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Adapting to sea level rise in Charlottetown, P.E.I.

Climate change adaptation measures can be adjusted as the science advances.



Charlottetown (population 32 000) is the capital of Prince Edward Island (P.E.I.) and sits on a natural harbour that opens toward the south of the Northumberland Strait. The city is vulnerable to coastal flooding from storm surges and sea level rise. Much of Charlottetown's historical development – the street network, municipal infrastructure and important heritage building stock – is situated in relatively low-lying neighbourhoods.

Climate change increases the city's flooding risk. Three climate impacts of particular concern are an accelerated rate of sea level rise, more intense and frequent storm surges, and the loss of sea ice. Winter ice forms a natural barrier that protects the coast from heavy wave action, but on occasion also causes direct damage to coastal infrastructure.

Charlottetown is an early Canadian innovator in planning how to adapt to the effects of climate change. Between 1999 and 2002, scientists from Natural Resources Canada, Fisheries and Oceans Canada (Bedford Institute of Oceanography), Environment Canada, Dalhousie University and Nova Scotia Community College undertook a comprehensive research project to assess the impacts of sea level rise on the city and the island. The project received strong support from Charlottetown City Council and the City's planning department.

Using digital cartography software, the science team mapped the potential flood depth and extent under three climate change scenarios. The flood maps were provided to the planning department for use in the development

A RECORD STORM SURGE

A storm on January 21, 2000, was the most intense in Charlottetown's history. A storm surge coincided with a high tide to produce record water levels of 4.23 metres (m) above chart datum (CD). For context, the city's waterfront begins to experience flooding at 3.60 m CD. The storm – which damaged wharves, dislodged a lighthouse from its foundations (ice ride-up) and flooded parts of the city's downtown core – caused an estimated \$20 million in damage to property and infrastructure across P.E.I. This record flood, as well as the succession of intense storms that have impacted P.E.I.'s coastline over the last decade, have heightened local awareness of the potential impacts of climate change and accelerated sea level rise.

approvals process and future adaptation planning. These maps have been a useful tool that has allowed the planning department to clearly demonstrate the potential impacts of sea level rise to prospective developers.



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In addition to the maps, the science team produced a report that outlined possible adaptation measures that the City of Charlottetown could implement to help address rising sea level. The measures include changing zoning regulations; acquiring flood-prone properties; flood-proofing basements; and moving key infrastructure to less vulnerable locations when the existing infrastructure reaches the end of its operational lifespan.

Since 2002, city planners have been integrating climate change considerations into the planning approvals process. Sea level rise and storm surge flooding are addressed mainly through development agreements. These legal agreements, negotiated between the developer and the City, establish criteria to which the developer must adhere to receive permission to develop. Development agreements apply in designated zones that have strategic importance to a city, such as a downtown waterfront, a historic district or important employment lands. In Charlottetown, they are known as comprehensive development areas (CDAs).

Charlottetown designated a portion of the downtown as the Waterfront CDA. Within this area, planners have negotiated on a case-by-case basis to have habitable space in new buildings located at least 4.93 m above CD, a figure derived from the science work undertaken in 2002. Several private and institutional buildings that adhere to this minimum ground floor elevation have since been built within the Waterfront CDA. They include a condominium building, a restaurant, two apartment buildings and the Naval Reserve Centre. These buildings have either been constructed on top of a mound of rock and earth fill or raised on pilings (see photograph).

Charlottetown's Waterfront CDA encompasses only one portion of the downtown. There are flood-prone areas in other parts of the downtown as well as in neighbourhoods beyond. Any development outside a CDA is "as of right," which means there is little room for negotiation – the development simply must adhere to minimum criteria established in municipal bylaws and by provincial law. In flood-prone areas outside the CDAs, municipal planners have provided prospective developers with maps showing potential flood levels as an information tool to inform development decisions. However, it is important to note that the zoning bylaws would need updating before planners could establish a minimum ground floor elevation accounting for projected sea level rise in areas outside a CDA.

SCIENTIFIC RESEARCH

The research on sea level rise and adaptation undertaken in Charlottetown was the first of its kind in Canada. The lessons learned have been incorporated into numerous science projects, including Impacts of Sea Level Rise and Climate Change on the Coastal Zone of Southeastern New Brunswick (2003 to 2006) and others in communities across Nunavut and Atlantic Canada (e.g. see the Halifax case study).

Charlottetown's Lot Grading Guidelines (2007) include recommendations aimed at building resilience to sea level rise and storm surges, including that

- habitable space in new buildings be located at least 4.93 m above CD in flood-prone areas
- building foundations be designed to resist the impacts of intense storms (including ice build-up)
- electrical and mechanical rooms be 4.93 m above CD
- basements below the recommended height not contain flammable, explosive, toxic or otherwise hazardous material
- the site design ensures that physical access to the building and parking lots is maintained in the event of a storm.

These voluntary guidelines have been used by the City as baseline criteria for negotiating development agreements.



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In 2008, the City partnered with the C-Change International CURA project (www.coastalchange.ca) – an interdisciplinary university-community research project that is examining the vulnerability of coastal communities to climate change in Canada and the Caribbean. As part of the project, researchers from the Centre of Geographic Sciences in Nova Scotia and Memorial University in Newfoundland and Labrador produced updated sea level rise vulnerability maps for Charlottetown by using the latest scientific data and techniques.

There were several steps in modeling future sea level rise and producing the new maps (Forbes, et al. 2012):

- **Scenarios for future sea level rise and extreme water levels**

The research team developed three sea level rise and extreme water levels scenarios for Charlottetown Harbour. Scenarios I and II are based on projections for emission scenarios published by the Intergovernmental Panel on Climate Change in 2007, while scenario III is based on semi-empirical projections from the most recent peer-reviewed literature. These sea level rise scenarios were combined with statistics for storm effects (combined tide and storm surge water levels) as well as local rates of subsidence (vertical movement in the earth's crust) to project what a 1-in-100 year storm would be like in the year 2100.

- **Visualizing potential flood levels**

Using 2008 LIDAR data from the Province of Prince Edward Island, the research team mapped the potential extent of flooding for each of the three climate change scenarios described previously. LIDAR uses an oscillating infrared laser beam installed underneath an aircraft to obtain precise elevation data of the study area.

The City's planning department will use the updated maps to inform the public and developers of changes to the minimum ground floor elevation and to guide the development of potential new adaptation measures or strategies. For example, the City is presently updating its Waterfront Concept Plan, which is expected to include mandatory minimum standards for ground floor elevation that would apply to all new buildings built in the waterfront area.

This example demonstrates that communities can implement, based on the best available science, simple first measures (such as raising the minimum ground floor elevation) to increase resilience to storm surges and rising sea levels. In the future, as new science and adaptation tools become available and greater public awareness is raised, adaptation measures can be adjusted or new ones implemented.

This case study is one in an ongoing series prepared by the Climate Change Impacts and Adaptation Division, Natural Resources Canada. The series illustrates a range of climate change impacts and adaptation responses from communities across Canada.

Watch for updates at adaptation.nrcan.gc.ca

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