

CLIMATE CHANGE ADAPTATION PLAN

Coastal Flooding, Coastal Erosions
and Inland Flooding
City of Bathurst



Prepared by

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Your Environmental Trust Fund at Work

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1. INTRODUCTION

Coastal New Brunswick is increasingly susceptible to the effects of sea level rise and storm surge events, as well as increased runoff due to heavy rainfall events or frequent winter snow melt, related to our [changing climate](#). Without contingency plans for such events and the implementation of adaptation measures to mitigate them, parts of the City of Bathurst could be in jeopardy when they occur. The City needs to be ready for them.

The City of Bathurst, located in northern New Brunswick along Chaleur Bay, has over 12,275 residents, with approximately 6,257 dwellings¹ and occupies approximately 92 km². The City is officially bilingual, with over 60% of the population speaking both languages. Pabineau First Nation (Kekwapskuk) is part of the Chaleur region. Bathurst was a service and trade centre during the nineteenth century, with shipbuilding as an important economic activity. The first pulp and paper mill was built in 1914 (Bathurst Power and Paper Company Ltd.), and the industry was the main economic driver during the first half of the century, followed by mining. Mining gradually replaced pulp and paper in the 1960s as the major industry, and continues to influence the local economy. Tourism has become the focus of local economic development today. Two major rivers flow into Bathurst Harbour, Tetagouche River and Nepisiguit River. The City is located along the estuary of these rivers, at the head of the Harbour. Two sandspits, Carron Point and Youghall Beach, form barriers at the entrance to Bathurst Harbour, so the City is not directly exposed to the Chaleur Bay. The center of the City is relatively protected by its location (Figure 1) and much of it is well above sea level. However, houses and cottages built along the sand spits are directly exposed to high velocity winds and storm events coming off the Bay, thus making them vulnerable to storm surge events and sea level rise. Bathurst receives considerable runoff from upland areas where current landuse (e.g. increased farming, clearcuts) has decreased the land's water retention capacity over time.

This adaptation plan is meant to be a living document, as the impacts of climate change will vary and produce diverse hazards, from increased coastal flooding, to severe and heavy rainfall events, as well as increased freeze-thaw events in winter, and heat waves and drought in the summer. The goal of this adaptation plan is to increase the City's overall [resilience](#) and to reduce the risks associated with climate change. This plan addresses coastal sea level rise, storm surge risk, erosion risk, and inland flood risk, as those were identified as priority [hazards](#) by the City.

Climate change adaptation is how people adjust to future climate conditions. Adaptation planning involves making adjustments in our decisions, activities, planning, and thinking, because of observed or expected changes in climate. To reduce the risks to the community and take advantage of opportunities, communities need to understand the problems and challenges posed by a changing climate and develop realistic approaches to dealing with them.

¹ Statistics Canada. 2012. Focus on Geography Series, 2011 Census. Statistics Canada Catalogue no. 98-310-XWE2011004. Ottawa, Ontario. Analytical products, 2011 Census. Last updated October 24, 2012.)

This document presents an assessment of the climate change impacts, as well as the risks and [vulnerabilities](#) of the City to coastal [storm surges](#), erosion and from heavy rainfall or runoff events. This assessment was carried out through an engagement process with City departments, a council committee, and a community stakeholder working group for the coastal portion. Information obtained from this process was compiled and summarized, resulting in the identification of 36 sites that are most at risk within the City. Site-specific adaptation actions that can be taken to mitigate the risk are described. A summary of the work that has been done to date is also included, and a detailed map book is provided as an appendix (Appendix 4), which identifies the 36 sites most at risk within the municipality.



Figure 1: City of Bathurst, city limits

2. CHANGING CLIMATE IN NEW BRUNSWICK

Climate change refers to variations in the "average weather patterns" that occur over time. The concentration of greenhouse gases (GHGs) in the Earth's atmosphere is increasing and increased GHG concentrations are contributing to climate change². The increased GHG concentrations are a result of both natural processes and human activity (mostly related to fossil fuel use), and global temperatures have begun to rise as a result. Not only is the world becoming warmer due to the high levels of greenhouse gases in the atmosphere, global warming is leading to the increased frequency and severity of weather-related events around the world. Sea levels are rising, ocean currents are shifting, and regional precipitation events are becoming increasingly dramatic and unpredictable³. Newly reported global projections from the IPCC⁴ Fifth Assessment Report (AR5) include an upper limit of 0.98 m of global sea-level rise by 2100. This expected rise in sea level increases the need for adaptation in order to minimize damages and costs.

In New Brunswick, coastal [sea level rise](#), erosion, extreme precipitation, inland flooding and increased temperatures are the main hazards associated with climate change. Sea levels around New Brunswick have risen by 24 cm (measured in Saint John) from 1920 to 2015 and coastal erosion rates have been changing⁵. It is expected that the sea level will rise 50-60 cm (plus or minus 35 cm) by the year 2100 in NB. A rise of coastal water, along with an increase in storm surges, can accelerate coastal erosion and result in the loss of public infrastructure, such as roads, wharfs and bridges, damage to private property, contaminate sources of drinking water via sea water intrusion, and damage or destroy coastal areas.

In recent years, the Province has seen large fluctuations in river runoff, more frequent winter thaws and an increased risk of ice jams. As a result, washouts, flooding of dwellings, service interruptions, sewage backup in basements, and drinking water contamination are more frequently experienced in New Brunswick. Costs associated with these occurrences are rising. From 2008 to 2012 the estimated total cost of flood related damage in this province exceeded \$100 million⁶.

² New Brunswick Department of Environment and Local Government website:
http://www2.gnb.ca/content/gnb/en/departments/elg/environment/content/climate_change/content/what_is_climate_change.html

³ IPCC, 2012: Summary for Policymakers. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation[Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 3-21.

⁴ IPCC: Intergovernmental Panel on Climate Change (<http://www.ipcc.ch/>)

⁵ New Brunswick Department of Environment and Local Government website:
http://www2.gnb.ca/content/gnb/en/departments/elg/environment/content/climate_change/content/climate_change_indicators/indicators/water/sea_level.html

⁶ New Brunswick Flood Risk Reduction Strategy, 2014: www.gnb.ca

The effects of climate change can be disastrous for both humans and our natural environment. The City of Bathurst has made the strategic decision to develop an adaptation plan to mitigate such effects. By planning for the climate of the future, the City wants to improve the community's economic, social, and environmental capacities to respond to climate change and minimize its impacts.



Flooding at Youghall Drive, December 2010. Photo: D. L'Anglais

3. EXPECTED CLIMATE CHANGE IMPACTS FOR BATHURST

In New Brunswick, climate change is expected to bring warmer, wetter and stormier weather, and increasing sea levels. The province has already experienced a rise of average annual temperatures of over 1.5°C during the last 30 years (1980-2015). Sea level rise, unpredictable weather combined with an expected increase in total precipitation and more extreme rainfall events, will affect New Brunswickers in many ways.

3.1 Increasing Sea-Level Rise and Storm Surge Events

The coasts of New Brunswick have different sensitivities to sea-level rise and associated storm impacts depending on elevation and exposure. Areas most vulnerable to this threat include most of the eastern coast of New Brunswick (Northumberland Strait, Gulf of St. Lawrence, and Chaleurs Bay)⁷. As a result, the City of Bathurst faces the risk of greater rates of erosion, well water contamination by seawater, and permanent loss of low-lying coastal areas due to sea level rise and associated storm surge events.

Flood scenarios due to predicted storm surges for 2010, 2030, 2050 and 2100 were used to map the extent and depth of the flood water at certain times⁷, and to identify the infrastructure that would be at risk. For each of these years, storm surge events that could occur with variable probability were identified ([return periods](#)), and used in the risk assessment.

Table 1: Sea level rise scenarios for the Municipality of Bathurst, Source: Daigle, 2014

Bathurst, HHWLT 1.72 m (CGVD28)					
Return period	Surge	Level 2010	Level 2030	Level 2050	Level 2100
1-Year	0.60 ± 0.20	2.32 ± 0.20	2.44 ± 0.27	2.56 ± 0.34	2.98 ± 0.58
2-Years	0.74 ± 0.20	2.46 ± 0.20	2.58 ± 0.27	2.70 ± 0.34	3.12 ± 0.58
5-Years	0.92 ± 0.20	2.64 ± 0.20	2.76 ± 0.27	2.88 ± 0.34	3.30 ± 0.58
10-Years	1.06 ± 0.20	2.78 ± 0.20	2.90 ± 0.27	3.02 ± 0.34	3.44 ± 0.58
25-Years	1.24 ± 0.20	2.96 ± 0.20	3.08 ± 0.27	3.20 ± 0.34	3.62 ± 0.58
50-Years	1.38 ± 0.20	3.10 ± 0.20	3.22 ± 0.27	3.34 ± 0.34	3.76 ± 0.58
100-Years	1.52 ± 0.20	3.24 ± 0.20	3.36 ± 0.27	3.48 ± 0.34	3.90 ± 0.58

⁷ Daigle, R., 2014. Rapport final. Scénarios : Élévation du niveau marin et inondations, Bathurst. Rapport de R.J. Daigle Enviro préparé pour la Municipalité de Bathurst.

3.2 Increasing Coastal Erosion

Decreased ice cover and increased sea level rise and storm surges due to climate change is expected to accelerate coastal erosion rates. Coastal erosion will have negative impacts on the tourism industry, property and infrastructure located directly along the coastline, and on coastal ecosystems such as beaches and salt marshes.

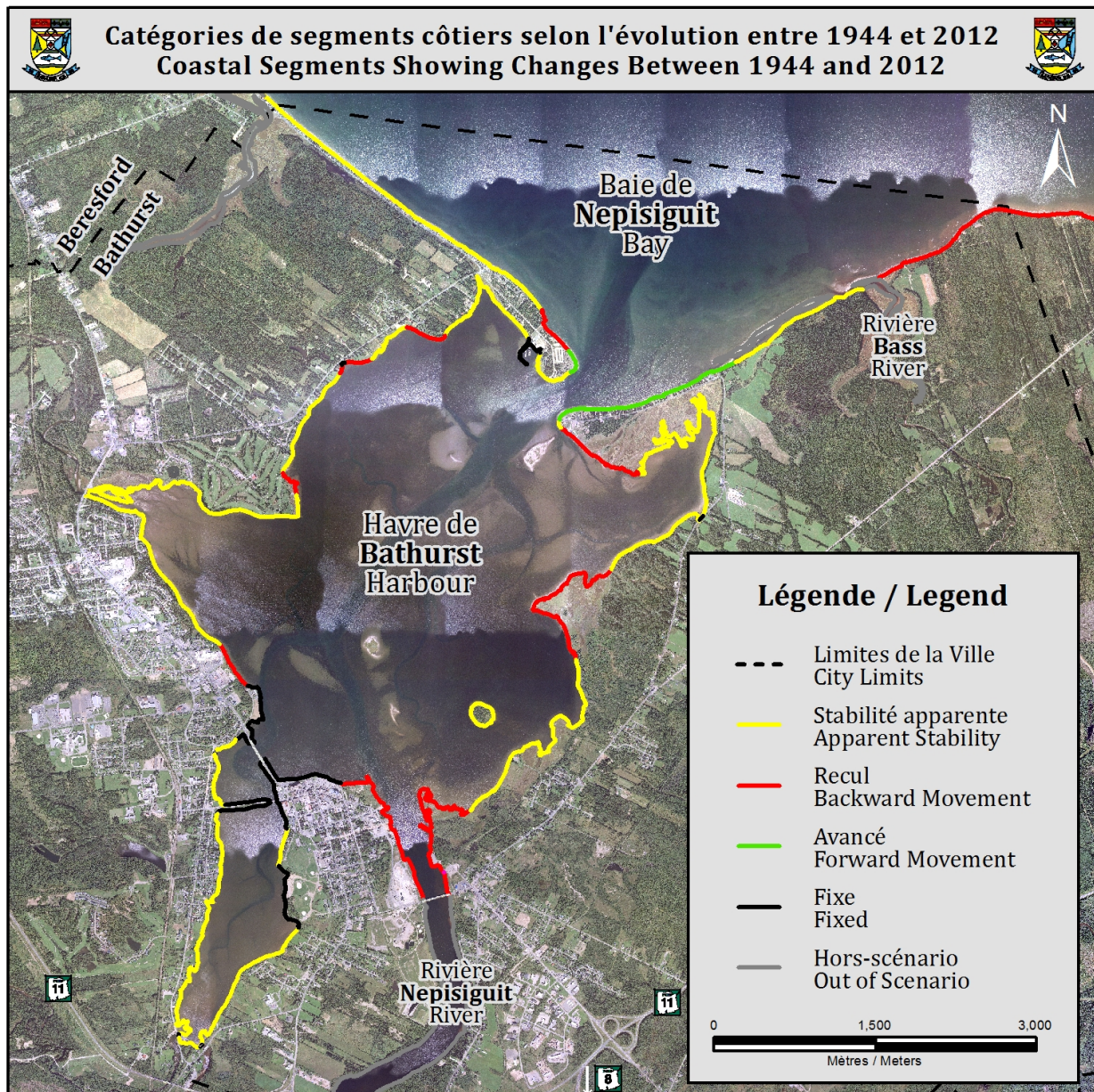


Figure 2: Coastal Segments Showing Changes Between 1944 and 2012. Adapted from Chelbi et al. 2015

An analysis of historical rates of erosion and predictions along the coast of the City of Bathurst was conducted⁸. The coastline of the City can be divided into two types of environment in terms of the wave energy received at the coast: Nepisiguit Bay which is open to Chaleurs Bay where the waves can be highest, and Bathurst Harbour whose entrance is protected by the beaches at Carron Point and Youghall Beach and where the waves are weaker overall (Figure 2).

While erosion is not of a significant concern for most of the City, localized erosion poses some serious challenges. An example is Youghall Beach, a significant recreational area for the City, where considerable erosion has occurred between 1944 and 2012 (Figure 3a). Without action, this beach could see further deterioration, placing at risk municipal infrastructure and the use of the beach for recreational and tourism purposes (Figure 3b).



Figure 3: Changes to Youghall Point between 1944 and 2012 (A), and the position of the coastline and the position of coastline scenarios 2030, 2050, 2100 for Youghall Point (B). Source: Chelbi et al., 2015

⁸ Meher Chelbi, Valerie Clement, Serge Jolicoeur, Stéphane O'Carroll, Michaël St-Pierre, Dominique Bérubé, 2015. Évaluation de la vulnérabilité aux changements climatiques pour la Ville de Bathurst.

3.3 Increased Temperature and Precipitation

Climate models project that by the year 2080 New Brunswick's mean annual temperature will increase by approximately 5°C (Figure 4). A warmer climate will result in more growing-degree (GDD) days and frost-free days, will cause earlier snowmelt and break up of ice, and is expected to lead to an increase in the possibility of ice jams and flooding.

Mean annual temperature 1971 to 2000 Predicted mean annual temperature in 2041-2070

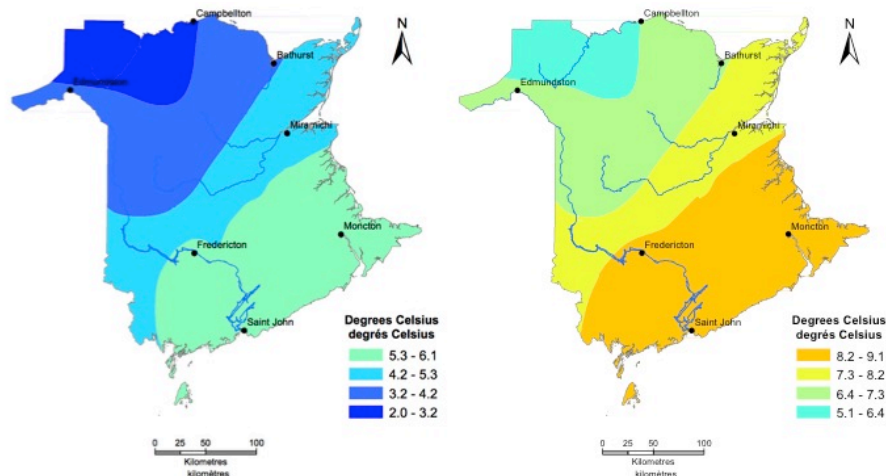


Figure 4: Historical average mean annual temperature (°C) (left), compared to the predicted mean annual temperatures in 2041-2070 under the [RCP 8.5 model](#) (right). Source: acasamaps.com, 2016

New Brunswick will also experience fewer, but more intense precipitation events, increasing the annual total precipitation throughout the province (Figure 5), potentially causing road washouts and flooding of low-lying areas, increased soil erosion and water contamination due to events such as overflowing of municipal waste treatment systems.

Annual precipitation 1971 to 2000 Predicted annual precipitation in 2041-20170

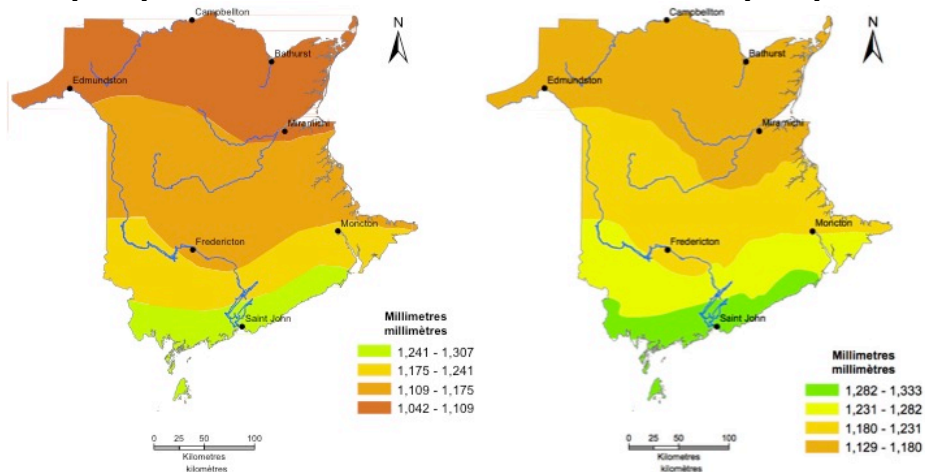


Figure 5: The historical annual total precipitation (mm) in New Brunswick (left), compared to the predicted annual total precipitation (mm) in 2080 under the [RCP 8.5 model](#) (right). Source: acasamaps.com, 2016

Depth to water table maps (UNB) were used to identify areas vulnerable to flooding during heavy rainfall events or snowmelt. These maps were validated against known problem areas, resulting in the identification of particular areas at risk. In general, due to the low-lying location of Bathurst at the mouth of several large rivers and watersheds, overland flooding is a common occurrence in certain areas of the city. While these maps can provide an initial indication of flood risk areas, further work is needed to develop inland flood scenarios. This scenario development has been initiated by the Université de Moncton, and modeling may be available in the next few years.

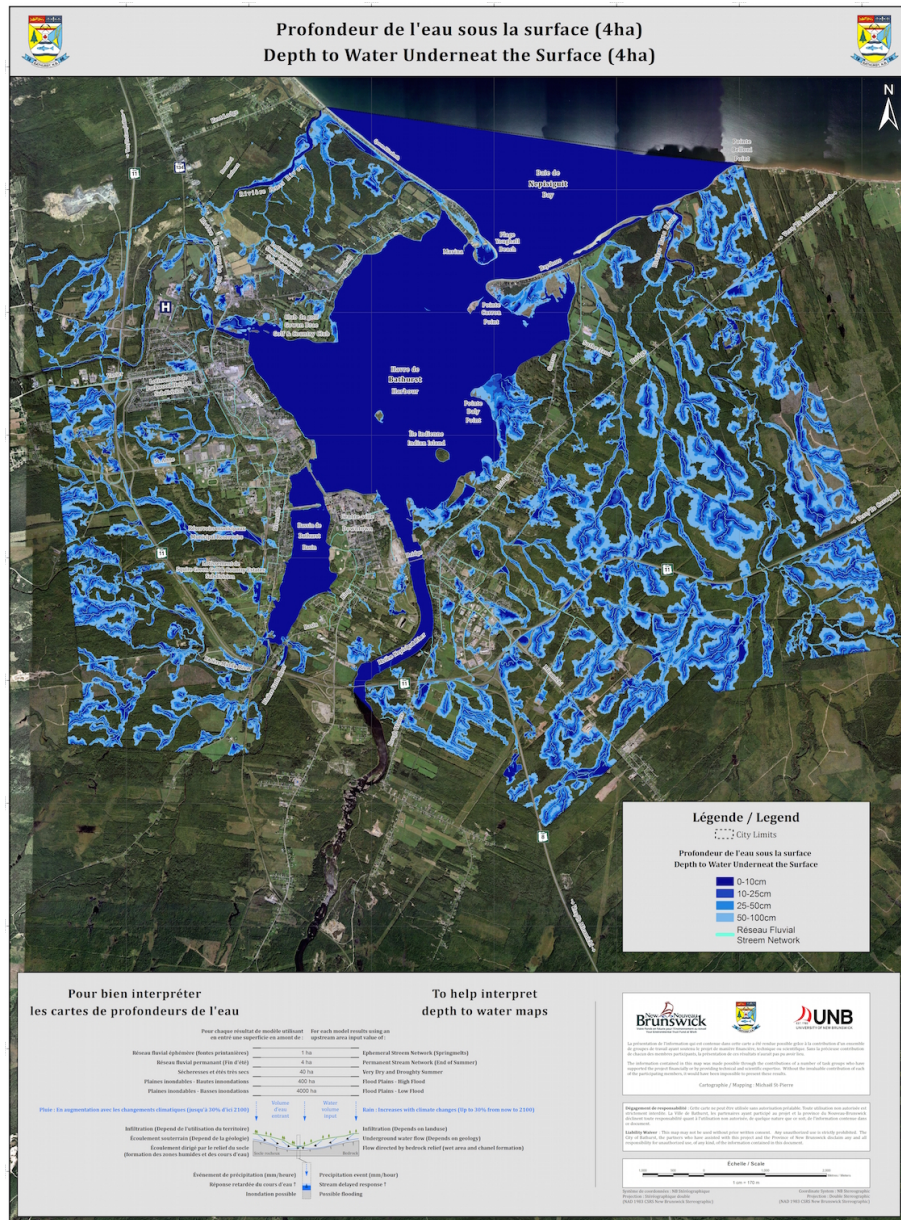


Figure 6: Depth to water table map; the blue outlines areas that are likely to flood around permanent stream networks as a result of the closeness of the water table to the surface. With modeling provided by Dr. Paul Arp, University of New Brunswick, 2016.

4. PREVIOUS STUDIES AND REPORTS

Hunter (1975) described the impact of coastal development along Youghall Beach and Carron Point in "Beach Resources, Eastern New Brunswick". A report from Bérubé et al. (2003) entitled "Geomorphological Evolution of Youghall Beach on the northeast coast of New Brunswick" described the erosion rates along Youghall Beach.

The report "Towards a community plan for adaptation and erosion and other impacts of climate change in the Point Carron area" (Chouinard et al. 2008) identified, with the input from local residents, researchers and civil servants, specific erosion issues in that area, problems with erosion control structures, and possible approaches to dealing with erosion. This report used an evaluation of the coastal erosion rates along Carron Point undertaken by O'Carroll et al. in 2008 entitled "Rates of Coastline Change in the Carron Point - Belloni Point Area, Bathurst, New Brunswick, between 1939 and 2007, 1939 and 1974, 1974 and 2007, and 1985 and 2007", as well as an evaluation of Carron Point and Bass River sand spits by O'Carroll et al. in 2008, entitled "Evolution of the Coastal Landscape in the Carron Point - Belloni Point Area (Bathurst, New Brunswick), 1939 to 2007". Subsequently, an educational booklet was produced "Carron Point: Life in a Coastal Ecosystem" providing information about coastal ecosystems, erosion control measures, and regulations and policies as they relate to coastal lands.

The impact of seawalls was evaluated for Carron Point in a report by Jolicoeur et al. in 2010 and 2012.

Infrastructure at risk from coastal flooding was assessed in a report by Simard et al. (2015), which also presented numerous possible flood scenarios for use in adaptation planning. Chelbi et al. carried out further work in 2015 to provide future erosion rates for coastal areas in the City of Bathurst in a report entitled "Évaluation de la vulnérabilité aux changements climatiques pour la ville de Bathurst".

5. RISK AND VULNERABILITY ASSESSMENT - COASTAL FLOODING, COASTAL EROSION AND INLAND FLOODING

Risk assessments identify [hazards](#) (e.g. coastal flooding), the potential impacts these hazards can have, and what the likelihood is for those impacts to occur. A vulnerability assessment evaluates how infrastructure and people will respond to the impacts.

Risk and vulnerability assessments help communities identify the most vulnerable areas and people, and develop responses that will increase the resilience of infrastructure and people, and the community as a whole, to increase its level of preparedness, and to minimize damages and costs related to impacts from climate change.

Flood risk scenarios as well as erosion predictions were used to map infrastructure at risk at various predicted flood levels in the next 85 years. Mapping was based on LiDAR, high precision digital elevation mapping, which was integrated into the City's [Geographic Information System](#).

Resilience is the ability to respond to change or disruption. This includes understanding potential changes, acting to reduce impacts before, during, and after a disturbance.

Risk is a measure of the expected outcome of an uncertain event. The determination of the risk of a climate change impact and stress to the component is based on the economic, health and safety, cultural and historical, and ecological and environmental consequences to the component and the likelihood that the climate change impact will occur. (Source: IPCC report)

5.1 Risk Assessment - Coastal Flooding, Coastal Erosion, and Inland Flooding

The risk assessment was carried out in consultation with City departments, the steering committee, and a community stakeholder working group for the coastal component.

a) Coastal Flood Risk Assessment:

In order to assess the risk and develop adaptation options for coastal flood risk, three potential timeframes were considered for which impacts were assessed: short-term (today), for a storm event of 2.8 m water level, with a 20% probability of occurring each year; medium-term (35 years), for a storm event of 3.0 m water level, with a 20 to 50% probability of occurring every year by 2050; and a long-term (85 years), worst case scenario, for a storm event of 3.9 m water level, with a 10 to 20% probability of occurring in 2100.



Impact of storm surge at Youghall Beach, 2010.
Photo: D. L'Anglais

These three scenarios help identify areas and infrastructure at risk today, and which require short-term planning, infrastructure improvements, and emergency readiness; areas that will be more frequently at risk in 35 years, and for which medium-term planning is appropriate, and the most severe case in 2100, which requires long-term planning for major infrastructure developments.

Table 2: Flood scenarios chosen for the City, representing short, medium and long-term potential storm surge events.

Storm surge event	Scenario 1	Scenario 2	Scenario 3
Flood level	2.8 m	3 m	3.9 m
Predicted probability of the event occurring in any given year	in 2015: 20% probability to 2050: 50-100% probability to 2100: 100% probability	in 2015: 4-10% probability to 2050: 20-50% probability to 2100: 100% probability	in 2015: <1% probability to 2050: <1% probability to 2100: 10-20% probability
Likelihood that the event will occur	This water level was observed during a storm surge in 2006 that caused widespread flooding. It is likely to occur fairly frequently, and increase in frequency in the next 50 years; by 2050, this could be a regular event.	A three m water level has not been observed in Bathurst. Under climate change, it is expected to become as frequent and likely in 2050, as 2.8 m are in 2015.	This water level is highly unlikely today, but more likely in 2100.

b) Coastal Erosion Risk Assessment

Future erosion risk along the coastline was determined by Chelbi et al. (2015. see Figure 2), and validated with City departments and the working group.

c) Inland Flood Risk Assessment

At this time, future flood scenarios for rainfall events are not available. Depth to water table mapping developed by Dr. Arp at UNB was used to identify areas likely at risk from flooding in the City. Those maps were validated with City staff. While these maps provide a broad indication of areas at risk, work is required to update the City's hydrographic network and develop predictive mapping that will be more exact in delineating flood risk areas, as modeling and information become available.

5.2 Assessment Results - Coastal Flooding, Coastal Erosion and Inland Flooding

Detailed results of the risk assessment are presented in Appendix 1. Thirty-six sites were identified as specific areas at risk, and while all of the sites require some form of adaptation, there are several areas of concern that stand out as presenting the greatest risk to the City of Bathurst:

Coastal beach areas

Flooding and inundation of low lying coastal lands due to sea level rise and storm surges, especially in the Bayshore Dr., Youghall Beach and Queen Elizabeth Dr. areas, already occur intermittently in places, with projections placing residents in these areas at increasing risk in the future. Although much of the shoreline has been protected from erosion by various measures, flooding remains a risk. In addition, as flood risk increases, so does the likelihood of those areas getting cut off due to roads being flooded.

Bathurst Harbour shorelines

Although flooding from storm surge events is less dramatic within the protected harbour than along the beaches, low lying shorelines are already being inundated, and the combination of coastal flood risk and inland flood risk creates challenges and problems for the municipal wastewater and storm water management systems, as well as shoreline properties where numerous property owners have implemented shoreline protection measures.

City roads

Numerous areas in the City experience flooding during heavy rainfall events and during snow melt. Drainage in certain areas in the City is a problem, as a result of too much runoff from upland areas. When the water is not retained upland from City infrastructure, roads and houses, it can overwhelm the stormwater management system, cause roads and basements to flood, and in some places, prevent homeowners from flushing their toilets.

Emergency measures

Transportation disruptions and access problems related to flooding of roads and bridges will make access difficult in some areas. Evacuations may be required with increasing frequency in some low-lying areas. During a flood event, residents may attempt to drive on submerged or semi-submerged roads to get to their homes, or they could be stranded in their homes or cottages. Flooding could also result in health and safety risks due to overflow of sewage wastewater.

Community readiness

Direct health impacts can be caused by localized flooding from seawater, where salt could potentially infiltrate freshwater wells, and backup of sewage into basements. A number of residential and cottage areas in the City are exposed to considerable risk, and residents could face high levels of stress. A lack of awareness, and personal readiness in case of an emergency, increases the vulnerability of residents considerably.

Municipal wastewater infrastructure

Some municipal infrastructure may not be well adapted to future flood events (e.g. undersized culverts and roads built below potential flood levels, sewage lines submerged at projected flood level, and salt water intrusion). Storm water and sewage infrastructure in Bathurst has mostly been separated over the last years, diverting runoff away from sewage infrastructure, which reduced pressures on that particular system. Of particular concern are those parts of the wastewater and storm water management system that currently experience saltwater infiltration, or could be easily inundated in a flood event. The aging sewage treatment facility will become increasingly at risk within the next 50 years.

The complete list of the 36 sites assessed is found in Appendix 1.



Storm surge at Youghall Beach, September 2002. Photo: D. Bérubé

6. ADAPTATION ACTIONS

Actions that the City can take to adapt to flood risk are subdivided under three categories: 1) adopt zoning based on relative flood risk (6.1); 2) take general actions that can be implemented city-wide (6.2); and 3) take specific actions for sites that have particular risks (Appendix 2).

6.1 Zoning

The municipality has the option of implementing specific zones within City limits that can identify high-risk areas and require certain measures to be taken by developers and landowners.

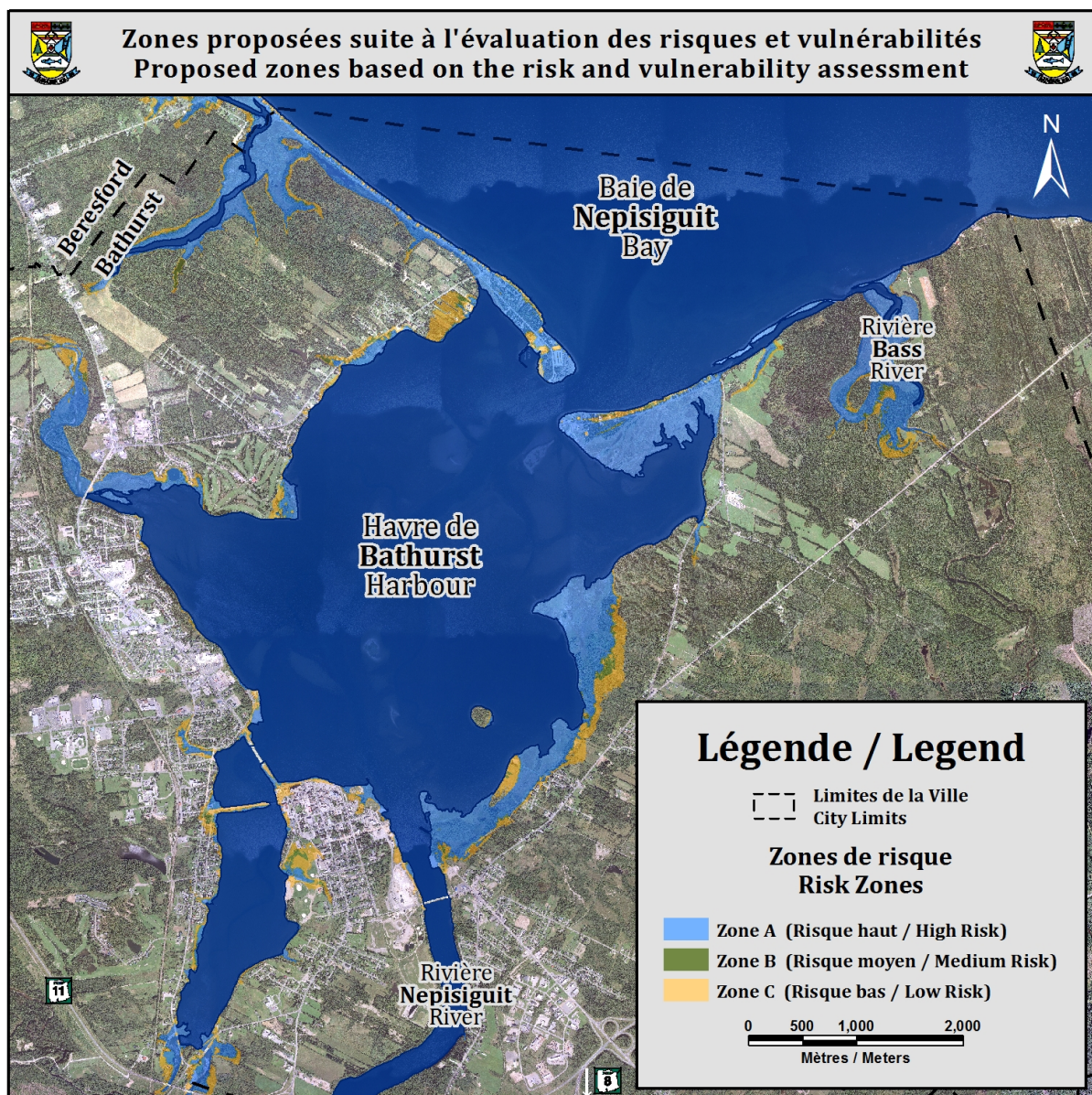


Figure 7: Map showing the approximate coastal risk zoning proposed for the City.

Changing municipal zoning and implementing new bylaws requires public input and participation, and proposed zones, bylaws and guidelines would have to go through such a public participation process.

Three zones are proposed for the City based on flood risk and vulnerability assessment (see Figure 6), as identified below. Different guidelines and development standards will apply for each zone, thereby allowing City development officers, municipal officials and residents the ability to clearly manage potential impacts (implemented through the municipal plan, overlay zoning, hazard zoning, etc.).

The three zones proposed for the City are:

Zone A: high-risk areas where residents and infrastructure are highly vulnerable today; areas that today have a considerable risk of getting flooded through extreme high tides and storm surges: 2.8 m in 2015, representing a storm surge that could occur every year with a 20% probability. As sea levels rise, and storm surges become more frequent, this zone will become even more at risk (50-100% probability in 2050). This zone also includes areas that are highly vulnerable to inland flooding, and the likelihood of basement flooding, washouts, etc. is very high. The impacts are hard to predict, and difficult to manage.

Zone B: medium-risk areas where residents and infrastructure are vulnerable today, but considerably less than in Zone A; areas that today have a risk of getting flooded through coastal storm surges and extreme high tides at 3 m, with a 4%-10% probability every year. This risk will increase to a 20-50% probability of occurring every year in 2050, and zoning might have to change over time.

Zone C: low-risk areas where residents and infrastructure are least vulnerable and the likelihood of flooding is very low today. These are areas that today have little risk of getting flooded. However, in the long-term (in 2100), a storm surge with 3.9 m water elevation could occur yearly with a 10 to 20% probability. This zone also includes areas that are vulnerable to flooding due to extreme rainfall events, but where impacts are expected to be manageable. Currently, the City's zoning By-law (2008-01, <http://www.bathurst.ca/bylaws.php>) includes a 30 m buffer around all waterways. This buffer and associated bylaw will be maintained as is until further data and information can be used to update a more accurate buffer.

The following provides a list of actions applicable for each zone. Specific actions for individual sites are provided in Appendix 2.

Zone A

- Set minimum elevation levels for any building permits for existing structures (bylaw); houses to have no living space below permitted elevation.
- Update building bylaws, development guidelines, and zoning regulations to reflect the newest climate projections, for example, develop mandatory setbacks from the shore, beyond those regulated by law.

- Carry out cost-benefit analysis of the continued cost increase in maintaining City infrastructure (sewage, stormwater management for example) versus moving infrastructure, using a 50-year time frame.
- Implement green buffers for all existing structures and future developments; rehabilitation of natural vegetation and systems so they can function as buffers (i.e. living shorelines; rehabilitated dune and beaches to allow for natural sediment movement).
- Consider waivers for areas where lots are still available (risk associated with developing property).
- Require backflow valves for private residences in all high-risk areas.
- Implement net-zero runoff, mandate wet ponds and retention ponds to reduce runoff risk;
- Establish regular schedule for updating flood maps and risk assessment, with provisions for extra mapping when new information becomes available that will substantially change high-risk areas.
- Ensure early warning system is in place for all residents.
- Identify wetlands, establish zoning regulations, zone all wetland areas as protected marsh (wetland conservation zone), beyond those already protected by regulation; protect Maritime Ringlet Butterfly habitat.

Zone B

- Develop standards and agreements with developers that are appropriate for the zone.
- Implement net-zero runoff, mandate wet ponds and retention ponds to reduce runoff risk;
- Mandatory set back from the shore (bylaw), based on the elevation and buffer required.
- Variances to allow for development, e.g. development can occur but no basements can be built, or if basements are built no equipment should be stored there.
- Implement green buffers for all existing structures and future developments; rehabilitation of natural vegetation and systems so they can function as buffers (i.e. living shorelines; rehabilitate dune and beaches to allow for natural sediment movement).
- Identify wetlands, establish zoning regulations, zone all marsh areas as protected marsh (conservation zone); protect Maritime Ringlet Butterfly habitat.

Zone C

- Develop standards and agreements with developers that are appropriate for the Zone.
- Implement net-zero runoff, mandate wet ponds and retention ponds to reduce runoff risk;
- Mandatory set back from the shore (bylaw), minimum elevation.
- Implement green buffers for all existing structures and future developments; rehabilitation of natural vegetation and systems so they can function as buffers (i.e. living shorelines; rehabilitate dune and beaches to allow for natural sediment movement).
- Identify wetlands, establish zoning regulations, zone all marsh areas as protected marsh (conservation zone); protect Maritime Ringlet Butterfly habitat.

6.2 General Adaptation Actions

Shorelines, dunes & vegetation buffers

Natural habitats such as saltmarshes, vegetation along watercourse, as well as natural features such as dunes all function as buffers against the effects from flooding and storm surges. Provincially significant wetlands (PSW) are protected by law, and a 30 m setback is required. Additional wetland areas currently not designated can be zoned by the municipality. Maintaining those natural features, and encouraging their re-establishment, is a low-cost adaptation option available to the municipality as well as individual homeowners:

1. Develop a shoreline management plan with guidelines for homeowners on how to protect their properties: develop uniform guidelines for the City in consultation with Department of Natural Resources and Department of Environment and Local Government.
2. Implement a shoreline monitoring program to record the changes that occur along the coast over the years.
3. Green buffers: ensure shore and stream buffer vegetation remains in place, implement a program that encourages landowners to increase vegetation buffer; use native plants along shorelines which will be able to tolerate the salt that might be an issue during flooding.
4. All wetland areas within the City should be zoned as conservation areas.



Armored shoreline at Carron Point after storm surge event causing erosion. Photo: D. McLaughlin

Stormwater management

1. Water retention measures upstream, and in the uplands
One of the most effective and efficient ways to reduce risk from heavy rainfall events causing City infrastructure to become overwhelmed is the retention of as much water in the upland and upstream as possible. In principle, any body of water, such as a wetland and swamp, can provide water retention functions. In addition, vegetation buffers along streams can slow down runoff, and retain more water, and forested areas retain more water than bare farmland. The City should consider a program to develop, with landowners, a diverse set of water retention options including wet ponds, wetlands, rain gardens, swales.
2. Development permits; In addition, development permits need to include a requirement not only for net-zero runoff, but also for the implementation of wet ponds and wetlands in the City.

Emergency Measures

Bathurst already functions as a regional emergency hub (KC Irving Community Centre), and the City is very active in building its capacity to respond to emergencies. Excellent cooperation exists with other municipalities as well as with the provincial Emergency Measures Organization (EMO). EMO responds to emergencies as they occur, but also plans for various disasters. A number of areas were identified through the adaptation planning process where EMO should focus some attention:

1. Coordinate with EMO on identifying emergency evacuation routes & meeting points that individual homeowners can use (especially in areas that would be cut-off from road access, such as Queen Elizabeth, Youghall, and Bayshore (Carron Point)).
2. Indicate evacuation routes with signage, and identify meeting points in case of flood events.
3. Conduct EMO simulations in high-risk areas every year.
4. Create a map with roads that might get blocked in case of storms, illustrating possible detours and general areas to avoid during flooding.
5. Create an inventory of boats in the area.
6. Promote "Sentinel" across Bathurst, and ensure residents are signed up for alerts.

Sentinel Alert is a web-based public warning system, developed by a Bathurst company and implemented widely, which helps emergency responders communicate effectively and efficiently with the public. It is an essential tool for municipalities and residents to be able to respond quickly to emergency events.

Community awareness

Residents of Bathurst who are located in low-lying areas are aware of flood risk. However, there has not yet been a concerted effort made to raise residents' awareness about the increasing risk from flooding, and how they themselves can be better prepared and avoid the negative effects resulting from flood events. Outreach and education should focus on the following key elements:

1. Provide information packages, specific to each zone, to inform residents about shoreline protection measures (which method should be used, such as natural buffers, armour stone, or nothing), flood proofing their homes, backflow valves, and how to prepare home emergency kits.
2. Develop a program and provide information about water management: how to retain water (e.g. raingardens), proper management of culverts, swales, wetlands, wet and dry proofing homes, etc.
1. Provide information about emergency preparedness, 72-hour emergency kits, and on how to develop a home emergency plan.
2. Place posts in strategic locations around the City as educational tools identifying potential flood levels.
3. Add specific climate change pages to the City's website where information, maps, education materials, and the adaptation plan can be easily accessible to the public.

Land use planning and development

Land use planning provides a number of tools to reduce risk to residents. The municipality can implement different zoning bylaws, establish setbacks and minimum building elevation levels. Specifically, the municipality can:

1. Develop zoning bylaws that reflect flood risk predictions and establish minimum elevations and setbacks.
2. Develop building guidelines for risk areas.
3. Developments in the downtown core need to take climate change into consideration: guidelines need to reflect this, such as limiting basements (or entirely prohibiting them) in high to medium-risk zones.
4. Develop and implement net zero runoff guidelines (including the requirement to implement water retention measures).
5. Update the municipal plan to reflect flood risk zones.

The City will update its hydrographic maps and incorporate flood risk modeling, both of which will be incorporated in the next municipal plan review.

6.3 Site Specific Adaptation Actions

The risk assessment identified 36 sites (Figure 6) that face particular risks and impacts over time. Adaptation options were developed for each of the sites as applicable, which are provided in Appendix 2.

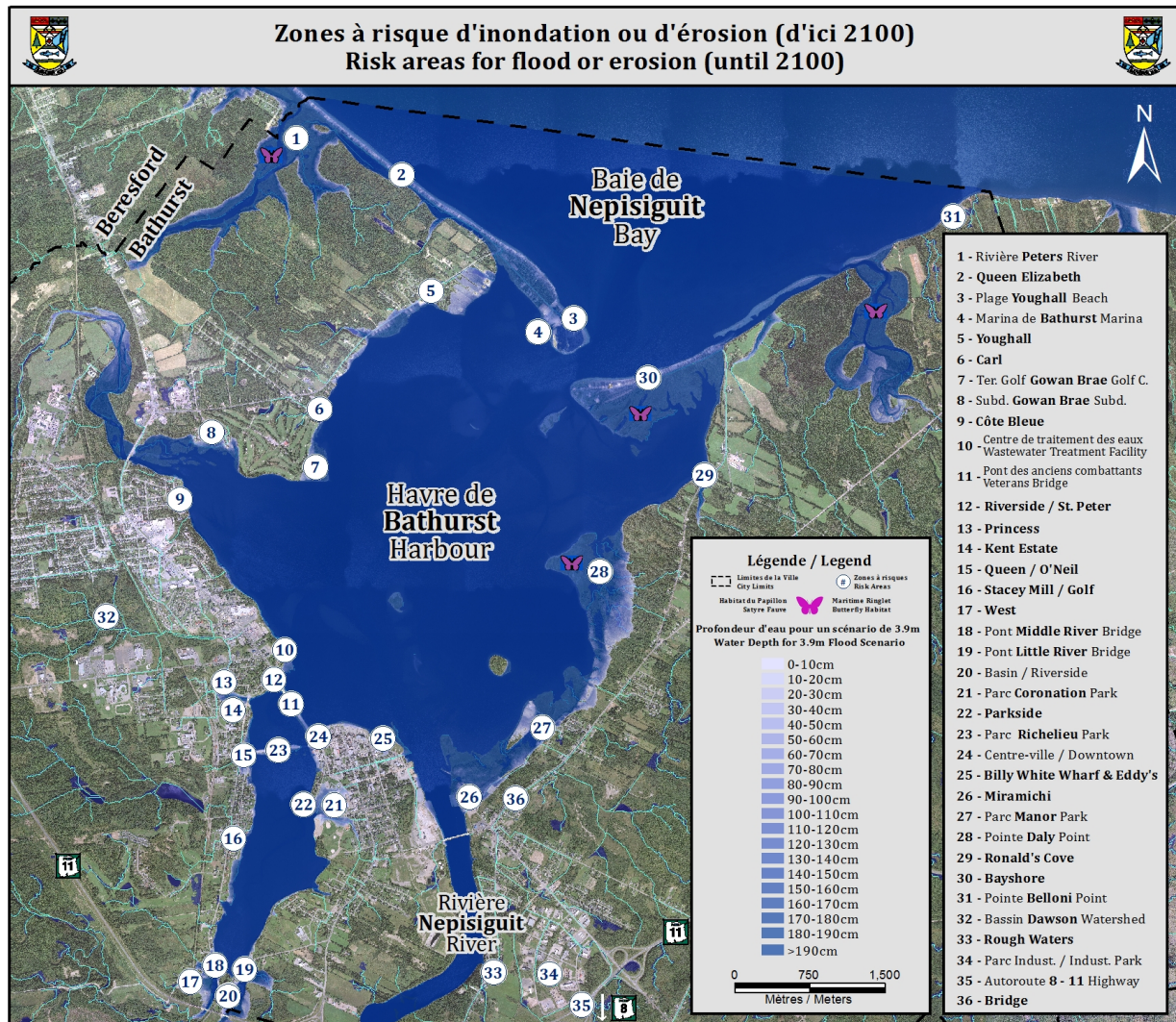


Figure 8: Overview map of 36 sites at risk for the City of Bathurst.

7. ADAPTATION PLAN IMPLEMENTATION

Implementing the actions proposed in the previous section involves a commitment on the part of the City planners, community engineers, community members, and emergency measures organization to ensure that the adaptation options are put into action. The following is a list of recommendations for next steps (please also refer to Appendix 3 for the Implementation Tracker):

Incorporating the Adaptation Plan into Municipal Operations:

1. Present Plan to City Council for approval;
2. Implement adaptation plan throughout municipal operations;
3. Update policies and regulations throughout municipal operations to reflect climate change and adaptation requirements;
4. Provide each City Department with maps, list of actions for their respective area and encourage City Departments to develop their respective future plans based on the information contained in the Adaptation Plan;
5. Communicate the risk and vulnerability assessment, as well as planned actions to all necessary levels of governments, where applicable, for example, NB's Department of Transportation;
6. Update hydrographic network mapping, flood risk assessments and maps as information becomes available. Incorporate scenarios into inland flood risk maps when flood scenario modeling becomes available.

Planning & Research:

7. Develop and implement new zoning in the next Municipal Plan Review;
8. Develop and implement new development guidelines;
9. Further research is needed in the following areas: A) cost-benefit analysis of maintaining municipal infrastructure in high risk areas; B) cost assessment of raising, moving, building up around lift stations at certain sites; and C) impact assessment of the groynes and jetties in the water on Youghall Beach.

Community Engagement:

10. Add climate change adaptation information to the City's website as soon as possible.
11. Develop City information package for homeowners;
12. Work with Bathurst Sustainable Development to carry out public education and outreach to raise awareness and inform residents.

Oversight and Ongoing Updates:

13. Establish a permanent Climate Change Action Committee to provide oversight and further direction to the implementation of the Adaptation Plan;
14. Have municipal departments submit annual progress reports on implementing adaptation actions;
15. The Adaptation Plan should be updated at least every 3 years, or as new information becomes available.

8. GLOSSARY

Adaptation—To adjust actions, policies, and planning in response to actual or expected climatic hazards to moderate their effects, and reduce their potentially negative impacts.

CGVD28—CGV stands for geodetic vertical datum, and is a reference standard for heights, 28 describes the year it was implemented (1928). CGV represents the tidal datum or mean water level from five tide gauges in Canada.

Climate Change—Climate change refers to any significant change in the measures of climate lasting for an extended period of time, including major changes in temperature, precipitation, or wind patterns, and others, that occur over several decades or longer.

Geographic Information Systems—Abbreviated as GIS, this is a tool that helps analyze and present spatial information, such as where houses may get flooded.

Growing Degree Days—Growing Degree Days (GDD) is a measure of the average annual number of days where temperatures fall within a temperature range permitting plant growth.

HHWLT—Higher high water large tide describes the average of the highest high water levels as an average over 19 years.

Resilience—The capacity to rebound after the impacts from hazards with minimum damage to social well-being, the economy, and the environment.

RCP 8.5 model—RCP 8.5 (RCP: Representative Concentration Pathways) is a climate model that predicts future climates, using future high energy demand and GHG emissions in the absence of climate change policies as basic assumptions. Developed in 2011, this model represents the pathway with the highest greenhouse gas emissions. (<http://www.iiasa.ac.at/>)

Return Period—The return period is an estimate of the average interval of time between similar flood events based on historical records and predictions about future climatic variability.

Sea-Level Rise—An increase in the mean level of the ocean. Sea-level is measured by a tide gauge.

Storm Surge—An abnormal rise in sea-level accompanying a hurricane or other intense storm, due to low atmospheric pressure and strong, on-shore winds, which may lead to damaging waves and coastal flooding.

Threat (Hazard)—Anything that can adversely affect a community.

Vulnerability—The degree to which a community is exposed to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.

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APPENDICES

Appendix 1: Site Risk Assessment - Coastal Flooding Coastal Erosion, and Inland Flooding

Appendix 2: Site-specific Adaptation Measures - Coastal Flooding, Coastal Erosion and Inland Flooding

Appendix 3: Implementation Tracker

Appendix 4: Maps of Individual Sites

Appendix 1: Site Risk Assessment - Coastal Flooding, Coastal Erosion and Inland Flooding

<u>See maps</u>		<u>Coastal flooding Scenario & risk level</u>			<u>Inland flooding</u>	<u>Ero sion</u>	<u>Risk & Impact</u>		<u>Vulnerabilities</u>			
<u>Site</u>	<u>#</u>	<u>2.8 m</u>	<u>3.0 m</u>	<u>3.9 m</u>			<u>Issue, Risk, Description</u>	<u>Impact</u>	<u>Public Infrastructure</u>	<u>Private Infrastructure</u>	<u>Future Plans for Site</u>	<u>EMO Specific Issues</u>
Peters River	1	none	none	none	X		Peters River is identified as a future area for residential development, and is at risk from inundation, both coastal and inland.	No impact to current infrastructure.	None.	None.	Yes, identified for future development.	None.
Queen Elizabeth	2	mediu m	high	high	X		Coastal flooding: flooding of houses, flooding of lift stations, people cut off in case of flood. Inland flooding: contributes to runoff, water over road.	Coastal flooding: Cut off even at 2.8 m, fully cut off at 3 m; many buildings impacted at 2.8 m; evacuations needed probably at 3.0 m for many residents; sewage line submerged.	Lift stations, road.	Houses, cottages.	Some vacant lots.	Residents might try to go through in hazardous conditions; evacuation issues, both ends might be cut off. Sewage and water was put in in 2006; can be shut off in case of problem.
Youghall Beach	3	mediu m	high	high		X	Erosion: Significant erosion along the beach, infrastructure damages. Coastal flooding: Important tourism area as it is the only public beach with facilities in the City (Leased to the City by the Province).	Coastal flooding: Cut off even at 2.8 m, fully cut off at 3 m; many buildings impacted at 2.8 m; evacuations needed probably at 3.0 m for many residents.	Boardwalk, parking lot, observation tower.	Houses, cottages.	To maintain beach infrastructure. A plan to armour beach front potentially underway for 2016 to prevent further erosion.	Some people might be cut off.
Bathurst Marina	4	mediu m	high	high			Coastal flooding: Infrastructure could be damaged during a storm surge, area of fuel storage. It is the only marina, with over 100 boats (considerable revenue for city, tourism attraction, and archaeological interest).	Coastal flooding: Submerged even at 2.8 m - no human safety risk, though buildings are cut off even at 2.8 m, fully cut off at 3 m; gas storage at marina is a risk.	None.	Yes.(managed by a non-profit association).	None known.	None.
Youghall	5	low	mediu m	high			Coastal flooding: Houses and road could be flooded, sections of road could be cut off.	Coastal flooding: At 2.8 m few homes are impacted; water in basement; similar for 3.0 m; at 3.9 m, many would have to be evacuated.	Road.	Houses.	5 prime building lots.	People might try to go through in hazardous conditions; some might be cut off.

Carl	6	low	low	medium			Coastal flooding: Houses could be flooded.	Coastal flooding: Likely water in basement in all scenarios, but especially at 3.9 m.	Road.	Houses.	None.	People with flooded basements, backed up sewage.
Gowan Brae Golf Course	7	low	low	low			Coastal flooding: Golf course and monument could be flooded. Historic Nicolas Denys site & monument also located here.	No risk to people or public infrastructure.	None.	Golf Course.	n/a	None.
Gowan Brae Subdivision	8	low	low	medium			Coastal flooding: Houses could be flooded. Recently developed, so does have minimum elevations.	Coastal flooding: Some basement flooding could occur at 3 m, and would occur at 3.9 m; some houses might have to be evacuated.	Road, sewage, water.	Houses.	n/a	People with flooded basements, backed up sewage.
Côte Bleue	9	low	high	high			Coastal flooding: Houses could be flooded.	Coastal flooding: Some basement flooding could occur in an earlier scenario, and would occur at 3.9 m.	None.	Houses.	n/a	People with flooded basements, backed up sewage.
Wastewater Treatment facility	10	low	low	low		X	Coastal flooding: Facility could be flooded, stop all treatment, overflow, sewage could spill. Inland flooding: could cause the facility to be overwhelmed and cause overflow	Coastal flooding: Above 3 m flood height, the facility would be impacted, and at 3.9 it would be fully flooded; essential service to City. Inland flooding: with high run off in City, backup of sewage is possible, treatment facility can get overwhelmed	Sewage treatment facility.	None.	Replacement needed within 25 years.	n/a
Veterans Bridge	11	medium	high	high			Coastal flooding: Bridge could be flooded, cut off.	Coastal flooding: Bridge not usable, but detour possible.	Bridge.	None.	n/a	People might try to go through in hazardous conditions; detouring might make passing of EMO vehicles difficult.
Riverside / St. Peter	12	low	medium	medium			Coastal flooding: Houses could be flooded.	Coastal flooding: Basements flooded at current storm surge height; significant flooding in more extreme events.	None.	Houses.	n/a	n/a
Princess	13	low	low	medium			Coastal flooding: Site is below flood level.	Coastal flooding: Basement flooding, more would occur at 3.9 m; houses may have to be evacuated.	None.	Houses.	Is being considered for development, owner has been informed.	n/a
Kent Estate	14	medium	high	high			Coastal flooding: Flooding of parts of the trailer park; culvert issues.	Coastal flooding: Some basement flooding would occur at 3.9 m; some houses might have to be evacuated.	Culvert.	Yes.	None.	n/a

Queen / O'Neil	15	low	low	medium			Coastal flooding: Flooding of houses.	Coastal flooding: Some basement flooding occurs at 2.8 m, and would occur at 3.0 m and more at 3.9 m; some houses might have to be evacuated at 3.0 m.	Lift station, road.	Yes.	One lot for sale.	People with flooded basements, backed up sewage.
Stacey Mill / Golf	16	low	low	medium			Coastal flooding: Flooding of houses.	Coastal flooding: Some basement flooding would occur at 3.0m and at 3.9 m; some houses might have to be evacuated.	Road.	Yes.	n/a	People with flooded basements, backed up sewage.
West	17	low	low	low			Coastal flooding: looding of houses	Coastal flooding: Some basement flooding would occur at 3.9 m; some houses might have to be evacuated.	Road.	Yes.	n/a	People with flooded basements, backed up sewage.
Middle River Bridge	18	low	low	low			Coastal flooding: Ramps to bridge flooded	Coastal flooding: Bridge not usable, detour not possible	Bridge owned by Province.	None.	Recently replaced.	People might try to go through in hazardous conditions; detouring might make passing of EMO vehicles difficult.
Little River Bridge	19	medium	medium	high			Coastal flooding: Ramps to bridge flooded.	Coastal flooding: Bridge not usable, but detour possible; 30 residents will be isolated if bridge is not passable.	Bridge owned by Province.	None.	Recently replaced.	People might try to go through in hazardous conditions; detouring might make passing of EMO vehicles difficult.
Basin / Riverside	20	low	low	medium			Coastal flooding: Houses could be flooded.	Coastal flooding: At 2.8 homes are impacted; similar for 3.0 m; at 3.9m, some may have to be evacuated at 3.0 m.	Road	Houses, business	n/a	People with flooded basements, backed up sewage.
Coronation Park	21	low	low	medium			Coastal flooding: Recreation area could be flooded out.	Coastal flooding: Buildings are likely to be severely impacted at 3.9 m, but no risk to people.	Recreation facilities.	None.	Master Plan in place.	None
Parkside	22	low	low	low		X	Coastal flooding: Houses could be flooded.	Coastal flooding: One building, likely flooding in basement at 3.9 m. Erosion: could impact houses.	None	Houses.	n/a	People with flooded basements, backed up sewage.
Richelieu Park	23	medium	medium	high			Coastal flooding: Causeway could be under water, park under water.	Coastal flooding: Causeway not usable, but detour possible. New elevations can be incorporated.	Road, causeway, park infrastructure.	None.	Increasing elevation, planned for 2016.	People might try to go through in hazardous conditions; passing of EMO vehicles difficult.

Downtown	24	low	low	medium			Coastal flooding: Much of the business district, including Service Canada building, could be flooded; gas station, historic part of town, seniors home (The Royal), etc.	Coastal flooding: At 2.8 m the Royal is impacted; other buildings will be impacted at 3.9 m, with a max of 60 cm over roads along shore; at 3.9 m the impact to the Royal may require evacuation.	Road, lift stations, federally-owned buildings, municipally-owned buildings & infrastructure.	Yes, gas stations & other buildings.	Further development of Downtown.	Flooded basements, backed up sewage; detours might make passing of EMO vehicles difficult; some people do not have cars.
Billy White Wharf & Eddy's	25	low	low	low			Coastal flooding: Flooding of land to be developed.	Coastal flooding: Impact felt at 3.9 m, with 20-30 cm in lowest spot. Some basement flooding, possibly some evacuation at 3.9 m.	Undeveloped.	Undeveloped.	Future development potential.	None.
Miramichi	26	medium	medium	medium			Coastal flooding: Trunk line flooding; flooded houses.	Coastal flooding: Sewage being pumped, which is a problem during high tide.	Sewage lines.	Houses.	n/a	People with flooded basements, backed up sewage.
Manor Park	27	low	low	low			Coastal flooding: Trunk line flooding; flooded houses	Coastal flooding: One home cut off during flooding. Basements flooded possibly above 3.0 m, but likely at 3.9. Buildings on island cut off at 2.8 m; flooded at 3.9 m.	Sewage lines.	Houses.	n/a	People with flooded basements, backed up sewage.
Daly Point	28	low	low	low			Coastal flooding: Marsh area could be flooded, some infrastructure damage.	Coastal flooding: Marsh will be flooded during all scenarios, some damages to trails may be sustained.	Board walks.	None.	Maintain as recreation area.	None.
Ronald's Cove	29	medium	high	high			Coastal flooding: Bridge could get flooded	Coastal flooding: Bridge not usable, but detour possible.	Bridge.	None.	n/a	People might try to go through in hazardous conditions; detouring might make passing of EMO vehicles difficult.
Bayshore	30	medium	high	high	X		Coastal flooding: Flooding of houses, flooding of lift stations, people cut off in case of flood. Erosion: of foreshore.	Coastal flooding: Cut off even at 2.8 m, fully cut off at 3 m; many buildings impacted at 2.8 m; some evacuations needed at 2.8 m, all need to be evacuated at 3.9 m. Erosion: threatens cottages and homes	Road, sewage, water.	Houses & cottages.	n/a	People might try to go through in hazardous conditions; evacuation issues, both ends might be cut off.
Belloni Point	31					X	Erosion: Erosion of cliff face.	Erosion: one house at risk	None.	Houses.	n/a	None.
Dawson watershed	32	-	-	-	X		Inland flooding: runoff from upstream causes flooding; St. Anne Street developments: KC Irving,	Inland flooding: basement flooding, road flooding, numerous houses at risk	Roads, sewage, water.	Houses.		People with flooded basements, backed up sewage.

							Walmart, Kent - too much development with insufficient stormwater management capacity; causes flooding along Coffin Crescent area as well as Duncan & Evangeline; CN culvert is not working well					
Rough Waters	33				X		Inland flooding: heavy run off upstream overwhelms infrastructure, causes flooding along road and in basements; sometimes in the spring people cannot flush their toilets, and culverts cause bottlenecks	Inland flooding: Basement flooding, road flooding, numerous houses at risk; health concerns about sanitary sewer backup	Roads, sewage, water.	Houses.		People with flooded basements, backed up sewage.
Industrial Park	34	-	-	-	X		Inland flooding: drainage in industrial park is insufficient, and flooding problems occur; interchange HWY 11 x 8 likely causes some of the problems. Road require repair more frequently because of drainage problems	Inland flooding: mostly commercial properties, but increased development and run off causes greater impact downstream if water is not retained.		Commercial	Future development likely	
Autoroute 8 & 11 Highway	35	-	-	-	X		Inland flooding: culverts currently in bad shape, flooding occurs; but if culverts are repaired, could cause flooding further downstream in City and in industrial park.	Inland flooding: impacts mostly industrial park.				
Bridge	36	-	-	-	X		Inland flooding: too much runoff upland causes flooding; culvert washed out during Arthur in 2012; Bridge & Sutherland - wet, beaver activity, lots of drainage problems across road all along.	Inland flooding: basement flooding, road flooding, numerous houses at risk	Roads, sewage, water.	Houses.		People with flooded basements, backed up sewage.

Appendix 2: Site-specific Adaptation Measures - Coastal Flooding, Coastal Erosion and Inland Flooding

Site	Map #	Zone	Actions	Lead	Support	Time-frame
Peters River	1	C	Minimum elevation for houses; Implement 0 runoff for all development, or a "no increase" in run off in St. Peters watershed area; No development within 3.9 m flood zone.	Municipal Planning		medium
Queen Elizabeth	2	A	Mandatory evacuation, before 3.9 m are reached; Carry out an inventory of boats in the area; Establish early warning system: use of broadband radio/use "knocking on doors" as warning system, ensure evacuation plan in place; Possibly put boardwalks or bridges across lagoon to permit residents to get to safety quickly (by themselves), and identify meeting points. Conduct practice runs every year (simulations).	Emergency Measures	Bathurst Sustainable Development Fire Department	short
			Study and evaluate raising of the road; Raise Kent Lodge Rd and Youghall Rd at each end of QE Drive; Study the relocation or raising of the lift stations; Move all at risk municipal infrastructure out of flood risk area (lift stations, etc.).	Engineering & Public Works		short-long
			Carry out inventory of what flood protection property owners have; Implement waivers for property owners; Recommend building on pylons; Do not disturb lagoon behind the road along QE drive, maintain as natural holding pond for flood waters (especially protecting the intersection Youghall & QE, as well as the lift station there); right of way permits the city to restrict any encroachment and removal of vegetation; Rehabilitate natural beach as buffer.	Municipal Planning	Bathurst Sustainable Development	short
			Provide information to homeowners about backflow valves; Inform about drinking water contamination potential; Propose raising owners house elevation; Inform about insurance in flood zones; Provide information on what to do if municipal services are interrupted, what can homeowners expect during a flood event; What to do about oil tanks; The role of a personal emergency plan (and 72 hour kits).	Bathurst Sustainable Development	Municipal Planning	short
Youghall Beach	3	A	Mandatory evacuation before 3.9 m are reached; Carry out inventory of boats; Establish early warning system with residents; Prohibit camping and boating during flood risk; Provide a map with roads that might get blocked in case of flooding to EMO.	Emergency Measures	Municipal Planning	short

Site	Map #	Zone	Actions	Lead	Support	Time-frame
Youghall Beach (cont.)			Elevate Kent Lodge Rd and Youghall Rd at each end of QE Drive; Relocate lift stations if needed: potentially develop new access road towards QE Drive; Dune restoration to protect municipal assets; beach nourishment might have to be done yearly; dune should be mobile so that sand can displace from front to back. Discuss erosion control project with provincial government departments to develop and implement measures that reduce erosion and protect municipal infrastructure; Impact assessment of groynes and jetties that were placed along shore (5 to 6) (are they increasing erosions, do they change the dynamics of the currents? what is their impact on Youghall Beach); Erosion control structures should be designed with sea level rise in mind, and in consideration of the lifespan of the structures (however, erosion in this area is 20 to 30 cm per year, lower than in other areas); Any re-building of recreational municipal infrastructure needs to consider a life span of a maximum of 10 to 15 years due to the risk of storms and flood events.	Recreation & Tourism	Engineering & Public Works	medium to long
			Adjust minimum elevation requirements & avoid basements; Implement green buffers aimed at shore stabilization.	Municipal Planning		short
			Provide information to homeowners: backflow valves, flood protection; drinking water contamination potential; raising house elevation; getting homes ready for an emergency (flood); insurance in flood zones; what if municipal services are interrupted; what can homeowners expect during a flood event; what to do about oil tanks; having an emergency plan (911 may not be able to respond); Consider Blue Flag certification for 2017, could allow for some coastal risk & sea level rise education; Pursue research opportunities.	Bathurst Sustainable Development Recreation & Tourism		short
Bathurst Marina	4	A	Gasoline and diesel storage tanks require flood proofing to prevent chemical spillage; Marina Association to develop an emergency plan within 3 years.	Marina Association	Emergency Measures	short
			Assess wharf if it can withstand 3 feet of water; Assess oil tank storage for flood proofing.	Marina Association	Engineering & Public Works	short
			Restrict residential development; Set up meeting with Board of the Marina Association to discuss risk and development of an emergency plan.	Municipal Planning		short
			Discourage stormchasers.	Bathurst Sustainable Development	Recreation & Tourism EMO	short
Youghall	5	B	Early evacuation will be required.	Emergency Measures		when needed
			Raise road at lowest points (in consideration of 50 year timeframe); Grade increase during next repairs or refurbishment; Evaluate raising or moving of lift station # 17.	Engineering & Public Works		medium

Site	Map #	Zone	Actions	Lead	Support	Time-frame
Youghall (cont.)			New developments: increase building elevation; No basements or no equipment in basements;	Municipal Planning		short
Carl	6	C	Inform the affected residents.	Municipal Planning	Bathurst Sustainable Development	short
Gowan Brae Golf Course	7	C	Restrict further development;	Municipal Planning		short
Gowan Brae Subdivision	8	C	Ensure new buildings are above predicted high water, no basements;	Municipal Planning		short - medium
			Inform the few affected residents.	Municipal Planning	Bathurst Sustainable Development	short
Côte Bleue	9	B	Study raising or moving lift station # 5; possibly build infrastructure up around lift station.			
Wastewater Treatment Facility	10	C	Look at multiple sewage treatment facilities across city when the current (built in 1974/76) will be at the end of its lifespan (within 25 years); Future system needs to be designed according to flood maps and climate change predictions; Short-term: raise access road.	Engineering & Public Works		medium - long
Veterans Bridge	11	C	Raise ramps and bridge.	NB DIT		medium - long
			Detour and close road.	Emergency Measures		short
Riverside / St. Peter	12	B	Road upgrade was done in 2013, no upgrades planned;	Engineering & Public Works		long
			Any development proposals should do so according to new elevation guidelines;	Municipal Planning		short
Princess	13	C	Lift station # 10 requires immediate attention to prevent water infiltration.	Engineering & Public Works		short
			Setback zoning; no further developments;	Municipal Planning		short
Kent Estate	14	B	Ensure shore buffer vegetation remains in place & encourage re-vegetation.	Municipal Planning	Bathurst Sustainable Development	short - medium
Queen / O'Neil	15	C	Use "knocking on doors" as warning system.	Emergency Measures		short
			Road upgrade redone completely in 2014 at a cost of \$2 million (has another 60 year lifespan); Study moving or raising lift station # 2.	Engineering & Public Works		short - medium

Site	Map #	Zone	Actions	Lead	Support	Time-frame
			Re-zone as road closures will be problematic. Prevent any changes to shoreline that impact buffer capacity negatively (removing vegetation).	Municipal Planning	Bathurst Sustainable Development	medium
Stacey Mill / Golf	16	C	Main sewage collector currently under water (1970's pipes); water infiltration occurring (saltwater) - repair and replace when funding is available.	Engineering & Public Works		short - medium
			Zone flood area as protected marsh; Prevent any changes to shoreline that impact buffer capacity negatively (removing vegetation).	Municipal Planning	Bathurst Sustainable Development	short
West	17	C	Prevent any changes to shoreline that impact buffer capacity negatively (removing vegetation).	Municipal Planning	Bathurst Sustainable Development	short
Middle River Bridge	18	N/A	Long-term suggestion: raise ramps & bridge.	NB Department of Transportation		
			During flood events close bridge and road.	Emergency Measures		when needed
			Inform residents.	Emergency Measures	Bathurst Sustainable Development	short - medium
Little River Bridge	19	N/A	Evacuation will be required as area will be landlocked. Identify what is blocked (map for emergency measures purposes).	Emergency Measures		when needed
			Long-term: raise ramps.	NB Department of Transportation		medium
Basin / Riverside	20	C	Raise road.	Engineering & Public Works		medium - long
			Building bylaws, adjust elevation requirements.	Municipal Planning	Bathurst Sustainable Development	short
			Provide information to homeowners about backflow valves; drinking water contamination potential; raising house elevation; getting homes ready for an emergency (flood); insurance in flood zones; what if municipal services are interrupted; what can homeowners expect during a flood event; what to do about oil tanks; having an emergency plan.	Bathurst Sustainable Development	Municipal Planning	short
Coronation Park	21	C	Road closure.	Emergency Measures		when needed
			No major development to be undertaken (plan exists, 2014, which was not climate change proofed); Permit only recreational developments. Flood proofing buildings (owned by municipality).	Recreation & Tourism	Engineering & Public Works	short - medium
Parkside	22	C	Flood proof building.	Private		
Richelieu Park	23	B	Road closure.	Emergency Measures		when needed
			South End trail will be raised by 1 m in 2016. No permanent structures permitted.	Engineering & Public Works	Municipal Planning	short

Site	Map #	Zone	Actions	Lead	Support	Time-frame
Downtown	24	C	Identify residents with mobility issues; Early evacuation; Ensure Royal staff have protocols in place in case of a flood, require for an emergency plan to be developed within 3 years; Gas station: Ensure flood event does not cause spill; Undertake inventory of fuel storage in Downtown.	Emergency Measures		short - medium
			Raise road where feasible; Dikes around the most vulnerable areas; Owners need to be informed about the flood risk maps and need to consider modifications to building (Royal); Flood proof gas tanks at gas station.	Engineering & Public Works		short - medium
			No new fuel tanks permitted; New buildings should be flood-proof, saltwater resistant, above highest predicted flood level.	Municipal Planning		short
Billy White Wharf & Eddy's	25	C	Zone flood area as protected marsh. Shore protection.	Municipal Planning		short
Miramichi	26	B	Collector line is currently under water, move when feasible.	Engineering & Public Works		medium - long
			Zone flood area as protected marsh.	Municipal Planning		short
Manor Park	27	C	Zone flood area as protected marsh	Municipal Planning		short
Daly Point	28	C	No further development at Daly Pt.; no infrastructure in flood zone	Municipal Planning		short
Ronald's Cove	29	B	Road closure.	Emergency Measures		when needed
			long-term: build up lowest area; raise ramps & bridge.	Engineering & Public Works		medium - long
Bayshore	30	A	Mandatory evacuation, with early road closure; Identify meeting points, and similar procedures as Youghall and QE with drill for emergency measures (every 2 or 3 years).	Emergency Measures		short when needed

Site	Map #	Zone	Actions	Lead	Support	Time-frame
Bayshore (cont.)			Build up road or provide escape route for water from marsh towards the ocean. Evaluate low berm/dyke behind road to prevent flooding in the short to medium-term, however that saltmarsh is very close to the road - and berm/dyke may only provide 20-50 years. Long term: raise road? Conduct cost-benefit analysis of maintaining houses/cottages building protection structure (armour stone along coast), and dealing with continued impacts (damages to municipal and private infrastructure) Move all at risk municipal infrastructure out of flood risk area (lift stations etc.); No buildings with basements	Engineering & Public Works		short - medium
			Consider zoning amendment for properties to be summer dwellings only; Restrictions on future developments; Implement green buffers aimed at stabilization of shoreline, rehabilitate natural beach as buffer; Implement bylaw requiring habitable area above predicted maximum flood level	Municipal Planning		short
			Provide information to homeowners: backflow valves; drinking water contamination potential; raising house elevation; getting homes ready for an emergency (flood); insurance in flood zones; what if municipal services are interrupted; what can homeowners expect during a flood event; what to do about oil tanks; having an emergency plan. Develop City Information Package. Possible flood audits (of homes) for people in vulnerable areas; Information to homeowners about shoreline protection measures (which to use, if any).	Bathurst Sustainable Development	Municipal Planning	short
			Research project under way for Carron Pt. Evaluating if the saltmarsh is accumulating or not (research being done by McGill University with planned extension of research to Daly Pt.).	Other	Recreation & Tourism Municipal Planning	short - medium
Belloni Point	31	C	Armour stones at the bottom of the cliff & improve drainage along cliffs; Potential planned retreat from coast.	Private		
			Bass River Bar: study project to reduce erosion along beach, which might include the dredging of a channel across the sandbar close to the mouth of Bass River.	?		
Dawson watershed	32		Ensure all developments in the area have net zero runoff and implement retention systems, preferably wet ponds or wetlands	Engineering & Public Works		medium
			Work with CN to repair culverts, and implement water retention measures (dry ponds, wetlands, wet ponds) above stream to retain more stormwater	Engineering & Public Works		short
			Work with landowners that have driveways and culverts to educate them about proper maintenance of culverts	Engineering & Public Works		short

Site	Map #	Zone	Actions	Lead	Support	Time-frame
			Work with landusers (farmers) upstream to implement reduced runoff, such as building of wetlands; discuss and co-ordinate projects with Ducks Unlimited	Engineering & Public Works		medium
Rough Waters	33		Work with farmers to reduce runoff, implement stormwater retention system along road.	Engineering & Public Works		medium
			Work with landowners that have driveways and culverts to educate them about proper maintenance of culverts	Engineering & Public Works		short
Industrial Park	34		Implement better drainage, and develop wet ponds, dry ponds and wetlands to retain water at source and reduce runoff; consider implementing increase in permeable surfaces.	Engineering & Public Works		short-medium
Autoroute 8 & 11 Highway	35		Work with DIT to develop stormwater retention systems around interchange	Engineering & Public Works		medium-long
Bridge	36		Work with landusers (farmers) upstream to implement reduced runoff, such as building of wetlands; discuss and co-ordinate projects with Ducks Unlimited	Engineering & Public Works		medium
			Work with landowners that have driveways and culverts to educate them about proper maintenance of culverts	Engineering & Public Works		short

Appendix 3: Implementation Tracker

Implementation Action	Lead	Short term	Mid-term	Long-term	Status
1. Incorporate inland flooding hazards in Climate Change Adaptation Plan;	Planning Department				Completed March 2017
2. Public Presentation of Plan (Inland Flood Risk)	Planning Department	X			Public Meeting April 18th, 2017
3. Council Resolution, amendment to city of Bathurst Climate Change Adaptation Plan (Inland Flooding)	Planning Department	X			Public Meeting April 18th, 2017
4. Implement adaptation plan throughout municipal operations;	City Council Department Heads	X	X	X	On going
5. Update policies and regulations throughout municipal operations to reflect climate change and adaptation requirements;	Planning Department		X	X	On going
6. Departments to adjust their operations according to the information and recommendations contained in the City of Bathurst Climate Change Adaptation Plan; departments set their engagements and responsibilities according to plan; copy of plan and maps will be provided to each Department.	Department Heads		X	X	Maps will be provided to city departments through city of Bathurst GIS System and website. Maps shall be modified as new data becomes available.
7. Communicate the risk and vulnerability assessment, as well as planned actions to all necessary levels of governments, where applicable, for example, NB's Department of Transportation & Infrastructure;	Planning Department	X			May 2017
8. Collect & complete stormwater infrastructure inventory, produce mapping using high Precision GPS, to help modeling of inland flooding.	Operational Services		X		2017-2018
9. Update hydrographic maps and implement inland flood risk modeling when it becomes available, incorporate into next municipal plan (Using UNB and/or UdeM new models).	Operational Services		X		2017-2018
10. Amend City of Bathurst Zoning By-Law, Ex.: Minimum first floor elevation & minimum watercourse set-backs;	Planning Department		X		2017-2018
11. Develop and implement new development guidelines;	Planning Department	X	X		
12. Further research is needed in the following areas: A) cost-benefit analysis of maintaining municipal infrastructure in high risk areas; B) cost assessment of raising, moving, building up around lift stations at certain sites; and C) impact assessment of the groynes and jetties in the water on Youghall Beach;	Public Works & Engineering		X		On going
13. Add climate change adaptation information to the City's website.	Planning Department Communications	X			2017-2018
14. Develop City information package for homeowners;	Planning Department Communications	X	X		Coastal Risk completed, Inland Flooding 2017-2018
15. Work with Bathurst Sustainable Development to carry out public education and outreach to	Communications	X	X	X	On going

raise awareness and inform residents;					
16. Undertake a feasibility study to evaluate how renewable energy sources could satisfy local electricity needs, including but not limited to hydropower potential of Bathurst harbor.	Operational Services		X	X	
17. Establish a permanent Climate Change Adaptation Plan Committee to provide oversight and further direction to the implementation of the Adaptation Plan;	City Council	X	X	X	Committee already in place
18. Follow up with municipal departments regarding progress made regarding adaptation actions;	City Council		X	X	
19. The Adaptation Plan should be reviewed at least every 3 years, or as new information becomes available.	Climate Change Adaptation Plan Committee		X	X	On going