SEA LEVEL RISE ADAPTATION PRIMER

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

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BRITISH COLUMBIA

Atlantic Climate Adaptation Solutions Association
Solutions d'adaptation aux changements climatiques pour l'Atlantique

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New Brunswick / Nouveau Brunswick CANADA
Prince Edward Island CANADA
Newfoundland Labrador

SFU SIMON FRASER UNIVERSITY
THINKING OF THE WORLD
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Photo 1 (top left): Seawall in Dothan, Alabama, accelerates erosion on adjacent properties (Photo Credit: Advanced Coastal Technologies).
Photo 2 (bottom): Lameque, N.B. (Photo from New Brunswick Coastal Areas Protection Policy).
Photo 3 (top right): Cottage at Pugwash, N.S. (Photo Credit T. Webster).
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EXECUTIVE SUMMARY

In 2011, the Flood Safety Section of the B.C. Ministry of Forests, Lands and Natural Resource Operations published draft technical guidelines for the design of sea dikes and coastal land use. These technical guidelines make provision for a sea level rise of 0.5 metres by the year 2050, 1.0 metre by 2100, and 2.0 metres by the year 2200. As sea levels rise over time, coastal communities will become increasingly vulnerable. In order to deal with effects commonly associated with sea level rise coastal communities on Canada's southern coasts will require resilience and adaptive capacity to ensure their long-term sustainability. Coastal hazards associated with sea level rise include:

- Coastal inundation (flooding) and reduced drainage capacity (due to higher groundwater levels)
- Coastal erosion
- Changes to coastal habitats and loss of wetlands such as salt marshes ("coastal squeeze")
- Reduction in coastal sea ice

In response, the B.C. Ministry of Environment commissioned the preparation of a Sea Level Rise Adaptation Primer. The purpose of the Primer is to create a resource for coastal management authorities (mainly local governments) to identify, evaluate and compare options for adapting to the impacts of sea level rise and associated coastal hazards. Although this Primer was prepared in B.C., the information it contains is intended to have national application to Canada's southern coasts, both Pacific and Atlantic. 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.

The B.C. Regional Adaptation Collaborative (RAC) partnered with the Atlantic RAC and Natural Resources Canada to investigate adaptation to sea level rise on both Canada's Atlantic and Pacific coasts. 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.

The Arlington Group Planning + Architecture Inc. was retained to prepare this Primer, assisted by EBA Engineering Consultants Ltd., a Tetra Tech Company, DE Jardine Consulting and Sustainability Solutions Group.

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

- Protect
- Accommodate
- Retreat
- Avoid

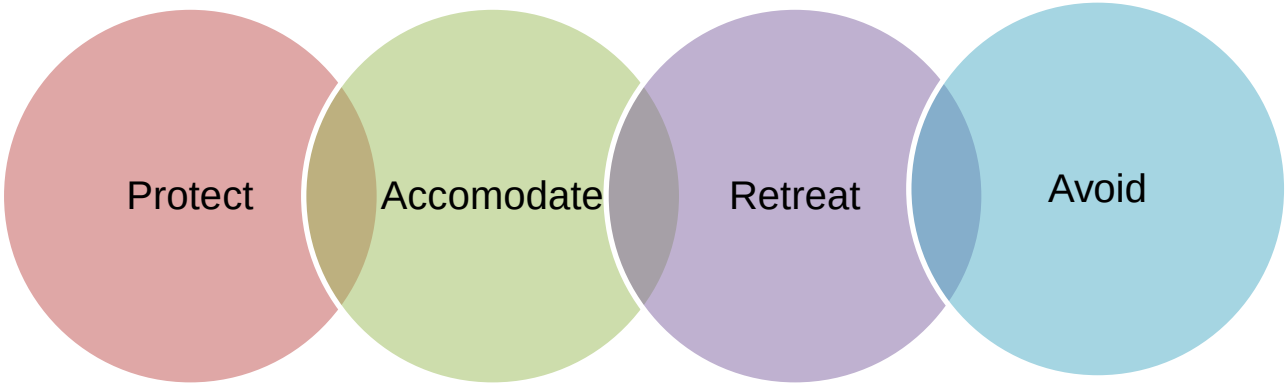
Protect is a reactive strategy to protect people, property and infrastructure from sea level rise and is typically the first response considered. Protecting the coastline through structural mechanisms such as dikes, seawalls and groynes has been the traditional approach to dealing with sea level rise in many parts of the world. It is natural for property owners and residents to want to protect existing assets and lifestyles. 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, for example a covenant indemnifying governments from the consequences of coastal hazards regardless of protection works that are undertaken.

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 a lesser risk.

Avoid involves ensuring 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. Regulatory tools may include the designation or zoning of lands for limited development or non-habitable 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.

These adaptation strategies are not mutually exclusive. They could apply to different geographical areas of the same local government or change over time for the same local government. As a result, they are portrayed as interconnected in the following diagram.



A total of 21 adaptation tools are included in this Primer, organized into five categories. They consist of four planning tools, four regulatory tools, five land use change or restriction tools, five structural tools (also known as flood protection works) and three non-structural tools (also known as soft armouring).

Planning tools identified in this Primer consist of local government growth management objectives and policies, mapping of potential coastal hazards, risk management and emergency planning.

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 have potential to achieve local government goals without being the responsibility of local government.

Structural tools (flood protection works) consist of physical structures on land or in water to protect land and buildings from coastal hazards. There is a wide range of hard protection or armouring works that fit into 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.

This breakdown indicates the different functions of the Primer tools. Several of the tools are interdependent and should be used in combination. For example, many of the adaptation tools rely on guidance from the appropriate planning tools. In addition, the regulatory tools discussed may be used in association with one or more land use restrictions. Building or subdivision regulations addressing coastal hazards can be implemented by means of a covenant on title or other legal restriction. Land use regulation in an area at risk from coastal hazards such as flooding may require dry or wet floodproofing measures or scour protection to be undertaken in accordance with other tools. Another possible combination of adaptation tools is sometimes referred to as hybrid shoreline protection systems: an integration of structural and non-structural protection methods. While structural and non-structural adaptation tools may appear to represent polar opposites, they are often used in combination.

Each of the adaptation tools includes a description of the tool, its implementation and the enabling legislation where applicable. The advantages and disadvantages of each tool are also examined; a triple bottom line approach (economic, environmental and social) is used for evaluation and governance consideration.

The tools in this Primer should be considered in the context of information gathering, public education and community engagement, which are also discussed. While not considered separately as tools, these are all essential to informed decision-making processes within a democracy.

Flood insurance, while not a tool available to local governments in Canada, is also discussed as it plays a major role in other developed countries. As the cost of responding to sea level rise and coastal vulnerability increases, insurance may become a tool introduced by senior governments in Canada. Emergency management is also included as separate from emergency planning and preparedness, since it includes elements not within the responsibility of local governments.

Also included in the Primer are a series of appendices consisting of acronyms; a glossary of terms; a spreadsheet profiling the adaptation tools; the approach to sea level rise in *Îles-de-la-Madeleine*, one of the most vulnerable areas of Quebec; 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 geographical areas: Canada, Quebec[1], U.S.A., and other international areas.

The goal of this Primer is to serve as a comprehensive resource to identify the adaptation tools local governments currently have available and to aid future decision-making with respect to adaptation to sea level rise.

[1] Studies in French

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INTRODUCTION

Climate change is here. Increased loss of life and damage to infrastructure due to the changing weather patterns of our warming earth is evident globally. 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).

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. Climate change also brings the prospect of more frequent and intense storms and poses additional risk for flooding, particularly if storms occur during high tides[2]. Effects commonly associated with SLR that will require resilience and adaptive capacity within coastal communities on Canada's southern coasts include:

- Coastal inundation (flooding) and reduced drainage capacity (due to higher groundwater levels)
- Coastal erosion (see Photo 1)
- Changes to coastal habitats and loss of intertidal habitat and wetlands such as salt marshes ("coastal squeeze"
- Reduction in coastal sea ice

These effects are referred to as coastal hazards in this document.

In several areas of Canada's coastlines, sea levels have been rising and will continue to rise even if climate change contributes only minimally to the process[3]. Geophysical factors unrelated to climate change also play a role. They include subsidence due to settlement of alluvial soils, drawdown of aquifers and tectonic forces.

Some of Canada's greatest vulnerabilities to climate change lie in its coastal areas, which are home to concentrated populations, economic centres and valuable ecosystems[4]. 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 11.5 million people, or 23%, lived on the Pacific coast, and 20% lived on the Atlantic coast. 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[5].

Climate change research in the context of Canadian coastal zones has considered the assessment of the vulnerability of coastal communities and populations as a critical component in the development of adaptation strategies. The reduction of vulnerability is an important measure of success. Community vulnerability is usually

[2] (National Round Table on the Environment and the Economy 2011)
[3] (Stanton, Davis and Fencl 2010)
[4] (Stanton, Davis and Fencl 2010)
[5] (Mason 2005)

taken to be a function of its exposure and sensitivity to a hazard or environmental change and its adaptive capacity or resilience. Vulnerability is lowered by reducing exposure to (or risk from) a hazard or by increasing resilience[6].

PHOTO 1 - EROSION OF GRAVES ON SOUTHERN VANCOUVER ISLAND (PHOTO CREDIT HAY & COMPANY CONSULTANTS INC.)

The scope of this Primer is the identification and analysis of existing tools that local governments on Canada's southern coasts have at their disposal in order to adapt to coastal hazards caused by SLR. This Primer is intended to be a nationally relevant document with application not only to B.C. but also southern Quebec and the Atlantic coasts of New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador.

The analysis of the adaptive tools explored in this Primer includes a description of each tool, its implementation and the enabling legislation, where applicable. The advantages and disadvantages are also examined and a triple bottom line approach (economic, environmental and social) is used for evaluation and governance consideration. The goal of this Primer is to serve as a comprehensive resource to identify adaptation tools in response to sea level rise and aid local government decision-making.

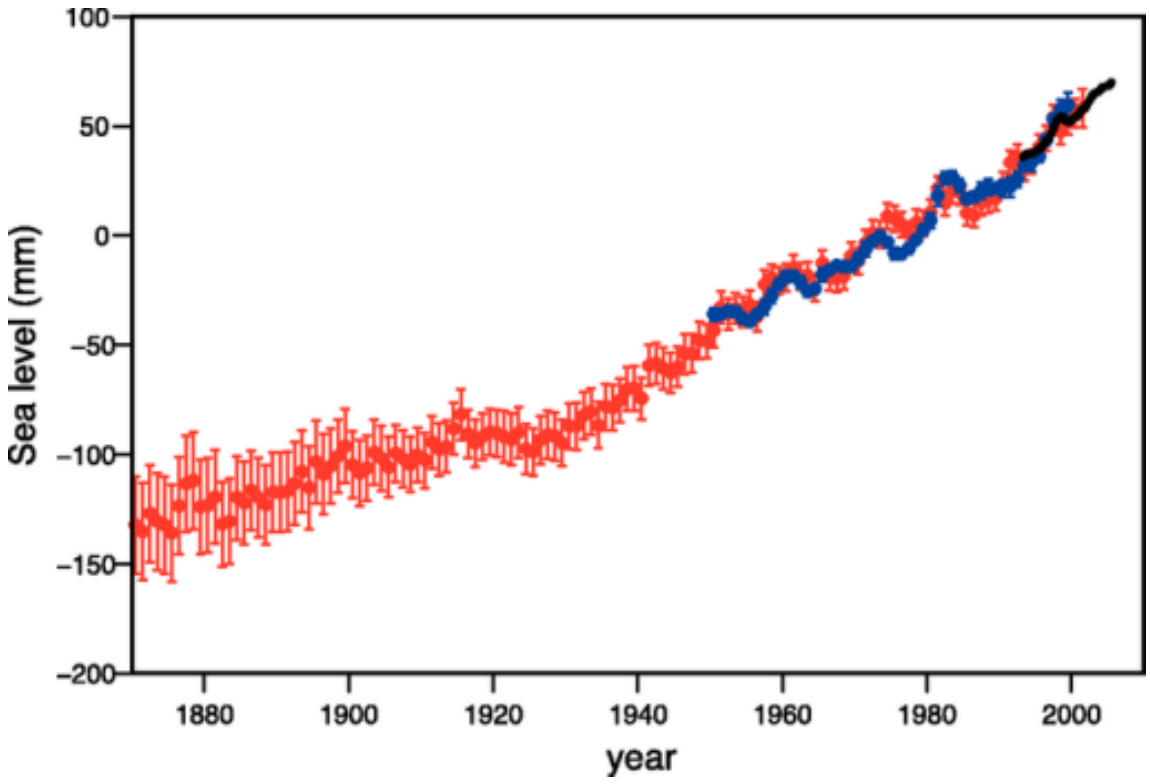
[6] (Mason 2005)

BACKGROUND SEA LEVEL RISE

HISTORICAL CHANGES

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)[7]. Since 1993, the rate of global sea level rise has increased to around 3 mm/year. Figure 1 - Global Mean Sea Level 1870-2003shows the global trend. The red curve shows reconstructed sea level fields 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.

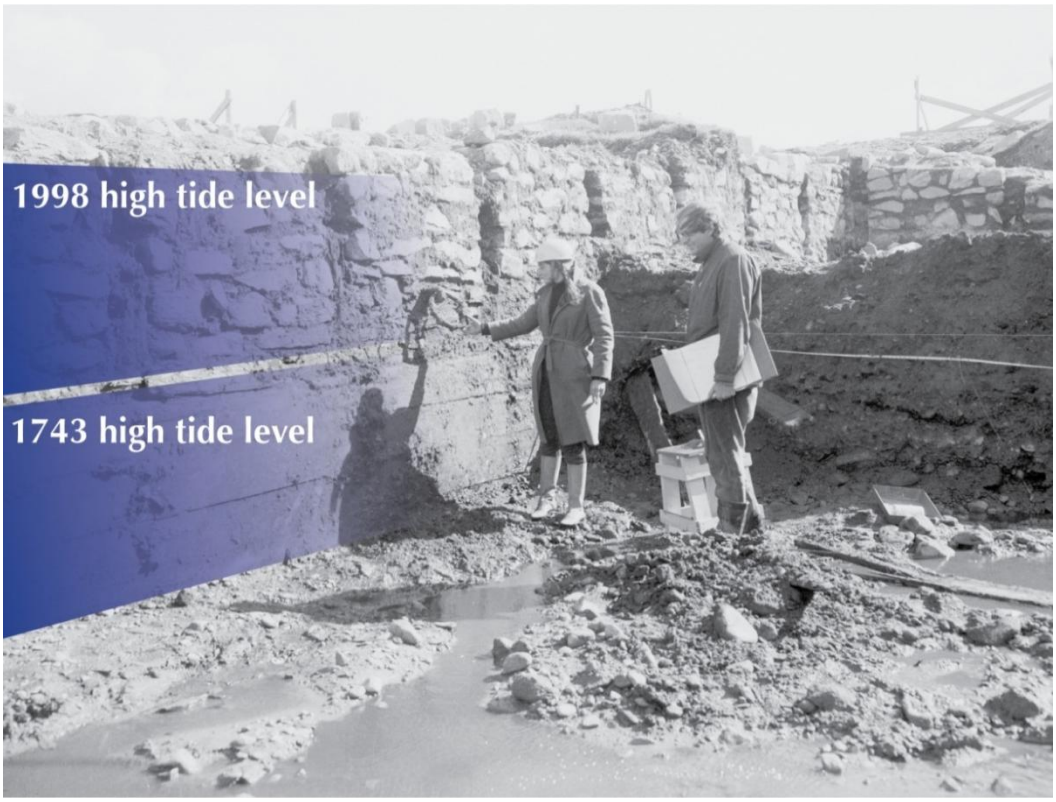
FIGURE 1 - GLOBAL MEAN SEA LEVEL 1870-2003



In Nova Scotia, the present rates of relative SLR are higher than the global mean; during the 20th century, the increase was about 30 cm. This trend is further exemplified at the Fortress of Louisbourg 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 Photo 2)[8].

[7] IPCC Fourth Assessment Report: Climate Change 2007
[8] (CBCL Limited 2009)

PHOTO 2 - 18TH CENTURY MOORING RING AT FORTRESS OF LOUISBOURG (PHOTO CREDIT AMBROSE MACNEIL)



Global factors contributing to SLR consist of a combination of thermal expansion, melting of glaciers and ice caps, melting of the Greenland ice sheet and melting of the Antarctic ice sheet. From 1961-2003, the melting of glaciers and ice caps was the largest factor causing the increase in sea level rise, closely followed by thermal expansion. From 1993 to 2003, the increased global rate of sea level rise was due mainly to thermal expansion, although all of these factors contributed[9].

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." Most of Atlantic Canada is subsiding, but the amount of subsidence varies greatly. In Nova Scotia, subsidence is estimated to be up to 20 cm/century[10]. On the other hand, the north shore of the Gulf of St. Lawrence in Quebec and Labrador is rebounding.

[9] (Intergovernmental Panel on Climate Change (IPCC) 2007)
[10] (CBCL Limited 2009)

Based on long-term harbour records, the following trends document sea level increases:

- 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)

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 U.S. Pacific coast, U.S. National Oceanic and Atmospheric Administration records indicate the mean sea level rise in Seattle has been 20.7 cm from 1898 to 2006 and has been steadily increasing over the past decade.

On the B.C. Pacific coast, sea level rise has occurred in most locations but at a lower rate than the global average of 17 cm over the past 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 post-glacial rebound. B.C. coastal sea level changes include the following[11]:

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

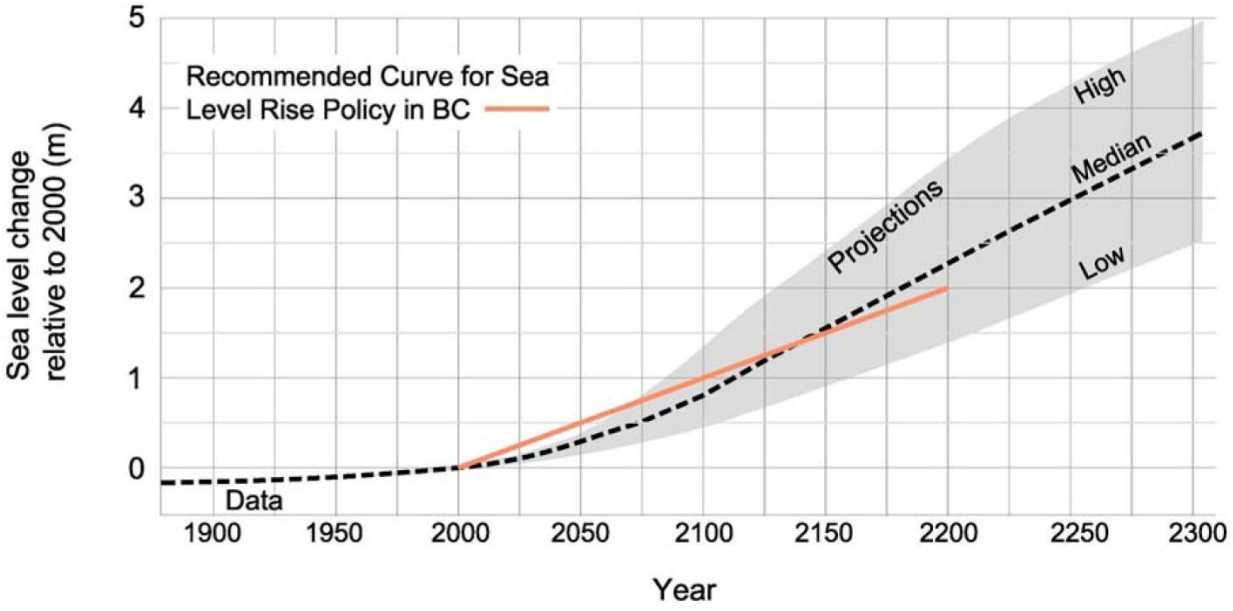
PROJECTED INCREASES IN SEA LEVEL

How will sea level change in the future? Predictions of SLR are subject to uncertainty and the longer the time frame, the greater the degree of uncertainty. The Intergovernmental Panel on Climate Change (IPCC) projected global sea level rise using six different scenarios. Variables include population projections, economic growth and the use of technology. Under the IPCC scenarios, the estimated rise in sea level to the end of this century (i.e., 2100) varies from 18 to 59 cm. These projections are now considered quite conservative based on the large body of research which has taken place since the IPCC scenarios were prepared in 2007. There is a considerable range in recent projections, but they generally anticipate a larger and more rapid rate of sea level rise.

Figure 2 indicates the low, median and high range of global sea level rise projections:

[11] Source: Marine Environmental Data Service, Fisheries and Oceans Canada

FIGURE 2 - GLOBAL SEA LEVEL RISE PROJECTIONS (SHADED AREA) AND RECCOMENDED SEA LEVEL RISE PLANNING CURVE (RED LINE) FOR B.C. (AUSENCO SANDWELL, 2011)



Both B.C. and Atlantic Canada anticipate SLR of 1.0 m by the year 2100. This is higher than the 2007 IPCC scenarios but is consistent with SLR projections in Europe and the U.S.A. Other SLR projections based on mass melting of Greenland and Antarctic ice sheets are much higher than 1.0 m by the end of this century.

Because of continuing increases in atmospheric greenhouse gas (GHG) concentrations[12], sea levels are expected to rise at accelerating rates into the next century. Even if drastic measures are undertaken to slow down or even stop GHG emissions, sea level rise will continue for centuries several millennia in the future[13].

This has significant implications. First, planning ahead for 20 to 30 years is considered a long-term perspective for most purposes, but this is well short of the life expectancy of most buildings and public infrastructure. Second, there will be a need to re-evaluate the amount and rate of change of SLR from time to time. Predictions of sea level rise will continue to evolve and be refined as the science progresses and more data is available. Third, the period of a century or more introduces a longer-range perspective than is typically used for planning or investment purposes.

The following B.C. milestones illustrate the passage of time in relation to SLR:

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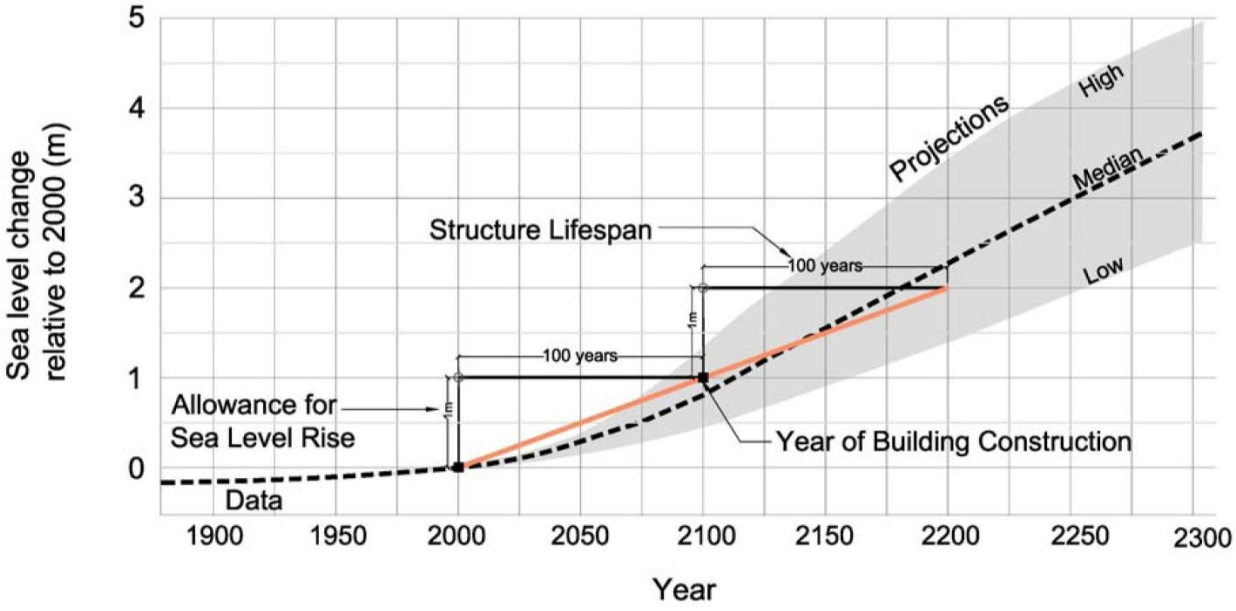
[12] Carbon dioxide (CO_2) levels in Arctic monitoring stations exceeded 400 parts per million (ppm) in the spring of 2012. Prior to the Industrial Age, CO_2 levels were around 275 ppm. CO_2 is the chief greenhouse house gas and persists in the atmosphere for 100 years.
[13] (Ausenco Sandwell 2011)

- The first local government to be incorporated in the province was New Westminster in 1859
- The second oldest local government in B.C. is the capital City of Victoria, which celebrated the 150th anniversary of its incorporation in 2012
- The oldest continuously occupied building in the province is less than 170 years old

All of these historical measures are less than the period used for sea level rise projections to the year 2200.

Figure 3 shows the effect of incremental increases in minimum building elevation planning over time, based on a 100 year lifespan for a structure.

FIGURE 3 - SEA LEVEL RISE ALLOWANCE FOR STRUCTURE LIFESPAN (AUSENCO SANDWELL, 2011)



STORM SURGE

Storm surge is one of the more potentially destructive coastal hazards associated with SLR. 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 storm water is carried further inland and at a higher elevation. It is anticipated climate change will cause more intense and frequent storms in the northern hemisphere and that SLR will increase the coastal areas at risk from these events.

PHOTO 3 -DEC. 21, 2010 STORM SURGE AT LORNEVILLE, N.S. (PHOTO CREDIT STEVE FERGUSON)

COASTAL SENSITIVITY

In Canada, where the total coastline exceeds 203,000 kilometres, sea level rise is a significant issue. 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 SLR. Most of the British Columbia coast has a low sensitivity, mainly due to relief, geology and coastal landforms. 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 SLR. In addition, small areas of high sensitivity occur locally in B.C., Quebec, and Newfoundland and Labrador.

At the 2011 census, the total population of Canada was 33,476,688. As noted in the introduction, there is a high concentration of population near the Pacific and Atlantic coasts. Prince Edward Island has the highest proportion

of its coastline and land area subject to flooding. However, the majority of dwellings in Canada at risk of flooding are in British Columbia[14].

FIGURE 4 - COASTAL SENSITIVITY TO SEA LEVEL RISE - NATURAL RESOURCES CANADA

ADAPTATION AND MITIGATION

Much of the focus of climate change is heavily weighted toward mitigation. In the context of climate change, mitigation means implementing policies to reduce greenhouse gas emissions (GHG). However, climate change mitigation policies will not stop sea level rise or its potential effects within the foreseeable future. Furthermore, even if the growth of GHG emissions could be halted tomorrow, this would do nothing to arrest the impacts of GHGs already in the atmosphere[15].

[14] (National Round Table on the Environment and the Economy 2011, 71-72)
[15] (National Round Table on the Environment and the Economy 2011)

Mitigation and adaptation do not share the same scale or time frame: adaptive capacity is expressed locally, whereas mitigative capacity is different for each activity and location. The results of mitigation must be aggregated at the global scale to properly assess their benefits in reducing climate hazards[16].

The focus of this Primer is on adaptation as a local government response. While these tools cannot be used to mitigate climate change, they can be used to reduce risks such as sea level rise and related coastal hazards which are associated with climate change. As a result, mitigation and adaptation will each be required in an ongoing process to decrease the residual risk associated with climate change in general and SLR in particular.

A proactive approach to sea level rise adaptation is more cost effective and less disruptive than reactive measures. Appropriate adaptation can significantly reduce the impact of sea level rise. Since SLR is a progressive and dynamic process, continuous adaptation is required. Adaptation should ideally aim at creating resilient communities through a triple bottom line approach that (1) minimizes the unplanned loss of land and physical capital such as infrastructure; (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. Adaptation should be viewed as an ongoing process whereby risks and opportunities are prioritized, risk reduction measures are implemented and the effectiveness of the outcomes is reviewed[18].

[16] (Jones, et al. 2007)
[17] (Hallegate 2011)
[18] (Linham and Nicholls 2010)

STUDY AREA

This Primer focuses on adaptation tools for Canada's southern coasts, namely the provinces of British Columbia, Quebec, New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland and Labrador.

FIGURE 5 - MAP OF CANADIAN PROVINCES (SOURCE: NATURAL RESOURCES CANADA)

BRITISH COLUMBIA

POPULATION 4,400,057 (2011 CENSUS)

The B.C. coastline has a total length of 25,725 km. Although much of it is rugged and deeply incised, approximately 5% of the population of B.C. lives near or below sea level. In the Lower Mainland this includes the City of Richmond, Queensborough in New Westminster, Vancouver International Airport on Sea Island, Ladner, Beach Grove and all farmland in Delta, Crescent Beach and farmland in Surrey, high value shore lands in False Creek and Stanley Park in Vancouver as well as most of the Southlands neighbourhood, and some waterfront areas of West Vancouver, Port Moody and White Rock. Significant Musqueam, Tsawwassen, Semiahmoo, and Squamish First Nations lands, also in the Lower Mainland, are all 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.

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 in Haida Gwaii. In all, some 59 of 160 municipalities and 14 of 29 regional districts in B.C. consist of coastal communities or contain direct coastline exposure.

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 (see Figure 2, page 6).

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, sea level rise will increase by an additional 1-2 mm per year, primarily affecting Richmond, Delta, Queensborough and the New Westminster Quay. On the west coast of Vancouver Island, sea level rise will be mitigated by tectonic uplift. 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

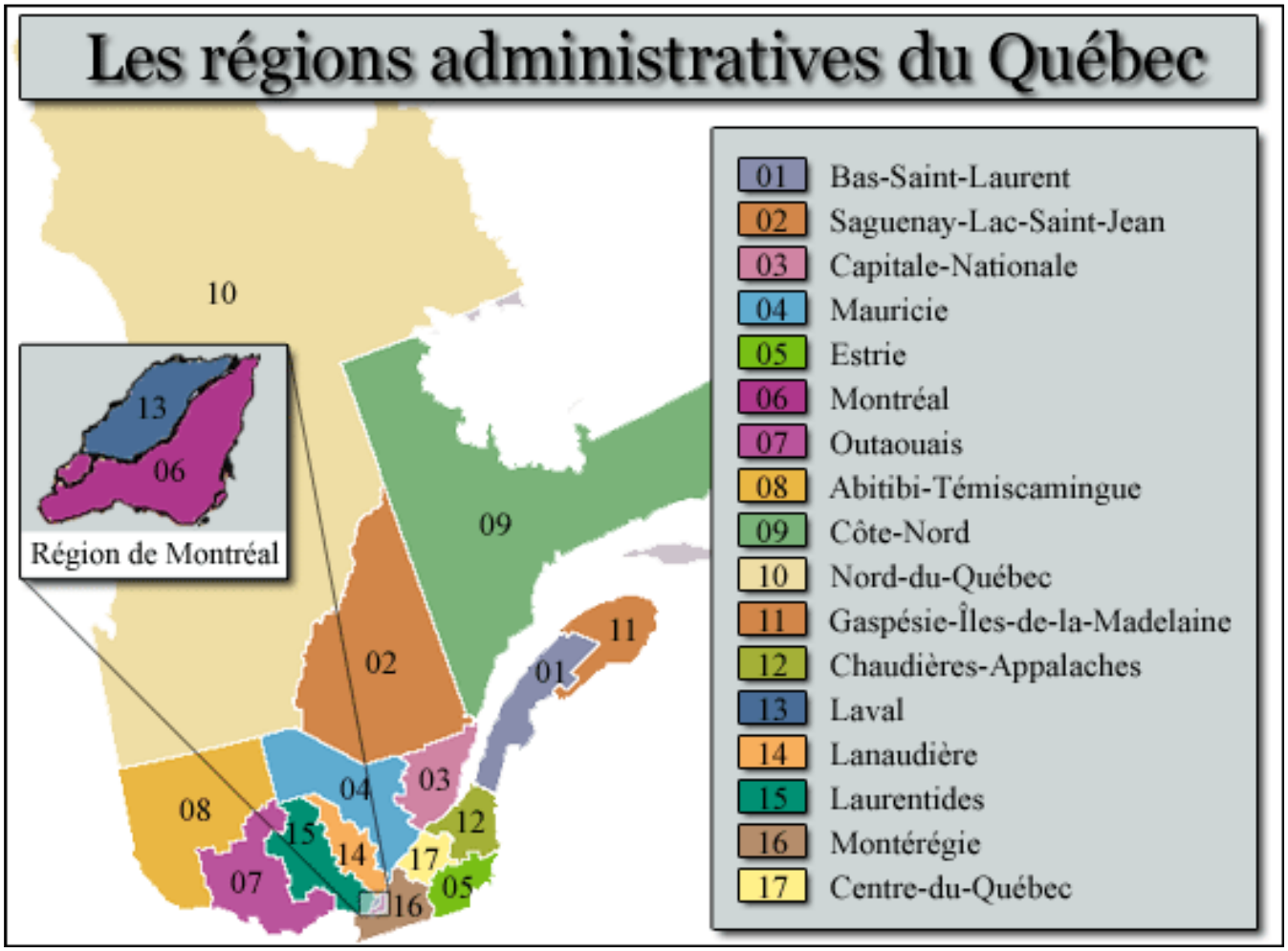
POPULATION 7,903,001 (2011 CENSUS)

The coastal region of Quebec stretches northeast of Quebec City and around the Gulf of St. Lawrence for 3,500 km. The province of Quebec consists of 17 administrative regions under the 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 SLR. Within these regions are 121 municipalities, home to a population of over 400,000 people.

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 (Îles-de-la-Madeleine) are in fact increasing their coastal reach into the sea through natural processes of erosion and sediment transport. Other communities are extending their coastal reach through dredging. Dramatic erosion during storm events is affecting the Côte-Nord region; and subsidence, or a shifting of the land mass downward relative to mean sea level, is affecting parts of the Bas-Saint-Laurent region and Chaleur Bay (Baie des Chaleurs) on the east point of the Gaspésie region[19].

[19] (Morneau 2012)

FIGURE 6 - QUEBEC ADMINISTRATIVE REGIONS (SOURCE: BANQUE D'IMAGES EN UNIVERS SOCIAL)



Most of the 121 municipalities along the coastal areas apply a 10 – 15 metre setback established in 1987by provincial policy for the protection of the shorelines. Some, though not all, areas for which more detailed research on erosion rates has been conducted have begun adopting more stringent regulations as a result of research findings and government recommendations.

BOX 1 - ANECDOTE FROM SEPT-ILES QUEBEC

HALLENGES FOR MUNICIPALITIES IN IMPLEMENTING NON-LEGISLATED PROVINCIAL RECOMMENDATIONS

As one of the municipalities in Quebec most vulnerable to SLR and erosion, it is anticipated that Sept-Îles will be among the first to adopt more stringent regulation on the matter. Due to its lack of capacity to conduct such research on its own, Sept-Îles has asked the province for detailed research on the phenomena to inform its new regulation development, putting the community at the forefront of advancement of this in the domain. Being at the edge, however, has meant piloting some rocky transitions as new approaches are being tested.

City director, Claude Bureau, offers the following reflections:

Knowing now about the impact of structural protection from erosion and how it often appears to cause more harm than good, coastal protection would benefit from provincial law and provincial management in order to ensure a consistent and effective approach across all coastal banks. As it is, municipalities and individual property owners are responsible for implementing structural protection. In some areas, such as Sept-Iles, new regulation has prohibited all structural approaches, other than rebuilding sandbanks. However, the province will not issue permits to individuals for rebuilding the sandbanks.

Additionally, recommendations stemming from the inter-ministerial report on erosion in the area included banning any increases to habitable surface area for buildings in the newly designated no-construction zones. Sept-Iles adopted this measure, as per the recommendation, but since then other municipalities have negotiated with the province to allow for increases via building up without increasing the footprint.

Such inconsistencies create confusion regarding how to proceed, at the least; and give grounds for legal challenges at worst.

NEW BRUNSWICK

POPULATION 751,171 (2011 CENSUS)

The province of New Brunswick has 5,501 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. A total of eight provincial counties and 50 municipal areas within them have coastline or areas exposed to the effects of SLR. 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.

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 pieces of 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.

PHOTO 4 - LAMEQUE, N.B. (PHOTO FROM NEW BRUNSWICK COASTAL AREAS PROTECTION POLICY)

NOVA SCOTIA

POPULATION 921,727 (2011 CENSUS)

The province of Nova Scotia has 13,300 km of coastline of which 7,500 km is salt-water coastline. This coastline includes some 3,800 coastal islands. 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 SLR. It is estimated that 70% of the population lives on or near the coastline. Approximately 95% of coastal land in Nova Scotia is privately owned. Coastal erosion is a serious problem in many areas of the province and a project under the RAC program is currently identifying highly vulnerable areas. This will assist communities as they develop land use plans for their areas.

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[20]. Development on the shoreline continues with no buffers mandated except for a few designated protected beaches.

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 the Sustainable Coastal Development Strategy. A 2012 draft of the Coastal Strategy anticipates a rise in sea level of at least one metre over the next century. The draft Strategy states "We cannot afford to ignore the fact that our coast is changing. By making smart decisions now and preventing damage from coastal hazards, we can protect our economy and way of life and support sustainable development"[21]. One of the Strategy's key objectives is that buildings and infrastructure be located, built and maintained in a manner that minimizes impacts from rising sea levels and storms.

PHOTO 5 - COTTAGE AT PUGWASH, N.S. (PHOTO CREDIT T. WEBSTER)

[20] (Province of Nova Scotia 2009)
[21] (Provincial Oceans Network (PON) 2011)

PRINCE EDWARD ISLAND

POPULATION 140,204 (2011 CENSUS)

The province of P.E.I has an ocean-influenced coastline of approximately 3,200 km. It is exposed to impacts of global sea level rise such as coastal erosion and infrastructure damage. A majority of the P.E.I. coastline has a high physical sensitivity to sea level rise. The provincial government is the major player in land use planning in P.E.I., managing about 90% of the land area in the province. 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 provincial legislation.

NEWFOUNDLAND AND LABRADOR

POPULATION 514,536 (2011 CENSUS)

Newfoundland and Labrador has a shoreline of 17,542 km. Over 90% of the population is located in coastal communities, including the capital of St John's. Sea level rise has been documented throughout the province[22]. Land subsidence from glacio-isostatic deformation and the continued increase in volume of the world's oceans due to ongoing melting of glacial ice are key factors in the rise of relative sea levels. With ongoing sea level rise, storm surge activity is having 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 marches[23].

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[24]. 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. Three issues covered in this document include coastal land use planning, coastal and marine infrastructure, and climate change.

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[22] (Catto, A Review of Academic Literature Related to Climate Change Impacts and Adaptation in Newfoundland and Labrador 2010)
[23] (Catto, A Review of Academic Literature Related to Climate Change Impacts and Adaptation in Newfoundland and Labrador 2010)
[24] Northern Labrador includes the Nunatsiavut Government, a 72,500 km2 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.

ATLANTIC CANADA

The four provinces in Atlantic Canada have worked collaboratively on adaptation to climate change for the past decade. This work has included workshops, the commissioning of regional studies, research projects and assembling teams with expertise in climate change and adaptation to SLR. At the political level, the four Atlantic Ministers of the Environment formally agreed to work collaboratively on adaptation to climate change in 2008, and an Atlantic Regional Adaptation Collaborative Program (RAC) was established with the assistance of Natural Resources Canada. This led to a wide range of collaborative activities throughout Atlantic Canada involving provincial agencies, municipal associations, engineering and planning associations and private sector stakeholders. Between 2009 and 2012, the Atlantic RAC gathered information which will make it easier for the four provinces to revise or develop new policy and legal tools to help plan for sea level rise and climate change adaptation in the next 100 years.

PHOTO 6 - SPILLARS COVE, N.L. (PHOTO CREDIT D. JARDINE)

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. There is considerable consistency in the analysis and documentation of issues among the four provinces, in part due to the Atlantic RAC. Nevertheless, the legal and policy framework for dealing with coastal zone planning and development varies for each Atlantic province. Newfoundland and Labrador appears to be 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 provinces rely on the generally accepted coastal engineering design standards for the life of structures in coastal areas, which is 50 years. One major exception to this standard 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.

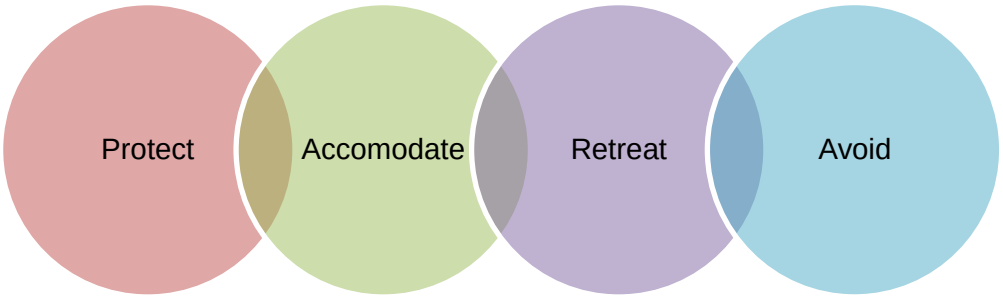
FRAMEWORK FOR DECISION MAKING

Appropriate adaptation tools are needed to minimize the long-term economic, environmental and social impacts of SLR on development in coastal areas. In most communities, effective change "on the ground" will come at the directive of local government. The following section provides analysis of a variety of adaptation tools and their potential applicability to communities located 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 where applicable. In addition, general advantages and disadvantages of each tool are noted. Economic, environmental and social criteria are discussed, as are the potential barriers or challenges to implementation. Economic criteria may include long-term capital and operational costs and benefits, funding to pay for infrastructure upgrading, and allocation of costs, including the loss of taxable lands. Environmental criteria may include impacts on natural resources, any sensitive ecosystems such as wetlands, water quality and greenhouse gas emissions. Social criteria will address public safety, health and welfare issues, potential disruption of public services, and protection of vulnerable groups. Separating the discussion of the tools in this way is intended to provide a broad perspective and recognize that trade-offs may be required.

To what end should the available adaptation tools be applied? The initial response to hazards or a potential threat is to protect people, property and infrastructure from any potential adverse effects. While protection has been the traditional response to coastal hazards, it is not suitable in all circumstances. Protection is one possible strategy but is not the only course available. Adaptation strategies to climate change in general and sea level rise specifically can be grouped into four broad categories[25]:

- Protect
- Accommodate
- Retreat
- Avoid

FIGURE 7 - STRATEGIES FOR ADAPTATION TO SEA LEVEL RISE



[25] 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).

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[26]. Such measures range from large-scale public projects to small-scale efforts by individual property owners. They tend to be expensive and may have limited long-term effectiveness in highly vulnerable locations[27]. It is natural for property owners and residents to want to protect existing assets and lifestyles. This view is reinforced if all the costs of protection are borne by governments at different levels (i.e., if individual property owners bear little or no risk).

The timing of a decision to commit to a protect strategy is key as this is not an approach that can easily be reversed. 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. 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[28].

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 level rises, 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[29].

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 that are undertaken.

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 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 a lesser risk.

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[26] (Adaptation - Coastal Zone 2007)
[27] (Adaptation - Coastal Zone 2007)
[28] (Hallegate 2011)
[29] (Adaptation - Coastal Zone 2007)

This strategy has been applied in Prince Edward Island when individual storm events have caused significant loss of shoreline. During one storm at Anglo Tignish on December 21, 2010, eight metres of land was lost.

PHOTO 7 - WELL ON BEACH AT ANGLO TIGNISH, P.E.I. AFTER STORM SURGE ON DEC. 21, 2010 (PHOTO CREDIT D. JARDINE)

As part of a managed retreat strategy, homes, cottages, lighthouses and even barns have been moved further inland to protect them from erosion and storm surge. This strategy may include moving roads further inland or completely re-routing them. This approach makes sense 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. In other cases, coastal erosion has resulted in the loss of entire building parcels.

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, and may or may not be a phased undertaking. Managed retreat is not currently used as frequently as the other strategies. However, it is anticipated that the use of managed retreat will increase in the future if the cost of a protect or accommodate strategy is based on a long-range perspective and a higher rate of sea level rise.

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. New structural elements are not part of an avoid strategy. 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 non-habitable 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 representing a composite of existing strategies as they are currently applied. 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 is not considered a viable response to SLR in Canada, as the conditions where it is used elsewhere in the world do not apply here. The economic and environmental costs of land reclamation, wherever implemented, are extremely high. There are limited instances where land reclamation may occur in Canada but these are most likely to take the form of soft armouring or hard protection typically implemented as part of a protect strategy[30]. For example, the application of a foreshore lease to enable the use of beach nourishment or other form of soft armouring, and the construction of a breakwater or other hard form of protection, are tools included in this Primer.

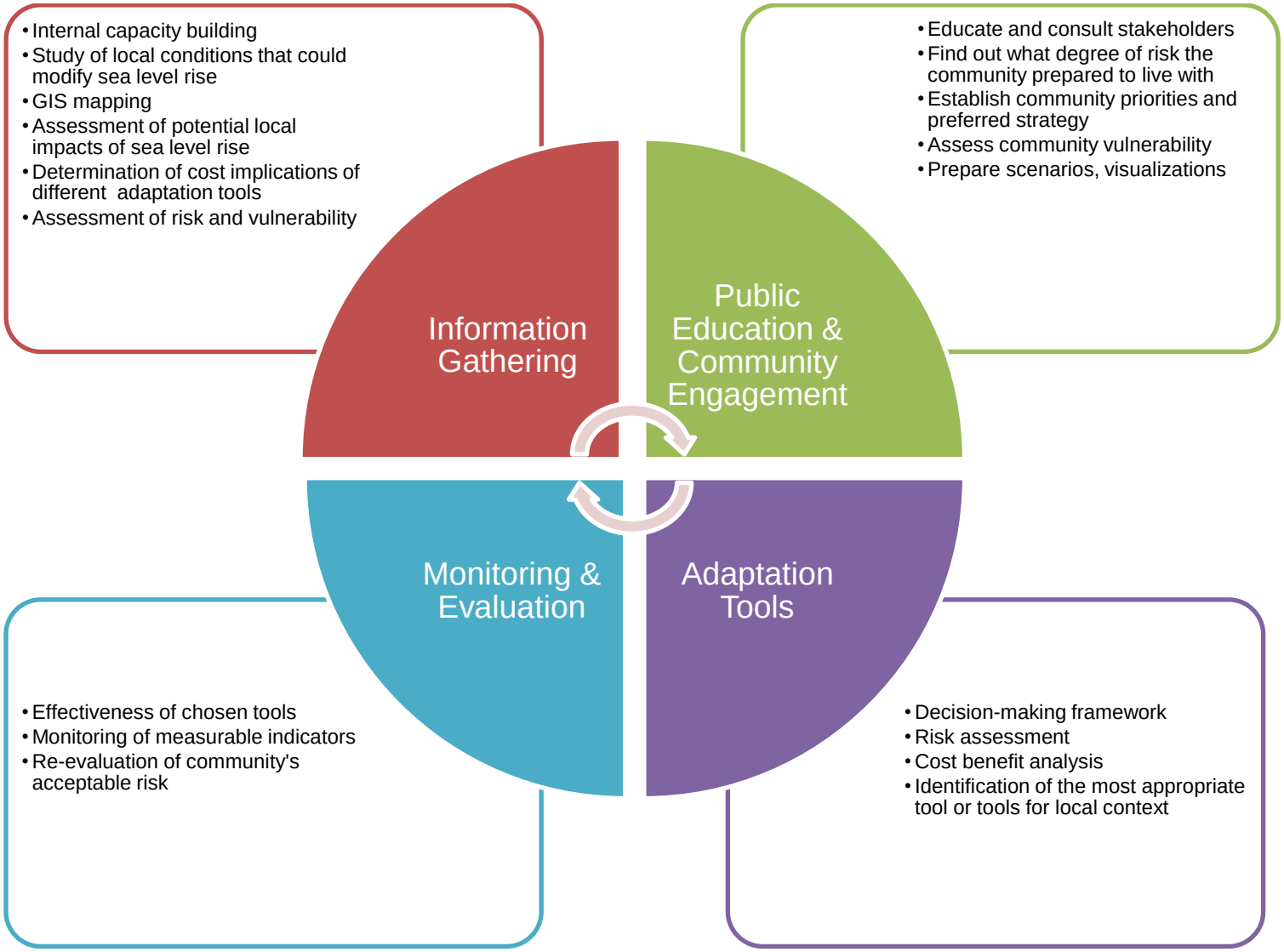
[30] Local infilling to create or enhance harbours and farmland has historically occurred in Atlantic Canada and in the Lower Mainland of British Columbia but is considered to have minimal applicability for the future due to prohibitive costs and environmental impacts.

SEA LEVEL RISE ADAPTATION FRAMEWORK

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[31]. 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 can also include the building of internal capacity such as identifying SLR champions or establishing a cross-departmental steering committee to address SLR. When sufficient baseline information resources have 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 to guide the decision-making process. While public education and community engagement are shown in Figure 8 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 best be applicable in individual communities. Some of the adaptation tools identified in this Primer will require ongoing public input and support to be successfully implemented. As the science of estimating SLR 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.

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

FIGURE 8 - SEA LEVEL RISE ADAPTATION FRAMEWORK

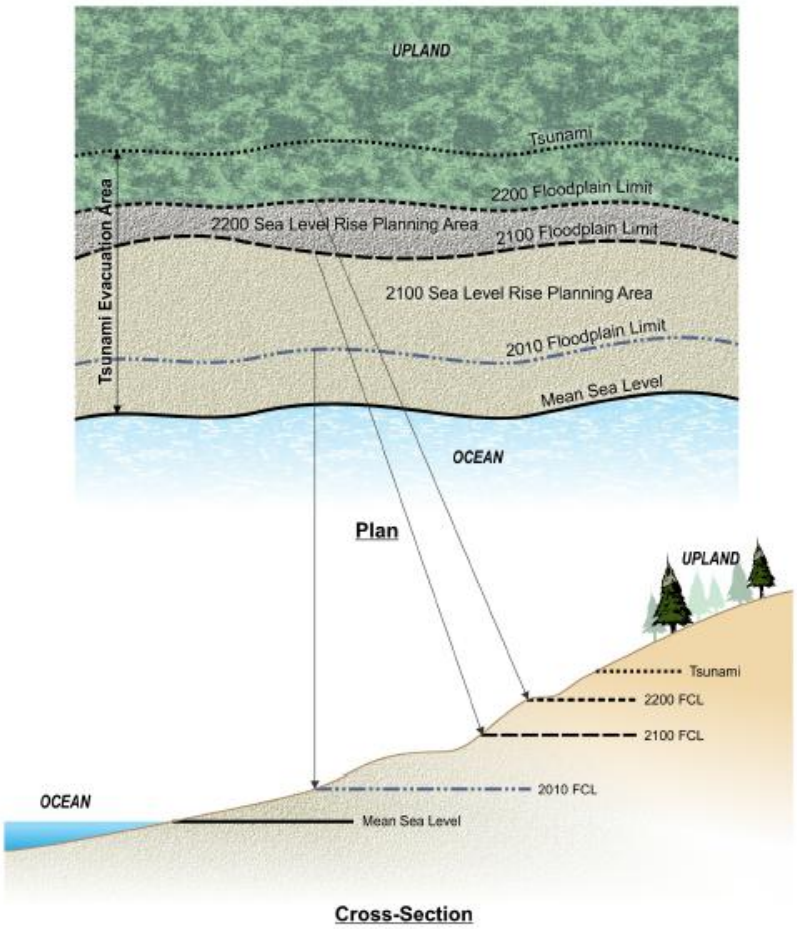


INFORMATION GATHERING

> "APPROPRIATE KNOWLEDGE AND UNDERSTANDING OF SEA LEVEL RISE AT A LOCAL LEVEL IS FUNDAMENTAL TO SUCCESSFUL ADAPTATION. THE MORE THAT IS KNOWN ABOUT A COASTAL SYSTEM, THE MORE TARGETED AND EFFECTIVE ADAPTATION MEASURES CAN BE. " (LINHAM AND NICHOLLS 2010)

Information gathering in the context of this Primer refers to the gathering of information resources with respect to the potential effects of SLR, 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 9 - Sketch of Coastal Hazard Mapping Components

FIGURE 9 - SKETCH OF COASTAL HAZARD MAPPING COMPONENTS (KERR WOOD LEIDAL ASSOCIATES LTD. 2011). FCL = FLOOD CONSTRUCTION LEVEL



Mapping environmental constraints and opportunities can demonstrate land sensitivity analysis including lands vulnerable to SLR; 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. Topics to be covered 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?
- What adaptation options should be considered for the community to address the consequences of sea level rise?

INFORMATION GATHERING - EXAMPLES

The B.C. Ministry of Environment has prepared an online inventory of information resources that includes design briefs and floodplain maps showing flood level isograms of water elevations for coastal areas subject to flood hazards. In addition to the work by Kerr Wood Leidel on the Coastal Floodplain Mapping Guidelines and Specifications document, a series of maps showing *potential* coastal flood hazard areas in BC was also developed. These are available on the Province of BC website and display potential year 2100 floodplain areas based on approximate Flood Construction Levels (incorporating sea level rise). However, the presence (or absence) of dikes or other flood protection work has not been factored into the analysis. It is also noted that the floodplain areas have not been ground-proofed, verified or studied to confirm their exact location. Therefore information displayed should be considered preliminary and useful only to raise awareness of the potential need for land use planning for coastal flood hazard, and to highlight areas that may benefit from the development of coastal floodplain maps[32].

The Pacific Climate Impacts Consortium (PCIC) has recognized that climate change impacts do not affect every region of British Columbia in the same way and so has developed the Plan2Adapt tool based on a number of climate models. The Plan2Adapt tool generates maps, plots, and data describing projected future climate conditions for regions throughout British Columbia. It is designed to help assess climate change at regional level based on a standard set of climate model projections.

[32] (Kerr Wood Leidal Associates Ltd. 2011)

This tool now also includes the identification of potential impacts, depending on the climate data generated for a particular region. 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.[33]

In Vancouver, the City has included detailed topographic information on VanMap, its web-based map system. This has been used in conjunction with a variety of other information layers such as zoning and B.C. Assessment data for land and improvements to determine flood vulnerability under different sea level rise scenarios[34].

In Quebec, given the higher population density of the Bas-Saint-Laurent coupled with the fact that erosion is not as dramatically visible in most of the area compared to its visibility in the Côte-Nord, municipalities are insisting upon solid scientific grounding for all regulation changes. This is driven by the potential impact on private property owners (i.e., 10-15 metre setbacks) and the likelihood that court challenges to the regulation changes will be numerous[35].

> « NOUS NE SOMMES PAS FORCEMENT PLUS INTELLIGENTS; C'EST QUE NOUS N'AVIONS PAS LE CHOIX. » ("WE'RE NOT NECESSARILY MORE INTELLIGENT, WE JUST DIDN'T HAVE A CHOICE.") - SERGE BOURGEOIS, CITY PLANNER, ÎLES-DE-LA-MADELEINE, ON ADOPTING MORE STRINGENT REGULATION RELATED TO SLR DESPITE NOT HAVING THE DETAILED MAPS AND DATA TO DEFEND THE CHANGES.

The New Brunswick Community Planning Act gives statutory authority for District Planning Commissions to 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 this, the Planning Commissions provide access to professional resources for all communities within their planning area. The Commission staff includes a director and planners (with Canadian Institute of Planners membership), building inspectors, GIS technicians and a development officer.

The 2009 State of Nova Scotia's Coast Summary Report recognizes that coastal risks will need to be dealt with at the municipal level, with support - particularly with research - from the provincial and federal governments,. While there are many information-gathering programs currently underway, the report acknowledges that there are still information gaps. For example, there is no current method to define the socio-economic values of natural systems and human structures at risk and more detailed information is required for better flood-risk mapping[36]. The 2012 draft Coastal Strategy continues to stress the importance of information in assessing the vulnerability of communities to coastal hazards, establishing planning strategies and for emergency management planning.

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[33] (University of Victoria n.d.)
[34] (Keenan and Yan 2011)
[35] See (Quebec Government 2006) and (Savard, et al. 2008)
[36] (Province of Nova Scotia 2009)

In Halifax, the impact of heavy wave action was identified as a key factor affecting harbour front properties. In response, the City 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.

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 throughout the province for planning and development purposes.

This document's bibliography provides extensive documentation of information sources in Canada and from other countries and their response to SLR.

PUBLIC EDUCATION AND COMMUNITY ENGAGEMENT

Public education and engagement must be developed in order to increase the understanding of how communities may be directly affected by sea level rise now and in the future. 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 can include:

- Understanding how communities may be directly affected by sea level rise now and in the future, including
    - Visualization scenarios
    - Mapping
    - Clarifying the limitations of specific tools
    - Using long-range time frame, etc.
- Making information available from a wide variety of sources
- Holding public information seminars and workshops
- Organizing conferences

The development of objectives and policies is not only about education and transparency of process. It is also about accommodating future growth safely while lessening the risk to people and property. Key questions that will need to be addressed when developing objectives and policies to adapt to SLR include the following:

- ✓ How much risk is acceptable?
- ✓ How will the risk be managed? and
- ✓ Who will bear the cost?

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", in part because the time frame is greater than a person's lifetime. This challenge must be recognized and taken into consideration when designing public education and community engagement processes. Long-time residents can play an important role in communicating past extreme events. This can help overcome the complacency that comes with extrapolating from a short time frame.

Public education can be a powerful tool in addressing private interests versus the public good, but this must be approached cautiously. For example, how much responsibility should land owners at risk bear compared to the community as a whole? If the cost of structural protection is examined over the short-term, the required expenditures may be seen as modest, but if the time frame is a century, other options may be seen as more viable. In certain instances, donating land for ecological purposes as a legacy to the community may represent a cost-effective solution. Working with private land owners successfully will require a process of engagement and education.

The costs associated with adaption to SLR and how they may be funded will also be of fundamental importance when exploring adaptation options. This, along with other variables such as risk assessment and vulnerability, may result in the process taking different forms from one coastal community to another.

PUBLIC EDUCATION AND COMMUNITY ENGAGEMENT - EXAMPLES

Carbon dioxide in the atmosphere and global climate change are largely invisible. Individuals often feel very disconnected from the prevailing imagery of climate change (such as ice floes melting), and scientific charts can be a challenge to interpret. The use of visual imagery to assist public education and community engagement with respect to sea level rise can make the effects of SLR more understandable in local communities. Advances in technology are giving rise to powerful new visual tools to engage the public and build awareness.

One such example of this is the work of the B.C. Regional Adaptation Collaborative (RAC), a partnership between the University of British Columbia's Collaborative for Advanced Landscape Planning (CALP) and the Corporation of Delta. This team has worked to identify, model, visualize and evaluate potential flood impacts and adaptation options for the Corporation of Delta. CALP has produced a set of 2D and 3D visualizations based on local hydrological modeling for sea level rise and storm surge dike breaches.

The visual materials generated by this project have been used with staff and a citizens' Working Group to understand the impacts, assess the policy implications and measure the social acceptability of various adaptation strategies. The goal of this project is to provide the Corporation of Delta with a set of policy recommendations for a range of hard and soft approaches, and a set of visuals to use for community engagement to build support for adaptation planning. This visualization has been made available for use by other local governments in B.C.

In Quebec, following the release of results from research on erosion in the *Côte-Nord*, extensive public consultation and other forms of information-sharing meetings with local stakeholders took place.

In all, over 100 meetings or consultations took place. These meetings played an important role in the subsequent regulation adopted by the local authorities. Quebec has used the internet as a resource through which to seek feedback for its Climate Change Action Plans. Consultations took place via online submissions for the 2006 - 2012 and 2013 – 2020 plans. For the 2013 – 2020 plan, three documents were available online for consultation including a strategy document, a climate change in Quebec situational analysis, and a vision document. Online forms were available to provide feedback by any individual or group to each of the documents. In Quebec, multi-stakeholder collaboration among different levels of government and local authorities, as well as university researchers and scientists from the non-profit sector has proven imperative in the work on adaptation to SLR. Key participants include provincial government Ministries, local authorities, NGOs and university researchers. The Ministry of Public Security has taken the lead in coordinating much of this work, largely due to the involvement of the Director of Risk Management, François Morneau, of the Ouranos Consortium. Ouranos is an NGO which brings together expertise concerning climate change and adaptation to provide data for decision-makers. In collaboration with the *Institut des sciences* de *la mer de Rimouski* (Marine Science Institute of Rimouski), of the Université du Québec à Rimouski (UQAR) and other academics, detailed research on varying erosion rates per coastal zone has been conducted since 2000. The availability of hard science has proven to be instrumental in the adoption of municipal regulation.

Additional research by the same group of organisations, plus the federal government, considered adaptation strategies for the municipalities most at risk from SLR (Îles-de-la-Madeleine, Sept-Îles and Percé) in 2005 – 2007. This collaborative research and the consultations therein, also proved instrumental in the uptake of municipal regulations. This is particularly important in the municipality of Îles-de-la-Madeleine, where updated erosion maps have not yet been published.

ADAPTATION TOOLS

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

1. Planning – 4 tools
2. Regulatory – 4 tools
3. Land Use Change or Restriction – 5 tools
4. Structural (Flood Protection Works) – 5 tools
5. Non-Structural (Soft Armouring) – 3 Tools

Planning tools identified in this Primer consist of local government growth 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 are considered the most precise as they are prescribed by legislation. 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 without being the responsibility of local government. One example is the acquisition of land by 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. There is a wide range of hard protection or armouring works that 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[37].

In addition to these tools available to local governments, insurance and emergency management are also discussed. Insurance plays almost no role in Canada but is widely used in other developed countries. Emergency management is used in all provinces but some key features are the responsibility of senior governments.

These broad groupings and tool identification have been used for organizational purposes in this Primer; a summary of the tools is shown in Figure 10.

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

FIGURE 10 - SEA LEVEL RISE ADAPTATION TOOLS SUMMARY

Planning Tools

Objectives & Policies
- Growth management objectives, establishment of policies and setting of priorities
- Coastal management approach based on sensitivity to impact

Coastal Hazard Mapping
- Coastal Floodplain Mapping
- Mapping of areas at risk of erosion due to sea level rise
- Identification of minimum floor elevations (Flood Construction Levels, or FCLs) to reduce risk to buildings in hazard areas

Risk Management
- Identification, assessment, measurement of the likelihood and consequences of risks to property, buildings and people
- Cost benefit analysis
- Vulnerability assessment
- Resilience assessment

Emergency Planning and Preparedness
- Prepare emergency plans for flooding and other disasters
- Undertake post disaster planning

Regulatory Tools

Subdivision Regulation
- Regulation of subdivision to protect development in areas subject to coastal hazards
- Regulation of subdivision where the natural environment would be adversely affected due to sea level rise

Building Regulation
- Regulation of building construction to address safety of land subject to coastal hazards

Regulation 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 & setbacks for land in floodplain - Floodplain Bylaw

Development Permit
- Regulation of specific development plans to protect environment or development from hazard

Land Use Change or Restriction Tools

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 SLR

Transfer of Development Potential
- Transfer of allowable development potential to an alternative location not at risk
- Creation of 'density bank' to accommodate density transfer

Easement, Covenant or Other Restriction
- 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

Land Trusts
- Management of land for conservation or other non-development purposes by land trust or other separate environmental organization

Foreshore Tenure
- Lease or Licence of Occupation of area from the Crown below the natural boundary to allow integrated management of foreshore with respect to SLR adaptation

Structural Tools (Flood Protection Works)

Scour Protection
- Foundation protection for a new or existing building
- Protection of a linear structure base
- Protection of underground services

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

Dikes
- Linear shoreline protection structure as a primary defense from flooding
- Includes accessories such as floodboxes and floodgates

Other Hard Protection
- Off-site structural works to protect shorelines from flooding
- Includes seawall, groyne, revetment and storm surge barrier
- Secondary protection including roads and back-up dikes

Wet Floodproofing
- Installation of building materials that can withstand temporary flood damage
- Location of electrical and mechanical fixtures above area subject to flood risk

Non-Structural Tools (Soft Armouring)

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

Dune Building or Rehabilitation
- Creation or rehabilitation of dunes to provide a buffer to reduce flood risk and environmental habitat
- Creation of off-shore islands

Beach Nourishment
- Addition of sediment on an ongoing basis to satisfy natural erosional forces

PLANNING TOOLS

OBJECTIVES AND POLICIES

TOOL DESCRIPTION

The setting of objectives and policies to manage development is a key tool available to local governments. There are many terms used for this process. They include comprehensive plans, community plans, neighbourhood plans, strategic plans, and growth management strategies. The terminology changes depending on the jurisdictions involved and the scope of the planning process. Common elements include the setting of broad objectives and establishing policies to achieve the established objectives. Typical objectives include accommodating future development by identifying land suitable for such purposes, protecting residents by avoiding development or managing risk on land subject to hazards, and protecting environmentally sensitive areas.

Policies are more specific and often reflect the means of implementing or attaining the overall objectives. Local government policies may identify how coastal hazards such as erosion and inundation should be addressed, conditions suitable to accommodate "appropriate growth" and where development should be avoided. At a detailed level, policies may include setbacks required to avoid coastal areas at risk, environmentally sensitive criteria, and means of reducing vulnerability and increasing adaptive capacity and resilience.

APPLICATION

Objectives establish the broad direction for the future of a community and the means of attaining those objectives by setting policies. Objectives and policies with respect to coastal hazards have applicability to every coastal community in Canada as an SLR adaptation tool. They can also be added to an existing policy framework such as an Official Community Plan or Climate Change Action Strategy. 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

In B.C., the Local Government Act under Section 877 requires all Official Community Plans (OCPs) to include statements and map designations for the area covered by the plan and to identify restrictions on the use of land subject to hazardous conditions - for example, flooding and/or erosion - or land that is environmentally sensitive to development. An OCP must also include the approximate location and phasing of any major road, sewer and water systems. The location and phasing of major infrastructure is important, as this will reveal the extent of infrastructure at risk from coastal hazards and could facilitate a managed retreat strategy through a phasing plan in an OCP.

The Local Government Act of B.C. also makes provision for a regional growth strategy. Although only 10 regional districts have adopted regional growth strategies, this has taken place in all coastal areas with a large population base in B.C. Under sections 849 and 850 of the Local Government Act, the purpose of regional growth strategy is to guide decisions on growth, change, and development. It must cover a period of at least 20 years and include a comprehensive statement on the future of the region including social, economic and environmental objectives. Objectives should deal with developing settlement patterns that minimize risks associated with natural hazards and protecting environmentally sensitive areas.

Québec governmental policy for the protection of riverbeds, shorelines, coastlines and floodplains specifies uniform setbacks based on grade and mandates a special permit for new construction near shorelines. The policy also bans all construction directly on the coastline. The 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, of the 86 RCMs, all but seven had adopted the measures. The policy was originally intended to be a provincial regulation, but was left as a policy to expedite the process. The policy may still become legislation, with updated setback lines for different coastal regions, based on the refinement of scientific data currently available or under study[38].

New Brunswick's Coastal Areas Protection Policy establishes setbacks for permanent structures. This represents an avoid goal in the setback area and could facilitate planned retreat. This policy, which came into force in 2002, divides 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 by provincial environmental impact assessment legislation or via municipal enabling legislation.

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.

In Nova Scotia, under the Municipal Government Act, and in the Halifax region by the Halifax Regional Municipality Charter, municipalities have the authority to develop Municipal Planning Strategies (MPS) under PART VIII of the Act, section 220.

[38] (Martel 2012)

The Cumberland County Integrated Sustainability Plan is a good example. This document is similar to Official Community Plans undertaken under the authority of the Local Government Act in B.C.

The Province of P.E.I. has adopted shoreline setback regulations for subdivision and development under the Provincial Planning Act. Up to 2011, the province used setbacks based on historical erosion monitoring sites and historical aerial photos. This information is being updated with aerial photos of coastlines from the years 1968, 2000 and 2010. Prince Edward Island also requires a watercourse, wetland and buffer zone activity permit for any temporary or permanent change made to or near a watercourse or wetland, under the Environmental Protection Act. A permit is required for all such alterations made within 15 metres (49.2 feet) of any watercourse or wetland boundary such as a coastal cliff. The regulations under this legislation also provide for a minimum buffer of 15 metres or 60 times the annual erosion rate for the area, whichever is greater, measured from the top of the bank adjacent to the beach. A coastal water body is included in the definition of a watercourse in the Environmental Protection Act.

In Newfoundland and Labrador, the 1990 Urban and Rural Planning Act makes provision for regional planning 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 of these are outdated. The Newfoundland Department of Environment has a “Policy for Development in Shore Water Zones”. This policy establishes criteria for issuing permits under the Water Resources Act, SNL, for all development activities in and affecting shore water zones. In marine situations, the high water level of a water body (1:100 year return period) must allow for maximum waves, wind setup, storm surge and ultimate mean sea levels under global climatic forecasts for a 1:100 year design.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

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 SLR may be time consuming and require a commitment of staff and financial resources. The development of this Primer is intended to assist in this process.
The planning process provides opportunities for public involvement and education and can offer transparency and accountability.	The addition of policies to address SLR may add controversy, particularly with Avoid or Retreat strategies.
The degree to which objectives are met and policies achieved can be measured and monitored over time.	

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

Economic considerations include the cost of undertaking the planning process designed to set objectives and policies and the cost of implementing the plan. The cost to undertake the process is easily measurable while the cost of implementation is much more difficult to assess.

There is also a cost to not planning. This may increase future obligations (e.g., development in areas at risk of coastal hazards with no protection measures) or, at worst, increase the magnitude of a future disaster due to failure to undertake adaptation measures.

ENVIRONMENTAL

The setting of objectives and policies in Official Community Plans has a history of considering environmentally sensitive areas, habitat at risk, and areas subject to coastal hazards. Adaptation to SLR is a logical extension of this historic role.

SOCIAL

Social considerations include setting objectives and policies to manage residential and other forms of development, recreation and open space needs, community facilities and other infrastructure needs given SLR in coastal communities. The plan's success often depends on a strong public education and consultation process.

IMPLEMENTATION MEASURES AND CHALLENGES

Implementation measures include having local government adopt a bylaw for an OCP, or having regional government undertake regional growth strategy. Other objective and policy processes may include approval by bylaw or resolution by the local government. Challenges include the time and resources required for the process and 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. Policies are distinguished from regulatory requirements but this distinction can become blurred. For example, the City of Vancouver has recommended that Flood Construction Levels be increased by an additional 1.0 m to address increased risk due to anticipated sea level rise. While this has not been implemented as a regulatory requirement, it provides a strong advisory message to developers.

COASTAL HAZARD MAPPING

TOOL DESCRIPTION

Coastal hazard mapping can include coastline areas susceptible to erosion. The purpose of such mapping is to identify coastal flood and erosion hazard(s) and to provide the technical basis for land use planning and development floodplain bylaws.

The Coastal Floodplain Mapping Guidelines and Specifications report by Kerr Wood Leidel and Associates for the B.C. Ministry of Forests Lands and Natural Resource Operations outlines four basic steps required to develop coastal floodplain maps:

1. Acquisition of detailed floodplain topography;
2. Coastal engineering analysis to estimate the water level components associated with the design condition and the associated Flood Construction Levels;
3. Preparation of floodplain maps indicating areas subject to flood hazard(s) and the magnitude of the hazard(s); and
4. Preparation of a Design Brief to document the analysis.

The Kerr Wood Leidel report also suggests that coastal floodplain maps contain the following elements: Flood Construction Levels (FCLs) out to the years 2100 and 2200; floodplain limits to 2100 and 2200; SLR planning areas for 2100 and 2200 and a tsunami evacuation planning area (if applicable)[39].

Coastal flood hazards are determined by the interaction of storm surges and waves with seabed bathymetry and coastal land cover. The mapping of coastal areas at risk of flooding or susceptible to erosion is a vital tool for land use planning with respect to SLR. This tool consists of superimposing new SLR levels on a topographic base map to identify new areas subject to hazards.

The intent of coastal floodplain maps is to locate the position of the future floodplain limits. Potential coastal erosion resulting from the position of the floodplain with respect to the surrounding terrain should be considered as part of the planning process to establish setbacks[40].To effectively map the extent of coastal hazards, accurate topographic data are required, ideally with a contour interval of 1m or less. The traditional method is to survey the topography on the ground. However, LiDAR (Light Detection and Ranging), which requires collecting elevation data from an aircraft using a laser, is increasingly 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 the ideal base map to determine coastal hazard risk[41].

Ground surveys provide the highest accuracy; however to cover an entire coastline this way 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. Further, specific site studies in highly critical areas may benefit from the increased accuracy that may be achieved through a ground survey.

[39] (Kerr Wood Leidal Associates Ltd. 2011)
[40] (Kerr Wood Leidal Associates Ltd. 2011)
[41] (Birch Hill GeoSolutions 2008)

Ground surveys are also required to establish ground and floodproofing elevations at a specific site where the FCL has been derived from a floodplain map. Floodplain map topography should not be relied upon for establishing specific building elevations[42].

An engineering analysis is 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[43]. Hazard maps typically show the physical boundaries of areas and what the hazard risks are based on a risk analysis factors such as a design flood. With SLR, hazard mapping will not only need to incorporate the increase in water levels, but the effects of storm surges and wind. These will vary depending on the local climatic conditions.

In Atlantic Canada areas at risk due to sea ice must also be documented as a coastal hazard. In recent years there has been a lack of sea ice during the winter months in several coastal areas of Atlantic Canada. 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” in recent years as they have observed significant damage to the park shoreline and dune systems after storm surges during winter months.

APPLICATION

The primary applications of coastal hazard mapping are to identify areas at risk due to the adverse effects of SLR, 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 is also a key element of public education aimed at increasing stakeholder awareness of areas at risk. As such, this approach could be applied to all coastal areas at risk of coastal hazards, irrespective of the other adaptation tools implemented.

Flood hazard mapping has been undertaken throughout Canada since the federal government initiated the Flood Damage Reduction Program in 1975. Under this program, the first priority was to create floodplain maps on a 50/50 cost shared basis with the provinces. The minimum specification for flood hazard maps was to identify areas subject to a design flood no lower than a 1 in 100 year event. B.C. adopted a design flood standard of 1 in 200 years, except on the Fraser River, where the 1984 flood of record was used, Atlantic Canada and Quebec adapted a flood standard of 1 in 100 years. This resulted in flood hazard mapping for over 700 communities in the six provinces in the study area, of which a large majority were in Quebec.

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[42] (Kerr Wood Leidal Associates Ltd. 2011)
[43] www.dfo-mpo.gc.ca

Upgrading the flood hazard maps on the basis of detailed research and sound science allowed local authorities to make regulatory changes that would stand up to legal challenge by property owners. Related applications for flood hazard mapping include site specific flood damage reduction studies, the relocation of infrastructure away from flood prone areas and the creation of brochures to better inform the public about areas at risk. Mapping under this program was completed by 2000.

The focus of current federal-provincial programs in B.C. is infrastructure upgrading, mainly dike upgrading and related infrastructure including pump stations, floodboxes, and other structural protection such as riprap. Current funding does not cover updated hazard mapping or hydraulic analysis, although this has been included as a secondary component in some projects. A strong case can be made for updated flood hazard mapping for coastal communities given SLR projections.

In Atlantic Canada under the Atlantic RAC project, digital elevation mapping has been completed for some coastal areas of Nova Scotia, including the Chignecto Isthmus, where an evaluation of flood risk to infrastructure was undertaken. This project included Canadian National Rail, whose main railroad line connecting Nova Scotia and New Brunswick runs through the Tantramar Marshlands area. The Province of New Brunswick maintains a coastal erosion database, which presents the 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.). These data are used to determine appropriate setbacks when new developments are being assessed in coastal areas.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR [44]

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. New mapping will help to reduce future coastal hazard risk and facilitate sustainable development. In order for this to occur, the consideration of hazard maps must be integrated into planning procedures and periodically updated.	In itself, new coastal hazard mapping will not cause a reduction in risk nor address SLR. 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 will help in the planning of more effective emergency response plans. It is essential that certain infrastructure, such as electricity supplies, sewage treatment, etc., 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 so they can continue to serve during an extreme event. 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.

[44] Adapted from (Linham and Nicholls n.d.)

Advantages	Disadvantages
Coastal hazard mapping can quantify what is at risk to (such as the number of houses or businesses). This can assist the development of risk management and will allow communities to prioritize areas for protect, accommodate, retreat or avoid strategies.	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 should promote greater awareness of the risks of SLR. 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.

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

Economic criteria include:

- 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
- Historic 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 if not currently in place
- Cost of adding a coastal hazard layer or updating hazard information

ENVIRONMENTAL

Coastal hazard mapping may include environmental data such as coastal habitats at risk or sensitive ecosystems. If structural protection is not selected and implemented, the habitat of these environmental areas may change over time due to increasing inundation. The groundwater may also change from freshwater to brackish to saltwater. Mapping identifies the infrastructure and communities subject to coastal risk. Mapping can also include coastal habitats or sensitive ecosystems at risk due to SLR.

SOCIAL

Social criteria include the identification of housing, roads, underground services, and community resources subject to coastal hazards. More informed decisions about growth management, emergency planning, and undertaking public education are three key social outcomes that typically result from the use of hazard mapping.

A lack of public understanding about the benefits of such mapping may provide a barrier to the use of hazard mapping. If the public 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 mapping can be used for a wide variety of applications. The connection to a GIS data system enables the detailed calculation of land areas, property values and building values as well as the identification of strategic assets. Not only can economic calculations be made from these, but they also provide the basis for better understanding the social and environmental considerations affecting vulnerable areas. Both current conditions and various sea level rise scenarios can now be modelled. Some aspects of coastal hazard mapping may be difficult to undertake at the community level due to the need for complex numerical modelling for the forecast of extreme water levels, storm surges and wave heights. The required expertise and modelling capacity may not be locally available, especially in smaller local governments. Coastal hazards associated with SLR do not respect jurisdictional boundaries. As a result, the opportunity to work collaboratively at a regional scale and with other stakeholders should be pursued. Provincial and federal government support in conducting and funding research would continue a long-standing tradition.

BOX 2 - EXAMPLE OF COASTAL FLOOD HAZARD MAPPING FROM HALIFAX REGIONAL MUNICIPALITY

HRM COASTAL HAZARD MAPPING

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, Open File, 6346, 2009. This report includes an understanding of present and future sea level rise (SLR), vertical land motion, extreme water levels (combined tide and surge), harbour seiche and wave run-up.

RISK MANAGEMENT

TOOL DESCRIPTION

Risk management has two components. The first involves the identification, assessment, measurement, and prioritization of risks from SLR. The second involves the response in the form of selecting the most appropriate adaption tools and strategy. Coastal hazards due to sea level rise may include the risk of a major disaster such as a dike failure. They may also include gradual changes such as increasing salinisation of groundwater.

A risk assessment may have aspects that affect people, the environment and the economy. 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. The setting of priorities reflects the importance of the coastal hazard and leads to a discussion on how those risks should be managed.

There is an expectation in Canada that government should manage all risks. The reality is that we have little, if any, control over sea level rise. As a result, the focus of this Primer is on adaptation measures.

APPLICATION

One aspect of risk management is determining how much risk a community is prepared to accept. When the 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. B.C.'s risk analysis led to higher risk management requirements in the form of flood hazard mapping and as a result required the construction of dikes to withstand a 1 in 200 year flood. Atlantic Canada and Quebec also undertook similar flood hazard mapping to identify areas subject to a 1 in 100 year flood. A 1 in 100 year standard is also used by the Federal Emergency Management Agency (FEMA) in the U.S.A. as well as in many European countries.

In 1972, B.C. began the non-structural management of floodplains following severe flooding in Kamloops that overtopped some area dikes. The purpose of the program initiative was to avoid total reliance on dikes by better managing development on floodplains and requiring the floodproofing of buildings. The objective was to better manage risk by providing protection even in the event of a dike failure. This approach was implemented in stages, since historic settlements were exempted from these requirements. In 2003 and 2004, legislative changes gave more responsibility to local governments, and historic settlements were included in floodproofing requirements.

Sea level rise has been identified as a risk for at least two decades. The assessment of the risk due to SLR has 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. Measurement indicators show a generally accelerating rate of change. The anticipation of a 1.0 m rise in sea level by the year 2100 represents the best available assessment of increasing risk by coastal provinces and the Government of Canada. Numerous other countries have come to a similar conclusion. As noted previously, however, considerable regional variation will take place (see Historical Changes page 3). Furthermore, the literature on climate change is developing very rapidly, and this may well affect long range projections of SLR.

In order to manage this increasing risk, higher FCLs will be required. It is now apparent that, because of the related consequences of climate change, including increased wind activity and wave run-up, a 1.0 m SLR cannot be adequately managed with a 1.0 m rise in dike elevations. Also, increasing the vertical elevation of a dike will require widening its horizontal base. As a result, studies of localized conditions will be needed before a more accurate assessment of risks can be made and before more precise adaptation responses are undertaken.

The anticipated management response from communities is that increased protection measures will be required in the future just to maintain the same level of protection (i.e., 1:100 years or 1:200 years) that has been historically provided. 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. An impact assessment can also be used to measure the effectiveness of various adaptation tools.

The use of insurance has been an important element risk management in other countries; however it has very limited application in Canada. This issue is discussed separately in this Primer.

ENABLING LEGISLATION

A risk management assessment, like the information gathering discussed earlier (see Information Gathering, page 25), does not require specific enabling legislation. However, it can occur in the preparation of an Official Community Plan or other planning process as authorized by provincial legislation. Examples of risk management include requiring large residential setbacks from oil storage areas or chemical plants, or an engineering report addressing the conditions necessary for the safe use of buildings in areas subject to rock fall or landslide hazards. Risk management is also undertaken as part of emergency planning and preparedness through the Emergency Management Act.

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.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
A long-term perspective is needed where major linear structures are involved. Given increasing risk over time due to SLR, this may affect the selection of the most appropriate approach to coastal hazards.	There is a significant cost to undertaking cost-benefit and other analytical studies. However, the cost must be measured against the risk and may represent a small cost for a large project or where the stakes are high.
Risk management can involve a rigorous analytic approach, including cost benefit analysis, but can be undertaken without specialized expertise.	
Risk management can be an essential tool to help determine the most appropriate response to coastal hazards.	

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

Risk management involves a rigorous process in comparing and selecting the most appropriate tools and strategy to be used. It can also include an assessment of the cost of "doing nothing." Land and buildings are generally easily measurable values and can easily be compared. 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.

In the case of adaptation to SLR, the costs and benefits of any potential adaptation option should be calculated – the benefits being the damages avoided and the costs being the full list of costs associated with implementing the adaptation tool. 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 is primarily used for social and economic criteria. However, risk management can also address environmental assets and species at risk due to SLR. The protection of wetlands is of particular importance due to historic losses, as are intertidal areas, due to their high productivity.

SOCIAL

Social criteria include determining the level of acceptable risk, what community assets will be protected, 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 New Orleans demonstrated the extreme vulnerability of persons lacking mobility, particularly those with low income and the residents of nursing homes.

IMPLEMENTATION MEASURES AND CHALLENGES

The implementation of risk management involves assessing risks, determining what level of risk is acceptable and managing that risk. The ultimate decision will depend on the overall strategy and which tool or combination of tools will most effectively allow the risk to be managed 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.

EMERGENCY PLANNING AND PREPAREDNESS

TOOL DESCRIPTION

Emergency planning and preparedness refers to measures undertaken in advance of a disaster. Emergency and post-disaster management refer to measures undertaken during and after a disaster and are discussed separately following the discussion of adaptation tools (see Emergency Management, page 111).

Coastal flooding can have a variety of consequences, including property damage, damage to or destruction of property contents, economic losses due to severed transportation links and other damaged infrastructure, loss of land due to erosion, business disruption in the affected area, population/community displacement, health and safety hazards and even death. Emergency planning and preparedness constitutes a vital tool for managing flood hazards.

APPLICATION

In 1999, the B.C. Water Management Branch and the Provincial Emergency Program (PEP) published the Flood Planning and Response Guide for British Columbia, to assist local authorities and diking authorities to prepare a flood response plan to guide activities during flood events[45]. This document includes sections on flood prevention, flood damage prevention, the preparation and implementation of a flood response plan and post flood management. It also contains descriptions of the types of floods and other natural hazards that occur in B.C. In the coastal context, it associates a high likelihood of flooding with a storm with excessive wind, an extreme tide with wind, a tsunami caused by an earthquake or submarine slide, a large wave generated by a landslide and failure of sea dikes. Under the Emergency Program Act in B.C., emergency planning applies to local authorities, which consist of local municipalities, the electoral areas of regional districts and the Park Superintendent of a National Park (if an agreement has been made between Canada and the Province). 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 supports local authorities to a certain level 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

[45] 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.

- 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 the readiness of the Emergency Operations Centre of each local authority, flood responses (flood alert, flood evacuation order and all clear when the threat of flooding has past) and recovery/disaster financial assistance. These later phases are critically important but are not considered part of the Primer toolkit.

Emergency planning and preparedness requirements also apply in other provinces. 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[46]. Similar provisions are in place in New Brunswick and Prince Edward Island.

In cases where a state of emergency exists, the Atlantic provinces can implement measures under acts such as the P.E.I. Emergency Measures Act so that action can be taken to protect public safety. The Atlantic provinces also have provincial emergency measures plans, and many local municipalities have emergency management plans to protect public safety in the event of floods and other disasters. The P.E.I. Office of Public Safety is willing to assist communities in upgrading their existing emergency response plans in the following ways:

- The 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 Public Safety Officer is available to speak to community council members on Municipal Emergency Management, or to conduct a community presentation on Personal Preparedness
- The 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
- The Guide to Business Continuity Planning (developed by the Government of Canada, Office of Critical Infrastructure Protection and Emergency Preparedness) assists local businesses in developing strategies to deliver and resume their services, during and after an emergency, respectively
- Crisis Communication Planning would assist local communities and businesses in outlining and delegating responsibilities in the event of a crisis, and how to communicate with clients and the public

[46] (Birch Hill GeoSolutions 2008)

- Emergency Management Training Planning is offered to individuals and organizations that have a role to play in an emergency. Training is offered in Basic Emergency Management, Incident Command System, Emergency Operations Centre Management, Exercise Design and Emergency Public Information

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
Local governments have the authority to prepare emergency management plans for a wide range of risks. SLR 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 SLR.	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.	

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

Economic criteria include the cost and resources for 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[47].

Since 1970, the federal government has administered the Joint Emergency Preparedness Program (JEPP), designed to assist local governments in the development of disaster preparedness projects through funds provided to provincial and territorial governments. This program provides financial assistance of up to 75% of a specific project to a maximum of $3,000,000, and has focused specifically on increasing local government emergency response capability. It is noted that federal contributions for emergency preparedness projects under the Joint Emergency Preparedness Program will end in 2013 as will federal funding provided under JEPP for urban search and rescue and for critical infrastructure initiatives.

ENVIRONMENTAL

This tool is not designed to address environmental issues.

[47] (Birch Hill GeoSolutions 2008)

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.

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.

IMPLEMENTATION MEASURES AND CHALLENGES

Implementation is required for each local government under the B.C. Emergency Program Act. Challenges include the securing adequate resources, updating plans and undertaking disaster simulation exercises. The preparation, updating, training, and testing of emergency plans should ensure that all plans are in place. However there may be some reluctance or tardiness in carrying out some of the maintenance, training and testing functions. Staff training of 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.

REGULATORY TOOLS

SUBDIVISION REGULATION

TOOL DESCRIPTION

Subdivision regulation of coastal land at risk is an important growth management tool. This tool can be used to prevent or establish conditions for the subdivision of land at risk from coastal hazards associated with SLR. 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 fee simple property, bare land strata lot, or a 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 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 also be the Chief Administrative Officer or a person contracted to undertake that responsibility. In non-municipal areas, the Approving Officer is, in almost all instances, 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. These three criteria cover the widest possible range of conditions applicable to coastal hazards associated with sea level rise.

Section 86 also allows the Approving Officer (as a condition of consent to an application for subdivision approval) to require a report by a qualified professional that the land may be used safely for the use intended. A covenant is then entered into under Section 219 of the Land Title Act and the report is registered as a charge on title if any parcels created by the subdivision are, or could reasonably be expected to be, subject to hazards such as flooding or erosion.

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 in Nova Scotia. Municipalities and non-incorporated areas must also comply with the provisions of the Environment Act.

In P.E.I., the Environmental Protection Act requires an environmental impact assessment for undertakings which can have a significant effect on the environment including an effect on any unique, rare or endangered feature of the environment, or which cause a public concern. This legislation has broad applications 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. Subdivision applications are reviewed under 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.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
Local government has 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.
Where the nature and extent of the risk has not been determined, the Approving Officer can withhold subdivision approval pending a report from a professional engineer or geoscientist experienced in geotechnical engineering.	Without the identification of potential coastal hazard areas, particularly areas at risk of flooding and erosion, it is difficult for the approving body to decline subdivision on the grounds of safety.
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 a subdivision.	Subdivision approval is discretionary; however, the matters that can be considered by an Approving Officer (s. 85-87 of the Land Title Act) are clearly specified in the legislation. The legislation also provides for an appeal to the Supreme Court (s. 89) for an aggrieved property owner (B.C. only).
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.	
This tool allows the conditions of future development to be regulated.	

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, or the cost of accommodation by adapting to the risk. These economic costs are generally borne by the property owner or developer. In the event of a flood, or if the risk increases and increased structural protection is required due to SLR, these costs may be incurred mainly by local and senior governments.

ENVIRONMENTAL

Environmental considerations involve the effect on the natural environment of the subdivision in the context of 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

Social considerations involve how the public interest is affected by the approval or refusal to approve a subdivision. The Official Community Plan or a similar guiding document should provide guidance as to the suitability of subdivision development, particularly for residential use.

IMPLEMENTATION MEASURES AND CHALLENGES

This tool relies heavily on accurate information resources and coastal hazard mapping to give grounds for the approval or refusal of a subdivision. Implementation measures require the exercise of authority of an Approving Officer or similar designate with discretion to allow or refuse the subdivision of land at risk from coastal hazards. Any subdivision development will need to comply with the Official Community Plan. A lack of current information resources may pose a challenge.

BUILDING REGULATION

TOOL DESCRIPTION

This tool refers to the ability of a building inspector or other appointed local government representative to ensure that a building can be safely used for its intended purpose. The regulation of building construction in Canada generally follows the National Building Code, with provincial variations and local additions where applicable.

APPLICATION

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

ENABLING LEGISLATION

Under the terms of the Constitution Act, building regulation in Canada is the responsibility of provincial and territorial governments. The National Research Council of Canada established the Canadian Commission on Building and Fires Codes, which is responsible for the Model National Building Code. Most provinces and territories have adopted the Model National Building Code or adapted it with variations and additions. While the Building Code does not have specific design requirements to protect buildings from coastal hazards, local building bylaws can include this additional requirement.

Although not all local governments in British Columbia have chosen to regulate building construction, the B.C. Building Code applies throughout the province whether or not a local building bylaw has been adopted. The City of Vancouver has its own enabling legislation from the Province of B.C. called the Vancouver Charter. The Vancouver Building Bylaw is based on the B.C. Building Code, with local amendments. This includes the regulation of buildings on lands subject to flooding by minimum flood construction levels (FCL), the specification of construction materials, and service equipment installation, and a covenant on title acknowledging the risk of flood damage. Although rarely used, adding floodproofing provisions to the B.C. Building Code by bylaw is one way this tool can be used to regulate building construction in an area subject to flood hazard, including coastal areas.

The B.C. Community Charter provides a second way that building regulation can be undertaken to address flood or other hazards. Under section 56 of this Act, a municipal building inspector is authorized to withhold the issuance of a building permit until satisfied the land can be safely used for its intended purpose. Under section 56, a building inspector can require a geotechnical report if it is considered that construction would be on land that is subject to or is likely to be subject to hazards such as flooding or erosion. Such a geotechnical report must be prepared and certified by a qualified professional stating that land may safely be used for the purpose intended (e.g., a residential building).

The Community Charter specifies that a qualified professional must be: 1) a professional engineer, or 2) a professional geoscientist with experience or training in geotechnical study and geohazard assessments. A building permit cannot be issued until such a report is completed and the owner enters into a covenant with the local government to meet the conditions specified in the professional's report. The owner must agree to a covenant on title that the land will only be used in the manner certified by the qualified professional. This same authority applies to regional districts under section 695 of the Local Government Act.

In Quebec there is currently no existing provincial regulation with respect to how local authorities deal with zoning bylaws, home-owner building permits or subdivision in the context of SLR. In general, the provincial government does not want to force local authorities' compliance on such matters. The province creates 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 regulation to implement the measures in the *Schéma*. There is, however, no forced compliance from one level to the next. The province develops policies and makes recommendations they hope the local authorities (cities) and regional authorities (RCMs) will adopt, but there is no obligation for the time being. 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, S 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. Two of these have been formed.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
The key advantage of this tool is its ability to withhold building permit approval until the hazard risk has been addressed.	The application of this tool comes very 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.	Reliance on a qualified professional introduces the risk of retaining a person who lacks the necessary skills. This is not considered a high risk but has been cited by local government officials as an area of concern[48]. Self-regulating professions are very conscious of their responsibility. In B.C. for example, the Association of Professional Engineers and Geoscientists is preparing guidelines for qualified professionals working to mitigate flood risks and adapt to sea level rise.

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

Building regulation as an adaptation tool has two primary purposes: the protection of property and public safety. The use of this tool will require a qualified professional to take responsibility in ensuring that the construction of a building meets provincial guidelines and local bylaws with respect to coastal hazard management. The cost for the use of this tool is 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. Costs for qualified professional services are highly variable depending on the site-specific circumstances but will be the responsibility of the individual property owner. Similarly, the cost for the implementation of protective measures could vary from zero to completely unfeasible. 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 is excessive.

The imposition of this tool on a property owner, in particular the cost of retaining a qualified professional is considered reasonable, as the consequences of constructing an unsafe building are not acceptable.

[48] Results from a survey undertaken in B.C. by the Fraser Basin Council following 2003 legislative changes concerning flood hazard management.

ENVIRONMENTAL

Building regulations as an adaptation tool only address identified hazards including natural hazards such as erosion and flooding. The successful implementation of building regulations relies on the proactive identification of areas at risk from the impacts of sea level rise.

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

No implementation measures are required as the Community Charter and Local Government Act authorize the local governments 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. Local government approval is not required for the building inspector to exercise this authority, which includes issuing or withholding a Building Permit. Unfortunately there is 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 jurisdictions, local government has chosen not to undertake a building inspection function. If there is no building inspector and no regulation of building activity, this regulatory tool will not be available.

The lack of provincial standards that can be applied to local conditions presents a challenge in some Atlantic Canada jurisdictions. However, compliance with the Building Code may be reinforced by mortgage and house insurance requirements. There is a requirement to obtain a building permit under provincial planning legislation prior to construction in all four Atlantic provinces. For example, in Prince Edward Island, each lot on a proposed subdivision plan must be categorized in accordance with one of five site suitability standards, including soil permeability, depth to water table and depth to bedrock. This is done to determine the type of servicing required and the minimum size required for a lot. All subdivision plans in P.E.I. must also include a storm water management plan (S27, P.E.I. Planning Act, Subdivision and Development Regulations) which is acceptable to the Minister responsible for the Environmental Protection Act.

REGULATION OF LAND USE

TOOL DESCRIPTION

Land use can be regulated through the establishment of appropriate zoning within areas subject to or potentially subject to coastal hazards. Zoning regulation can include a wide range of considerations including different land uses, land use densities, setbacks, siting circumstances and servicing standards in different areas of a local government jurisdiction. Zoning is the most commonly used form of land use regulation but, whether direct or indirect, it can occur in other forms including neighbourhood plans, character guidelines, capital works plans, strategic plans, and growth management plans.

APPLICATION

Zoning is a tool available in all provinces, although the specific scope of zoning ranges from jurisdiction to jurisdiction. The three key elements of land use regulation pertaining to SLR and coastal hazards in general consist of minimum building setbacks from coastal hazards or structural protection from coastal hazards, minimum elevation of buildings in relation to flood risk, and type of land use. This tool could also be used to create a new composite zone, such as a Sea Level Rise Planning Area, with respect to adaptive measures for coastal areas at risk.

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.

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 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.

In B.C., provincial guidelines call for new construction consisting of habitable space to be located above the 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). This provides a strong direction to local governments, mindful of liability risk. While the role of provincial guidelines is unique to B.C., 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 rates 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 at the municipal level. To date, only the RCMs of Sept-Rivières, Manicouagan, and Haute-Côte-Nord, all located in the Côte-Nord region, have adopted regulations stemming from the inter-ministerial report recommendations. In 2011, the same inter-ministerial group proposed a uniform 30-metre setback for all other coastal communities in Québec (outside the Côte-Nord region). 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. This research is currently underway.

Based on the research of erosion rates in the Côte-Nord region of Quebec, the Province has required RCMs there to adopt regulations related to new construction, but there is no provincial policy. For the most part, the Province prefers to avoid imposing legislation that is not supported or understood by the municipalities responsible for implementation[49]. Precise maps have not yet been developed for the regions of Bas-Saint Laurent and Gaspésie on the south shore of the Gulf of St. Lawrence, and consequently no new regulation regarding adaptation to erosion has yet been adopted in these areas, except in the municipality of Îles-de-la-Madeleine, one of the most vulnerable areas of Quebec. There, zoning regulations adopted in 2010 increased the setback to 15 to 30 metres.

As a result of public consultation and multi-stakeholder research on SLR in Îles-de-la-Madeleine, undertaken by the Ouranos Consortium, and despite the area not having the same detailed erosion maps as were done for the Côte-Nord, the municipality changed the zoning. Updated and more specific maps on erosion and subsidence rates will be published by UQAR, and this is expected to have a significant impact on the setback rules currently being implemented in the new regulation, and will likely result in an amendment to the current setback lines.

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.

[49] (Morneau 2012)

PHOTO 8 - 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[50].

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.

In Newfoundland and Labrador, land use planning is the responsibility of the provincial, federal, municipal, Innu Nation and Nunatsiavut governments, as well as private land owners. The largest land holder is the provincial government. Three provincial departments share responsibility for land use regulation. 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 is responsible for the protection of the environment and the

[50] (Province of Nova Scotia 2009)

allocation of Crown land resources and is the lead agency responsible for climate change policy. This Department also 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 of Environment and Conservation's Policy for Development in Shore Water Zones establishes criteria for issuing permits under the Water Resources Act for all development activities in and affecting shore water zones[51]. 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. In marine situations, the high water level of a water body (1:100 year return period) must allow for maximum waves, wind setup, storm surge and ultimate mean sea levels under global climatic forecasts for a 1:100 year design. Written permission is required for a number of activities including the removal of surface vegetation, construction, expansion activities related to marinas, boathouses, jetties, wharves, moorings, and other docking facilities. The third department, Natural Resources, is responsible for supporting and ensuring access to mineral resources.

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. There is an allowance in the Lands Act for a reduction to 10 metres for residential lots. Some older land grants and some squatters' rights claims are exempt from the shoreline buffer requirement. There is an interdepartmental Land Use Committee, which deals with large scale land use developments. All Crown land inside a municipality is still covered by the provincial rules. Some municipalities do have development guidelines that restrict what can happen in the buffer zone but the ownership of the buffer zone remains with the Province.

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. The regional planning authority for Corner Brook – Humber Valley has included climate change adaptation as one of the issues to consider in their planning process.[52]

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

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 cannot 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.

[51] 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.
[52] See draft Humber Valley Regional Land Use Plan 2011-12.

Advantages	Disadvantages
Zoning gives a local government great flexibility in addressing different conditions and needs within its physical boundaries.	Technical requirements 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.	

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

Zoning by its nature confers development rights, which have different values for different zones and for different areas. While zoning has significant economic implications, zoning change is addressed in terms of the public interest, for example, meeting changing community needs and managing competing interests and managing conflict.

ENVIRONMENTAL

Environmental criteria include the identification and zoning of environmentally sensitive areas and managing environmental hazards.

SOCIAL

Social criteria include growth management and zoning to accommodate future population needs, 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 education and acceptance could also pose challenges.

In Quebec, the provincial setback lines vary according to available data on erosion rates. In areas with detailed data, such as the Côte-Nord, the setback line was established using a 100 year projected timeline. That is, if the area is experiencing three metres of erosion on average per year, the projection of erosion over 100 years is 300 metres, plus a 15 metre buffer zone, for a setback of 315 metres. This is somewhat in conflict with what the inter-ministerial research team (which conducted the erosion study in 2000 - 2004) had suggested to municipalities at the time, which was to establish setbacks using a 25 year projection. In the same case of an average three

metres of erosion per year over 25 years, the result would be 75 metres, plus the 15 metre buffer for a setback of 90 metres. The challenges experienced here involve residents who were willing to relocate outside the municipality's setback zone, but not the Province's, for various reasons. In areas where the municipal regulation does not allow for reconstruction, potential grounds for legal challenges surface, given the conflicting standards.

DEVELOPMENT PERMIT

TOOL DESCRIPTION

A Development Permit is a form of land use regulation with terminology distinctive to B.C. It is identified separately because it combines policy objectives and guidelines with site specific regulation. A Development Permit can be used to 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 agreement 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.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

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 DPA should provide a clear indication of the objectives applicable to a specific area within a local government's jurisdiction.	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 use of a Development Permit provides for the use of an independent professional to address risk (i.e., professional engineer with relevant expertise) at the applicant's expense.	It should be noted that DPA 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 scope of development applicable to a hazard is very broad, as it includes a subdivision, building construction (whether or not a building permit is required) and alteration of land (e.g., re-grading, soil removal or soil deposition).	
In B.C. 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.	

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 requires a public approval process and each Development Permit requires public notice.

IMPLEMENTATION MEASURES AND CHALLENGES

Implementation measures require an amendment to the Official Community Plan or zoning bylaw to comply with the DPA requirements. This includes an amending bylaw and public hearing. Once a DPA is in place, Development Permit approval requires a public notice and a resolution of approval from the local government. Challenges include the need to prepare background studies of hazards and environmentally sensitive areas as the basis for DPAs and the administrative procedures to implement the process.

LAND USE CHANGE OR RESTRICTION TOOLS

LAND ACQUISITION

TOOL DESCRIPTION

Local government 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) and related requirements, including vehicular access and setbacks for public safety. Land acquisition can also be done to prevent the development or to hold it in public ownership for exclusive public use, for example, environmental protection purposes.

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. Where structural protection is to be provided above the natural boundary or high water mark and the land is not in public ownership, land purchase typically takes place.

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

Land acquisition may occur through negotiation and purchase, but expropriation is also an option. Expropriation is governed by federal or provincial statutes (e.g., Expropriation Act for Government of Canada, B.C., N.S., P.E.I., N.B., An Act Relating to Expropriation, Urban and Rural Planning Act for N.L.), which may be also delegated to local governments, Crown corporations and other public bodies such as diking authorities. Where expropriation is used, the owner is entitled to "be made whole" by compensation for the market value of the expropriated property, injurious affection to the remainder of the property (if any), disturbance damages, and business loss.

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

ENABLING LEGISLATION

In B.C., section 8 of the Community Charter grants a municipality the fundamental powers of a natural person. A municipality is also authorized to expropriate property in accordance with the Expropriation Act under section 31 of the Community Charter.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
This can be an important tool for implementing linear protection measures where existing land ownership boundaries do not allow a cost effective configuration for shoreline management.	Disadvantages may include a high purchase cost, as this tool is primarily used to protect urban development and may include the cost of acquiring and demolishing existing building improvements. This would typically apply to the acquisition of highly valued coastal property, which is in finite supply.
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 resources. Both local governments and senior governments may be reluctant to set aside funds for land acquisition purposes unless it is part of a capital improvement project.
Where necessary, expropriation will enable property acquisition if a voluntary purchase is not possible.	Expropriation has the disadvantage that price is not controlled by the acquiring agency.
Land purchase could also be the 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 generally 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.

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

Land acquisition is potentially expensive and has 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

Social considerations may include the acquisition of private land necessary to protect the public interest. This may involve the acquisition of land necessary to expand a linear corridor (e.g., dike or seawall). Other social considerations may include the acquisition of public open space, archaeological sites and public access along a dike.

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. For a local government, implementation would occur by bylaw. Strategic or Official Community Plans may identify properties needed for future land acquisition and, if so, make provision for funding the required acquisition.

BOX 3 - EXAMPLE OF LAND ACQUISITION FROM BAS ST. LAURENT, QUEBEC

LAND ACQUISITION

In 2010 in the Bas St. Laurent of Quebec, 100 homes were destroyed due to a storm event which eroded 7 metres of shoreline. In response the province 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.

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 is used to offer protection for sensitive coastal resources and remove it from hazard areas. The tool is used to 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 used 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. It is important that the areas suitable for additional density should not be implemented in the zoning bylaw (i.e., rezoned in advance) as that would preclude the need for property owners to acquire additional density.

Density transfer could also occur by setting up 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 SLR. The transfer of development potential is a market-oriented tool, but it requires organization and management by a local government. The use of incentives and the value of the development potential should be market-based.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

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.

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 would be restricted and the reduced value transferred to areas suitable for increased density. A market-based mechanism would be 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, its success would need to form an integral part of growth management including active involvement and administrative support from 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 has 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.

EASEMENT, COVENANT OR OTHER RESTRICTIONS

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. This 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.

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.[53]

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.

[53] 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).

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 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[54].

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 2001Conservation 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

[54] (Atkins, Hillyer and Kwasniak 2004)

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[55]. 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.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

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.	

[55] (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 of the local government for 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.

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 based 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 TLC Land Conservancy 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, enhancements such as coastal wetland and sand dune creation, or rehabilitation.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
Land trusts have a primary focus on environmental protection and enhancement. While local governments have extensive parks and recreation programs, environmental protection is rarely a primary objective, particularly if human access and property rights are being restricted.	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.	

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.

PHOTO 9 - ENGLISHMAN RIVER ESTUARY ON VANCOUVER ISLAND, B.C. 76.7 HECTARE ACQUISITION BY THE NATURE TRUST OF B.C. (PHOTO CREDIT: NATURE TRUST OF B.C.)

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 has been put in place. Challenges include obtaining the resources to acquire, restore, and manage environmentally significant lands. Time constraints may also apply.

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.[56] 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. Fee simple ownership of foreshore areas by a local government should not be considered an option although some fee simple water lots do exist (e.g., pre-Confederation lots in New Westminster). In B.C., no fee simple ownership for land covered by water will now be approved.

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.

Foreshore leases have widespread applications and are typically used for marinas, docks, log storage, aquaculture and water-based industrial uses. In a few instances, the local government will partner with the Crown to take over the administration and management of foreshore areas, including issues relating to trespass. This is termed a head lease. Under this arrangement the local government is granted long-term tenure over a foreshore

[56] 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.”

area with a revenue-sharing arrangement with the Crown. In return the head lease transfers all responsibility for management and environmental issues to the local government.

BOX 4 - EXAMPLE OF FORESHORE TENURE FROM WEST VANCOUVER, BC

WEST VANCOUVER HEAD LEASE

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. The current 30 year head lease expires in June 2013. A 30 year replacement lease is being undertaken under Section 175(2) of the Community Charter and Section 6 of the Municipal Liabilities Regulation.
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 10 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 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. Dept. 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, S 7, provides for a reservation of shoreline on Crown lands that border on 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.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

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).
A foreshore lease works in conjunction with zoning.	Foreshore leases are not typically used for SLR adaptation.
	The applicability of this tool will be limited to areas with suitable shoreline conditions and bathymetry.
	With a head lease, the local government would be required to assume responsibility for all management including environmental issues.

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 B.C., foreshore leases have typically been used for marine facilities associated with upland development. One challenge will be to refocus this tool as part of an SLR 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 the successful implementation of a head lease (see Box 4 - Example of Foreshore Tenure from West Vancouver, BC, page 74), which it originally entered into in order to protect the pristine nature of the coastline and to have the ability to decline dock applications. The District has worked in co-operation with upland owners and has not detrimentally affected fish habitat. In addition, the foreshore lease does not affect any federally controlled waterways such as shipping channels for the Port of Vancouver or B.C. Ferries routes.

PHOTO 10 - WEST VANCOUVER, B.C. SEAWALL

STRUCTURAL (FLOOD PROTECTION WORKS)

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.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
This tool is used to provide a barrier to protect the foundation of a building or other structure from wave action or other form of rapidly moving water. If the foundation of a building is not protected, the building will not be protected.	Costs can be significant and include designing, transporting, installing and maintaining erosion/scour protection. A related cost is pedestrian access such as additional steps and wheelchair accessible ramps.
The presence of erosion/scour protection provides awareness and a vivid and constant public reminder to passers-by that the site is subject to flooding or inundation risks and that mitigation 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.

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

The main economic consideration for this tool is the cost of the erosion protection measures. For a scour apron, this will typically include 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 also has application for a sheet pile retaining wall for a linear corridor in order to prevent the toe of the structure from being undermined. For a submerged structure such as a pipeline, a scour blanket will typically consist of armouring consisting of filter stone around and cover stone above and around the structure to be protected. Costs will vary depending on site specific circumstances.

ENVIRONMENTAL

Scour protection primarily addresses the protection of building foundations and linear structure foundations. Environmental criteria will be limited if the scour protection is site-specific to a building, particularly through infill development. The scope of environmental considerations may increase if the erosion protection applies to a linear corridor such a seawall, a storm water or sewage outfall or a pipeline crossing. While intertidal areas are typically associated with high environmental values, the protective measures will often result in some reduction or loss of environmental quality in order to protect the linear corridor.

SOCIAL

This tool is intended to minimize risk to the foundations of buildings and structures. If the risk to a building is reduced, so will the risk to inhabitants or employees.

IMPLEMENTATION MEASURES AND CHALLENGES

Implementation typically occurs following an engineering analysis of risk and appropriate mitigation to reduce the risk to an acceptable level. 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 of 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 for protection measures are not requested. If there are no gatekeepers responsible for public protection, the risk to a specific building or 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 risk associated with not providing scour protection in an area subject to flooding and sea level rise.

STRUCTURAL ELEVATION

TOOL DESCRIPTION

Structural elevation can be achieved in several ways including: raising the ground level below a building with the placement of fill; raising the 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 approach may also be described as super elevation or dry floodproofing.

APPLICATION

This tool can reduce the damage to buildings, infrastructure and land at risk of inundation by raising their elevation. The increase in elevation above the natural ground level is determined by a risk assessment by a qualified professional or as determined 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 take the form of creating non-habitable space (crawl space or cellar) for the elevation subject to the flood hazard. 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 to do structural elevation comes from 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 provincial guidelines, which take sea level rise and related impacts such as wave run-up into account.

The application of this tool 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 for sea level rise, storm surge, wave action in coastal areas is for 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.

One exception to this 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. In the Town of Shediac and the Beaubassin-est Rural Community, N.B., the minimum elevation of the habitable part of all dwellings must be 4.3m (CGVD28). This reduces the risk factor for exposure to floods from storm surges and other high water events.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
One indirect impact of structural elevation in established communities, particularly for infill development, is a 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 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%[57]. Associated costs include additional steps or handicapped accessibility provisions, if applicable.
By raising the habitable floor elevation to a specified design flood event, flood damage can be measurably reduced.	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.
Structural elevation is not a permanent solution, as sea levels will continue to rise, but may last the lifetime of the building.	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.

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

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 should be raised to withstand a flood with an annual probability of 0.5% or a one in 200 year flood. Such a flood could occur two years in a row but the long run probability of this design standard is 0.5% each year. 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 will increase.

Coastal floodplain mapping is an important first step in developing a flood hazard management plan, as floodplain maps identify flood hazards(s) and can provide information on the spatial distribution of Flood Construction Levels (FCLs)[58] but can have a considerable cost attached.

The cost of structural elevation will depend 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

[57] (Arlington Group Planning + Architecture Inc. 2001)
[58] (Kerr Wood Leidal Associates Ltd. 2011)

sloped area. The amount of fill could be substantial. For a 1 metre elevation rise to accommodate a two storey building with 200 m² 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 m² of fill would be required. For a 2 metre elevation rise, the amount of fill would increase to over 500 m².

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 floodproofing reflects the additional cost of site preparation and building construction to adapt to sea level rise compared to not providing floodproofing. The cost of adding development including critical infrastructure[59] in an area at risk is another economic consideration that will increase over time. Critical infrastructure includes all the services that support development in an area subject to the risk of flooding. The cost of floodproofing can also be compared to the cost of development in an area without risk of coastal flooding or inundation.

PHOTO 11 - WATERFRONT HOUSE 3 METRES ABOVE GROUND ELEVATION ON NORTH SHORE OF KAUAI ISLAND, HI (PHOTO CREDIT GRAHAM FARSTAD)

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

ENVIRONMENTAL

This regulatory tool primarily addresses the protection of buildings and property. Environmental criteria will be limited in areas subject to infill development. 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.

SOCIAL

This tool primarily minimises risk to building inhabitants and structures themselves. Social considerations increase as the amount of structural elevation increases. For each metre of structural elevation rise, the horizontal length required will typically increase by 3 metres unless retaining walls are used. As a result, the social implications will be greatest on small infill development where a large elevation rise is required. 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 can be implemented after a building is constructed but would incur greater costs. The challenges facing structural elevation increase depending on the amount of elevation rise required and the site coverage. Cost is one but not the only consideration. A large structural elevation rise on a small property may not be feasible. The aesthetics of having elevated and non-elevated structures in same community may be a drawback if the elevation change is significant. This is partly a design issue as the use of non-habitable space on the first floor may overcome this concern.

Handicapped accessibility poses an additional challenge in order to meet the maximum rise to run requirements for a ramp in the Building Code. The structural elevation of heritage buildings also poses a particular challenge.

DIKES

TOOL DESCRIPTION

Dikes are a linear protection tool, and 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 side slope on the seaward side. The lower cross-section on the seaward side may have a vertical rise of 1 compared to a horizontal change of 5 (1V:5H), for the purpose of dissipating wave energy. This is not needed on the landward side where a gradient of 1V:2H or 1V:3H is typical. 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.

APPLICATION

Recent research, including a report by Ausenco Sandwell in 2011[60], has resulted in a re-evaluation of the vulnerability of communities to flooding due to storm surges and wave action. Due to these factors, as well an increase in sea level rise, the B.C. Government amended its Flood Hazard Area Land Use Management Guidelines in 2011. The previous requirements for a typical dike at sea level were to have a crest elevation of 3.5 metres. The current requirements call for a dike crest elevation of 8.2 metres. The primary driving factors for this increase are a combination of higher sea level rise and an increased provision for wave run-up. An increase of this magnitude has major implications of which the increase in dike height is only a part.

Assets protected by dikes can include people, infrastructure and agricultural land. 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).

It is important to recognize that, because agricultural land can tolerate some overtopping, the construction elevations and design of earthen dikes within the region provide a lesser standard for agricultural land 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 but are not financially responsible for repairs to such dikes.

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) some of which was constructed over 300 years ago. The Federal Maritime Marshland Rehabilitation Act passed in 1948 enabled federal assistance for the preservation and extension of the dikeland area. Much of the earthen infrastructure was constructed in the early 1950s; this system is currently maintained by the N.B. Department of Agriculture, Fisheries and Aquaculture.

Hard protection for shorelines must be design 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[61], which comprises three volumes: Draft Policy Discussion Paper, Sea Dike Guidelines and Guidelines for Management of Coastal Flood Hazard Land Use. There are numerous technical publications providing guidance on the engineering design.

[60] Climate Change Adaptation Guidelines for Sea Dikes and Coastal Flood Hazard Land Use, Ausenco Sandwell for B.C. Ministry of Environment, January 2011.
[61] (Ausenco Sandwell 2011)

PHOTO 12 - 2011 UPGRADE TO SEA DIKE AND OLIVER PUMP STATION RICHMOND, B.C. (PHOTO CREDIT CITY OF RICHMOND)

In B.C. approvals for 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, the Navigable Waters Protection Act, the Environmental Assessment Act and possibly others depending on the complexity of the works.

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. 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 and 1960s without any consideration for rising sea levels and climate change. This upgrading was conducted after the passing of the Federal Maritime Marshland Rehabilitation Act in 1948. In 2000, the provincial Agricultural Marshland Conservation Act was passed to protect these soils for future generations. It is thought that a number of these dikes in the Upper Bay of Fundy region could overtop during the next high Saros tide peak in 2013[62] and that a majority of the diked land is at risk from rising sea levels and storm surge. Under a joint Atlantic RAC project with New Brunswick, a GIS assessment of individual dike vulnerability in the Tantramar marshlands area

[62] 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.

is being conducted to determine new elevations and associated engineering modifications for the dikes in the area.

The Nova Scotia Department of Agriculture and Fisheries 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.

In New Brunswick dikes protecting agricultural lands have been maintained by the Province. Parts of the Town of Sackville are protected by dikes, but they are not part of the funding for dike management.

In P.E.I. permits are required under the Environmental Protection Act for any watercourse alteration, including shoreline protection systems. N.B. has similar legislation in place.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

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 or natural areas and increase 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.	

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; 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. Economic implications also include risk and vulnerability assessment due to the consequences of flooding. 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).

Economics will justify erosion and flood control only at selected locations, such as densely populated areas, and areas of high natural or cultural importance.

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 effect on the economic costs and resulting benefit-cost ratio). Given long-term implications and costs associated with increased dike structures, it is anticipated that the appeal of retreat and avoid strategies will increase over time.

ENVIRONMENTAL

Environmental implications could include the impact of 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 can impede natural shoreline migration, an adaptive response of coastal habitats to rising sea levels.

PHOTO 13 - SEA DIKE AND UPGRADED OLIVER PUMP STATION, CORPORATION OF DELTA, B.C. (PHOTO CREDIT GRAHAM FARSTAD)

SOCIAL

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, however, 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 decrease over time.

Hard protection methods have a long history of successful use, although the consequences can be very severe in the rare instance of failure, such as the Hatzic dike breach in the Lower Fraser Valley in 1948. Dikes can also provide a secure corridor, such as a road or trail, and often enhance recreation values.

Funding for dike upgrading requires large capital outlays, is typically program-based and requires approval by different levels of government. This may pose a challenge where the need 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 views are impacted.

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

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.

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 generally massive, 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.

PHOTO 14 - NW ARM SEA WALL AT FLEMING PARK UNDER CONSTRUCTION JUNE 2012, HALIFAX, NS

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.

Closure dams and tidal barriers are constructed across river estuaries and are equipped with gates that can be closed in the event of a storm surge[63].

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.

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

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.

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

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
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 increase property values.	A groyne offers limited protection against extreme events and may negatively impact adjacent riparian areas.
Most revetments and seawalls do not interfere significantly with longshore drift.	A seawall reflects more wave energy, which may cause localized erosion at the toe and require a deep foundation.
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.	Seawalls and other hard protection structures are expensive to construct and maintain, can be unsightly and restrict shore access.

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

See the discussion of dikes (page 85) as the economic considerations are similar except for the linear corridor requirements of a dike. 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

See the discussion of dikes (page 86) as the environmental criteria are similar except for the linear corridor requirements of a dike. Groynes, breakwaters and storm surge barriers may cause environmental impacts and transfer risk onto nearby properties.

PHOTO 15 - SEA WALL IN DOTHAN, ALABAMA ACCELERATES EROSION ON ADJACENT PROPERTIES (PHOTO CREDIT ADVANCED COASTAL TECHNOLOGIES)

SOCIAL

See the discussion of dikes (page 86) as the social criteria are similar.

IMPLEMENTATION MEASURES AND CHALLENGES

Implementation measures for any form of hard protection will, in most cases, involve large costs and funding for those costs. Apart from the construction costs, hard protection measures require land acquisition for the linear corridor or site specific structure as well as access for maintenance and emergency measures. This may affect numerous landowners. There are often environmental and social issues as outlined above. 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.

BOX 5 - EXAMPLE OF HARD PROTECTION CHALLENGES FROM SEPT-ILES, QC

EXAMPLE: SEPT-ÎLES, QC HARD PROTECTION CHALLENGES

In the municipality of Sept-Îles in Quebec structural measures to protect against erosion have historically involved primarily riprap structures constructed and paid for by the municipality, sometimes with assistance from the Province, or private property owners. The latter approach requires a permit before such a measure can be implemented, though many private property owners have done so without permits over the years.

The result is a mix of patches of riprap with varying degrees of construction quality and integrity. The riprap installed in the bay to protect the downtown core from flooding such as occurred in the 1980s 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 up against 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 rather than protecting from erosion, particularly in the gap areas where the structures are not as well constructed or are absent.

For this reason, in 2000, municipal officials went to the CRE-Côte-Nord (regional committee of elected officials for the Côte-Nord), to request that the provincial government conduct detailed research on erosion in the area and how best to protect from it. As a result of the research, all structural measures, save for adding sand to the banks, have been prohibited since 2005.

WET FLOODPROOFING

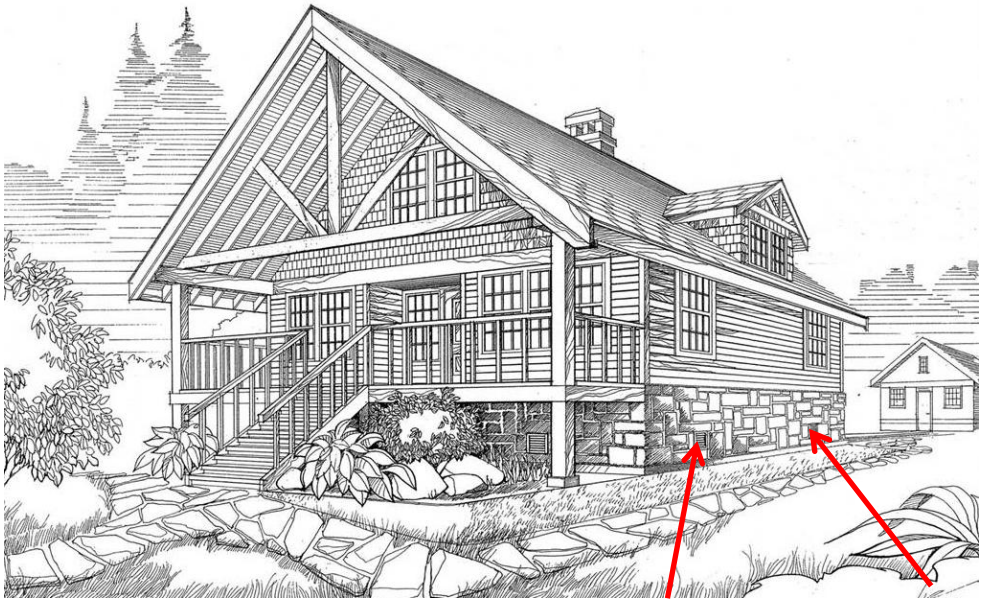
TOOL DESCRIPTION

Wet floodproofing consists of providing protective measures below the Flood Construction Level of a building which allows water to enter and exit a structure with minimal damage. Wet floodproofing employs 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 height.

APPLICATION

Wet floodproofing has limited applicability for structures and is not commonly used. The most likely applications include existing developments with small land parcels built where the infrastructure is below but not substantially below the 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 provide a viable alternative to the cost of adding structural fill and elevating an existing residential property on a small lot above the floodplain. Note in Figure 11the window openings (as shown by the red arrows) to allow for passage of flood waters.

FIGURE 11 - WET FLOODPROOFING DESIGN[64] WITH WINDOW OPENINGS (AS SHOWN BY THE RED ARROWS) TO ALLOW FOR PASSAGE OF FLOOD WATERS (DRAWING CREDIT THE ARLINGTON GROUP).



Wet floodproofing may also be used where the area subject to flooding is not used for habitable purposes. The vehicle parking areas and the areas for storage of goods not damageable by floodwaters are two possible applications.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
Can reduce the time and cost of cleanup after a flood	Wet floodproofing has limited applicability and appeal for SLR.
Wet floodproofing can be less costly than other retrofits as no additional land is required and the appearance of the building is not affected	Clean-up is still required post-flood
Allowing water to enter and exit a building may be a cost-effective alternative to structural upgrading for dry floodproofing	A residential building will be uninhabitable during a flood; other accommodation has to be provided. A commercial building cannot generally be used during a flood and may have goods damaged by floodwaters if they cannot be moved to higher ground.
A wide range of water resistant materials can be used at reasonable cost.	

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

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

Economic criteria include the cost of installing or retrofitting flood-resistant materials, constructing or retrofitting electrical and other services damageable by floodwaters at a higher elevation, ensuring adequately sized openings are provided to equalize hydrostatic pressure, the temporary loss of use of areas subject to flooding, and ensuring damageable goods are not located in areas subject to flooding. Wet floodproofing may be a cost-effective tool, but only in limited circumstances.

ENVIRONMENTAL

Environmental criteria do not apply to this tool.

SOCIAL

Social criteria concern the reduction of risk to people and buildings. Post-flood recovery time may be rapid compared to dry floodproofing.

IMPLEMENTATION MEASURES AND CHALLENGES

Implementation measures require the use of flood-resistant materials, the use of building openings to equalize hydrostatic pressures and the location of electrical, mechanical, heating and ventilation equipment above the areas at risk of inundation. A detailed list of flood-resistant materials and their application is 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 where wet floodproofing is applicable for long-term adaptation SLR.

NON-STRUCTURAL (SOFT ARMOURING)

COASTAL WETLAND CREATION OR RESTORATION

TOOL DESCRIPTION

Coastal wetlands comprise 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[65]. Functionally, coastal wetlands induce 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 traditional human-made coastal defences that are static and

[65] (Ecology Action Centre n.d.)

typically require the continuous input of resources[66]. 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 retreat. This tool does not apply to rocky coastlines or where the ocean depth drops rapidly.

PHOTO 16 - FRASER RIVER PARK VANCOUVER, B.C. (PHOTO CREDIT HAY & COMPANY CONSULTANTS INC.)

ENABLING LEGISLATION

Specific legislation is not generally required to undertake wetland restoration although the Federal Species at Risk Act could apply. Wetland creation can 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.

[66] (Singh, Walters and Ollerhead 2007)

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

Advantages	Disadvantages
The main benefit is the reduction of incoming wave and tidal energy by dissipation in the intertidal zone, achieved by increasing surface roughness.	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[67]	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.
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 SLR is not too rapid to keep pace, wetlands are capable of adapting to SLR without further intervention or investment.	

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

Economic considerations include the 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 would not apply to existing intertidal areas, which are in Crown ownership throughout Canada.

ENVIRONMENTAL

This tool provides the dual benefits of environmental enhancement and reduced flood risk. Environmental criteria include the environmental benefit of the wetland creation or restoration such as new or enhanced habitat for fish and shellfish and improved water quality.

[67] (Singh, Walters and Ollerhead 2007)

SOCIAL

Social criteria are not directly applicable, as this tool is used for environmental purposes. Wetland creation in conjunction with other tools could reduce the land requirements for linear protection if this is the only means of protection from coastal hazards.

IMPLEMENTATION MEASURES AND CHALLENGES

Like any adaptation strategy, the appropriateness of wetland or salt marsh restoration should 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[68]. 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 is required to undertake and 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.

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[69]. 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.

[68] (Singh, Walters and Ollerhead 2007)
[69] (Linham and Nicholls 2010)

PHOTO 17 - DUNE PROTECTION CONSISTING OF SAND FENCE WITH SPRUCE BOUGHS, SOURIS CAUSEWAY, P.E.I. (PHOTO CREDIT D. JARDINE)

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 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.

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

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 force.	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 SLR 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.

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 is (e.g., increased habitat in limited supply, tool that works with nature).

SOCIAL

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

In Sept-Îles in Quebec there is regulation[70] banning all structural protection for private property owners, except for sandbanks. However, 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.

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.

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[71].

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

[70] 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, last updated in 2010.
[71] (Linham and Nicholls 2010)

budget is used to describe the measurement of migrating and eroding sediment in a manner similar to the measurement of river bed aggradation.

PHOTO 18 - PARLEE BEACH, N.B. (PHOTO CREDIT D. JARDINE)

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

ADVANTAGES AND DISADVANTAGES OF TOOL FOR ADAPTATION TO SLR

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.

Advantages	Disadvantages
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.

EVALUATION AND GOVERNANCE CONSIDERATIONS

ECONOMIC

Economic criteria 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 criteria 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.

DISCUSSION

The 21 tools noted in Figure 10 - Sea Level Rise Adaptation Tools Summary (page 32) have been organized into five broad categories; planning, regulatory, land use change or restriction, structural and non-structural. This breakdown indicates how the different tools can be applied functionally.

Several of the tools are interdependent and should be used in combination. For example, many of the adaptation tools discussed rely on guidance from the implementation of appropriate planning tools. In addition, the regulatory tools discussed may be used in association with one or more land use restrictions. Land use regulation may also result in an easement on title, land trust agreement or the transfer of development potential. Building regulations or subdivision regulations addressing a coastal hazard can be implemented by means of a covenant on title. Land use regulation in an area at risk of coastal flooding may require that dry or wet floodproofing measures or scour protection to be undertaken in accordance with the condition of a covenant on title.

The integration of structural and non-structural protection methods is sometimes referred to as hybrid shoreline protection systems. At first glance, structural and non-structural adaptation tools may appear to represent polar opposites; however, they are often used in combination. Non-structural tools offer flexibility and can play a role complementary to structural tools by reducing the cost of construction that would otherwise be required; they can also offset negative environment effects resulting from hard protection measures. Non-linear control structures can act as artificial headlands to form pockets that trap beach sediments; if there is a large enough supply of sediment to the shoreline, the construction of artificial headlands, beach nourishment or other control structures can be an effective defence against coastal hazards. Hybrid shoreline protection often proves to be a more reliable and cost-effective means of adaptation.

BOX 6 - EXAMPLE OF HYBRID TECHNIQUES FROM P.E.I

HYBRID TECHNIQUES

Examples of hybrid techniques have been implemented at the Panmure Island Causeway and near the 16th hole at the Crowbush Golf Course on P.E.I. after a major storm surge on Boxing Day, 2004. At Crowbush Cove, a low-lying armour stone base or revetment was installed parallel to the shoreline, with sand placed on top of the revetment to re-establish the dune in the area. Marram grass was re-seeded on the dune to help with stabilization. Maintenance is required after storm events to replace removed sand. The same type of system was installed on the Panmure Island Causeway.

Depending on the application, the tools, individually or in combination, can be used to meet the four overall goals or strategies identified in Figure 7 - Strategies for Adaptation to Sea Level Rise (page 19), namely:

- Protect
- Accommodate

- Retreat
- Avoid

These strategies were shown as overlapping circles to illustrate the fact they are neither "pure" approaches nor mutually exclusive. In fact, a local government may quite logically undertake different strategies in different areas at different times.

Table 1 is a matrix showing the different adaptation tools and how they relate to the four overall strategies.

A protect strategy may be adopted for an historic area where all buildings and infrastructure would be 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. Finally, retreat may apply for any areas that are a specified elevation below a Flood Construction Level. Different strategies may also apply to the same areas but over different periods.

For example, a protect strategy may represent the historic approach in a particular area. With a new risk analysis, the current approach may become an accommodate strategy by requiring all new development to provide scour protection and dry floodproofing of buildings. The long-term strategy may lead to retreat if the cost of maintaining dikes and other structural protection becomes excessive in relation to the value of land and improvements needing protection.

Table 1 - Compatibility Matrix (page 104) identifies the tools compatible with each strategy and the tools that are not applicable to or not appropriate for a particular strategy. Planning tools are recommended for each strategy, although not all would be equally applicable. Land use changes, structural and non-structural tools vary considerably depending on the applicable strategy. As an example, a land trust would not be applicable to a protect strategy but would be compatible with the other strategies. An easement or land acquisition could apply to all strategies although the functions might be very different. Land acquisition and easements may be required for a larger dike footprint in a protect strategy or could be used to acquire development rights or prevent development as part of a retreat strategy.

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	Subdivision Regulation	Recommended	Recommended	Applicable	Not applicable
	Building Regulation	Recommended	Recommended	Not applicable	Not applicable
	Regulation of Land Use	Recommended	Recommended	Recommended	Recommended
	Development Permit	Applicable	Applicable	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

OTHER ADAPTATION (NON-LOCAL GOVERNMENT) RESPONSES

INSURANCE

The approach of insurance companies towards meeting the cost of hazard-induced asset loss has, in the past, been largely reactive. Increased insurance premiums and refusal of reinsurance are based on previous losses incurred. While this approach can provide a disincentive for asset investment within high-risk hazard areas, it can also put extreme pressure on local, provincial and federal government to provide "protection" against the hazard. Being able to fall back on higher levels of government in the event of a disaster does not send a clear signal to property owners, and at risk areas will not necessarily be affected by insurance premiums, unless there have

been hazard events in the past, since premiums are generally not targeted to the affected areas of the coastal margin[72].

Insurance could play a role in sea level rise adaptation as it is widely used in other developed countries with extensive shorelines and coastal areas at risk. However, insurance has not been included as an adaptation option as it is not a tool available to local governments and its availability in Canada is very limited. Flood insurance due to overland flows, surface water flooding or flooding caused by groundwater is not available to homeowners in any province in Canada. In this country flood insurance applies to very limited circumstances (e.g., burst water line, sewer back-up).

Flood insurance is available for commercial development as a specific endorsement rather than part of an all perils policy. These endorsements for commercial property may be obtained for flooding due to sewer backup and surface water including waves and tidal waves. Such endorsement is offered only if there is little known flood risk.

The circumstances surrounding flood insurance are not generally understood. 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[73].

In order to consider the potential role insurance and the insurance industry could play, some background discussion is warranted. This requires some introduction as to the conditions necessary for insurance to be a viable tool. In addition, because the implementation of flood insurance varies greatly from one developed country to another, some discussion of the different models is also needed.

The insurance industry has identified six necessary conditions, as follows, for insurance to be viable:

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. This means assigning a value to land and buildings. In the case of life insurance, it even means assigning a value to human life.
4. Randomness - the risk to be insured against 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.

[72] (Ministry for the Environment 2008)
[73] (Sandink, et al. 2010)

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. Some but not all of these conditions are present for insurance in Canada. The biggest challenge facing flood insurance concerns mutuality. The risk of flooding does not apply equally throughout a province or most communities; it is limited to specific areas. Property owners most exposed to a flood risk will be motivated to purchase flood insurance. If those purchasing flood insurance are mainly in high risk areas, the number of people (or households) insured to cover possible flood losses would be relatively small. For example, an endorsement specifically for flood insurance would generate minimal demand in Regina, SK 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. If the pool of insured to cover the anticipated costs is concentrated in the high risk area, flood insurance rates would be prohibitively expensive. 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. This occurs as the demand for flood insurance is concentrated in areas with a high risk of flooding. Few persons 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. The result of adverse selection is insurance rates that are prohibitively high for homeowners.

There are several ways these challenges to the use of flood insurance can be addressed. One way is by bundling flood insurance with other forms of insurance. This means combining the flood risk with other property insurance coverage such as fire and theft. Bundling enables insured risks to be 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. This is the case in the United Kingdom. There, flood insurance, whether inland or coastal, is included with other insured risks and is required by mortgage companies. In addition to the United Kingdom, bundled coverage is in place in Japan, Spain, Portugal, Switzerland and Israel. Following severe flooding in 2002, the Organization for Economic Co-operation and Development prepared a report favouring bundled flood insurance coverage over optional coverage.

Bundling would occur if house insurance were to include flood protection as an integral component. If insurance is bundled, policy holders would recognize a flood risk as one of several risks for which protection is provided. Where flood insurance is available as optional coverage, the penetration rate is much lower, often less than 10%. This also adds to administrative costs.

Another approach to insurance is not requiring that the full cost of flooding be covered. This occurs in the U.S.A. where 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 such as Hurricane Katrina.

Flood insurance is widely used in several 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. A 2006 study by the RAND Corporation indicated a market penetration rate of 49% for single family homes nationwide in Special Flood Hazard Areas or up to 52% including private insurers[74].

The National Flood Insurance Program involves all levels of government: federal, state and local. It has three main objectives; (1) the identification of flood hazard areas and flood risk, (2) mitigation of flood risk through local management of floodplains and (3) the spreading of risk through insurance. 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. State governments oversee regulations set by local governments for development within floodplains. 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, about 75% of all communities in the U.S.A. This program offers flood insurance to homeowners, renters, and business owners in participating communities. 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

[74] (Dixon, et al. 2007)

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. There, 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[75]. 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.

GERMANY

Private insurance companies in Germany have offered insurance for natural hazards as an optional supplement to building and contents insurance since 1991[76]. 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 hazards 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

[75] (US Department of Homeland Security; and FEMA 2012)
[76] (Sandink, et al. 2010)

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.

UNITED KINGDOM

The United Kingdom has 12,429 km of coastline. Approximately 2.2 million homes are at risk due to coastal or inland flooding, 10% of all homes in the United Kingdom. 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 that high 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[77].

Flood risk has been grouped according to three classes of flood zones. 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[78].

Building insurance is not compulsory in the United Kingdom, but such insurance is generally mandatory where mortgage financing is obtained. 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[79].

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

[77] (Sandink, et al. 2010)
[78] (Department for Communities and Local Government, UK Government 2010)
[79] (Sandink, et al. 2010)

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[80].

Flood insurance in the U.K. is an important tool that is part of a wider context with many similarities to Canada. 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 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 Planning 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. 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. Local authorities must also consider future development in a Coastal Change Management Area where it is demonstrated it will be safe for its planned lifetime and not have an unacceptable impact on coastal change.

Repeated references to safety over the planned lifetime of a building and risk-based assessment should be seen in the context of recommended contingency allowances for net sea level rise that increases from 4.0mm/year at present, to 8.5mm/year after 2025, to 12.0mm/year after 2055 and to 15.0mm/year after 2085 for London, East England and Southeast England.

DISCUSSION

There are several reasons why insurance may receive increasing attention going forward with adaptation to SLR. One is that the areas at risk of coastal flooding and the subsequent cost of damage are anticipated to increase exponentially over time. The current cost of flood damage to private property is largely met by the provincial

[80] (Institution of Civil Engineers (ICE) 2010)

government and, for major events, the federal government through Disaster Relief assistance. 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 SLR 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).

The use of flood insurance has been successfully introduced in many other jurisdictions. The application of flood insurance varies greatly in different countries. 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 use of flood insurance is much higher if it complements other forms of risk reduction undertaken by property owners and local governments. The fact that the insurance industry is not a disinterested party should not prevent a broader discussion of the potential benefits of flood insurance in adapting to coastal hazards.

EMERGENCY MANAGEMENT

DESCRIPTION

Emergency and post disaster management refers to measures undertaken during and after a disaster. Emergency planning and preparedness refers to measures undertaken in advance of a disaster and is discussed under Planning Tools. Emergency management is distinguished from emergency planning for three 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. Second, this Primer is intended to focus on tools available to local government. Third, all other tools are undertaken in advance of and with the objective of preventing or reducing the consequences of a disaster. Since emergency management takes place during and after a disaster, it is not considered an adaptation tool.

Emergency activities can be structured in four components: (1) preparedness; (2) response; (3) recovery; and (4) mitigation[81]or adaptation. While the first phase, preparedness, primarily rests with local government, some or all of the other phases are the responsibility of senior governments. The first is discussed under planning and preparedness 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 also recognizes the interests of the provinces, territories and local authorities in relation to federal assistance provided during a provincial emergency[82].

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 (see page 45). 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 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 British 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.

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

PHOTO 19 - STORM SURGE AT NORTH LAKE HARBOUR P.E.I., DEC. 21, 2010 (PHOTO CREDIT SOURIS WILDLIFE FEDERATION)

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[83].

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

[83] (Birch Hill GeoSolutions 2008)

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 (page 45), 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
- 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 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 is 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 and the 2003 wildfires in B.C.'s Okanagan Valley.

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.

INTER-AGENCY COLLABORATION, A COHESIVE APPROACH TO SLR

The research in Quebec indicates that local authorities are reliant upon provincial agencies to provide research upon which to base regulation changes, as well as province-wide policy on coastal protection to ensure coherency from one municipality to the next. As powers have been delegated from the Province to municipalities, support to local municipalities, particularly in B.C., has been degraded over time with respect to flood hazard management and management of coastal areas. Without the broader base of support in terms of research and guidance at the provincial level, many smaller municipalities simply do not have the resources to address the potential effects of SLR in their communities. Within the provincial government, certainly in terms of project funding, the focus is primarily on structural measures to address flooding and SLR and there is little support for other alternatives. Without the resources to complete basic information-gathering for coastal communities, the use of proactive, resilient adaptation tools will remain, and municipalities will instead continue the reactive, knee-jerk adaptation strategy of building structural protection.

THE COST OF SLR AND ADAPTATION

The cost of 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[84].

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 level rise factored into the design. This area also has very expensive real estate subject to flood risks.

The report addressed coastal lands that would be risk without SLR (baseline case) and the additional lands at risk due to climate change. By the 2050s, 6% to 18% of the land at risk of ocean flooding will be so 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 allowed, but existing dwellings could be rebuilt following storm surges. 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.

A costing study by Delcan[85] identified 27 reaches in the Lower Mainland of B.C. where various forms of structural protection have been provided. These consist of 17 areas with dike protection built to provincial requirements (called standard dikes); 7 areas where a lesser standard of dike protection have been provided; and 5 areas where flood protection is in the form of structural elevation, seawalls and other forms of hard protection. The study documents the increased vulnerability for these different areas resulting from storm surge, wave run-up and wind action. If all protection was in the form of dikes, the required crest elevation in some areas would range from 6.1m to nearly 8.0m depending on the local conditions. These elevations are significantly above current constructed dike elevations.

[84] (Hallegate 2011)
[85] Unpublished

In Quebec the financing available to municipalities for adapting to SLR comes via the Framework for Natural Disaster Risk Prevention funds (*Cadres principaux pour la prévention des risques naturels*), from the Ministry of Public Security. In November 2006, $55 million was designated to support municipal adaptation projects to climate change, with $26.6 million specifically earmarked for adaptation to coastal erosion. Municipalities must apply to the fund and contribute a portion of the total initial budget. The provincial money represents a one-time investment, and 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, once it is finalised.

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. In a small municipality such as this, the main way to raise that amount of money is to levy a tax. Such a tax, however, applied to all residents; with the dominant perception being that the benefit of the work would essentially go only toward protecting the interests of the ocean front property owners; it was felt that such a tax would not go over well. 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[86].

FUNDING PROJECTS RELATED TO SEA LEVEL RISE IN CANADA.

The federal government has responsibility for its properties in Atlantic and Pacific coastal areas. These properties include harbours, national parks, coast guard operations, airports and other transportation links, and infrastructure facilities. The federal government uses different approaches to adapt to sea level rise, coastal erosion, coastal storm damage and other climate change impacts. These approaches include hard and soft protection, hybrid techniques and planning methods such as retreat in some national parks.

There is 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 on a case-by-case basis depending on the funding programs available. This funding includes financial assistance to provinces and local governments for shoreline protection measures, storm damage funding and other climate-related impacts 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

[86] (Bureau 2012)

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.

BOX 7 - ANECDOTE OF SHORELINE EROSION FROM STORM DAMAGE IN THE BAS-SAINT LAURENT REGION, QC

MAJOR DAMAGE FROM THE DECEMBER 2010 STORM IN THE BAS-SAINT-LAURENT REGION

Detailed research on erosion according to coastal area has not yet been published for the *Bas-Saint-Laurent* region of the Gulf of St. Lawrence. As a result, no regulation has been enacted by this region to respond to increasing erosion rates.

In December 2010, a major storm event eroded 7 metres of the shoreline and destroyed nearly 100 homes in the region. In the absence of a regulated 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 re-building elsewhere on safer grounds, as an emergency measure. The agreement entailed the owners selling the property to the municipality for $1. The municipality, as owner of the land, cannot build, but can develop recreational uses for the land. 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 have been forced to remain in damaged homes in high-risk areas. Given the lack of regulation on erosion in the area, construction and re-construction permits can still be issued.

This precedent of provincial compensation cannot be maintained, however, in the event that increasing major storm events destroy more private properties. In 2011 the province suggested that the region adopt a 30m standard setback. Neither the region, nor any of its municipalities, adopted this position, as more detailed research has been requested in order to create varying setback lines, per coastal zone, as per what the science is showing. This is, in part, to ensure that should any citizen ever legally challenge new regulations, sound science proving the need exists to back up any policy changes. The research is currently under way and is hoped to be available in the coming years. (Savard 2012)

In Atlantic Canada, the provincial governments fund shoreline protection projects, or projects to restore damage from climate change events, on provincially owned lands and infrastructure. This includes roads, bridges, provincial parks, golf courses, heritage sites and other facilities. Provinces also engage in federal-provincial-local cost shared projects under some federal programs such as the Infrastructure Fund, Building Canada Fund or the Gas Tax Fund.

Municipalities in Atlantic Canada which 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, roads / streets, parks, recreational facilities, and other municipal infrastructure. When possible, municipalities take advantage of federal/ provincial / municipal and provincial / municipal funding programs.

Municipalities in British Columbia have also taken proactive action. Responses vary considerably depending on the particular government 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 have played an essential role in the implementation of structural protection measures.

In Atlantic Canada, there do not appear to be any programs which fund shoreline protection works for private lands. Typically private land owners take individual actions to protect their shoreline property; however, in some cases land owners take action cooperatively to protect a vulnerable section of shoreline.

In 2011, Nova Scotia implemented a new requirement for Federal Gas Tax Reporting for the period 2010-2014. Nova Scotia municipalities must prepare a Municipal Climate Change Action Plan (CCAP) to access the Gas Tax funds. These plans must be submitted by Dec. 31, 2013. A guidebook for preparing a CCAP to obtain these funds is available at www.nsinfrastructure.ca.

FUNDING PROGRAMS IN OTHER COUNTRIES

Sea level rise and coastal erosion have worldwide impacts on coastal areas. The approaches taken by some foreign jurisdictions may be of some guidance as Canadians consider how to respond to coastal impacts.

NEW JERSEY SHORE PROTECTION PROGRAM

The State of New Jersey provides an excellent example of innovative funding. The New Jersey Dept. of Environmental Protection, Bureau of Coastal Engineering have a Shore Protection Fund which dedicates USD$25 million dedicated 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." (Realty Transfer Act – N.J. S.A. C. 13:19-16.1)

Shoreline protection projects can be funded through this source, which can be a federal-state-local cost share or a state-local cost share. 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

In the Government of Western Australia coastal protection policy, the State Government, Department of Transport provides assistance by funding for 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. Future developments on the coast must have adequate erosion protection for a 100-year planning period. Grants are available to coastal managers as follows:

- Local government authorities, who have vested responsibility for coastal management;
- State Government departments actively involved in coastal management;
- Aboriginal Land Councils with responsibility for coastal management; and
- Other corporate bodies directly involved with coastal management.

ENGLAND - FLOOD AND COASTAL RESILIENCE PARTNERSHIP FUNDING

The national government in 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 plus any other benefits. The program is funded through the Department for Environment Food and Rural Affairs (Defra) and is currently structured to fund projects up to the 2014/15 fiscal year. This program will fund projects in England, which qualify for the Flood Defence Grant-in-Aid (FDGiA) capital funding and which meet four outcome measures:

- All benefits arising as a result of the investment, less those valued under the other outcome measures
- Households moved from one category of flood risk to a lower category
- Households better protected against coastal erosion
- Statutory environmental obligations met through flood and coastal risk management

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 by Defra. 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 +5m Dutch Ordinance Level (NAP). The Dutch government has also made a policy decision to maintain the coastline at its 1990 position. In their National Spatial Strategy of 2004 they actually guarantee safety against flooding and the preservation of the spatial quality of the coastal zone.

APPENDIX A – 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

APPENDIX B – 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 which 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

APPENDIX C – PRIMER OPTIONS

Type of Tool	Tool	Description of Tool	Examples	Authority	Legislation (if applicable)	Means of Implementation/ Responsible Party	Implementation Mechanisms	Means of Enforcement
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	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
	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
	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

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
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
	"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

Type of Tool	Tool	Description of Tool	Examples	Authority	Legislation (if applicable)	Means of Implementation/ Responsible Party	Implementation Mechanisms	Means of Enforcement
	Soft Armouring	Coastal protection measures that strengthen or mimic natural buffers	Artificial island (barrier island) or reef to reduce the impact of storm surges Beach nourishment/enrichment Dune creation Wetlands creation or restoration	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 Building Canada Fund	Green Shores concept is a triple bottom line approach based in B.C. designed to encourage sustainable use of coastal ecosystems through planning and design, and which recognizes the ecological features, and functions of coastal systems. It is at the information resources stage but could result in soft armouring.	Local government management Lease provisions

APPENDIX D - LEGISLATIVE MATRICES

BRITISH COLUMBIA

B.C. Legislation	Key Elements	Key Provisions	Responsible Party
Local Government Act	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	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	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	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		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 SLR, 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 SLR, 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 SLR, 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 10m 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 SLR 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 gouvernmentale 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	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	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	
Federal Maritime Marshland Rehabilitation Act	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	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
	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	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, 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	Enabling legislation which provides rights to parcels of land	Section 7 – Reservation of Coastline	Provincial government
Environmental Protection Act	Provides regime for environmental assessment in the province	Part X – Environmental Assessment and Control of Undertakings	Provincial government, Minister

APPENDIX E – QUEBEC, MUNICIPALITY OF ÎLES-DE-LA-MADELEINE ZONING

CONTEXT AND HISTORY

Îles-de-la-Madeleine consists of 200 square kilometres of low-lying small islands with a population of 13,000, in the region of Gaspésie-Îles-de-la-Madeleine, located in the Gulf of St. Lawrence. This municipality is also one of the areas of Quebec most vulnerable to SLR.

STRUCTURAL MEASURES AND FINANCING

Historically, adaptation to SLR has been achieved through structural measures such as riprap, rock walls and other retaining devices. These measures have all been financed by the municipality, with the exception of disaster assistance from the Province for extreme storm events. In the last decade, in large part due to research in the Gulf area and extensive public consultation throughout Îles-de-la-Madeleine on the matter, it has become widely recognised that such measures have tended to, in fact, cause more harm than good, to the extent of accelerating SLR. As a result, structural measures to protect against erosion are currently banned in certain high erosion zones in the current zoning regulation, passed in 2010.

PLANNING

The master plan for Îles-de-la-Madeleine was revised to include more measures regarding SLR and adopted in 2010.

Orientation 1, action 1.7 outlines the need for a study to be conducted regarding subsidence risks.

Chapter 7, article 7.3 of the planning tools section limits building footprint surface along the shoreline.

REGULATION

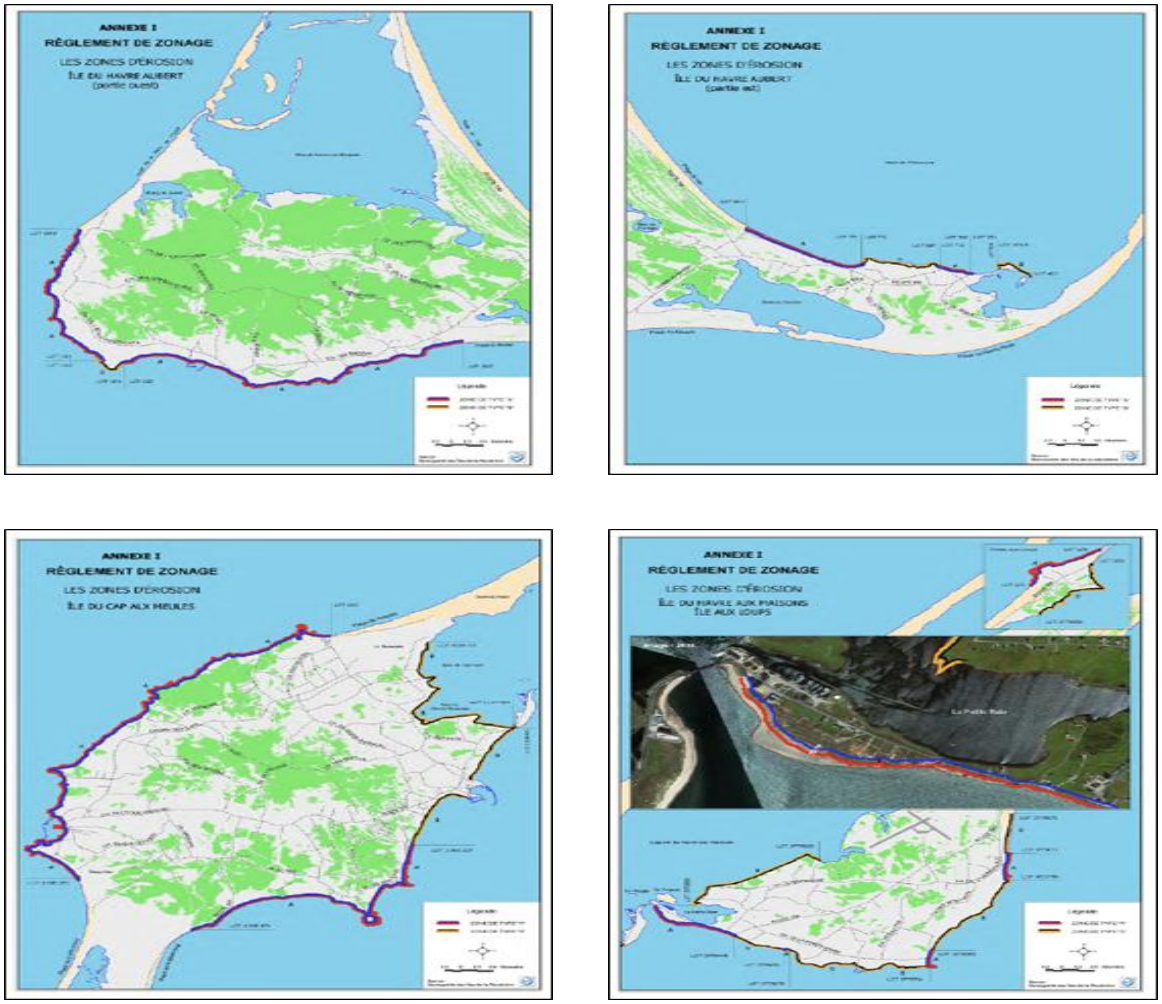
Règlement de zonage No 2010-08 (Zoning rule no. 2010-008). Adopted on Dec 14th, 2010.

Article 5.16 prohibits the following works from being implemented in the non-construction zones (defined below): buildings, septic tanks, removing trees or shrubs, underground water infrastructure, roads, and any structural protection measures for SLR. Expansion of the habitable surface for existing buildings is also prohibited, along with the re-construction of properties that have been destroyed or damaged to a sum of equal or greater than half its value.

Erosion zone A: high erosion rate, requires a setback of 30 metres.

Erosion zone B: low erosion rate, requires a setback of 15 metres.

FIGURE 12 - EXAMPLE EROSION ZONES IN ÎLES-DE-LA-MADELEINE[87]



[87] Image source: Règlement de zonage No 2010-08, Îles-de-la-Madeleine

CONSULTATION

From 2005 – 2008 Ouranos Consortium led a multi-stakeholder study to consider adaptation strategies to SLR including government officials, university researchers and citizens from three municipalities considered to be the most vulnerable to SLR: Îles-de-la-Madeleine, Sept-Iles and Percé. They convened citizens together with experts to consider what was happening in their communities and to identify the most appropriate adaptation strategies. An integrated design process was used, which was successful for achieving fairly broad level buy-in, but which in retrospect ought to have included more engineers or technicians responsible for building and approving permits for structural protection measures. The process was not easy to begin, but gradually the dialogue opened up. Ouranos coordinated and guided this process, with the idea being to understand where no-construction zones should be, why they should be there, and why they should not be the same everywhere. The resulting report is entitled: ***Étude de la sensibilité de côtes de la vulnérabilité des communauté***s ***du golfe de St. Laurent aux impacts des changements climatiques*** (Climate change impact study on coastal susceptibility and community vulnerability in the Gulf of St. Lawrence).

This process played a very important role in Îles-de-la-Madeleine, which changed its regulations despite not having updated maps with detailed erosion rates.

APPENDIX F - ATLANTIC CANADA MUNICIPAL POLICES AND BYLAWS

INTRODUCTION

In Atlantic Canada a number of municipalities have incorporated measures to discourage or prohibit development near areas subject to flooding, storm surges, sea level rise, coastal erosion and other impacts of climate change. These measures are implemented via policies, guidelines, bylaws, official plans and similar documents. Some of the measures include buffer zones, vertical or horizontal setbacks, erosion rate setbacks, retreat, hazard maps and other adaptation strategies.

Tables 1 to 4 provide more information on municipal instruments in place in communities across Atlantic Canada. This is not meant to be a complete list but does provide a summary of some of the instruments in place.

TABLE 2 - 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 10m buffer zone of a watercourse plus an extra 13m for main building, 9m for accessory building and 5m 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 23m 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,	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.

Municipality	Title of Instrument	Section of the document	Title	Prohibition	Other
				measured from the top of the bank to the nearest exterior part of the proposed building or structure.	
		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.	
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 22.9m 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 20m and no structure shall be located with 30m 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.

TABLE 3 - 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.
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 2.5m 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 30.5m 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	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	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

Municipality	Title of Instrument	Section of the document	Title	Prohibition	Other
(Central, Joggins and Pugwash areas)				shoreline buffers, all development and outdoor storage shall be prohibited.	single detached dwelling of at least 929 square metres for a minimum shoreline buffer of 8m.
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.
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.		

TABLE 4 - 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 SLR 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.

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 4.3m (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.

Municipality	Title of Instrument	Section of the document	Title	Prohibition	Other
Village of Clair					The Town has a climate change adaptation plan via a CIP project with funding from NRCan.

TABLE 5 - 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.	

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.	

ANNOTATED BIBLIOGRAPHY

CANADA

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 and the tools they provide for mitigating flood hazards. Also referenced are provincial policies and information resources such as provincial guidelines, floodplain maps, design briefs, dike inventory maps, and climatic and hydrometric data such as the Ministry of Environment River Forecast Centre, Water Survey of Canada and Meteorological Service of Canada. 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.

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. If these prove accurate, areas of the province prone to coastal flooding and erosion will be severely impacted over the next century. Many areas expected to flood with a 1:100 year recurrence interval at current sea level will likely flood once every 20 years or more frequently.

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. The main climate change impacts addressed are coastal flooding, in our test case community of Annapolis Royal, and agricultural and residential water demands in the face of potential increase in drought, in the Pereau River watershed. 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

The purpose of the handbook is to help 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 helps decision-makers 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 notes the three themes of the 2008 Nunavut Climate Change Partnership titled “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

The Partnership consists of four organizations: the Government of Nunavut; Canadian Institute of Planners; Natural Resources Canada; and Indian and Northern Affairs Canada. The toolkit focuses on a community development process for small settlements in 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. A 29.6 km dike system at the head of the Bay of Fundy protects 7,280 hectares of land from tidal flooding. Major infrastructure includes CN Rail. GIS modelling illustrated the flood extent for a 1 in 10 year storm for the year 2000 (i.e., present day threat) and again in 2085. 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) in Vancouver B.C. followed the May 2011 release of new climate change adaptation guidelines for sea dikes and coastal flood hazard land use by the Government of B.C. The City of Vancouver partnered with Port Metro Vancouver to apply the Province's methodology to 80 coastline sites including recommended FCLs. Rather than a blanket approach of increasing FCLs by 1 metre and formally amending floodproofing policies, the City undertook interim measures through public education, encouraging in-stream and new development applications to undertake adaptive measures to meet the interim guidelines. The year 2100 was considered an appropriate planning given the lifecycle of most infrastructure. While formal adoption is expected, the City's approach has featured collaboration with key stakeholders such as the Urban Development Institute and the Fraser Basin Council's Joint Program Committee for Integrated Flood Hazard Management. 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 in Delta, B.C. consisted of 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 visioning process took place over a three year period. Phase one included the establishment of a Citizen's Working Group, the definition of climate change scenarios and early exploration of adaptation options. Visioning was based on a sea level of 1.2 metres by the year 2100. The second phase consisted of data collection and modelling of adaptation options. Multiple workshops were held with municipal staff, the Citizen's Working Group, and invited experts. The final phase consisted of policy implications, capacity building and dissemination of results. 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.

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

For future scenarios based on a series of simulated data, thirty year time periods have been adopted by common practice. 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. Scenarios were developed for 11 New Brunswick municipalities.

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

Storm surges occur frequently in Canada mainly due to extra-tropical cyclones, also referred to as winter storms. The hurricanes from the Gulf of Mexico can affect eastern Canada, including Lakes Ontario and Erie regions, after they get modified and acquire some extra-tropical characteristics. 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. 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. Such maps can be used to improve public awareness of tsunamis and for planning purposes (i.e., to reduce or avoid the risk).

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, but the choice of level for planning purposes is a policy decision.

The Halifax Regional Municipality (HRM) has been a leader among Canadian municipalities in climate-change planning (Mehdi et al., 2006). 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.

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. Despite extensive sandy shores, sediment supply is limited and sand is transferred landward in coastal dunes, barrier washover deposits, and flood-tidal delta sinks. 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.

The expected acceleration in relative sea level rise, together with projections of increasing storm intensity and greatly diminished winter ice cover in the southern GSL, implies a significant increase in coastal erosion hazards in future.

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. It was observed that there is a large variance of preparedness for sea level rise adaptation around Nova Scotia. 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 aims to integrate relevant existing scientific climate change data and adaptation processes with community knowledge of climate change, in order to develop new tools that incorporate climate change concerns in community planning initiatives. Community engagement is a central component of the project team's approach, and the project relies heavily on existing community knowledge and understanding of climate related events. 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:

- recognizing climate change as a legitimate concern;
- 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;
- not approving subdivisions which could be negatively affected by climate change impacts;
- recognizing the impacts of increased coastal erosion, coastal flooding and inland flooding;
- recognizing the potential impact of climate change on the Town's sewer management system, water supply system, roads and bridges;
- revising the current emergency plan to recognize coastal erosion and flooding issues;
- helping with educating the public and town staff and council on climate change awareness issues.

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

The authors note that the Vancouver shoreline has been in constant change since 1898, largely through human intervention. They state that the city's land base is threatened by sea level rise, which will disproportionately impact industrial lands, historic areas, and the public realm such as waterfront parks, seawall and other public spaces -- in fact, much of what defines Vancouver as a livable city. It notes that a sea level rise of 1m 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 km2 landmass. Maps showing the location of areas affected by 1m, 2m, 3m, 4m 5m and 6m 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 and 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).

Historically, the main causes of coastal flooding have been due to astronomical (tides) and meteorological factors (storms). Tsunamis also pose a flood hazard to coastal communities in B.C. Estimating the associated flood hazard from tides and storms typically has been predicated on the assumption of a stationary mean sea level. However, information from the global community of scientists and scientific agencies indicates sea level rise is already occurring and is expected to continue for some time. Furthermore, it is anticipated that the rate of sea level rise will increase in the future. As the sea level rises, it poses increased risk of flooding to coastal communities, and also poses a challenge for local governments in terms of land development planning.

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, 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.

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.

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, as one of many inputs, information on spatial patterns and temporal trends in the coastal population. 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 show what the economic consequences of climate change would be 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

A national scale assessment of climate change impacts and adaptation, with a focus in each province in Canada. This assessment documents 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.

N.B. 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.

Parewick, K., R. Keenan, K. Dr. Vodden, and N. Dr. Catto. *Climate Change Adaptation Tool Development: Community Consultations.* Final Report, Municipalities of Newfoundland and Labrador, n.d. Available at: http://www.google.ca/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&sqi=2&ved=0CC4QFjAA&url=http%3A%2F%2Fwww.municipalitiesnl.com%2Fuserfiles%2Ffiles%2FCLIMATE%2520CHANGE%2520TOOLKIT%2520CONSULTATION%2520FINAL%2520REPORT.doc&ei=kIL4UMO9HKSQiALkrYGYAw&usg=AFQjCNGuN60a5yyeT1Z_tDadD1PiE9NN5Q&bvm=bv.41248874,d.cGE

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.

The technical report and feedback from consultation will then feed into the development of the Sustainable Coastal Development Strategy, a draft of this strategy was released for feedback late 2011 with the final strategy awaiting adoption..

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.

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).

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. Extensive historical documentation includes federal government program initiatives since 1953 and in the four case study provinces, including cost sharing programs.

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. Reasons include risk based pricing; bundled approach, which helps reduce the problem of adverse selection; complementary flood risk reduction measures by government; and the alignment of public and private interests through the setting of deductibles and premiums.

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. The viability of salt marsh restoration projects in the Bay of Fundy is also briefly considered. The paper recognizes that although research and restoration of coastal wetlands has been ongoing on the Pacific Coast in California, on the Gulf Coast in the Mississippi Delta, on the north eastern coast of the U.S.A. and in the U.K., the Bay of Fundy presents unique conditions not seen in previous research. These include the significant role of ice in shaping marsh morphology, the Bay's macrotidal regime, and the upper Bay's turbid waters with high amounts of suspended sediment. This study also indicates that the presence of salt marshes can increase the effectiveness of other more traditional coastal defences. Includes a description of a specific example in the Bay of Fundy involving the realignment of dikes and the restoration of salt marshes on the seaward side of the dike.

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 salinisation 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.

Limitations of this study include: the use of coastal elevation and tidal-range data to determine what land area would be inundated if sea levels rose above today's mean high tide, limiting the level of detail; also areas already at or below sea level but protected by dikes or seawalls are excluded from the analysis. The economic impacts quantified by this study include damage to dwellings, agricultural land and buildings and forests in Canada's coastal areas. 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 salination of fresh water; damages from erosion; and ecosystem effects.

The results of this study have clear policy implications for Canadian national, regional and local authorities. 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

Land use planning is an essential element in the integrated management of Canada's coastal zone as human usage of land and water invariably results in impacts to the environment. For planning in the

coastal zone—a broad region including watersheds and lands bordering the ocean, as well as the coastal ocean itself—this means looking at and involving social, economic, political and environmental elements. 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 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.

In general, the Local Climate Change Visioning process resulted in an increased awareness of climate change as an issue, and of local adaptation and mitigation actions that could be taken to address it. The visualizations resulted in an increased concern and heightened sense of urgency, as well as an increased desire to take action to address climate change. A workshop with Delta staff identified top priorities for climate change planning in the municipality, and verified that the imagery would be useful in communicating impacts to the public and increasing awareness and the sense of urgency.

These results suggest that a visioning approach may help to overcome common social and perceptual barriers to climate action (particularly a lack of knowledge of local collective actions that can be taken to address the problem), and be useful to a variety of planning processes.

The Sustainable Planning Branch, New Brunswick Department of Environment and Local Government. *A Coastal Areas Protection Policy for New Brunswick.* Fredriction, 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. The range of global sea level rise by the end of the 21st century was estimated to be in a range 0.18m to 0.38m based on the most optimistic B1 scenario (i.e., low population growth, rapid changes in economic structures and a move to a service/information economy). Under the A2 scenario of high population growth, slow economic development and slow technological change, sea level rise projections were 0.23m to 0.51m by the end of this century. Under the least optimistic A1F1 scenario based on rapid economic growth, fossil intensive energy sources, and global population peaking around 2050, sea level rise projections were 0.26m to 0.59m by the end of this century.

The dike elevation for most of the dike system in the Fraser River delta region was 6.64m above the current chart datum. While this was above the highest predicted water elevation of 6.38m due to storm surges for a 200 year return event, these values did not take into account run-up associated with storm surges and wind waves, nor did it include sea level change due to climate impacts. Variations along the west coast were noted, including subsidence in the Fraser Delta and tectonic changes. These changes would moderate the impact of sea level rise on the west coast of Vancouver Island and amplify the impact along the Fraser River delta and coastal communities along the Strait of Georgia.

Weiss Reid, J. *Researching the Role of Communities in Integrated Coastal Management in Nova Scotia.* Independant 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. The application of

planning marine and coastal environments is in its infancy. The field of planning has typically been limited to management of land use in terrestrial environments. Contemporary coastal planning is made up of elements of urban/town planning and regional development, protected areas (conservation) planning, strategic environmental planning, resource planning and marine planning. As the concept of planning is being adopted in marine and coastal environments, greater emphasis is being placed on the role of planning, the planning process, the role of a coastal planner and the application of planning tools such as zoning.

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. Current issues affecting Nova Scotia's coastline include:

- Threats to coastal development posed by the impacts of climate change (increase in number of storms, erosion of shorelines, flooding and sea level rise)
- An increase in uses of coastal areas (e.g., tourism, aquaculture, coastal trails, ATV use, housing, fishing, blood worm harvesting);
- The decline of marine ecosystems caused by infilling salt marshes, dunes, and beach areas
- Pollution generated from land-based human activity in the watershed (pesticides, sewage and other pollutants carried to the ocean through waterways)

QUEBEC STUDIES

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. The government's goal is a 20% reduction of emissions below 1990 levels, and appropriate adaptation to impacts currently underway. 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. Objectives are elaborated for achieving these needs and labelled as strategic orientations.

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 NGO Ouranos in collaboration with the Quebec government, proposes a five step methodology geared toward municipalities for developing climate change adaption 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

In 2000, the provincial government convened an inter-ministerial research team and other relevant experts to examine coastal erosion in the Côte-Nord region of Quebec. The Ministries of Public Security, Environment, Transportation, Municipal Relations, Regional Relations and Natural Resources, along with the Conférence Régionale des Élus de la Côte-Nord (North-Coast regional committee of elected officials),

as well as scientists from the Université du Québec à Rimouski (UQAR) and the Université de Sherbrooke, installed over 5,000 measuring stations along 2,000 km of coastline and monitored erosion over five years. New erosion maps were produced, demonstrating that dramatic erosion has been taking place - on average between 60cm and one metre per year - and that it is not occurring at the same rate, depending on the 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 STUDIES

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.

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

The adaptation strategy 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 notes that the elevation of high tide could increase by as much as 1.5 m. over the course

of this century. The report identifies the most vulnerable sectors and the reasons for their vulnerability. Key sectors include ecosystems and critical species in San Diego Bay due to inundation and erosion, stormwater, wastewater, potable water and energy infrastructure due to flooding and inundation, and local transportation due to saturated and pavement degradation from regularly occurring flood events. Shoreline parks and recreational facilities were considered extremely vulnerable but also with a higher adaptive capacity than most other systems. Given these findings, the report called for a comprehensive strategy 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.

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"). Under the optimistic scenario, the world begins taking action in the very near future and greatly reduces emissions by mid-century with additional decreases through the end of the century. Under the pessimistic scenario, greenhouse gas emissions continue to skyrocket throughout the 21st century.

In the rapid stabilization case, climate change has only moderate effects. Florida's annual average temperature increases 1ºF by 2050 and 2ºF by 2100, while sea levels rise by 3.5 inches by 2050 and 7 inches by 2100. In the business-as-usual case, Florida's average annual temperatures will be 5ºF higher than today in 2050 and 10ºF higher in 2100. Sea level rise will reach 23 inches by 2050, and 45 inches by 2100.

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.

OTHER INTERNATIONAL

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

In 2007 the International Federation of Surveyors commissioned a working group 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 concluded 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 so as to reduce some of the future negative effects of climate change in the coastal zone. While developed countries have more technical, institutional and financial capacity for coastal adaptation than developing countries, developing countries have less development on vulnerable coastal lands. The report recommended the application of land use planning to avoid potentially costly and unsustainable development through retreat and adaptation policies where populations and economic activities overlap into the most hazardous zones.

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. Priority areas of focus for these reports are water management, land use planning and designing & renovating buildings. The study found 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. There was some evidence of long-term strategic approaches that included changing risks due to climate change on paper. However, this appeared to have limited influence on actual decisions, and there was little evidence that the costs of locating new development in vulnerable areas was being considered.

Delta Committee. *Working Together with Water.* Findings of the Deltacomissie, Netherlands: Deltacommissie, 2008. Available at: http://www.deltacommissie.com/doc/deltareport_full.pdf

The Dutch Cabinet tasked the Delta Committee with investigating strategies for the future, long-term development of the coast (2100–2200), paying attention to both safety and environmental quality. The Delta Committee was asked to consider 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. This region of the Netherlands where nearly 9 million people reside is also the centre of the nation's economy where 65% of the GNP is generated.

The strategy for future centuries is based on two pillars: flood protection and sustainability. The vision went beyond flood protection to embrace interactions with life and work: agriculture, nature, recreation,

landscape, infrastructure and energy. 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. These values were considered plausible upper limits based on the latest scientific insights.

The study concluded that the Netherlands must accelerate its efforts because the current standards of flood protection are not being met everywhere, are out of date, and must be raised due to rapid climate change including a probable increased rate of sea level rise. Risk management was based on a combination of factors to reduce probability and consequences. 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.

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. 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, the total costs of growing with the climate and ensuring improved protection are €2.4 to €2.8 billion per annum up to 2050.

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.

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.

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. The key objective is to achieve sustainable development based on economic, social and environmental dimensions. Considerable attention is given to meeting the challenge of climate change, flooding and coastal change. Local planning authorities are called on to "adopt proactive strategies to mitigate and adapt to climate change, talking 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 to reduce risk and consider it as part of a managed retreat strategy.

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. The risk management strategy has not been changed and considerable detail is provided which is not available in the current and broader based policy framework.

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 0.4m 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 0.4m, 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 Enviromental 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.

Jones, Roger N., Paul Dettmann, Geoff Park, Maureen Rogers, and Terry White. "The relationship between adaptation and mitigation in managing climate change risks: a regional response from North Central Victoria, Australia." *Mitig Adapt Strat Glob Change*, 2007: 685-712. Available at: http://ies.lbl.gov/iespubs/3jones.pdf

This paper considers how adaptation and mitigation are complementary in managing the risks associated with climate change. The author reviews the application of risk management methods to climate change assessments. The paper indicates that mitigation and adaptation have two main areas in which they complement each other. Firstly, they each manage different components of future climate-related risk. Mitigation reduces the number and magnitude of potential climate hazards, reducing the most severe changes first. Adaptation increases the ability to cope with climate hazards by reducing system sensitivity or by reducing the consequent level of harm. Secondly, they manage risks at different extremes of the potential range of future climate change. Adaptation works best with changes of lesser magnitude at the

lower end of the potential range. Where there is sufficient adaptive capacity, adaptation improves the ability of a system to cope with increasingly larger changes over time. By moving from uncontrolled emissions toward stabilization of greenhouse gases in the atmosphere, mitigation limits the upper part of the range. However the author notes that mitigative and adaptive capacity do not share the same scale: adaptive capacity is expressed locally, whereas mitigative capacity is different for each activity and location but must be aggregated at the global scale to properly assess its potential benefits in reducing climate hazards.

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 aims to support good adaptation planning. It covers 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. Numerous diagrams and illustrative pictures are also provided.

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.

This analysis shows that the Lower Elevation Coastal Zone concentrates people, economic activity and resulting infrastructure, so the impacts of climate change and sea level rise could be large, especially if the magnitude of change is large. This will be exacerbated by coastal development, which is a profound trend that is likely to continue through the century; however, effective adaptation could minimise the impacts. Hence, assessing the future depends on several distinct dimensions including the magnitude of sea level rise and climate change, socio-economic change, and the success or failure of adaptation.

RSPB, Environment Agency, Natural England and Defra. *Coastal Futures - Humber Community Project.* November 2, 2010. Available at: http://www.coastalfutures.org.uk/humber.html.

As a partnership between government agencies and non-governmental organizations, 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.

"Humber Community Project: Lessons learned and best practice in community engagement on changing coasts" available at: www.coastalfutures.org.uk/community_engagement_report

"Economics of Managed Realignment in the U.K." available at: www.coastalfutures.org.uk/EconomicsOfManagedRealignment

State of New South Wales - Department of Planning. *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

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. Improved understanding of sea level rise and variability is required to reduce the uncertainties associated with sea level rise projections, and hence to contribute to more effective coastal planning, management and adaptation in the presence of the many pressures on coastal regions. This paper summarizes the importance of determining local sea level change and local land motion to better understand at a local level the potential effects that need to be adapted to. Rising sea levels have been and will continue to be felt most acutely through extreme events (periods of above average sea level).

U.K. Climate Impacts Programme: Projections, Adaptation Tools, Case Studies

Since 1997 UKCIP has been leading the way in developing climate change projections and tools and resources to support climate change adaptation by government, business, civil society and other

agencies. Their most recent comprehensive report on projections is the UKCP09, with a section focusing on marine and coastal areas that includes relative sea level rise figures for different regions. This can be accessed at: http://ukclimateprojections.defra.gov.uk

In addition, UKCIP has produced a number of useful tools for local government and other decision-makers to learn about and engage in climate change adaptation planning and actions. 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. An overview of UKCIP tools with links and an explanation of when and how to use each one is provided at: www.ukcip.org.uk/tools

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. This can be accessed at: www.ukcip.org.uk/case-studies/

U.K. Flood & Coastal Erosion Risk Management Programme

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 available at: http://evidence.environment-agency.gov.uk

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).

Accessible at: http://publications.environment-agency.gov.uk/

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.

Accessible at: http://publications.environment-agency.gov.uk/

A collection of case studies on practical considerations associated with implementing flood risk management options (coastal and other) are available at: www.environment-agency.gov.uk/research/

Links to other research of import for the U.K. and Europe are provided at: http://evidence.environment-agency.gov.uk/

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