation are for the most part significantly different than for mitigation. The development of an adaptation strategy begins with an assessment of climate change vulnerabilities – to heat, precipitation, extreme weather, wind speed, sea level rise, melting permafrost, changes in climate zones that affect plant, animal and insect species, and other factors.

P.E.I. Department of Environment, Justice and Labour has a fact sheet that addresses permitting procedures and various shoreline protection measures. Available at: http://www.gov.pe.ca/photos/original/eff_shorerosion.pdf

Province of Nova Scotia. *Our Coast*. The 2009 State of Nova Scotia's Coast Summary Report, Halifax: Province of Nova Scotia, 2009. Available at: http://www.gov.ns.ca/coast/documents/state-of-the-coast/WEB_SummaryReport.pdf

This summary report is a complete overview of the 2009 State of Nova Scotia's Cost Technical Report and summarizes the condition of the coastal areas and resources of Nova Scotia. The full technical report is available at: http://www.gov.ns.ca/coast/state-of-the-coast.asp. The purpose of this report is to create a baseline to determine future trends, and it describes the physical, ecological and socio-economic characteristic of the coast. Six priorities are identified and examined in detail – one of which is sea level rise and storm events – more specifically, an examination of the factors that determine sea level rise in Nova Scotia and to examine the social, economic and ecological implications of the hazards associated with sea level rise and storm events. The report recognizes gaps in information that need to be addressed in order to effectively manage the coast.

Province of Nova Scotia, Canada-Nova Scotia Infrastructure Secretariat. *Municipal Climate Change Action Plan Guidebook.* Canada-Nova Scotia Agreement on the Transfer of Federal Gas Tax Funds, Halifax, NS: Service Nova Scotia and Municipal Relations; Canada-Nova Scotia Infrastructure Secretariat, 2011. Available at: http://www.nsinfrastructure.ca/pages/Municipal-Climate-Change-Action-Plan-Guidebook1.aspx

The purpose of this guide and the accompanying template is to help municipalities prepare Municipal Climate Change Action Plans (MCCAP) that meet the municipal obligation described in the 2010 - 2014 Municipal Funding Agreement. The guide aims to help municipalities reduce greenhouse gas emissions and identify priorities for climate change adaptation.

Provincial Oceans Network (PON). *Nova Scotia's Draft Coastal Strategy.* Draft, Halifax: Nova Scotia Government, 2011. Available at: http://www.gov.ns.ca/coast/

This draft strategy focuses on seven issues crucial to effective coastal management in Nova Scotia:

- Coastal development
- Working waterfronts
- Public coastal access
- Sea level rise & storm events
- Coastal ecosystems and habitats
- Coastal water quality
- Governance

For each of these issues, the strategy establishes goals, objectives and actions. In many cases the same actions and objectives support several goals, and involve several government entities. The focus of the strategy is integrated management of Nova Scotia's coasts. The goal identified with respect to sea level rise and storm events is: "*people and property are safe from coastal hazards*." A number of objectives and actions are identified with respect to this goal in the draft strategy.

Richards, William, and Real Daigle. "Scenarios and Guidance for Adaptation to Climate Change and Sea-Level Rise: N.S. and P.E.I. Municipalities." commissioned by the Atlantic Climate Adaptation Solutions Association (Solutions d'adaptation aux changements climatiques pour l'Atlantique), 2011. Available at: http://atlanticadaptation.ca/sites/discoveryspace.upei.ca.acasa/files/ACASA%20Scenarios%20and%20Guidance%20for%20Adaptation%20NS%20and%20PEI_1.pdf

This report contains climate change and sea level rise scenarios for 22 municipalities in Nova Scotia and Prince Edward Island. For the climate projections in this report, the authors extracted and then combined projections for the A1B and A2 scenarios. Estimates of global sea level rise values were extracted directly from Rahmstorf (2007). Estimates of extreme total sea levels and associated levels of risk for this report were extracted from published results (Bernier, 2005).

Rodshaw Environmental Consulting Incorporated and CCAF A041 Project Team. *Coastal Impacts of Climate Change and Sea-Level Rise on Prince Edward Island.* Climate Change Action Fund project CCAF A041 - Synthesis Report, Dartmouth, N.S.: Government of Canada, 2001. Avaiable at: http://www.coastalchange.ca/download_files/external_reports/Shaw_%282001%29_CoastalImpactsofClimateChangeandSLRonPEI.pdf

The goals of this project were to assess the physical and socio-economic impacts of climate change and accelerated sea level rise on the coast of P.E.I. particularly in relation to:

- anticipated increase in the frequency and extent of storm surge flooding in Charlottetown;
- anticipated decrease in sea ice, increase in wave energy, and probable increase in rates of shore erosion, as well as increased risk of flooding of the North Shore of P.E.I.

The project also considers feasible and effective adaptation measures that might be adopted on P.E.I. to minimize the impacts of these changes.

Sandink, Dan, Paul Kovacs, Greg Oulahen, and Glenn McGillivray. *Making Flood Insurable for Canadian Homeowners.* A Discussion Paper, Toronto: Institute for Catastrophic Loss Reduction & Swiss Reinsurance Company Ltd, 2010. Available at: http://www.iclr.org/images/Making_Flood_Insurable_for_Canada.pdf

The study provides documentation on flood management in Canada with a focus on British Columbia, Ontario, Quebec and Alberta. Floods are the most frequently occurring natural hazard in Canada, nearly five times as frequent as wildfires, the next most common disaster. Current flood damage remittance measures for homeowners in Canada through government relief and the limited scope of insurance are compared to various international approaches. An overview of flood insurance in the U.S.A, France, Germany and the United Kingdom is provided. Key distinctions between private vs. public and optional vs. bundled insurance (e.g., flood insurance linked with other forms of insurance or with a mortgage) are made.

The report concludes that flood insurance could and should play a significant role in providing post-flood financial assistance to homeowners in Canada. The United Kingdom system is preferred as the most adaptable to Canada. This model features a high penetration rate based on bundled, private insurance through an active partnership between private insurers and government.

Singh, Keith, Bradley B. Walters, and Jeff Ollerhead. "Climate Change, Sea-Level Rise and the Case for Salt Marsh Restoration in the Bay of Fundy, Canada." *Environments*, 2007: 71-84. Available at: http://www.environmentsjournal.ca/index.php/ejis/article/view/14267

This paper explores the feasibility of using coastal salt marsh restoration as a tool to adapt to sea level rise and mitigate climate change – using the Bay of Fundy as a case study. In particular it explores the ability of marshes to self-adapt to changes in sea level, their function as a buffer of coastal processes, their cost-effectiveness relative to traditional, static, man-made defences, and their ability to accumulate carbon. The paper investigates the possibility of using these attributes of salt marshes to increase the protective capacity of a coastline by increasing the amount of salt marsh through restoration projects.

Stanton, Elizabeth A., Marion Davis, and Amanda Fencl. *Costing Climate Impacts and Adaptation A Canadian Study on Coastal Zones.* a Report Commissioned by the National Round Table on the Environment and the Economy, Stockholm Environment Institute (SEI), 2010. Available at: http://www.sei-international.org/mediamanager/documents/Publications/Climate-mitigation-adaptation/Economics_of_climate_policy/sei-canada-coastal-zones-june-2010.pdf

This report identifies sea level rise and larger, more frequent, storm surges as the two great threats to Canada's coastal zones. The potential impacts of these two threats are destruction of property, coastal erosion, the salinization of aquifers and permanent flooding of low-lying areas. While studies to date have shown that one third of the Canadian coastline has a moderate or high level of sensitivity to sea level rise, little research exists quantifying the likely economic impacts. This study begins to fill that gap, combining a physical model of sea level rise and storm surge flooding with socio-economic analysis and a review of existing research policies related to climate impacts and adaptation.

Estimates in the study exclude:

- damage to public infrastructure (such as roads, railways, ports, and public buildings);
- damage to non-residential private property and infrastructure (stores, factories, hotels, marinas);
- business losses due to sea level rise and storm surges (reduced tourism revenue, the cost of an extended shutdown);
- relocation costs for people whose homes are destroyed (beyond the cost of replacing the dwelling);
- damage due to the salinization of fresh water; damages from erosion; and ecosystem effects.

The report offers several policy recommendations regarding the improved accuracy of sea level rise studies, and the implementation of adaptation measures similar to those quantified in the report.

Stewart, P., R. Rutherford, H. Levy, and J. Jackson. *Guide to Land Use Planning in Coastal Areas of the Maritime Provinces.* Canadian Technical Report of the Fisheries and Aquatic Sciences No. 2443, Dartmouth, Nova Scotia: Oceans and Environment Branch, Maritime Regions, Department of Fisheries and Oceans and Bedford Institute of Oceanography, 2003. Available at: http://www.dfo-mpo.gc.ca/Library/316491.pdf

This guide to land use planning in coastal areas has been prepared to provide information that will assist in coastal land use planning, with a particular focus on the Maritime provinces. The report is divided into a series of overviews and fact sheets that cover key land use planning and related topics, including coastal environments and maritime ecosystems, legislative frameworks for planning, and engineering aspects of coastal structures.

Tatebe, Kristi, Alison Shaw, and Stephen R.J. Sheppard. *Technical Report on Local Climate Change Visioning for Delta: Findings and Recommendations.* Report prepared for the Corporation of Delta, Vancouver, Canada: The Collaborative for Advanced Landscape Planning (CALP) at UBC, 2010. Available at: http://www.calp.forestry.ubc.ca/wp-content/uploads/2010/02/Delta-Technical-Report_V1-0.pdf

This report is a summary of the CALP's use of 3D visualization techniques and participatory processes for the Corporation of Delta, a local municipality facing serious potential consequences from sea level rise if quick, decisive action is not taken. The Local Climate Change Visioning project has developed compelling visualization techniques to explore visions of the future under climate change. There were two main components of this research. Phase 1 constructed frameworks and methods for downscaling climate change impact information and visualizing alternative climate futures at the local scale. Phase 2 tested the influence of these visualizations on the awareness, emotional responses, and motivation for behaviour change of the local community participants.

The City of New York. A Stronger, More Resilient New York. New York City, N.Y.: City of New York, 2013.

This plan was the result of New York's Special Initiative for Rebuilding and Resiliency (SIRR) taskforce following the impacts of Hurricane Sandy in October 2012. The plan proposes over 250 initiatives designed to strengthen and protect the built environment and citywide infrastructure of New York City.

The Sustainable Planning Branch, New Brunswick Department of Environment and Local Government. *A Coastal Areas Protection Policy for New Brunswick.* Fredericton, New Brunswick: New Brunswick Government, 2002. Available at: http://www2.gnb.ca/content/dam/gnb/Departments/env/pdf/Water-Eau/CoastalAreasProtectionPolicy.pdf

This document, the Coastal Areas Protection Policy, is intended to inform New Brunswick communities about the government's plans for protecting that province's coastal areas, both now and in the future. It covers what is important to protect in N.B.'s coastal areas and why, and explains how future development activity will be governed using established zones based on environmental sensitivity.

Thomson, R. E., B. D. Bornhold, and S. Mazzotti. *An Examination of the Factors Affecting Relative and Absolute Sea Level in British Columbia.* Canadian Technical Report of Hydrography and Ocean Sciences 260, Sidney, B.C: Fisheries and Oceans Canada - Institute of Ocean Sciences, 2008. Available at: http://www.dfo-mpo.gc.ca/Library/335209.pdf

The report documents and projects global average sea level rise for six "emissions market scenarios" based on the 2007 IPCC report.

Weiss Reid, J. *Researching the Role of Communities in Integrated Coastal Management in Nova Scotia.* Independent Research Project, Prepared in partial fulfillment of a Master of Planning at Dalhousie University, Halifax, N.S.: Dalhousie University, 2004. Available at: http://www.ecologyaction.ca/files/images/file/WeissReid.pdf

Coastal planning includes the development of strategies and policies specific to the character of the coast, its resources and uses, ultimately providing a framework for decision-making. This thesis explores the role of planning in coastal and marine environments.

The study notes that the need for management of human activity in marine and coastal environments is the result of increasing development pressure around the use of and access to natural resources along the coastline. It explores current issues affecting Nova Scotia's coastline including:

- Threats to coastal development posed by the impacts of climate change;
- An increase in uses of coastal areas;
- The decline of marine ecosystems caused by infilling salt marshes, dunes, and beach areas;
- Pollution generated from land-based human activity in the watershed.

Quebec

Ministry of Sustainable Development (MDDEP). *Le Québec et les changements climatiques, plan d'action 2006 - 2012: un défi pour l'avenir. (Quebec and climate change action plan 2006 - 2012: a challenge for the future).* Quebec, QC: Government of Quebec, 2008. Available at: http://www.mddep.gouv.qc.ca/changements/plan_action/index-mesures.htm

This provincial government climate change action plan lays out high level mitigation and adaptation objectives. Section 2.3 of this document is entitled «LES ACTIONS VISANT L'ADAPTATION DU QUÉBEC AUX CHANGEMENTS CLIMATIQUES» (Actions related to Quebec's adaptation to climate change). In sub point 2.3.2, measure 23 of the plan includes conducting more detailed research into the impact of climate change on coastal zones in order to develop plans for better protecting sensitive ecological zones as well as infrastructure.

Ministry of Sustainable Development (MDDEP). *Stratégie gouvernementale d'adaptation aux changements climatiques 2013-2020, Un effort collectif pour renforcer la résilience de la société québécoise. (Government strategy for adapting to climate change 2013-2020, a collective effort to reinforce Quebec's resiliency.)* Document de consultation (consultation document), Quebec, QC: Quebec Government, 2012. Available at: http://www.mddefp.gouv.qc.ca/changements/plan_action/pacc2020.pdf

This consultation document lays out the proposed government priorities related to adapting to climate change for 2013 - 2020. Section 3, dealing specifically with adaptation tools, outlines: the need for solid research in order to prioritise issues; increasing awareness on these issues; analysing the vulnerability of communities and ecosystems; communicating the data to the impacted communities; developing and implementing appropriate technologies; and, adapting legal instruments and governance structures according to adaptation needs.

Ouranos. *Élaborer un plan d'action aux changements climatiques - Guide destiné au milieu municipal québécois. (Creating action plans for dealing with climate change - A guide for Quebec municipalities).* Quebec, QC: Quebec Government (MDDEP, MAMROT), 2010. Available at: http://www.fcm.ca/Documents/tools/PCP/elaborer_un_plan_d_adaptation_aux_changement_climatiques_FR.pdf

This guide, developed by the Ouranos Consortium in collaboration with the Quebec government, proposes a five step methodology, geared toward municipalities, for developing climate change adaptation plans: 1. Evaluation of climate change impact; 2. Defining the potential consequences and analysis of vulnerability; 3. Risk assessment; 4. Identifying and prioritising risk management strategies for known risks; 5. Develop and implement an action plan. Each of the steps is broken down to offer suggestions on how to achieve the objectives in the Quebec municipal context. The guide aims to create awareness among municipal officials, while offering tools to take concrete steps toward creating tailor-made adaptation plans.

Quebec Government. *Évaluation du risque d'érosion du littoral de la Côte-Nord du Saint-Laurent pour la période de 1996 - 2003 (Coastal erosion risk assessment for the North Coast region of the St. Lawrence, from 1996 - 2003).* Quebec Government, 2006. Available at: http://www.crecotenord.qc.ca/index2.php?option=com_docman&task=doc_view&gid=468&Itemid=77

This report outlines findings of a collaborative five year assessment of coastal erosion in coastal regions of northern Quebec. New erosion maps were produced, demonstrating that dramatic erosion has been taking place - on average between 60cm and one metre per year - but that erosion is not occurring at a consistent rate and depends on coastal characteristics. On average, data indicates that set back levels throughout the region should be between 60 and 160 metres.

Rioux, C., D. Roussel, A. Eisenberg, M. Kleiser et M.-C. Lévesque. *Évaluation économique des risques associés à l'érosion des zones côtières et aux méthodes d'adaptation dans le golfe du Saint-Laurent : secteurs de Sept-Îles, Percé et des Îles-de-la-Madeleine. (Economic risk assessment associated with erosion of coastal areas and adaptation methods in the* Gulf of *St. Lawrence: Sept-Îles, Percé and Îles-de-la-Madeleine)*. Gestion des ressources maritimes, Département des sciences de la gestion, Université du Québec à Rimouski. Rapport de recherche remis au Consortium Ouranos et au PIACC de Ressources naturelles Canada (project A-1414). 2007. Available at: http://www.ouranos.ca/fr/symposium/documents/Eisenberg2012.pdf

This study is an evaluation of the economic implications of erosion risks in coastal zones, measured against the costs of protection against such risks. It seeks to establish the economic costs of adaptation. The study hones in on three areas, considered to be the most vulnerable to climate change and erosion. For each area, estimates are made of the value of properties at risk, the average rate of erosion, and future erosion rates and variability. The economic risk is presented as annual costs and compounded costs from 2008 to 2050.

Savard, J-P, et al. *Étude de la sensibilité des côtes et de la vulnérabilité des communautés du golfe du Saint-Laurent aux impacts des changements climatiques (Climate change impact study on coastal susceptibility and community vulnerability in the Gulf of St Lawrence)*. Report Summary, Ouranos, 2008. Available at: http://ouranos.ca.

This study summarises multi-stakeholder research undertaken between September 2005 and December 2007 by Ouranos in collaboration with the Université du Québec à Rimouski, l'Institut des sciences de la mer de Rimouski (ISMER), the Ministère de la sécurité publique du Québec and Environment Canada. Research evaluates the potential climate change impact on the coastal region of the Gulf of St. Lawrence, considers adaptation proposals, and identifies socio-economic vulnerabilities in the region. The study looks at the whole of the gulf, but hones in on the Sept-Îles, Percé and Iles-de-la-Madeleine areas.

Senneville, S., and F. Saucier. *Étude de sensibilité de la glace de mer au réchauffement climatique dans le golfe et l'estuaire du Saint-Laurent (Climate change impact study on the susceptibility of sea ice in the Golf of St. Lawrence* and its estuary*)*. Montreal, QC: Ouranos, 2007. Available at: http://ouranos.ca.

This report uses atmospheric data for regional modelling of sea ice concentration and thickness in the Gulf of St. Lawrence, honing in on the areas from Trois Rivières to the Belle Isle and Cabot Straits. The study considers the variation in the number of days that ice can protect banks from swells via attenuation and reducing wind. Data demonstrates that the sea ice cover is diminishing, which has an impact on erosion.

USA

Dixon, Lloyd, Noreen Clancy, Seth A. Seabury, and Adrian Overton. *The National Flood Insurance Program's Market Penetration Rate: Estimates and Policy Implications.* Prepared as part of the 2001-2006 Evaluation of the National Flood Insurance Program, U.S.A.: RAND, 2007. Available at: http://www.rand.org/pubs/technical_reports/TR300.html

This study was prepared as part of the 2001-2006 evaluation of the National Flood Insurance Program. It estimated that 49% of single family homes in Special Flood Hazard Areas (i.e., subject to a flood risk of 1 in 100 years or greater) have flood insurance policies. This includes an estimated 3.6 million single family homes. Although one third of flood insurance policies are written outside Special Flood Hazard Areas, the market penetration rate is extremely low - approximately 1%.

Grannis, Jessica. *Adaptation Tool Kit: Sea-Level Rise and Coastal Land Use*: *How Governments Can Use Land-Use Practices to Adapt to Sea-Level Rise*. Washington, DC: Georgetown Climate Centre, 2011. Available at: http://www.georgetownclimate.org/sites/default/files/Adaptation_Tool_Kit_SLR.pdf

This tool kit, prepared by Jessica Grannis with assistance from students in Georgetown Law's Harrison Institute for Public Law, provides local and state governments and their citizens with practical knowledge to help adapt to sea level rise in a prudent and balanced manner. The Tool Kit offers a menu of currently available legal devices that can reduce the harmful impacts of future sea level rise. A strong theme of the Tool Kit is that local governments have significant legal authority and tools now to plan for future changes. The 18 tools identified in this document are grouped under planning tools, regulatory tools and spending tools. Each tool is described, and how it can be used to facilitate adaptation outlined, examples of how the tools have been used are also included. Finally, the Tool Kit also provides a top-level analysis of the advantages and disadvantages of each tool.

Hirschfield, Daniella, and Brian Holland. *Sea Level Rise Adaptation Strategy for San Diego Bay.* U.S.A.: ICLEI Local Governments for Sustainability, 2012. Available at: http://www.icleiusa.org/climate_and_energy/Climate_Adaptation_Guidance/san-diego-bay-sea-level-rise-adaptation-strategy-1

This report sets out projected impacts of climate change in San Diego Bay and calls for development of an official adaptation strategy. The report was prepared through a collaborative regional stakeholder process that included most public agencies and private sector representatives with a major interest in the future of San Diego Bay. The report identifies key vulnerabilities and recommends action including: public education, stakeholder engagement, incorporation of future risks from sea level rise in FEMA maps associated with Flood Insurance Studies, incorporation of sea level rise change into local and regional plans, and clear and consistent regulatory guidance from regulatory agencies.

Rozum, John S. and Sarah D. Carr. *Tools for Coastal Climate Adaptation Planning: A guide for selecting tools to assist with ecosystem-based climate planning*. Coastal-Marine Ecosystem Based Management Tools Network and NatureServe 2013. Available at https://connect.natureserve.org/toolkit/ebm-tool-network/climate-adaptation-planning-tools.

The purpose of Tools for Coastal Climate Adaptation Planning is to provide the information necessary for coastal natural resource managers and community planners to select appropriate tools for their projects. This guide focuses on spatially explicit solutions for climate-related planning. It provides detailed information on a set of key tools that either alone or used in conjunction with other tools can facilitate multi-sector climate adaptation planning (i.e. climate adaptation planning that incorporates elements of ecosystem health and social wellbeing) and describes the utility and role of tools in relevant planning processes. The guide focuses on software and web-based tools that help incorporate data (geophysical, environmental or socioeconomic) and specialized analyses into the planning process. This guide is targeted at practitioners and decision makers involved in coastal zone management, natural resource management, protected area and habitat management, watershed management, conservation, and local planning in the coastal United States including the Great Lakes. The information and tools in this guide are also highly applicable to many inland and international regions.

Stanton, Elizabeth A, and Frank Ackerman. *Florida and Climate Change - The Costs of Inaction*. Tufts University, 2007. Available at: http://www.ase.tufts.edu/gdae/Pubs/rp/Florida_hr.pdf

This report examines the potential costs to Florida if greenhouse gas emissions continue unchecked. To do this, it compares an optimistic scenario ("rapid stabilization") and a pessimistic one ("business-as-usual").

Within the two scenarios identified, the report estimates monetary values for four major categories:

- loss of tourism revenue, if the more unpleasant climate of the business-as-usual case makes Florida no more attractive year-round than it is today in its slowest season (autumn);

- increased hurricane damages, due to the greater frequency of Category 4 and 5 storms predicted by many climate scientists;
- the value of residential real estate that is at risk from sea level rise; and
- increased costs of electricity generation as temperatures and air-conditioning requirements rise.

The report concludes that for just these four categories the annual costs of inaction are projected to total $92 billion by 2050 and $345 billion by 2100 - figures that respectively would constitute 2.8% and 5.0% of the state's projected Gross State Product. The report goes on to state that if estimates were included for other sectors such as agriculture, fisheries, insurance, transportation, and water systems – to say nothing of ecosystem damage – the totals would be even larger.

U.S. Climate Science Program and the Subcommittee on Global Change Research. "Coastal Sensitivity to Sea Level Rise: A Focus on the Mid-Atlantic." U.S. Climate Change Science Program Synthesis and Assessment Product 4.1, 2009. Available at: http://www.climatescience.gov/Library/sap/sap4-1/

This synthesis and assessment product (SAP) examines potential effects of sea level rise from climate change along the mid-Atlantic coast of the U.S. into the 21st century. This SAP describes the physical environments; potential changes to coastal environments, wetlands and vulnerable species, societal impacts, and impacts of sea level rise; decisions that may be sensitive to sea level rise; opportunities for adaptation, and institutional barriers to adaptation.

U.S. Department of Homeland Security; and FEMA. *The State of FEMA - Leaning* F*orward: Go Big, Go Early, Go Fast, Be Smart.* Annual Report, FEMA, 2012. Available at: http://www.fema.gov/pdf/about/state_of_fema/state_of_fema.pdf

This is a summary of the state of FEMA for the 2013 budget year. It includes a detailed breakdown of where FEMA's funding is allocated. One of the components of this breakdown is a flood hazard mapping and risk analysis program.

International

Abel, Nick, et al. "Sea level rise, coastal development and planned retreat: analytical framework, governance principles and an Australian case study." *Environmental Science & Policy* 14 (2011): 279-288. Available at: https://publications.csiro.au/rpr/pub?list=BRO&pid=csiro:EP101185

This article explores the option of planned retreat to allow natural defences to reclaim lands as one adaptation option to address sea level rise. The authors use an analytical framework to explore obstacles and opportunities for planned retreat. This framework is applied to South East Queensland, Australia, where the authors note the option of planned retreat is disappearing The authors offer the following guiding principles to implement the changes in coastal governance required for successful planned retreat: (a) allocate authority and resources between levels of governance according to their effectiveness at each level; (b) strengthen development rules and incentives to relocate as an unwanted threshold is approached; (c) allow for uncertainties by enabling rules and incentives to be changed when circumstances change; (d) reassign public and private benefits, costs, risks, uncertainties and responsibilities from governments to beneficiaries of development; (e) institutionalise catastrophes as opportunities for change, not signals to rebuild.

Allison, I., N.L. Bindoff, R.A. Bindschadler, P.M. Cox, N. de Noblet, M.H. England, J.E. Francis, N. Gruber, A.M. Haywood, D.J. Karoly, G. Kaser, C. Le Quéré, T.M. Lenton, M.E. Mann, B.I. McNeil, A.J. Pitman, S. Rahmstorf, E. Rignot, H.J. Schellnhuber, S.H. Schneider, S.C. Sherwood, R.C.J. Somerville, K. Steffen, E.J. Steig, M. Visbeck, A.J. Weaver. 2009. *The Copenhagen Diagnosis, 2009: Updating the World on the Latest Climate Science.* University of New South Wales Climate Change Research Centre (CCRC), Sydney, Australia. Available at: http://www.copenhagendiagnosis.com/

This report synthesizes the most policy-relevant climate science published since the close-off of material for the last IPCC report. The report effectively serves as an interim evaluation of the evolving science midway through an IPCC cycle – IPCC AR5 is due for completion in 2013.

Each section begins with a set of key points that summarises the main findings.

With respect to sea level rise in particular, the report states current sea level rise has been underestimated: Satellites show recent global average sea level rise (3.4 mm/yr over the past 15 years) to be ~80% above past IPCC predictions. This acceleration in sea level rise is consistent with significant contribution from melting of glaciers, ice caps, and the Greenland and West-Antarctic ice-sheets. The report also states revised sea level predictions indicate that: By 2100, global sea level is likely to rise at least twice as much as projected by Working Group 1 of the IPCC AR4. For unmitigated emissions it may well exceed 1 meter. The upper limit has been estimated as ~ 2 meters sea level rise by 2100. Sea level will continue to rise for centuries after global temperatures have been stabilized, and several meters of sea level rise must be expected over the next few centuries.

Boateng, Isaac. *Spatial Planning in Coastal Regions: Facing the Impact of Climate Change.* Publication of FIG Commission 8 Working Group 8.4 – Urban Planning in Coastal Region, Copenhagen, Denmark: International Federation of Surveyors (FIG), 2010. Avaiable at: http://www.fig.net/pub/figpub/pub55/figpub55.pdf

This report was commissioned in 2007 by the International Federation of Surveyors to investigate emerging coastal habitat issues connected to rising sea levels as a result of climate change and its influence on planning in coastal regions. Two objectives were established: to identify the impacts of rising sea levels on coastal habitats and to develop planning policy and implementation guidelines to assist in achieving sustainable coastal adaptation.

Case studies from twelve separate countries were covered under six headings:

- Impacts of climate change
- Coastal vulnerability
- Measuring sea level rise and monitoring its impacts
- Valuation of coastal resources and coastal adaptation
- Policy development process for coastal adaptation
- Challenges of moving coastlines

The study concludes that the impacts of climate change are already affecting many coastal regionals around the world. These impacts are likely to intensify over the next century. The need therefore is to plan for adaptation now to reduce some of the future negative effects of climate change in the coastal zone.

Catovsky, S, et al. *Adapting to Climate Change in the U.K.: Measuring Progress.* United Kingdom: Adaptation Sub-Committee, 2011. Available at: www.cakex.org.

While many jurisdictions are still in earlier stages of developing climate change action plans, in the U.K. such plans have been implemented, legislation has been enacted, and work is now proceeding into the stage of monitoring and evaluating implementation. This report is the second in a series that defines measures for evaluating progress on reducing vulnerability to climate change, and provides a review of progress to date. Despite some evidence of progress, the report concludes that land use planning decisions in areas with flood risk (coastal, river and surface water) may be increasing overall vulnerability, and chosen methods of flood defence (mainly structural) may bind communities and landowners to rising costs in the future.

Delta Committee. *Working Together with Water.* Findings of the Deltacomissie, Netherlands: Deltacommissie, 2008. Available at: http://www.deltacommissie.com/doc/deltareport_full.pdf

This strategy was developed by the Delta Committee at the request of the Dutch Cabinet to identify innovative measures to protect the Dutch coast and the low-lying hinterland against the consequences of climate change and to include the interaction with increased river discharge in its recommendations. The Dutch coastline consists of 350 km, with 3,600 km of primary flood defenses, predominately dikes. A majority of the country's population lives in low-lying adjacent areas that are below sea level.

The strategy is based on two pillars: flood protection and sustainability. The Delta Committee stated that a regional sea level rise of 0.65 to 1.3 m by 2100, and 2 to 3 m by 2200 should be taken into account, including the effect of land subsidence.

The study contained 12 recommendations as a matter of urgency based on a conclusion that the level of flood protection must be raised by at least a factor of 10.

Recommendations focused on building with nature by expanding the coast seaward with increased beach nourishment (85 million m3 of sand/year from the continental shelf) and strengthened storm surge barriers, including island polders. Safety standards were set as: 1/250 a year for fresh water rivers, 1/2,000 a year for lower tidal reaches, 1/4,000 a year for an extreme water events (e.g., storm surge) for coastal regions other than Central Holland and 1/10,000 a year for Central Holland. Limiting the consequences of flooding included regulation such as zoning, compartmentalisation, early warning, crisis management and contingency planning.

A final recommendation consisted of setting up a Delta Fund for flood protection at arm's length from the national budget financed by a combination of loans and part of the country's natural gas revenues. The cost of implementing the Delta Programme was estimated to be €1.2 to €1.6 billion per annum until 2050, and €0.9 to €1.5 billion per annum thereafter to 2100. Costs included strategic land acquisition and compensation for damages and loss of benefits. Including maintenance and management.

Department for Communities and Local Government, U.K. Government. *National Planning Policy Framework*. U.K. Government, 2012. Available at: www.communities.gov.uk

This document reflects the current planning policies of the National Government for England and how they are expected to be applied. Local planning authorities are called on to "adopt proactive strategies to mitigate and adapt to climate change, taking full account of flood risk, coastal change and water supply and demand considerations." Planning for new development is advised to avoid increased vulnerability due to the impact of climate change, including suitable adaptation measures and planning of green infrastructure. Significant attention is given to risk assessment management in order to avoid the transfer or risk and development in high risk areas. Development in vulnerable coastal areas, referred to as Coastal Change Management Areas, is given particular attention.

Department for Communities and Local Government, U.K. Government. *Planning Policy Statement 25: Development and Flood Risk*. U.K. Government, 2010. Available at: www.communities.gov.uk

The U.K. government's Planning Policy Statement 25 sets out the national policy for Development and Flood Risk as it relates to land use planning. PPS 25 explicitly addresses climate change impacts and provides direction on including climate change information (including sea level rise projections and associated vulnerability and risk assessments) in land use planning by regional, local and urban planning authorities in the U.K. A risk-based approach is called for at all levels of government

Planning Policy Statement 25 has been replaced by the National Planning Policy Framework (see reference above). However, the risk management strategy has not been changed and considerable detail is provided in PP 25 which is not available in the current and broader based policy framework.

Department of Climate Change and Energy Efficiency. *Climate Change Adaptation Actions for Local Government*. Canberra, ACT: Australian Government, 2010. Available at: http://www.climatechange.gov.au/what-you-can-do/~/media/publications/local-govt/localadaption_localgovernment.pdf

This report was developed as part of the Australian Government's support for adaptation to climate change and aims to help to address the need to prepare Australian governments, vulnerable industries, communities and ecosystems to manage the unavoidable consequences of climate change. This report forms part of a suite of tools being developed to assist local governments in identifying and implementing climate change adaptation actions. In particular, this report complements Climate Change Impacts & Risk Management – A Guide for Business and Government, released in 2006.

The adaptation actions that have been identified during this study are those that provide a net economic, social or environmental benefit no matter what level of climate change occurs.

Entec U.K. Limited; Risk Management Solutions; and Risk & Policy Analysts. *Coastal Flood Risk – Thinking For Tomorrow, Acting Today.* Summary Report, Association of British Insurers, 2006. Available at: http://www.abi.org.uk/Publications/ABI_Publications_Coastal_Flood_Risk__Thinking_for_Tomorrow_Acting_Today_fa6.aspx

This report was published by the insurance industry, and assesses the impacts of sea level rise on flood risk for the United Kingdom. Integrating data from various sources, this review considers what the impacts of a catastrophic storm (such as that experienced on the east coast of England in 1953) would be in today's context and then with an additional 0.4 m of sea level rise factored in. The analysis is illustrated through the use of five case studies. According to their modeling, a single major storm event could give rise to costs of between £7.5 billion and £16 billion with a sea level rise of 0.4 m, and without any further development in affected areas. Investment in improved flood defences could reduce this financial cost by between £3.7 billion and £6.8 billion.

Hallegate, Stéphane. *SR17: The Economic Growth Impact of Sea-Level Rise.* Migration and Global Environmental Change - Commissioned as part of the U.K. Government's Foresight Project, U.K. Government Office for Science, 2011. Available at: www.bis.gov.uk

This report looks beyond the direct economic implications of sea level rise on the built environment to consider the broader economic impacts of sea level rise on the economic system as a whole. The paper proposes a framework within which to discuss the economic growth impact of sea level rise and summarises current debates on the measures of economic growth. It also reviews the mechanisms through which sea level rise can affect economic growth, namely the loss of land (including natural capital), the loss of infrastructure and physical capital, the additional cost from extreme events and coastal floods (loss of social capital) and the increased expenditure for coastal protection.

Institution of Civil Engineers (ICE). "Facing up to Sea Level Rise: Retreat? Defend? Attack? The future of our estuarine cities." Building Futures Series, 2010. Available at: www.buildingfutures.org.uk/projects

This publication was produced as a "think piece" to provoke consideration of the implications of rising sea levels on urban areas of the U.K. It graphically documents the results of a design charrette structured around three future scenarios for the cities of Kingston-Upon-Hull and Portsmouth. The report asks what a strategy of retreat, defense, or attack would look like from an infrastructure and architectural perspective for the two coastal cities. The publication serves to visualize the potential implications of these three different strategies over the next 100 years as well as outlining key messages and considerations for government, planners, architects, engineers, urban designers and the public.

Linham, Matthew M., and Robert J. Nicholls. *Technologies for Climate Change Adaptation – Coastal Erosion and Flooding.* TNA Guidebook Series, New Delhi, India: Magnum Custom Publishing, 2010. Available at: http://www.unep.org/climatechange/adaptation/InformationMaterials/Publications/Publication/tabid/6712/Default.aspx?ID=6189

This publication profiles thirteen major adaptation technologies that reduce impacts of coastal erosion and flooding due to climate change. For each technology, a definition is provided, as well as a description of how the technology is used; advantages and disadvantages are assessed, and costs

and benefits are estimated. This guidebook divides adaptation technologies into: (1) capital goods such as dikes or seawalls and (2) technologies focusing on information, capacity building, institutional arrangements and policy and strategy development. The contents of this guidebook is very informative, with applications from around the world, but particularly from Great Britain, the Netherlands and the United States. The document focuses specifically on protection of the coastline against increased flooding, inundation and erosion.

Maharaj, R. *Coastal Engineering Design of a Rip-Rap Revetment System for Shoreline Protection.* SOPAC Preliminary Report No.124, Yaren District, Republic of Nauru: South Pacific Applied Geoscience Commission, 2000. Available at: http://ict.sopac.org/VirLib/LR0124.pdf

This report presents preliminary results and design guidelines for a coastal protection system for a section of an eroding coastline, in Yaren District, Republic of Nauru. These guidelines were drafted and prepared following a request from the office of the President, Republic of Nauru (RON), to SOPAC, to assess an appropriate protection system for a chronically eroding coast in Yaren District. Yaren District is located in the southwest part of Nauru and is the site of the capital of Nauru.

Nicholls, Robert J., and Abiy S. Kebede. *R6.1: The Implications on the U.K. of the Impacts of Climate Change and Sea-level Rise on Critical Coastal Infrastructure Overseas, 2010 to 2100.* Report submitted to Foresight, Government Office for Science, United Kingdom: Government for Science, U.K. Government, 2010. Available at: http://www.bis.gov.uk/assets/foresight/docs/international-dimensions/11-1022-implications-on-uk-climate-change-sea-level-rise.pdf

This study considers the indirect effects of international climate change on the United Kingdom. Using a synthesis of the existing scientific literature and policy-related documents, the study explores the physical environment and associated critical infrastructure in the coastal sector worldwide; the potential changes to coastal environments and the potential demand for new infrastructure; societal impacts and potential implications of sea level rise on infrastructure elsewhere in the world, and the current and predicted potential threats and opportunities of these on the U.K.'s citizens, government, and businesses. The report also discusses the potential implications on the U.K.'s future adaptation policy.

RSPB, Environment Agency, Natural England and Defra. *Coastal Futures - Humber Community Project.* November 2, 2010. Available at: http://www.coastalfutures.org.uk/humber.html.

The Humber Community Project was established to support communities dealing with coastal change and sea level rise. The project website (www.coastalfutures.org.uk) provides materials outlining strategies and approaches, as well as a number of case study profiles. Project reports include one on lessons and best practices for community engagement, and an economic assessment of managed realignment as an option for adapting to sea level rise.

State of New South Wales - Department of Planning. *New South Wales (NSW) Coastal Planning Guideline: Adapting to Sea Level Rise.* NSW, Australia: State of NSW, 2010. Available at: http://www.planning.nsw.gov.au/adapting-to-sea-level-rise

This document was prepared to provide guidance on how sea level rise is to be considered in land use planning and development assessment in coastal NSW. The aim of this guideline is to promote ecologically sustainable development and in particular to encourage a precautionary approach to land use planning in light of potential sea level rise impacts in coastal areas. This guideline therefore adopts a risk-based approach to planning and development assessment in coastal areas.

Tol, Richard S J, Richard J T Klein, and Robert J Nicholls. "Towards successful adaptation to sea level rise along Europe's coasts." *Journal of Coastal Research*, 2008: 432-442. Available at: http://www.bioone.org/doi/full/10.2112/07A-0016.1

This paper examines the current status of adaptation to sea level rise and climate change in the context of European coasts. At the European Union Level, while coastal management is a focus, this effort is mainly targeted at today's problems. This paper suggests a need for a concerted effort to address adaptation in coastal zones across Europe. Sharing experience among countries would facilitate this process.

UNESCO/IOC. *Sea-level Rise and Variability – A Summary for Policy Makers.* France: United Nations Educational, Scientific and Cultural Organization; Intergovernmental Oceanographic Commission, 2010. Available at: http://unesdoc.unesco.org/images/0018/001893/189369e.pdf

This paper summarizes the importance of determining local sea level change and local land motion to better understand at a local level the potential. Coastal zones have changed profoundly during the 21st century, with increasing populations, economies and urbanization. Today, low elevation coastal zones below 10 m elevation contain about 10% of the world's population. With coastal development continuing at a rapid pace, society is becoming increasingly vulnerable to sea level rise. Rising sea levels have been and will continue to be felt most acutely through extreme events (periods of above average sea level).

UKCIP. *U.K. Climate Impacts Programme: Projections, Adaptation Tools, Case Studies.* Available at: www.ukcip.org.uk/tools

Since 1997 UKCIP has been leading the way in developing tools and resources to support climate change adaptation by government, business, civil society and other agencies. The UKCIP Adaptation Wizard is one such tool, which walks the user through five steps to assess vulnerabilities, identify adaptation options, implement, monitor and evaluate. This is accompanied by other supports such as a risk-based decision-making framework and Local Climate Impacts Profile tool, all of which can be applied to sea level rise. A list of climate change adaptation case studies in the U.K. is also available. At least two (Chichester District Council and The Broads Authority) deal with sea level rise.

Environment Agency. *U.K. Flood & Coastal Erosion Risk Management Programme.* Available at: http://evidence.environment-agency.gov.uk

The Environment Agency and Department of Environment, Food and Rural Affairs (Defra) recently partnered to deliver the "Flood and Coastal Erosion Risk Management Programme" for the U.K. This joint program continues to build on years of work by both agencies on climate change impacts and adaptation, including the extensive body of work by UKCIP. More information is

The Environment Agency has produced two recent reports of interest. The 2009 report "Investing for the Future: Flood and Coastal Risk Management in England, a Long-term Strategy" outlines current flood and coastal erosion risk in the U.K. along with an assessment of the level of investment that would be required to manage the increasing risk through 2035. This includes an analysis of the benefits of investment and potential for new sources of investment. The study concludes that investment should almost double to £1 billion annually (from £570 million in 2009).

In 2010 the Environment Agency released "The Coastal Handbook: A Guide for all Those Working on the Coast," which was developed as a comprehensive resource on information for coastal management in the U.K., and to improve understanding by Environment Agency and local government staff, of respective roles and responsibilities. A chapter is devoted to "Coastal change, adaptation, resilience and land management," and other supporting information for adapting to sea level rise and coastal erosion is included in other sections.

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Adaptation Initiatives in Canada. 14 August 2008. http://www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/adaptation107/566 (accès le April 19, 2012).

Allison, I., et al. *The Copenhagen Diagnosis, Updating the World on the Latest Climate Science.* Sydney, Australia: The University of New South Wales Climate Change Research Centre (CCRC), 2009.

APEG Professional Engineers and Geoscientists of BC. «Professional Practice Guidelines - Legislated Flood Assessments in a Changing Climate in BC.» 2012.

Arlington Group Planning + Architecture Inc. *Flood Hazard Area Land Use Management.* Fraser Basin Council, 2008.

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Ausenco Sandwell. «Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use.» Draft Policy Discussion Paper, 2011.

Barron, Sara, et al. «A Climate Change Adaptation Planning Process for Low-Lying, Communities Vulnerable to Sea Level Rise.» *Sustainability*, 2012: 2176-2208.

Batterson, M., et D. Liverman. «Past and Future Sea-Level Change in Newfoundland and Labrador: Guidelines for Policy and Planning.» *Newfoundland and Labrador, Dept of Natural Resources, Geologic Survey Report*, 2010: 129-141.

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