IT'S TIME TO PREPARE NOW

7 Steps to Assess Climate Change Vulnerability in Your Community

With funding support through Natural Resources Canada's Regional Collaborative Adaptation Program

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Newfoundland Labrador

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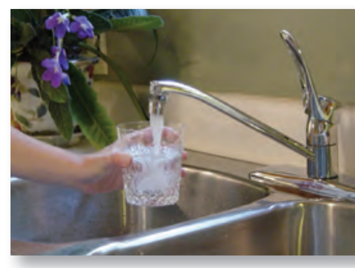

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Introduction

Climate change is one of the most serious challenges facing government and community leaders today. Many communities across Canada are already experiencing the impacts of climate change. It is critical to examine how climate change will affect your community and to prepare for more variable weather patterns. In the past, communities were planned with the assumption that basic weather and climate patterns would remain the same over time. Today, the climate is much less predictable and communities need to prepare for uncertainty and extremes.

Outlined in this workbook is a seven-step process to help you examine your community's vulnerability to climate change. The issues examined are coastal vulnerability, flooding, slope movement, drinking water supply, wildfires, and winter conditions. This workbook is one of many tools that your community can use to prepare for climate change and other weather related hazards. In 2011 the Government of Newfoundland and Labrador released *"Charting our Course: Climate Change Action Plan 2011"* which establishes the province's approach to climate change. The plan sets out government's commitment to reduce greenhouse gas emissions and improve the resilience of communities to the impact of climate change.

Climate is the long term condition of the atmosphere such as temperature and precipitation trends. Weather is the condition of the atmosphere over a short time period.

Getting Started - Explaining Weather and Climate

Weather is the current condition of the atmosphere which can change over minutes, days or months. Climate is the pattern or cycle of weather conditions such as temperature and precipitation measured over a period of 30 years or more. Aspects of climate include temperature, precipitation, wind speed and direction, sunshine, fog and the frequency and intensity of extreme events. Climate may affect your community in a variety of ways depending upon local geography and other features of your community. This guide will help you plan for the immediate and long-term impacts of climate change which may include slow, on-going processes such as sea level rise, or sudden events such as storm surges or wildfires.

Photo credit: Vickie Thorne

Strong winds can cause severe property damage. This house in Francois, NL was split in half and blown down a hill during tropical storm Florence in 2006. In the future, there may be more frequent and more extreme storm events.

Photo credit: Environment Canada

This photo shows ice accumulation in Bonavista, NL. Under projected climate changes, winters may become more variable with a greater mixture of snow, ice and rain.

Trends and Variability

It is widely accepted that our climate is warming and becoming more variable. The gradual increase in average global temperatures over a long period of time is a climate trend. Climate variability refers to the occurrence of highs and lows that are above or below the average state of the climate. Examples of variability include extreme events such as heavy rainfall, strong winds or extreme temperatures. Another example would be unusual temperatures or wide fluctuations in temperature within a single season. In the short term, changes in the variability of the climate may have a bigger impact on communities than a change in the long term climate trend. The consequences of this for local communities include seasons that are less predictable and weather that is more erratic.

Communities can prepare for the future by considering climate change in their planning and development processes. For example, increased variability may mean that winter temperatures shift from below freezing to above freezing more often. This could result in a greater number of freeze/thaw/refreeze events, more freezing rain events, and an increase in ice-related driving hazards. Communities may need to change their road clearing strategies to deal with a wider range of road conditions during the winter months.

What this Workbook Will Do

This workbook will help you plan for climate and weather related issues that affect your community and assist you with developing strategies to deal with those issues. The focus is on climate change adaptation, which involves anticipating and planning for climate change. Mitigation, lowering emissions and working to reduce future climate change, is also important but is not the focus of this guide. For further information on mitigation, please see the resource guide at the back of this workbook.

How this Workbook Can Help

The process outlined in this workbook will:

- Raise your awareness of climate change and weather-related issues;
- Help you identify the types of issues related to climate change and water resources that are impacting your community;
- Outline how the climate might change in the future and impact your community;
- Help you prepare for these impacts;
- Provide guidance on community-level decision making, zoning and permitting, infrastructure investments and community development; and
- Provide information that you can use in existing planning efforts such as emergency plans, land use plans and economic development plans.

Seven-Step Process

Each chapter of this workbook focuses on a climate change and weather-related issue. Within each chapter is a seven-step process to assist you with assessing your community's vulnerability to these issues. This seven-step process starts with identifying the problem and ends with identifying your adaptation options. The seven steps are:

1 Identify the types of climate and weather-related issues that have affected your community;

2 Locate where these issues have occurred or could occur in your community;

3 Assess what infrastructure has been or will be impacted;

4 Identify the residents who have been or will be most affected as well as those who can provide assistance in the community;

5 Assess which economic sectors have been or will be most impacted by the issues;

6 Identify how the natural environment has been or will be affected; and

7 Determine the best ways to address the issues identified.

This seven-step process may need to be completed again in later years given that your community and the climate may change. Certain steps may need to be repeated or revisited after you gain more information or if new questions and concerns arise.

Community Mapping

To complete the chapters in this workbook, you will need a map of your community. If you do not have a map to use for this purpose, please see Section A: Sources of Information and Technical Support in the Resource Guide at the back of the workbook to find out how you can obtain one. Steps 2-7 of each chapter require that you identify on the map areas in your community where issues have occurred and could occur in the future. At each step in the process you will be asked to identify particular issues by drawing on your map. Upon reaching step seven of the chapter(s) that you have chosen to complete, your map will show:

Proper planning can save lives, prevent damage to important infrastructure and save money in the long-term.

- The location where the issue has occurred and where it could occur;
- The infrastructure that has been or could be impacted;
- Individuals and groups that have been or will be most affected and those who can provide assistance;
- Economic sectors that have been or could be impacted; and
- Environmentally sensitive areas that have been or could be affected.

This information can guide you in directing adaptation efforts and future planning and development in your community.

Community mapping in Logy Bay, NL. Areas and infrastructure at risk from river flooding were mapped out by community members.

Photo credit: Kimberly Bittermann

Recommendations for Workbook Completion

Table 1 outlines a recommended course of action for assessing climate change issues in your community.

Table 1: Organizing Action in Your Community

Action	Responsibilities
1. Establish main community contacts	❑ Select main contacts to participate as members of the project team
2. Gather background information *(Page #'s referenced are for Sections A & C of Resource Guide)*	❑ Gather relevant community information, such as: • Climate data *(p. A9-ACASA / p. A5)* • Emergency and sustainability plans • Maps *(p. A1)* • Infrastructure and environmental studies *(p. C4)* ❑ Determine who would be interested in participating in this process and have important information to contribute
3. Set up a community workshop or series of meetings	❑ Choose how you want to work through the 7 steps: • 1 half-day or full-day community workshop • A series of 2-3 meetings ❑ Identify a date, location and participants for the workshop or meetings
4. Investigate adaptation options	❑ Contribute suggestions and ideas ❑ Consider examples from other communities ❑ Consider how your community has adapted in the past
5. Present and discuss summary of findings	❑ Present findings to committee and community members ❑ Assess your adaptation options
6. Moving forward on adaptation options	❑ Develop a workplan to implement your adaptation options and incorporate them into community planning

At the back of this workbook there is a resource guide that includes additional information on the issues identified throughout the workbook, a list of definitions, a section on funding opportunities and a section on other decision-making tools available. Here you will also find case studies that offer examples of how other communities have adapted to climate-related issues.

Photo credit: Department of Transportation and Works, NL.

Slope movement from flooding after Tropical Storm Chantal hit Newfoundland and Labrador, 2007.

As you go through this process, use the resources available to identify, explore and address the issue(s) your community faces. Resources include previous studies in your area conducted by government, universities or other groups; newspaper articles; local knowledge; maps; on-line sources; museums and archives.

Establishing a climate change adaptation committee, hosting a workshop and conducting interviews are all useful ways to collect information from community members. People you may want to contact include:

- ❏ Current and past mayors and councillors
- ❏ Town staff
- ❏ Elders and seniors
- ❏ Members of environmental organizations
- ❏ Emergency service personnel (police, fire, search and rescue)
- ❏ Planners
- ❏ Engineers
- ❏ Water and sewer workers
- ❏ Lands management personnel
- ❏ Fish harvesters
- ❏ Farmers
- ❏ Members of volunteer organizations
- ❏ Community researchers
- ❏ Foresters
- ❏ Coast guard personnel
- ❏ Members of stewardship groups
- ❏ Public health nurses

Strong winds and waves can batter communities, causing damage to houses and docks along the coast, as seen in Port-aux-Basques, NL.

Photo credit: Don Pittman

Identifying Your Issues

This step will help you:

- Identify the issues related to water, weather and climate that have affected your community in the past; and
- Identify the issues that could affect your community in the future.

Things to consider:

- **Coastal vulnerability**
- **Flooding**
- **Drinking water supply**
- **Slope movement**
- **Winter conditions**
- **Wildfire**

Issue Identification

Here you will identify the climate-related issues that have occurred in your community and issues that could occur in the future.

Weather-related events can cause changes to the physical environment and result in damage to infrastructure, property, heritage sites or environmentally sensitive areas. In some cases, weather related issues such as increased precipitation can put people at risk and make it necessary to evacuate certain areas.

Photo credit: Fire and Emergency Services, NL

Landslide in Daniel's Harbour, NL, 2006.

Photo credit: Department of Transportation and Works, NL

Road washout in the Placentia area after Tropical Storm Chantal hit Newfoundland and Labrador in 2007.

Issues that have impacted your community

Table 2 can be used to help you identify the issues related to water, weather and climate that have had an impact on your community. In the absence of written records, traditional and anecdotal local knowledge is a valuable resource.

Table 2: Issues that have impacted your community

Issue	Yes	No	Details
Flooding	❑	❑	
Coastal vulnerability	❑	❑	
Drinking water supply	❑	❑	
Slope movement	❑	❑	
Winter conditions	❑	❑	
Wildfire	❑	❑	
Other	❑	❑	

Damage on the Bonavista Peninsula, NL from Hurricane Igor, 2010.

Photo credit: Fire and Emergency Services, NL

Answer the following questions to further consider how climate change may be affecting your community:

Have you noticed changes in the weather and climate in your community?

❑ Yes ❑ No

If yes, what are the changes?

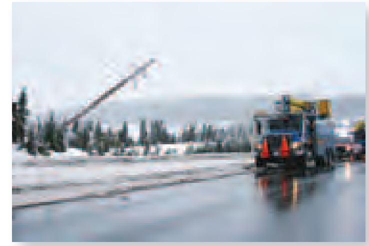


Photo credit: Fire and Emergency Services, NL

Bonavista Ice Storm, 2010.

Use Table 3 to indicate what types of changes have been occurring in your community:

Table 3: Changes in Your Community

Factor	Change	Comments
Air temperature		
Extreme events		
Wind		
Snow		
Rain		
Sea level		
Other		

Wildfire in Badger, NL, 2005.

Photo credit: Fire and Emergency Services, NL

Summary of Changes

Table 4 provides a summary of anticipated climate changes. This table shows an increase in climate indices, or variables, between the past (1961-2000) and anticipated future (2046-2065) climatology. The size of the arrow represents whether the change is expected to be small or large. These values were generated by climate simulations from the Canadian General Circulation Model. Although these changes will vary across the province, they provide a general idea of how the climate might change. These projected changes will have implications for communities and will be explored in the pages that follow.

Table 4: Projected Changes in Climate Variables for Newfoundland and Labrador

Variable	Direction of change	Change
Temperature average (°C), annual	⇧	4.01
Temperature average (°C), spring	⇧	3.88
Frost free days*	⇧	44.51
Growing degree days**	⇧	684.23
Precipitation average (mm/day), annual	⇧	0.05
Precipitation average (mm/day), spring	⇧	0.17
Precipitation average (mm/day), winter	⇧	0.13
Heavy rain events	⇧	1.34

Table produced by Dr. Joel Finnis, Memorial University of Newfoundland, Department of Geography.

*Frost free days refer to the number of days between the last spring frost and the first fall frost.

**Growing degree-days are a measurement of heat accumulation and are used by people in agriculture to help anticipate when a plant will be ready to harvest.

Local knowledge is also a key source of information on changing conditions. Residents who have lived in an area for a long time may have observed changes to local weather patterns and climate. This knowledge can be combined with observations made by researchers in order to understand the changes happening in your community.

What We Can Expect in the Future

Taking into account climatic changes, economic development and social changes, use Table 5 to explore what issues might affect your community in the future. In the 'Comments' column, record any information you think is relevant, such as:

- Whether or not the issue is new in your community;
- How serious you think the issue will be; and
- What the reason is for the change.

Table 5: Climate Change Issues in The Future

Issue	Future Issue Yes	Future Issue No	Comments
Flooding	❑	❑	
Coastal vulnerability	❑	❑	
Drinking water supply	❑	❑	
Slope movement	❑	❑	
Winter conditions	❑	❑	
Wildfires	❑	❑	
Other	❑	❑	

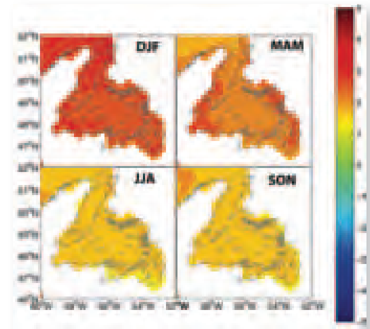


Photo credit: Diagram taken from "An Atlas of Climate Change for the Island of Newfoundland" by Dr. Joel Finnis, Memorial University of Newfoundland. Report available at www.atlanticadaptation.ca

Seasonal change in mean daily temperature between the late 20th (1968-2002) and mid-21st (2038-2072) centuries, as represented by the Canadian Regional Climate Model and the Canadian General Circulation Model. Winter (DJF), spring (MAM), Summer (JJA), and Autumn (SON) are shown separately.

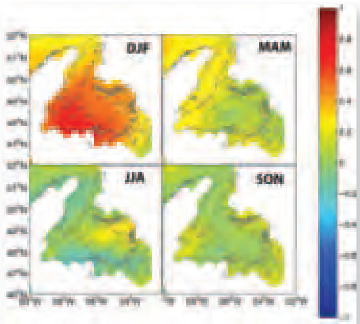


Photo credit: Diagram taken from "An Atlas of Climate Change for the Island of Newfoundland" by Dr. Joel Finnis, Memorial University of Newfoundland. Report available at www.atlanticadaptation.ca

Seasonal change in mean daily precipitation (mm), between the late 20th (1968-2002) and mid-21st (2038-2072) centuries, as represented by the Canadian Regional Climate Model and the Canadian General Circulation Model. Winter (DJF), spring (MAM), Summer (JJA), and Autumn (SON) are shown separately.

Before you work through any chapter of this workbook, you should take some time to identify the most important issues in your community.

Using Table 6, identify issues that you feel are important enough for your community to consider in detail.

Table 6: Issues that your community should consider in detail

	Please indicate with a √ if you think this issue is important enough to consider in detail.	
Issue	**Yes**	**No**
Flooding	❑	❑
Coastal vulnerability	❑	❑
Slope movement	❑	❑
Drinking water supply	❑	❑
Winter conditions	❑	❑
Wildfire	❑	❑
Other	❑	❑

Now that you have a better understanding of the types of issues affecting your community, explore the locations where those issues are occurring and who or what is most impacted. This workbook is divided into chapters based on specific issues such as flooding, coastal vulnerability and winter conditions. Please work through the chapters that are relevant to your community.

Road damage on Random Island, NL, due to Hurricane Igor, 2010.

Photo credit: Fire and Emergency Services , NL

Photo credit: Department of Transportation and Works, NL

Road repair in the Placentia area after Tropical Storm Chantal hit Newfoundland and Labrador in 2007.

Final Checklist

At the end of each of the seven steps, there is a final checklist of questions about the work you just completed. Please take the time to answer these questions as they are intended to focus your thoughts on the issues your community is facing and ensure you have the required information.

Before moving on to the consideration of specific issues, please ask yourself the following questions and check the box if you have gained the required information or understanding. If you feel that there are gaps in your knowledge, please work through the chapter again and refer to the Resource Guide at the back of the workbook for assistance. Once you have gathered the information asked for in this Introduction chapter, you will be ready to work through the chapter(s) most relevant to your community.

	Do you have an understanding of the historical weather patterns and climate-related issues in your community?
	Have you identified the types of weather and climate-related issues that currently affect your community?
	Have you identified the types of issues that might affect your community in the future?

CHAPTER 1

Flooding and Climate Change

STEP 1: Understanding Flooding in Your Community

Many communities in Newfoundland and Labrador have been built in flood sensitive areas along the coastline or near rivers and streams, and as a result, have had to cope with flooding. Floods are one of the most common natural hazards in the province and often the most costly. Due to climate change, the occurance of extreme precipitation events that result in flooding is expected to increase.

Newfoundland and Labrador experiences, on average, 6 floods per year with an average cost greater than $3.2 million annually.

Floods can result in injuries and loss of work and can damage infrastructure, environmentally sensitive areas, crops and heritage sites. Flooding can lead to road closures, isolating communities and limiting access to food, supplies and fuel.

Types of Flooding

Heavy rainfall or snow and ice melt can cause river and stream volumes to swell and flood. This type of flooding can also occur along the shores of lakes or ponds.

Water ponding is the surface accumulation of water that often happens after heavy rainfall. Ponding occurs where water cannot drain away, typically in flat, low-lying areas or in front of damaged culverts or drainage trenches.

> Flooding can result in injuries and costly damage to infrastructure. Proper planning may reduce flood hazards.

> Please note that coastal flooding is covered in Chapter 2- Coastal Vulnerability and Climate Change.

Photo credit: Fire and Emergency Services, NL

The Town of Bonavista, NL during Hurricane Igor, 2010.

Photo credit: Fire and Emergency Services, NL

Road washout in the Five Coves area of the Bonavista Peninsula, NL during Hurricane Igor, 2010.

Factors that Impact Flooding

Environmental causes of flooding include rainfall, snowfall, snowmelt and debris or ice jams. Floods often occur when a sudden and large amount of water is added to a river or stream after heavy rainfall, rapid snowmelt or the break-up of ice. Soil conditions, the shape of the landscape and vegetation cover affect the likelihood of a flood. Steeper slopes cause water to move more rapidly, increasing the likelihood of a flood, but vegetation cover slows the movement of water, decreasing the likelihood of a flood.

Human activity can have an impact on where, and to what extent, flooding will occur. The ground surface (pavement or natural vegetation) affects how fast and how much water gets into a drainage system. Culverts and drainage trenches can divert water away from key areas in your community. Dams can control the timing and quantity of water flowing into a river, while also regulating the drainage of wetlands. However, poorly maintained or overloaded infrastructure can cause flooding due to blockages, backup of water flow or dam failure. The location, size, design, construction material and maintenance of key infrastructure can all affect the occurrence and severity of flooding.

Please answer the following questions related to flooding in your community.

How have floods impacted your community?

What caused these floods?

Timing

Floods can occur any time of the year but are less frequent in the summer. Heavy rainfall often causes river flooding in early fall due to hurricanes and tropical storms. River flooding in late winter and early spring is generally caused by rain falling on snow-covered or frozen ground.

Ice jams, also common at this time of year, can cause isolated incidences of flooding in many communities.

What time of the year have floods occurred in your community?

Floods can occur any time of the year. By monitoring conditions, you can anticipate and prepare for flooding.

How often have floods occurred?

Photo credit: Fire and Emergency Services, NL

Workers monitoring conditions after winter flooding near Noel's Pond, NL.

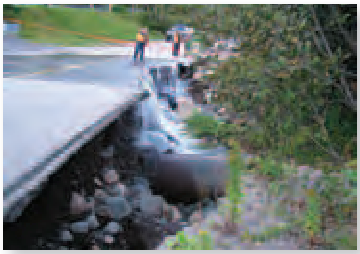


Photo credit: Fire and Emergency Services, NL

Road washout on the Burin Peninsula, NL

Flooding in the Future

In the future, you may see changes in when and how often flooding occurs. Your community may experience more frequent intense precipitation as well as an increase in storms and strong winds. Faster snowmelt and more freeze-thaw cycles can result in ice movement, triggering ice jams. Future changes in land-use may also affect flooding. If there is development near rivers and vegetated ground is replaced with pavement, water from heavy rainfall will not be able to drain properly and will be more likely to pool and cause flooding.

However, if flood risks are considered in planning and development and proper infrastructure is used, problems related to flooding may be decreased and even avoided. A river, for example, will tend to flood over and over again in the same place. By identifying where previous flooding has occurred in your community, you may be able to minimize the damage of future floods.

Please answer the following questions related to flooding in your community.

Have the causes of floods changed? Has the extent, frequency or location of floods changed? Briefly describe these changes.

The community of Port Rexton, NL during Hurricane Igor, 2010.

Photo credit: Fire and Emergency Services, NL

Place a check mark beside each question that you can answer with 'yes'. If there are any questions that require a 'no' answer, use the Resource Guide, located at the back of this workbook, to help you address them. After you have gathered more information, you should return to these questions to make sure each one has been properly addressed.

Final Checklist

	Have you identified the causes of flooding in your community?
	Have you identified when flooding is more likely to occur in your community?
	Have you identified how flooding might change in the future?

Communities in Newfoundland and Labrador may experience more frequent and extensive flooding due to climate change. Proper land-use planning can help minimize the impacts.

Photo credit: Fire and Emergency Services, NL

Culvert failure near Port Rexton, NL after Hurricane Igor in 2010.

STEP 2: Identifying Locations Affected by Flooding in Your Community

To complete Steps 2-7, you will need a map of your community. Please refer to the Resource Guide at the back of the workbook to find out how to obtain a map.

This step will help you:

- Locate the areas within your community that are at risk of flooding.

Things to consider:

- **Landscape features**
- **Planning and zoning**
- **Vegetation**
- **Drainage**
- **Elevation**
- **Proximity to lakes and rivers**
- **Limit of flood area**
- **Other**

Location Assessment

Here you will determine where floods have occurred and which areas of your community could be at risk.

Certain areas of your community may be more vulnerable to flooding. Infrastructure built close to a river or along a pond or lake that may already be prone to flooding will likely become more vulnerable in the future.

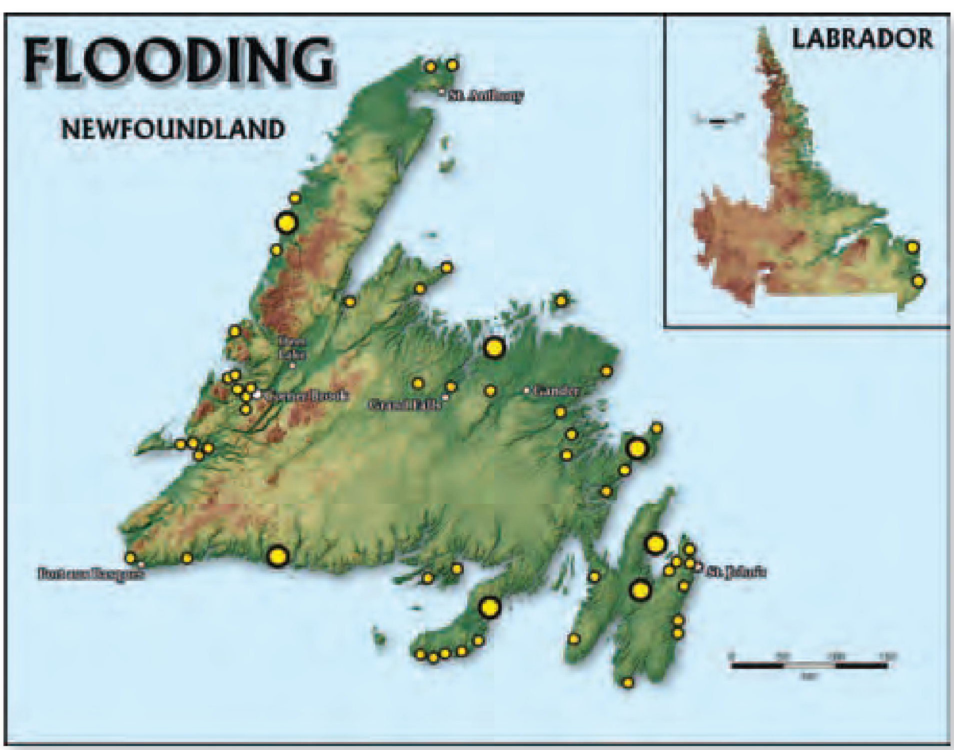


Figure source: Martin Batterson, Department of Natural Resources

Historically, there have been many incidences of coastal flooding in Newfoundland and Labrador. Each dot on this map corresponds to a known location of either coastal or river flooding. The large dots indicate that flooding has affected a large area while the small dots represent individual sites of flooding. 1755 to 2012.

Please answer the following questions related to flooding in your community.

What areas of your community have been flooded? Please explain.

Have certain areas been more affected by flooding than others?

Use Table 1 to identify factors that have affected where flooding has occurred in your community.

Certain areas of your community may be at increased risk of being affected by flooding.

Table 1: Factors Affecting Flooding in Your Community

Factor	Check any factors that have affected flooding	Comments or information sources
Shape of the landscape	❑	
Drainage	❑	
Elevation	❑	
Proximity to lakes and rivers	❑	
Vegetation	❑	
Overloaded infrastructure (culverts, storm water systems)	❑	
Infrastructure maintenance	❑	
Planning, zoning and land use	❑	
Other	❑	

Community Mapping

Do you know what areas of your community are prone to flooding? If yes, by drawing on your map, please identify these areas.

Do you expect the areas affected by flooding to change in the future? If yes, how?

What are some of the factors that you believe may lead to this change?

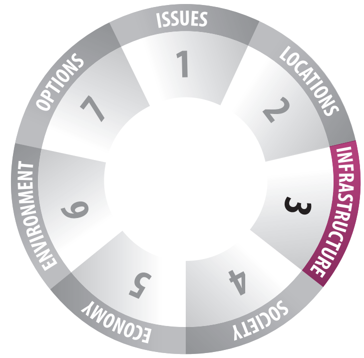
Final Checklist

	Have you identified where flooding has occurred in the past?
	Have you identified where flooding might occur in the future?

Photo Credit: Kimberly Bittermann

Community Mapping in Irishtown-Summerside, NL

STEP 3: Identifying Facilities and Infrastructure Affected by Flooding in Your Community



This step will help you:

- Identify key infrastructure in your community;
- Locate identified infrastructure; and
- Better understand the potential impact of flooding on infrastructure.

Things to consider:

- **Police and fire stations**
- **Hospitals and nursing homes**
- **Water supply and treatment**
- **Sewage and wastewater**
- **Power sources**
- **Roads, bridges, culverts and trails**
- **Schools**
- **Community and heritage buildings**
- **Other**

Facilities and Infrastructure Affected

Here you will identify the location and characteristics of key infrastructure so you can determine where to focus your adaptation efforts.

Photo credit: Fire and Emergency Services, NL

Washout near the water supply system in Fortune, NL.

It is important to know the location of infrastructure that may be impacted by flooding, as well as, characteristics such as its age and state of repair. You should also determine if flooding has damaged the infrastructure in the past.

As you go through this step, keep these questions in mind:

- What key infrastructure in your community would be vulnerable in the event of a flood?
- Is any infrastructure in need of repair, replacement or upgrades?
- Does the state of this infrastructure make damage from flooding more likely?
- Who should be involved to address these concerns?

Use Table 2 to record information on key infrastructure in your community. Examples of key infrastructure include: police and fire stations; hospitals and nursing homes; water supply and treatment stations; sewage and wastewater systems; power sources; roads, bridges, and culverts; trails; schools, churches, heritage structures, community centres and other community buildings.

Proper planning and recognition of how key infrastructure might be impacted in the event of a flood can help minimize losses.

Table 2: Inventory of Community Infrastructure

Infrastructure	Could it be impacted by flooding? If yes, how?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

*A larger version of this table is available in the Resource Guide at the back of the workbook.

What is the condition of the culverts, bridges and dams in your community? Are they in need of upgrades, replacement or maintenance?

Is there other infrastructure in your community that helps divert or control water? If so, is this infrastructure adequate and well maintained?

How has water build-up in roadside ditches been dealt with in your community?

Photo credit: Fire and Emergency Services, NL

Damage in Elliston, NL during Hurricane Igor, 2010.

Photo credit: Kimberly Bittermann

Dam in St. George's, NL.

Have any buildings in your community been damaged by flooding? If yes, list examples.

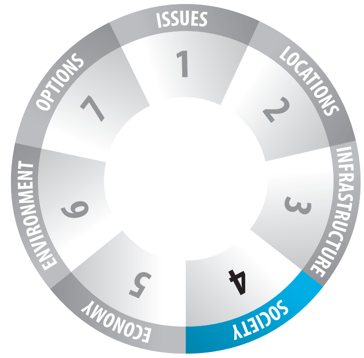
Community Mapping

By drawing on the map you started in Step 2, identify the location of important infrastructure in your community that may be impacted by flooding. Identifying drainage infrastructure such as main culverts, drainage trenches or storm sewer inlets is also important.

Final Checklist

	Have you identified infrastructure that has been impacted by flooding?
	Have you identified infrastructure that may be at risk in the future?

STEP 4: Identifying Individuals and Groups Most Affected by Flooding in Your Community and Those Able to Assist



This step will help you:

- Determine individuals and groups most impacted by flooding and where they live;
- Consider social or cultural impacts of flooding; and
- Determine who can help.

Things to consider:

- **Elders and youth**
- **Single parent households**
- **Special needs**
- **Literacy levels**
- **Emergency services**
- **Volunteer and community groups**
- **Recreation and cultural activities**
- **Isolated locations**
- **Other**

Social Assessment

Here you will identify the individuals and groups most likely to be impacted by flooding, where they live and who can assist.

Flooding can damage homes and infrastructure, forcing evacuations. Roads leading to homes, stores and services, can be washed out leaving people and communities isolated. It is important to recognize that dealing with flooding may be more difficult for some residents and they may need help from others. Understanding who may be most affected will help to target important areas for investment and set priorities for planning.

Volunteer groups and other community support may be a resource you can draw upon to help residents respond and adapt to flooding events.

Photo credit: Fire and Emergency Services, NL

Members of the Fire Department in Five Coves, NL providing assistance after Hurricane Igor, 2010.

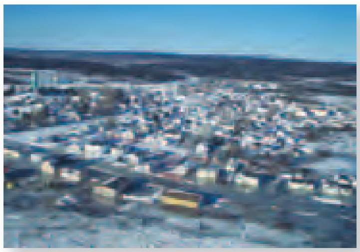


Photo credit: Department of Environment and Conservation, NL

Winter flooding in Badger, NL 2003.

Case Study: River Flooding in Badger, NL

In February 2003, an ice jam blocked three rivers causing a major river flood in the Town of Badger, forcing more than 1000 people to leave their homes. The floodwaters froze, due to minus 20°c air temperatures, encasing the community in ice. The ice did not melt for several months leaving most of the houses uninhabitable. The Red Cross, along with other groups and volunteers, provided critical assistance to the community. Displaced residents went to temporary shelters in Grand Falls-Windsor and many Newfoundlanders ensured that essential relief services were available to those impacted by providing food, clothing, personal items and cash vouchers.

Please answer the following questions related to the social implications of flooding.

List individuals and groups who have been affected by flooding in your community.

Do you have a communication plan to let residents know if flooding is forecasted?

Are there obstacles to residents receiving help during a flood (communication, transportation)?

Does your community have an up-to-date emergency plan?

❑ Yes ❑ No

If yes, does this plan address potential barriers for people affected by flooding?

If no, do you have the necessary resources to create an emergency plan?

Are there important heritage or recreational areas that have been affected by flooding in the past or may be affected in the future? If yes, please describe.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

Department of Environment and Conservation official standing on frozen flood water outside the Town Hall in Badger, NL 2003.

Photo credit: Fire and Emergency Services, NL

Damage from Hurricane Igor in Trouty, NL.

Photo credit: Department of Environment and Conservation

Winter flooding in Badger, NL 2003

Are there any other ways that local lifestyles or culture have been or may be impacted by flooding?

Other individuals in your community may be able to help, such as those with first aid training, emergency response experience or amateur radio training. It is important to have up-to-date contact information for these individuals and groups as cellular service may be unavailable during an extreme event.

Please fill out Table 3 with agencies or individuals that could help in the event of a flood (or refer to your emergency plan if an up-to-date list already exists).

Table 3: Community Contact List

Agency/Person	Business phone #	Home phone #	Comments/Role

*A full size version of this table is available in the Resource Guide.

There are other resources that may be available in your community and could be useful in the event of a flood. A few examples are listed in Table 4. Please complete the table and add any other resources that could be helpful if a flood occurs.

Table 4: Inventory of Community Resources

Resources	Owner (s)	Phone #	Comments
Boat			
Backhoe			
Generator (Note power output)			
Grader			
Satellite phone			
Other			

*A full size version of this table is available in the Resource Guide.

Certain people in your community may have the ability, experience or resources to help others cope with the impacts of a flood.

Community Mapping

By drawing on the map you started in Step 2, identify the areas in your community where people vulnerable to flooding live, as well as, the location of community services, volunteer groups or others who can help in the event of a flood.

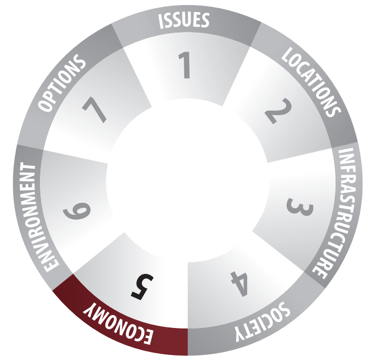
Photo credit: Kimberly Bittermann

Community mapping in Fortune, NL.

Final Checklist

	Have you identified where people most vulnerable to flooding live?
	Have you identified who can help during an emergency?
	Have you considered other social or cultural impacts a flood might have on your community?

STEP 5: Identifying Economic Consequences of Flooding in Your Community



This step will help you determine:

- Your most important economic sectors;
- How flooding may impact those sectors; and
- How flooding could affect the financial resources of your community.

Things to consider:

- Fisheries
- Forestry
- Tourism
- Food and agriculture
- Construction
- Manufacturing
- Transportation
- Stores and services
- Budget
- Insurance costs
- Other

Economic Assessment

Here you will identify your community's important economic sectors and financial resources and assess how they could be affected by flooding.

Flooding can have serious economic consequences for communities, affecting local businesses and employment, as well as, damaging the infrastructure required for the local economy. It is important to consider the financial resources required to respond to damage caused by flooding and other extreme weather events related to climate change.

Photo credit: Fire and Emergency Services, NL

Repeated flash flooding in the summer of 2008 forced evacuations and caused thousands of dollars of damage in Gambo, NL. The Trans-Canada Highway was closed for officials to pump out tonnes of water that had pooled in culverts.

Please answer the following questions related to flooding and your economy.

What businesses, services and industries contribute most to your community's economy?

Has flooding impacted them in the past? If yes, how?

What businesses, services and industries are expected to be most important in the future?

Traffic was backed-up on the Trans-Canada Highway in Terra Nova National Park, NL due to major road damage after Hurricane Igor, 2010.

Photo credit: Fire and Emergency Services, NL

How could flooding impact them in the future?

If applicable, what will happen to your tax base if these businesses, services or industries are impacted by flooding?

Can you estimate the costs associated with addressing climate-related flooding in your community? What revenue sources exist to cover these costs? What costs would have to be covered by your community?

Flooding can result in major economic loss. Infrastructure can be damaged and communication, travel and transportation disrupted.

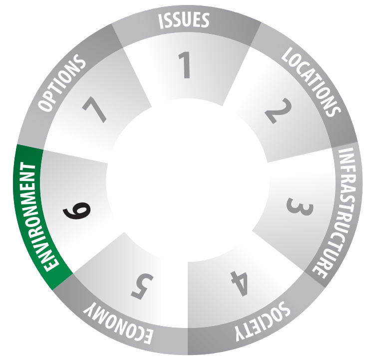
Community Mapping

By drawing on the map you started in Step 2, identify locations where your key economic activities take place. This can direct and guide your decisions related to flooding.

Final Checklist

	Have you identified where your key economic activities take place?
	Have you determined if they will be impacted by flooding?
	Have you attempted to calculate the financial costs associated with flooding in your community and how you would cover these costs?

STEP 6: Identifying Environmental Impacts Caused by Flooding in Your Community



This step will help you:

- Determine if flooding could cause other environmental problems; and
- Understand how flooding may affect important species or natural areas.

Things to consider:

- **Hazardous and toxic sites**
- **Oil facilities**
- **Ports**
- **Landfills**
- **Tailings ponds**
- **Pests and diseases**
- **Fish and wildlife**
- **Parks and protected areas**
- **Sensitive habitats**
- **Other**

Environmental Assessment

Here you will consider how flooding may affect the natural environment and identify sensitive areas that may be a planning priority for your community.

This step will help you locate sites where flooding could have environmental impacts. For example, a storm could cause sewage backup, polluting a local wetland, thereby affecting that ecosystem. By identifying these sensitive areas, you may be able to find ways to minimize negative impacts.

Photo credit: Kimberly Bittermann

Flooding may impact important natural habitat.

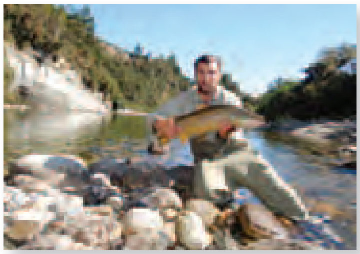


Photo credit: Philip Blundon

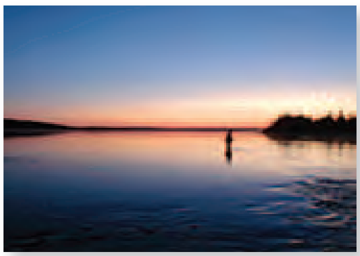


Photo credit: Philip Blundon

Case Study: Fish Habitat

River flooding can have a negative impact on fish and their spawning habitats. These impacts can vary depending on the timing and the size of the flood. High water flows can wash away vegetation and cause erosion. Sediment and debris can change spawning habitats and eggs can be washed away or buried. In addition, increased river volumes can cause fish to become stranded in pools along the river bank as well as cause changes in water quality and temperature.

Please answer the following questions related to the environmental impacts of flooding.

Could flooding cause environmental problems in your community?
If yes, please explain.

Are there endangered species or habitats in your community that may be threatened by flooding?

Fishing conditions in the province may change in the future due to flooding and other climate-related factors.

Are there concentrations of hazardous waste in your community?

❑ Yes ❑ No

If yes, are they stored safely?

❑ Yes ❑ No

Could flooding increase the risk of hazardous waste being released into the local environment?

❑ Yes ❑ No

If yes, briefly describe how flooding could increase the risk of hazardous waste release.

Do you have an environmental protection plan in place?

❑ Yes ❑ No

If not, you may want to consider developing one.

Community Mapping

By drawing on the map you started in Step 2, identify environmentally sensitive areas in your community, as well as other areas where flooding could have environmental impacts. Examples include waste disposal sites, hazardous material storage sites and areas that could be at risk if waste was released from these sites during a flood.

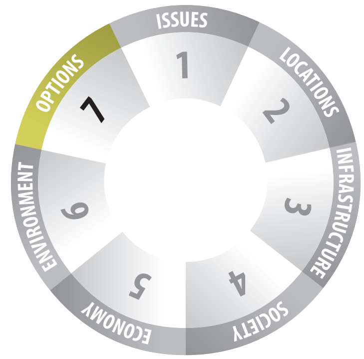
Final Checklist

	Have you identified environmentally sensitive areas in your community?
	Have you assessed how these areas might be affected by flooding?
	Have you considered how flooding might impact your local environment and fish and wildlife species in the future?

Photo credit: Kimberly Bittermann

Community mapping in Indian Bay, NL.

STEP 7: Identifying Adaptation Options for Your Community



This step will help you:

- Evaluate how your community has dealt with flooding in the past; and
- Identify ways to reduce the negative impacts of flooding.

Things to consider:
- **Infrastructure**
- **Technology**
- **Financial resources**
- **Human resources**
- **Policy and planning**
- **Emergency measures**
- **Education and awareness**
- **Other**

Adaptation Options

Here you will identify actions to deal with the impacts of flooding in your community.

This step will help you identify possible adaptation options to reduce the impacts of flooding. It will also help you determine the best solutions for your community while enhancing your ability to cope with future issues. The community mapping exercises that you have completed in this chapter will illustrate where flooding could cause the greatest problems for your community. Key adaptation concerns and priority areas for planning may become apparent once you have had a chance to discuss the information you have collected.

Photo credit: Norm Catto

Drainage system and gabion protection installed after Tropical Storm Chantal in Dunville, NL. Having the proper infrastructure in place to deal with a flood can save money in the long term and prevent damages that cause disruptions to the economic sectors in your community.

Photo credit: Fire and Emergency Services, NL

Road washout during Hurricane Igor left the community of Salvage, NL isolated from essential services.

Considering all of the information in Steps 1 to 6, list the main flooding issues in your community.

Which past actions or measures have been successful in reducing the impacts of flooding in your community? Please list.

What actions or measures were most effective?

What adaptation options would your community like to try? What are the barriers to trying these options?

Are there ways that these barriers could be overcome?

Potential Options

Flooding can be addressed in a number of ways. Six potential options are explained below and you will find more examples, in the form of case studies, in the Resource Guide at the back of the workbook.

1. **Infrastructure:** Infrastructure such as culverts and trenches can divert water away from key areas in your community. Coastal areas that are prone to flooding can be protected by levees, sea walls, groynes or other infrastructure. Timely maintenance of this infrastructure is critical. In the event of a flood, you can use sandbags as a temporary measure to protect an area from rising water levels. In Indian Bay, NL, sandbags have been used to prevent damage to homes and the local graveyard. When the nearby river floods, boulders are used to secure gravestones and sandbags are placed around houses and the graveyard. This is a cost effective way to reduce damage to the community.

2. **Displacement/relocation:** In exceptional cases, relocation may be necessary due to flooding. For example, residents in Stephenville, NL who lived in the flood control area were relocated for safety reasons in 2005. They were compensated for their property through funding from the provincial and federal governments.

3. **Monitoring:** Monitoring environmental variables (stream flow, water levels, ice conditions and precipitation) can make it easier to predict flooding and take preventative action.

4. **Education:** Educating residents is an important part of building awareness around the impacts and risks associated with flooding. If people know what to do in the event of a flood they will be better prepared to handle the situation if it arises.

5. **Preventative zoning and permitting:** Community planning should incorporate flood risk assessments into the decision-making process. When considering new developments, preventative action must be taken in flood sensitive areas. Re-zoning or instituting stricter building setbacks, for example, would be considered preventative actions.

Photo credit: Kimberly Bittermann

Protective stone installed to stabilize a river bank in Bay Roberts, NL.

6. **Emergency measures:** Having an up-to-date emergency plan is an important step in preparing for a major flood.

Considering the previous list of options, please identify new adaptation options that may help address flooding in your community.

Please list the adaptation options you would like to pursue to address flooding in your community:

1.

2.

3.

4.

5.

Not all of these options will have the same cost or require the same time, resources or personnel. Certain solutions will be more effective or have long-lasting impacts. In the conclusion of this workbook you can further consider the benefits and feasibility of pursuing each of these options and developing action plans for implementation.

CHAPTER 2

Coastal Vulnerability and Climate Change

STEP 1: Understanding Coastal Vulnerability in Your Community

Most communities in Newfoundland and Labrador are built near the coast and are vulnerable to storms, flooding, sea level rise and erosion. These naturally-occurring forces continually shape our coastline and can be destructive for communities. Addressing coastal vulnerability can save lives, improve development and reduce damage to infrastructure. Coastal impacts will have important social and economic implications for Newfoundland and Labrador. Storm surges and flooding can affect infrastructure, services, and business activity, as seen with Hurricane Igor. Coastal erosion and sea level rise can impact community development and place homes, businesses and coastal infrastructure at risk. Changes in the ocean environment can affect ice conditions shipping routes as well as site selection and the long term sustainability of aquaculture farms.

Types of Coastal Impacts

Storms: Storms that affect the province are low-pressure systems, some of which are hurricanes. While storms can occur any time of the year, the Atlantic Hurricane Season is from June 1st to November 30th. The impact of a storm will depend upon factors such as the storm's direction as it approaches the coast, wind speed, water level and depth close to shore, the shape of the coast, the type of coast (rocky, sediment), storm duration, location and types of coastal infrastructure and other recent storm damage.

Photo credit: Kimberly Bittermann

The fish plant and main road in Fortune, NL.

Photo credit: Don Pittman

Storm Surges: A storm surge is a temporary rise in local sea level caused by storms approaching the coast. The surge is caused by the wind "pushing" the water causing it to pile up higher than usual. The low pressure from the storm also increases the water level. The increase in level can vary from less than a metre to several metres and can cause coastal flooding, particularly when it coincides with high tide.

Flooding: Coastal flooding can occur when intense, offshore low-pressure systems drive ocean water inland. The water 'pushed' ashore is called a storm surge. Coastal flooding can also occur if a storm is combined with higher than normal tide levels. Communities can be devastated as water sweeps ashore damaging buildings and infrastructure. Flooding at the coast can be more severe when it coincides with inland flooding and high tides.

Erosion: Coastal erosion is a slow, ongoing process occurring along much of the province's coastline. Coastal cliffs can be undercut by waves or by human activity. In either case, slope angle is increased which may lead to failure of the slope above. Wind and rain can also cause erosion, particularly on cliffs composed of sediment, while freeze-thaw cycles can cause erosion of bedrock cliffs. The removal of vegetation from a slope, either naturally or by cutting, can also trigger erosion.

Please list the types of coastal impacts your community has faced.

Coastal areas can experience strong winds and waves, which may result in damage to boats, wharves and facilities

During a storm in late 2010, waves undercut the base of this cliff at Sandy Cove Beach in Sandy Cove, NL.

Photo credit: Loretta Crisby-Whittle

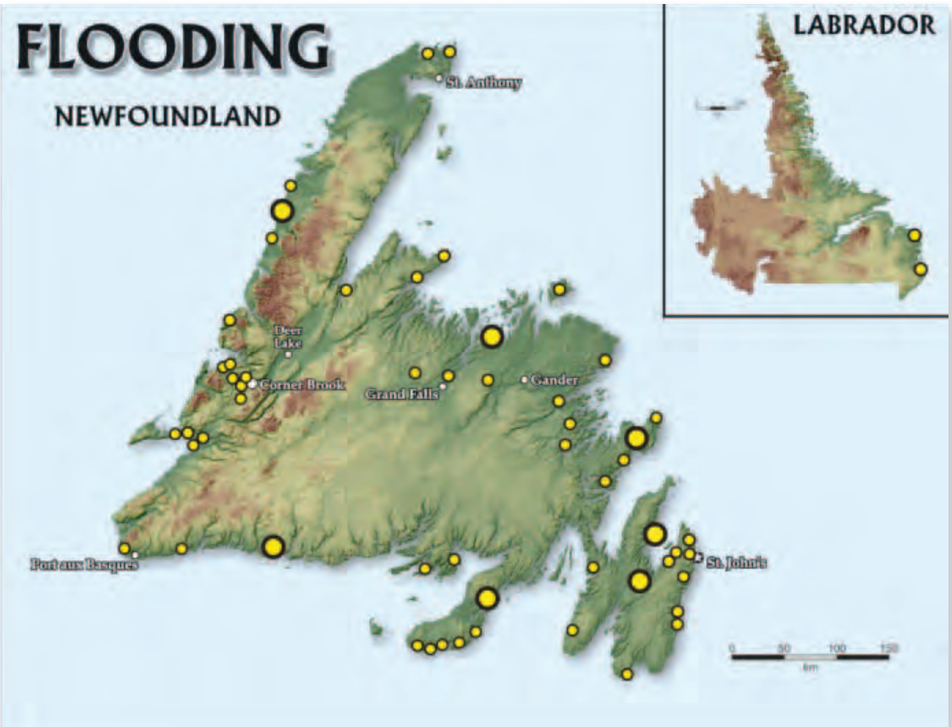


Figure source: Martin Batterson, Department of Natural Resources

Historically, there have been many incidences of coastal flooding in Newfoundland and Labrador. Each dot on this map corresponds to a known location of either coastal or river flooding. The large dots indicate that flooding has affected a large area while the small dots represent individual sites of flooding. 1755 to 2012.

Timing

Most reports of coastal flooding (over 90%) in Newfoundland and Labrador are between September and February with December, January and February being the worst months. Your community may experience more coastal flooding and erosion during this time.

Photo credit: Fire and Emergency Services, NL

Flooding in Hampden, NL in May of 2010 forced this shed and greenhouse out to the ocean.

Please answer the following questions related to coastal vulnerability in your community.

What time of the year has your community experienced storms, storm surge, flooding or erosion?

Which coastal impacts have affected your community the most? Have these been magnified by development along the coast?

This map shows the sensitivity of coastal areas to sea level rise: red areas are most sensitive and green areas are least sensitive.

Sea level rise will vary based on local geography and landscape history.

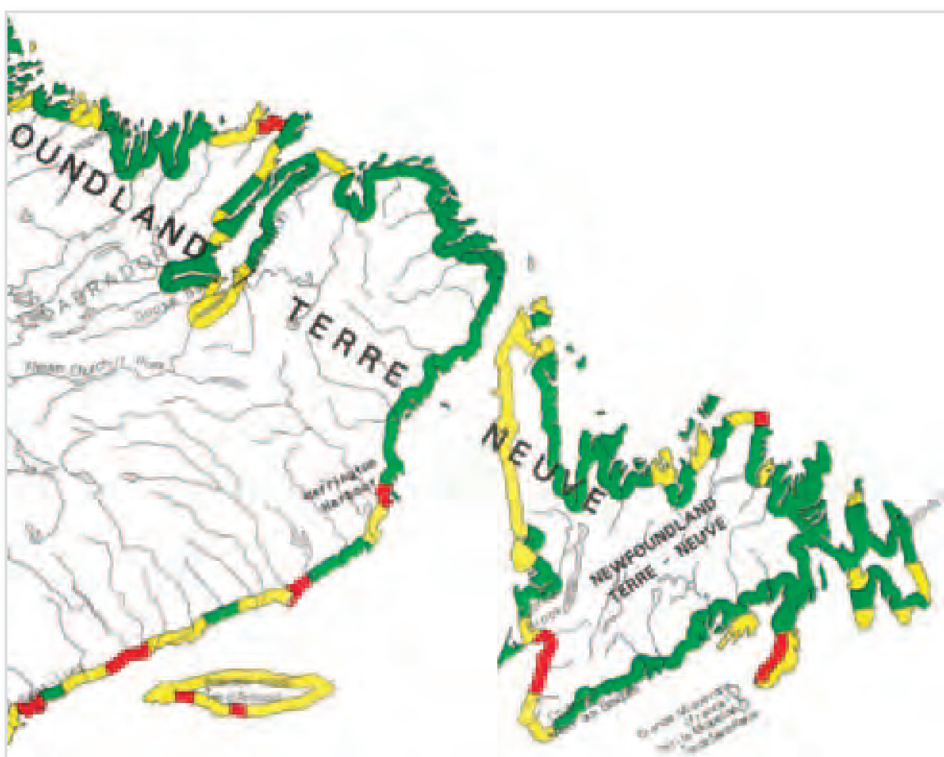


Figure source: Geological Survey of Canada

Future Coastal Vulnerability

Communities in Newfoundland and Labrador will see an increase in the frequency and severity of storms, storm surge, flooding, and erosion. Sea level, which is expected to rise worldwide, is already rising throughout most of the province. With increasing air temperatures, glaciers and ice sheets are melting and contributing to this rise in sea level. Warmer temperatures also cause water molecules to expand leading to a further rise in sea level. Areas covered by, and adjacent to, ice sheets which formed during the last ice age are still experiencing the effect of post-glacial crustal rebound, with some areas falling (most of Newfoundland) and others rising (most of Labrador). This will either add to or subtract from the global trends of sea level rise.

Low-lying areas will be the most vulnerable to sea level rise and will be at an increased risk of coastal flooding and erosion.

Climate projections indicate an increase in the number and severity of storms, heavier rainfall in shorter periods of time and stronger winds. The rate of coastal erosion caused by waves will increase if storms become more frequent and intense, as predicted.

Stronger winds may result in sea ice being pushed onshore more often. Sea ice can act as a natural barrier for the coast protecting it from the erosive power of waves and storms. However, when pushed onshore by the wind, sea ice can pile up on coastal infrastructure such as wharves, buildings and roads resulting in damage. Changes in sea-ice conditions can also have an impact on transportation, affecting access to coastal areas and activities such as hunting.

Development can also affect the type and severity of coastal impacts. Infrastructure such as roads, wharves, stages and sea walls are all ways in which human activity alters the coastline. While some of this infrastructure is used to protect coastal areas, it can lead to unintended consequences elsewhere. For example, constructing a wharf in a certain location may change the way sediment is transported causing either erosion or sediment build-up elsewhere along that coast.

Photo credit: Kimberly Bittermann

Destabilized bank in Flat Bay, NL.

Photo credit: John Drover

People and infrastructure along the coast are vulnerable to coastal impacts. (Change Islands, NL)

It is important for residents of coastal communities to be aware of areas that could be affected by flooding and erosion so future development can be effectively managed. It is much easier to avoid a problem than to face costly repairs afterwards. By including a risk assessment of coastal impacts in the planning and development process, your community may be able to take preventative action to protect vulnerable areas.

Please answer the following question related to coastal vulnerability in your community:

Have you noticed changes in the frequency or severity of storms, storm surge, flooding or erosion in your community?

Final Checklist

	Have you identified the types of coastal impacts affecting your community?
	Have you identified what caused these impacts and what factors affected their severity?
	Have you identified when these coastal impacts are most likely to occur?
	Have you identified how coastal impacts might change in the future?

The town of Placentia, NL has a history of flood events. It was built very close to sea level and is therefore at high risk for coastal flooding.

Photo credit: Government of Newfoundland and Labrador

STEP 2: Identifying Vulnerable Locations in Your Community

To complete steps 2 -7, you will need a map of your community. Please refer to the Resource Guide at the back of the workbook to find out how to obtain this map.

This step will help you:

- Locate the areas within your community that are vulnerable to coastal impacts.

Things to consider:
- **Landscape features**
- **Planning and zoning**
- **Development**
- **Vegetation**
- **Drainage**
- **Elevation**
- **Type of coastline**
- **Wave action**
- **Sea level rise**
- **Limit of flood area**
- **Other**

Location Assessment

Here you will determine where coastal impacts have occurred and which areas of your community could be at risk.

Certain areas of your community will be more vulnerable to coastal impacts. Infrastructure built along the coast is already at risk and is likely to be more vulnerable when sea level rises during extreme weather events.

Photo credit: Kimberly Bittermann

Stephenville Crossing, NL is located on a beach at the mouth of the St. George's River watershed, which makes the town vulnerable to coastal flooding.

Photo credit: Cnst. Burridge, Deer Lake RCMP

Roads near the coast are extremely vulnerable to coastal impacts.

Please answer the following questions related to coastal vulnerability:

What areas of your community have been affected by storms, storm surge, flooding or erosion? Please explain.

Use the table below to identify factors that have affected coastal vulnerability.

Table 1: Factors affecting coastal vulnerability

Factor	Check box if factor has influenced coastal vulnerability	Comments or information sources
Shape and slope of the coast	☐	
Coastal protection	☐	
Storm activity	☐	
Sediment type (rock, sand, gravel)	☐	
Sea level rise	☐	
Vegetation	☐	
Planning, zoning and land uses	☐	
Other	☐	

Community Mapping

By drawing on your map, identify where storms, storm surge, flooding or erosion have occurred in your community.

Do you expect the areas affected by these coastal impacts to change in the future? If yes, how? What are some of the factors that may lead to this change?

Sea level is rising in most of Newfoundland and some parts of Labrador. This may cause long-term issues and will increase the impact of storm surges and coastal flooding.

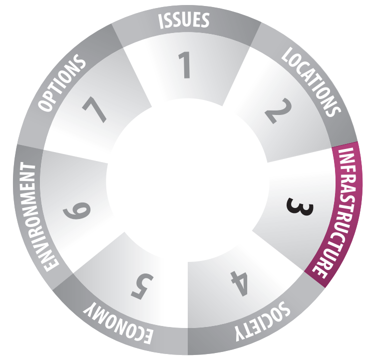
Final Checklist

	Have you identified where coastal impacts have occurred in your community?
	Have you identified where coastal impacts might occur in the future?

Photo credit: Melanie Irvine

An organic farmer in Lumsden, NL, is growing a range of vegetables near the coast. Coastal flooding could have significant impacts on these crops.

STEP 3: Identifying Vulnerable Facilities and Infrastructure in Your Community



This step will help you:

- Identify key infrastructure in your community;
- Locate identified infrastructure; and
- Better understand the potential risk to infrastructure due to coastal impacts.

Things to consider:

- **Police and fire stations**
- **Hospitals and nursing homes**
- **Water supply and treatment**
- **Sewage and wastewater**
- **Power sources**
- **Roads, bridges, culverts and trails**
- **Schools**
- **Community and heritage buildings**
- **Other**

Facilities and Infrastructure Affected

Here you will identify the location and characteristics of key infrastructure so you can determine where to focus your adaptation efforts.

It is important to know the location of facilities and infrastructure that may be affected by storms, storm surge, flooding or erosion, as well as the age and state of repair of those facilities and infrastructure. You should also determine if coastal impacts have already damaged any facilities and if there is infrastructure in place to help minimize damage in the future.

Photo credit: Fire and Emergency Services , NL

The main road in Hampden, NL was washed out after heavy rainfall in May 2010.

Case Study: Annapolis Royal, Nova Scotia

It is important to identify any key infrastructure that could be at risk in the event of a flood. The town of Annapolis Royal, built along the Bay of Fundy in Nova Scotia, conducted a study to investigate the risk and extent of flooding in the event of a tidal surge. The town discovered that their fire station would be safe from rising water levels as it was on a small rise. However, while mapping the flood risk zones. The town realized that the fire station would become an island, isolated from the rest of the community. As a result, a boat was purchased for the fire station and rescue equipment that had been stored there was moved to other locations.

It is important for communities to understand how key infrastructure may be impacted by storms, storm surge, flooding or erosion.

High tides and a winter storm caused high water levels in the town of Annapolis Royal, NS threatening to damage the wharf and flood the town.

Photo credit: NovaNewsNow.com

As you move through this step, keep the following questions in mind:

- What key infrastructure would be vulnerable to coastal impacts?
- Is any infrastructure in need of repair, replacement or upgrades?
- Does the condition of this infrastructure make damage from coastal impacts more likely?
- Who should be involved to address these concerns?

Please fill in Table 2 with information on infrastructure in your community.

Examples of key infrastructure include: police and fire stations, hospitals and nursing homes, water supply and treatment facilities, sewage and wastewater systems, power sources, roads (main, side and artery), bridges, culverts, trails, schools, churches, heritage structures, community centres and other community buildings.

Table 2: Inventory of Community Infrastructure

Infrastructure	Could it be affected by coastal impacts?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

*A full size version of this table is available in the Resource Guide.

Please answer the following questions related to infrastructure in your community.

Does your community have coastal protection such as seawalls or breakwaters? Are there parts of the coast in your community that need protection?

Has any infrastructure in your community been damaged by storms, storm surge, flooding or erosion? Is there any infrastructure that may be vulnerable in the future?

Do you have enough information to answer these questions? If not, do you know how to obtain this information?

Community Mapping

By drawing on your map, identify the location of important infrastructure in your community that may be affected by coastal impacts. Identifying infrastructure that protects the coast and drainage infrastructure such as main culverts or drainage trenches is also important.

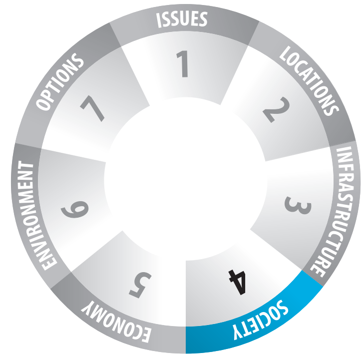
Photo credit: Kimberly Bittermann

During a community workshop in Indian Bay, NL, areas vulnerable to coastal erosion identified on the map.

Final Checklist

	Have you identified infrastructure that has been affected by coastal impacts?
	Have you identified infrastructure that may be at risk in the future?

STEP 4: Identifying Individuals and Groups Most Affected by Coastal Impacts in Your Community and Those Able to Assist



This step will help you:

- Determine who is most affected by coastal impacts and where they live; and
- Determine who can help.

Things to consider:

- **Elders and youth**
- **Single parent households**
- **Special needs**
- **Literacy levels**
- **Emergency services**
- **Volunteer and community groups**
- **Recreation and cultural activities**
- **Isolated locations**
- **Other**

Social Assessment

Here you will identify the individuals and groups most likely to be affected by coastal impacts, where they live and who can assist.

Coastal impacts like storms, storm surge, flooding and erosion can damage infrastructure and property and force evacuations. It is important to recognize that coping with coastal issues may be more difficult for some residents and they may need help from others. Volunteer groups and other community support may be a resource you can draw upon to help residents respond and adapt to coastal impacts.

Photo credit: Fire and Emergency Services, NL

Road closure in Hampden, NL.

Please answer the following questions related to people, heritage and lifestyle in your community.

Who has been affected by storms, storm surge, flooding or erosion in your community?

Are there obstacles to residents receiving help during a major coastal event (e.g. communication, transportation)?

Does your community have an up-to-date emergency plan? ❑ Yes ❑ No

If yes, does this plan address potential barriers for people affected by coastal impacts?

If no, do you have the necessary resources to create an emergency plan?

Are there important heritage or recreational areas that have been affected by storms, storm surge, flooding or erosion or that may be affected in the future?

Are there any other ways that local lifestyles or culture have been or may be affected by coastal impacts?

How will you inform residents if a major coastal event is in the forecast for your community?

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There may be individuals and groups in your community, such as those with first aid training, emergency response experience or amateur radio training, who could help if a coastal event occurred. It is important to have up-to-date contact information for these individuals and groups as cellular service may be unavailable during an extreme event.

Photo credit: Kimberly Bittermann

Coastal erosion is occurring near the main road in Fortune, NL.

Please fill in the table below with agencies or individuals that could help during a major coastal event.

Table 3: Community Contact List

Agency/person	Business phone #	Home phone #	Comments/Role

*A full size version of this table is available in the Resource Guide.

There may be other resources in your community. A few examples are listed in the table below.

Please complete the table and add any other resources that could be helpful in dealing with major events.

Table 4: Inventory of Community Resources

Resources	Owner (s)	Phone #	Comments
Boat			
Backhoe			
Generator			
Grader			
ATV			
Truck			
Satellite phone			
Other			

*A full size version of this table is available in the Resource Guide.

Community Mapping

By drawing on the map you started in Step 2, identify the areas in your community where people most vulnerable to coastal impacts live and the location of community services, volunteer groups or others who can help if a coastal event occurs.

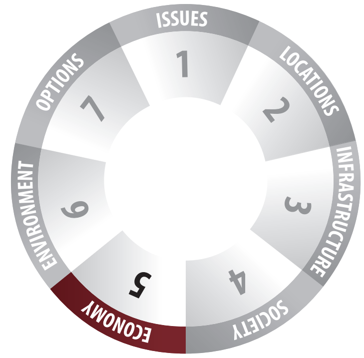
Photo credit: Ron Saunders

The Matthew Legacy Building in Bonavista, NL is one example of important cultural infrastructure that could be vulnerable to coastal impacts.

Final Checklist

	Have you identified where people most vulnerable to coastal impacts live?
	Have you identified who can help during an emergency?
	Have you considered the impact on other social or cultural activities in your community?

STEP 5: Identifying Economic Consequences of Coastal Impacts on Your Community



This step will help you determine:

- Your most important economic sectors;
- How coastal impacts may affect these sectors; and
- How coastal impacts could affect the financial resources of your community.

Things to consider:
- **Fishery**
- **Forestry**
- **Tourism**
- **Food and agriculture**
- **Construction**
- **Manufacturing**
- **Transportation**
- **Stores and services**
- **Budget**
- **Insurance costs**
- **Other**

Economic Assessment

Here you will identify your community's key economic sectors and financial resources and assess how they may be affected by coastal impacts.

Storms, storm surge, flooding and erosion can have serious economic consequences for communities, affecting local businesses and employment, as well as, damaging the infrastructure required for the local economy. It is important to consider the financial resources required to respond to damage caused by coastal impacts and other extreme weather events related to climate change.

Photo credit: John Drover

Change Islands, NL.

Photo credit: Martin Goebel

A narrow roadway along the coast in Chamberlains, Conception Bay ,NL.

Photo credit: Martin Goebel

The same narrow roadway after a series of coastal storms in 1992. The road was severely damaged by erosion and many cobbles were washed upon the embankment.

Please answer the following questions related to coastal impacts and your economy.

What businesses, services and industries contribute most to your community's economy?

Have storms, storm surge, flooding or erosion affected them in the past? If yes, how?

What businesses, services and industries are expected to be most important in the future?

How could coastal impacts affect them in the future?

What will happen to your tax base if these businesses, services and industries are affected by coastal impacts?

Can you estimate repair or replacement costs due to damage caused by coastal storms, flooding or erosion in your community? What revenue sources exist to cover these costs? What costs would have to be covered by your community?

Coastal impacts can result in major economic loss. Sudden and extreme events could damage infrastructure and wash out roads or trails disrupting travel and transportation.

Community Mapping

By drawing on the map you started in Step 2, identify locations where key economic activities take place. This can direct and guide decisions related to coastal impacts.

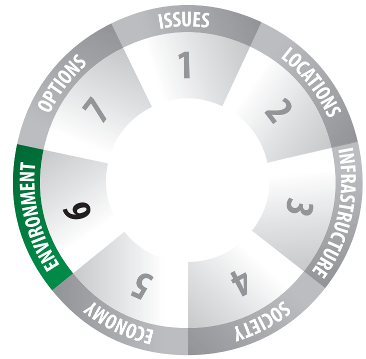
Final Checklist

	Have you identified where your community's key economic activities take place?
	Have you determined if they will be affected by coastal impacts?
	Have you attempted to calculate the financial costs associated with coastal impacts and have you assessed how your community would cover these costs?

Photo credit: Kimberly Bittermann

The fish plant in Fortune, as in many Newfoundland communities, is located near the shoreline.

STEP 6: Identifying Environmental Consequences of Coastal Impacts in Your Community



This step will help you:

- Determine if coastal impacts could cause other environmental problems; and
- Understand how coastal impacts may affect important species or natural areas.

Things to consider:

- **Hazardous and toxic sites**
- **Oil facilities**
- **Ports**
- **Landfills**
- **Mining sites**
- **Tailings ponds**
- **Pests and diseases**
- **Fish and wildlife**
- **Parks and protected areas**
- **Sensitive habitats**
- **Other**

Environmental Assessment

Here you will consider how coastal impacts may affect the natural environment and identify sensitive areas that may be a planning priority in your community.

This step will help you locate sites where coastal impacts like storms, storm surge, flooding or erosion could have negative environmental consequences. For example, there may be an estuary in your community that serves as an important feeding or nesting site for birds. If coastal flooding occurs during a sensitive part of the life cycle, entire populations of birds could be destroyed. By identifying sensitive areas, you may be able to find ways to minimize negative impacts.

Photo credit: Kimberly Bittermann

A shorebird feeds along the shoreline near Bay Roberts, NL. Coastal areas provide important habitat and feeding grounds for many species.

Please answer the following questions related to the environmental consequences of coastal impacts.

Could storms, storm surge, flooding or erosion cause environmental problems in your community? If yes, explain.

Are there endangered species or habitats in your community that may be threatened by coastal impacts?

Are there concentrations of hazardous waste in your community?

❑ Yes ❑ No

If yes, are they stored safely?

❑ Yes ❑ No

Could coastal storms, flooding or erosion increase the risk of hazardous waste being released into the local environment?

❑ Yes ❑ No

If yes, briefly describe how these coastal impacts might increase the risk of hazardous waste release.

Does your community have an environmental protection plan in place?

❑ Yes ❑ No

If not, you may want to consider developing one.

Community Mapping

By drawing on the map you started in Step 2, identify environmentally sensitive areas in your community such as streams, wetlands or marshes. It is also important to identify other areas where coastal impacts could have negative environmental consequences such as waste disposal sites or hazardous material storage sites.

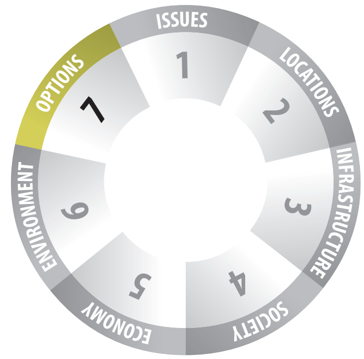
Final Checklist

	Have you identified environmentally sensitive areas in your community?
	Have you assessed how these areas might be affected by coastal impacts?

Photo credit: Melanie Irvine

This part of the shoreline in Lumsden, NL is eroding; sand is being washed out to sea.

STEP 7: Identifying Adaptation Options for your Community



This step will help you:

- Evaluate how your community has dealt with coastal impacts in the past; and
- Identify ways to reduce the consequences of coastal impacts.

Things to consider:

- **Infrastructure**
- **Technology**
- **Financial resources**
- **Human resources**
- **Policy and planning**
- **Emergency measures**
- **Communication**
- **Other**

Adaptation Options

Here you will identify actions to deal with the impacts of coastal storms, flooding and erosion in your community.

This step will help identify possible adaptation options to reduce the impacts of coastal storms, flooding and erosion on your community. It will also help you determine the best solutions for your community and enhance your ability to cope with any future issues. The community mapping exercises that you have completed in this chapter will illustrate where coastal impacts could cause the greatest problems for your community. Key adaptation concerns and priority areas for planning may become apparent once you have had a chance to discuss the information you have collected.

Fortune, NL

Photo credit: Kimberly Bittermann

Photo credit: Kimberly Bittermann

Stephenville Crossing, NL.

Considering all of the information in steps 1 to 6, list the main coastal issues in your community.

List any actions or measures that have been successful in reducing the impacts of the issues identified in the previous question?

What actions or measures were most effective?

Are there adaptation options that you were unable to put in place due to barriers or challenges?

❑ Yes ❑ No

If yes, what were the barriers or challenges that you faced and how could they be overcome?

Potential Options

There are a number of ways to reduce coastal vulnerability in your community. Six options are explained below and there are more examples, in the form of case studies, in the Resource Guide at the back of the workbook.

1. **Infrastructure:** Infrastructure, such as culverts and trenches, can divert water away from key areas in your community. Coastal areas that are prone to flooding or erosion can be protected by levees, sea walls, groynes or other infrastructure. Timely maintenance of this infrastructure is critical. As a temporary measure, sand bags can be used to protect an area from rising water levels in the event of a flood. This can be a cost effective way to reduce damage to the community.

2. **Displacement/relocation:** In certain cases, it may be necessary to relocate people living in areas prone to coastal flooding or bank erosion.

3. **Monitoring:** Monitoring environmental variables such as wind speed and direction, water levels, ice conditions, wave energy and precipitation can help your community anticipate potential problems. Monitoring changes in these variables and taking preventative action can help minimize damage in your community.

4. **Education:** Education is an important part of helping residents prepare for coastal impacts such as storms, storm surge, flooding and erosion. Any development in an area at increased risk of experiencing erosion, for example, should not be permitted or preventative measures should be implemented.

5. **Preventative zoning and permitting:** Community planning should incorporate an analysis of coastal vulnerability into the decision-making process. When considering new developments, preventative action must be taken in areas that are at risk of coastal flooding and erosion as well as areas that may be at risk due to sea level rise and increased storm surge. Rezoning particular areas in your community or instituting strict building setbacks from cliff edges, for example, would be considered preventative actions.

6. **Emergency measures:** Having an up-to-date emergency plan is an important step in preparing for storms, storm surge, flooding or erosion.

Considering the adaptation options listed previously, please identify new adaptation options that may help address the coastal vulnerability of your community.

There are resources available to assist you in assessing the extent to which your community is vulnerable to the impacts of climate change along the coast.

Many of these resources are free or available at minimal cost; for more information please see the Resource Guide at the back this workbook.

Please list the options that you would like to pursue in order to adapt to coastal impacts in your community:

1.

2.

3.

4.

5.

Not all of these options will have the same cost or require the same time, resources or personnel. Certain solutions will be more effective and have long-lasting impacts. In the conclusion of this workbook you can further consider the benefits and feasibility of pursuing each of these options and develop action plans for implementation.

CHAPTER 3

Slope Movement and Climate Change

STEP 1: Understanding Slope Movement in Your Community

Slope movement occurs when soil, rock or snow moves down-slope under the influence of gravity. It can be very slow moving (soil creep) or extremely fast (rockfall, debris flow, avalanche) and can involve a small amount of material, such as a single rock, or whole hillsides. Slope movements can be triggered by undercutting slopes and removing surface vegetation as well as by weather related events such as heavy rainfall or rapid snowmelt.

It is likely that slope movement has affected your community at some time, as throughout history, numerous incidences of landslides, rock falls and avalanches have occurred in Newfoundland and Labrador. Slope movement can have a significant impact on people and infrastructure; damaging buildings, blocking roads and cutting off access to medical assistance and supplies. Understanding the potential impacts of slope movement is an important part of planning within your community.

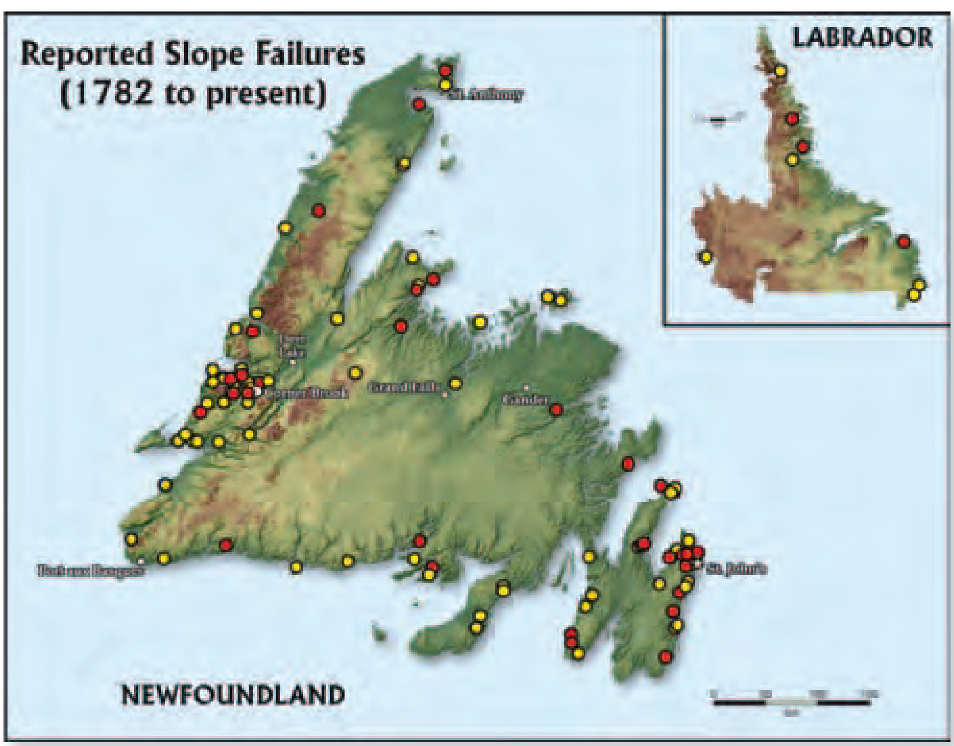


Figure Source: Martin Batterson, Department of Natural Resources, NL.

The figure at left shows incidences of landslide, avalanche and rockfall. Red dots indicate slope movements that resulted in fatalities and yellow dots represent those that resulted in infrastructure damage.

Martin Batterson, Debris flows - In 1973, a debris flow destroyed four houses in Harbour Breton, NL.

Types of Slope Movement

Types of slope movement are distinguished by key characteristics such as the kind of material that is moving and the speed at which it moves.

Debris Flow: Debris flows involve a mixture of sediment and water and can be extremely fast moving. They are commonly triggered by heavy rainfall or rain-on-snow events.

Slump: Slump is a type of landslide where the slope failure surface is on a curve. Material above the failure surface commonly remains intact as it moves downslope.

Soil Creep: Soil creep is the slow movement of material downslope, but can result in considerable damage to infrastructure.

Rockfall: Rockfalls are commonly the result of freeze-thaw action on bedrock cliffs. Rocks wedged out from bedrock fall rapidly and can cause significant damage to infrastructure and property.

Avalanche: Avalanches are another form of rapid slope movement and generally consist of a combination of snow and ice. Avalanches are most commonly triggered by a heavy snowfall over a smooth steep slope (30° to 50°).

Aerial photo of the landslide in Daniel's Harbour, NL in April 2007.

Photo credit: Martin Batterson

Factors Affecting the Vulnerability of an Area to Slope Movement

Factors that make an area susceptible to slope movements:

- **Slope:** Slope movement is more likely to occur on steeper terrain, and in some cases, boulders may roll away from the base of a steep slope.
- **Weather:** Many slope movements occur after a heavy rainfall, during rain-on-snow events or during periods of rapid snowmelt. This is due to either the added weight of water in the soil or the erosion of the supporting soil base. In the winter, freezing rain followed by heavy snowfall may lead to an avalanche on steep slopes.
- **Bedrock geology:** Rock types that are greatly jointed or fractured are more susceptible to weathering than rocks with no joints or fractures. Weathered rocks are more likely to become unstable and move downslope .
- **Surficial geology:** Cliffs composed of loose material such as sand and gravel erode more quickly than bedrock cliffs. Also, since thick soils can absorb more water than thin soils, steep slopes covered with thin soil are more susceptible to slope failure following periods of heavy rainfall or rapid snowmelt.
- **Past slope movement:** Slope movement is more likely to occur in areas where it has previously occurred.
- **Human impacts:** Development near the top of a slope can affect drainage and the overall stability of that slope if preventative measures are not put in place. Removing vegetation from a steep slope or digging up the lower part of a slope, thereby creating a steeper grade, are also examples of how human activity can lead to slope movement.
- **Sediment:** The type of sediment (silt, sand, gravel, till) will influence slope stability. Sand and gravel can be easily eroded whereas other sediment types erode more slowly.

Photo credit: Pat Careen

An example of Slump - Point Lance, NL.

Photo credit: Norm Catto

An example of Soil Creep - Quidi Vidi, St. John's, NL

Photo credit: Government of Newfoundland and Labrador

Retaining wall built to prevent slope movement in Springdale, NL.

Please answer the following questions related to slope movement in your community.

How have slope movements impacted your community?

What caused these slope movements?

Slope Movement in the Future

Many areas will likely experience an increase in the occurrence of slope movement as climate patterns continue to change. Increased amounts of precipitation, extended periods of heavy rainfall, rapid snowmelt and heavy snowfall during the winter will all contribute to the increased likelihood of slope movement.

Through careful planning and development, your community may be able to reduce the risk of slope movement occurring and diminish the impact on your community if it does occur. Please note that options to reduce the likelihood of slope movement occurring are discussed at the end of this chapter.

Based on future climate projections outlined in the introduction, do you think slope movements will happen more often in your community?

Place a check mark beside each question that you can answer with 'yes.' To address questions that you answered with 'no,' please refer to the Resource Guide at the back of this workbook for help.

Final Checklist

	Have you identified how slope movement has impacted your community?
	Have you identified what caused slope movement in your community?
	Have you assessed whether slope movement might occur more often in the future?

Photo credit: Kimberly Bittermann

An example of Slope Movement. Irishtown-Summerside, NL.

STEP 2: Identifying Locations Affected by Slope Movement in Your Community

To complete steps 2 - 7, you will need a map of your community. Please refer to the Resource Guide at the back of the workbook to find out how to obtain this map.

This step will help you:

- Locate the areas within your community that are at risk of slope movement.

Things to consider:

- **Planning and zoning**
- **Development**
- **Slope grade**
- **Vegetation**
- **Drainage**
- **Rock type**
- **Sediment type**
- **Snow accumulation**
- **Other**

Location Assessment

Here you will determine where slope movements have occurred and which areas of your community could be at risk.

Certain areas of your community may be more vulnerable to slope movement such as steep slopes or cliffs with infrastructure built at the base or on the top.

Photo credit: Nicole Renaud

Slope failure is causing this fence to slump downwards in Irishtown-Summerside.

Photo credit: Government of Newfoundland and Labrador

Rockfall in Upper Island Cove, NL.

Case Study: Upper Island Cove, NL

On February 14, 1999, an eight tonne rock fell from a hill behind Upper Island Cove in Conception Bay, NL. The boulder rolled down the approximately 100m slope, striking and damaging a house, an aluminum shed and a vehicle. The boulder hit the bedroom and chimney of the home, knocking the bed across the room but thankfully leaving the occupant uninjured. Bricks from the chimney damaged another car in a neighbouring driveway. Approximately 15 homes were evacuated, with over 40 people displaced, as the area was assessed for any further danger.

This incident was well documented by government geologists and private consultants and it was found that the rock came from a wedge type failure. The rock travelled down a direct path, bouncing and splitting in two at the base of the slope. A follow-up study identified other loose blocks that required stabilization and suggested that the risk of another rock fall was high. In response to this hazard, protective measures were installed during the summer of 1999.

Please answer the following questions related to slope movement in your community.

What areas of your community have been affected by slope movement?

Have some areas been more affected than others?

Use Table 1 below to identify factors that have influenced where slope movement has occurred in your community.

Table 1: Factors influencing slope movement in your community

Factor	Check box if factor has influenced slope movement	Comments or information sources
Shape of the landscape	☐	
Drainage	☐	
Rock type	☐	
Sediment type	☐	
Vegetation	☐	
Planning, zoning and land uses	☐	
Other	☐	

Community Mapping

Do you know what areas in your community are vulnerable to slope movement? If yes, please identify these areas by drawing on your map.

If you are unsure, there are resources available to help you determine these areas including aerial images and topographic maps. Aerial photographs from various years are valuable as they can illustrate changes in landscape over a period of time. In addition, knowledge from community members may be helpful to determine locations of slope movements that were not publicly recorded either because they happened a long time ago or because of their small size. Newspapers may have reports of recent or large events; as well, the Geological Survey of Newfoundland and Labrador maintains a database of reported events in the province.

Information on how to obtain the above-mentioned resources is available in the Resource Guide at the back of the workbook.

Do you expect that the areas in your community affected by slope movement could change in the future?

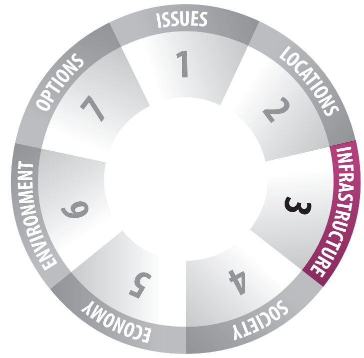
Final Checklist

	Have you identified where slope movements have occurred?
	Have you considered where slope movements might occur in the future?

Community mapping can help assess vulnerabilities and identify areas that have been impacted by slope movement. The completed map can provide guidance on how to minimize the impacts of future events.

Photo credit: Kimberly Bittermann

STEP 3: Identifying Facilities and Infrastructure Affected by Slope Movement in Your Community



This step will help you:

- Identify key infrastructure in your community;
- Locate identified infrastructure; and
- Better understand the potential impact of slope movement on infrastructure.

Things to consider:

- **Police and fire stations**
- **Hospitals and nursing homes**
- **Water supply and treatment**
- **Sewage and wastewater**
- **Power sources**
- **Roads, bridges, culverts and trails**
- **Schools**
- **Community and heritage buildings**
- **Other**

Facilities and Infrastructure Affected

Here you will identify the location and characteristics of key infrastructure so you can determine where to focus your adaptation efforts.

Photo credit: Department of Natural Resources, NL

Rockfall on Pitts Memorial Drive in St. John's, NL, April 2007. There were no injuries but the road was closed for several hours.

It is important to know the location of infrastructure that may be affected by slope movement, as well as characteristics such as its age and state of repair. You should also determine if slope movement has damaged the infrastructure in the past.

As you go through this step, keep these questions in mind:

- What key infrastructure in your community would be vulnerable to damage from slope movement?
- Is any infrastructure in need of repair, replacement or upgrades?
- Does the state of this infrastructure make damage from slope movement more likely?
- Who should be involved to address these concerns?

Examples of key infrastructure include: police and fire stations; hospitals and nursing homes; water supply and treatment stations; sewage and wastewater systems; power sources; roads, bridges, and culverts; trails; schools, churches, heritage structures, community centres and other community buildings.

Please fill in Table 2 with information on infrastructure in your community

Table 2: Inventory of Community Infrastructure

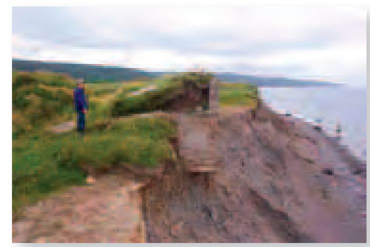
Infrastructure	Could it be impacted by slope movement? If yes, how?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

*A full size version of this table is available in the Resource Guide.

Are you aware of any unstable slopes in your community that may need stabilization?

Point Verde, 1999

Have any buildings in your community been damaged by slope movement? If yes, list examples.



Point Verde, 2003

Is infrastructure development planned for areas with steep slopes?

Point Verde, 2005

Are you aware of any infrastructure that is currently not at risk but may be at risk in the future?

Point Verde, 2011. Structure now on beach.

Photo credit (all): Martin Batterson

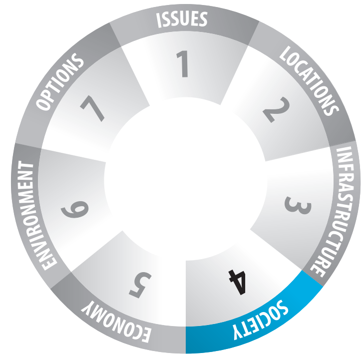
Final Checklist

	Have you identified infrastructure that has been impacted by slope movement?
	Have you identified infrastructure that may be at risk in the future?

Photo credit: Family of the late Dr. O.V. Smith; Sheida, Babs and Maureen Mackinnon

This photo shows the remains of a house that was destroyed in an avalanche at Tilt Cove, NL in March 1912.

STEP 4: Identifying Individuals and Groups Most Affected by Slope Movement in Your Community and Those Able to Assist



This step will help you:

- Determine individuals and groups most impacted by slope movement and where they live;
- Consider social or cultural impacts of slope movement; and
- Determine who can help.

Things to consider:

- **Elders and youth**
- **Single parent households**
- **Special needs**
- **Literacy levels**
- **Emergency services**
- **Volunteer and community groups**
- **Recreation and cultural activities**
- **Isolated locations**
- **Other**

Social Assessment

Here you will identify individuals and groups most likely to be impacted by slope movement, where they live and who can assist.

Slope movement can be devastating to communities if it results in injuries and damage to homes and infrastructure. It is important to recognize that some members of your community may not be able to respond and react to slope movement in the same manner as others. Understanding who may be most affected can help target important areas for investment and set priorities for planning. Volunteer groups and other community support may be a resource you can draw upon to help residents prepare for and respond to slope movement.

Photo credit: Fire and Emergency Services, NL

Daniel's Harbour has been impacted by slope movement.

Photo credit: Government of Newfoundland and Labrador

St. John's Battery, NL

Case Study: The Battery, St. John's, NL

On the night of February 16, 1959, there were 200 km/hr winds and 55 cm of snow in St. John's. At 1:05 am residents in the Outer Battery heard a sound described as a loud clap of thunder. An avalanche struck 2 houses, sweeping them downslope and into the rear of two other houses. Rescuers were on the scene almost immediately to help search for the fourteen people swept down the slope by the avalanche. Over 50 residents dug through debris and quickly rescued a man, his wife and child as well as 3 children from the other family. One of the children, a two year old girl, was swept 60 m downslope and was rescued by a resident who saw her through his window. After two hours of digging they rescued a 16 year old girl and after 10 hours her friend was rescued. Unfortunately, five of the residents could not be saved.

Since 1959, no serious incidents have occurred in the Battery, although residents have reported minor rockfalls and avalanches. Due to development of the historic site as well as increased activity and foot traffic in the area, there have been concerns about rockfalls. The Newfoundland and Labrador Geological Survey contacted the City of St. John's, who was already concerned about the rockfall hazard, and told them of the history of avalanches in the area. The Geological Survey recommended that the Canadian Avalanche Association visit the site; which they did. They recommended the fencing be designed for avalanches as well as rockfalls. In addition, the Historic Site commissioned two reports in 1980 and 1992 which identified a rockfall hazard and recommended remedial work. New warning signs were placed at North Head Trail to divert people away from the slopes and protective fences were constructed in 1998, but have not yet been tested by a significant rockfall or avalanche.

Protective fencing in the Battery, near St. John's, NL

Photo credit: Geological Survey of Newfoundland and Labrador

Please answer the following questions related to the social implications of slope movement.

List individuals and groups who have been affected by slope movement in your community.

Are there obstacles to residents receiving help if there is an incidence of slope movement (communication, transportation)?

Does your community have an up-to-date emergency plan?

❑ Yes ❑ No

If yes, does this plan address potential barriers to people receiving help if there is an incidence of slope movement?

If no, do you have the necessary resources to create an emergency plan?

Are there important heritage or recreational areas that have been affected by slope movement in the past or may be affected in the future?

Are there any other ways that local lifestyle or cultures have been or may be impacted by slope movement?

Please note that it is extremely important to use caution when slope movement occurs as secondary slides are common and can injure those responding to the first slide.

There may be individuals and groups, both within your community and outside, with first aid training, emergency response experience or amateur radio training who could help in the event of a slope movement. It is important to have up-to-date contact information for these individuals and groups in case of an emergency.

Please note that it is extremely important to use caution when slope movement occurs as secondary slides are common and can injure those responding to the first slide.

Please fill in the Table 3 on the next page with information on agencies or individuals that could help in the event of a major slope movement (or refer to your emergency plan if an up-to-date list already exists).

Table 3: Community Contact List

Agency/Person	Business phone #	Home phone #	Comments/Role

*A full size version of this table is available in the Resource Guide.

There are other resources that may be available in your community and could be useful in the event of a slope movement. A few examples are listed in Table 4.

Please complete the table and add any other resources that could be helpful if slope movement occurs.

Certain people in your community may have the ability, experience or resources to help others cope with the impacts of slope movement.

Table 4: Inventory of Community Resources

Resources	Owner (s)	Phone #	Comments
Large shovels or other rescue tools			
Backhoe			
Generator (Note power output)			
Other (satellite phone, radio)			

*A full size version of this table is available in the Resource Guide.

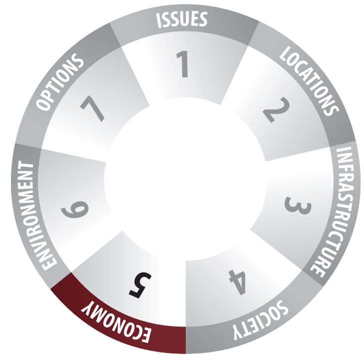
Community Mapping

By drawing on the map you started in Step 2, identify the areas in your community where people most vulnerable to slope movement live, as well as, the location of community services, volunteer groups or others who can help in case of a major event.

Final Checklist

	Have you identified where people most vulnerable to slope movement live?
	Have you identified who can help during an emergency?
	Have you considered the potential social or cultural impacts of slope movement on your community?

STEP 5: Identifying Economic Consequences of Slope Movement on Your Community



This step will help you determine:

- Your most important economic sectors;
- How slope movement may impact these sectors; and
- How slope movement could affect the financial resources of your community.

Things to consider:

- Fishery
- Forestry
- Tourism
- Food and agriculture
- Construction
- Manufacturing
- Transportation
- Retail and services
- Budget
- Insurance costs
- Other

Economic Assessment

Here you will identify your community's key economic sectors and financial resources and how they could be affected by slope movement.

Slope movement can have serious economic consequences on communities, affecting local businesses and employment, as well as, damaging the infrastructure required for the local economy. It is important to consider the financial resources required to deal with damages caused by slope movement. .

Slope movement can result in major economic loss by damaging infrastructure as well as utility poles, fences and other structures.

Photo credit: Norm Catto

A protective wall was built along the roadside to deal with slope movement at Frenchman's Cove, Humber Arm South, NL.

Please answer the following questions related to slope movement and your economy.

What businesses, services and industries contribute most to your community's economy?

Has slope movement impacted them in the past? If yes, how?

What businesses, services and industries are expected to be most important in the future?

How could slope movement impact them in the future?

If applicable, what will happen to your tax base if these businesses, services or industries are impacted by slope movement?

Can you estimate the costs associated with addressing slope movement in your community? What revenue sources exist to cover these costs? What costs would have to be covered by your community?

Photo credit: Kimberly Bittermann

Destabilized bank in Flat Bay, NL.

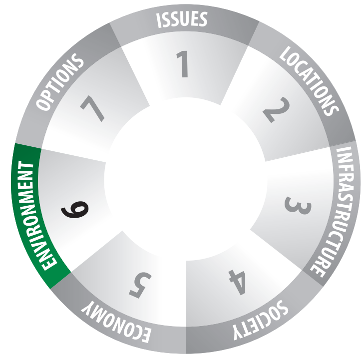
Community Mapping

By drawing on the map you started in Step 2, identify locations where key economic activities take place. This can direct and guide your decisions related to slope movement.

Final Checklist

	Have you identified where your key economic activities take place?
	Have you determined if they will be impacted by slope movement?
	Have you attempted to calculate the financial costs associated with slope movement in your community and how you would cover these costs?

STEP 6: Identifying Environmental Impacts Caused by Slope Movement in Your Community



This step will help you:

- Determine if slope movement could cause other environmental problems; and
- Understand how slope movement may affect important species or natural areas.

Things to consider:

- **Hazardous and toxic sites**
- **Oil facilities**
- **Ports**
- **Landfills**
- **Tailings ponds**
- **Pests and diseases**
- **Fish and wildlife**
- **Parks and protected areas**
- **Sensitive habitats**
- **Other**

Environmental Assessment

Here you will consider how slope movement may affect the natural environment and identify sensitive areas that may be a planning priority for your community.

This step will help you identify environmentally sensitive areas in your community that could be affected by slope failure. For example, a landslide can remove hillside vegetation and fill nearby streams with debris, thereby decreasing water quality for plant and animal habitats. By identifying these sensitive areas, you may be able to find ways to minimize negative impacts.

Photo credit: Kimberly Bittermann

Beach habitat is important to many species, including the Piping Plover.

Please answer the following questions related to the environmental impacts of slope movement.

Could slope movement cause environmental problems in your community? If yes, please explain.

Are there endangered species or protected habitats in your community that may be threatened by slope movement?

Are there concentrations of hazardous waste in your community?

❑ Yes ❑ No

If yes, are they stored safely?

❑ Yes ❑ No

Could slope movement increase the risk of hazardous waste being released into the local environment?

❑ Yes ❑ No

If yes, briefly describe how slope movement could increase the risk of hazardous waste release.

Do you have an environmental protection plan in place?

❑ Yes ❑ No

If not, you may want to consider developing one.

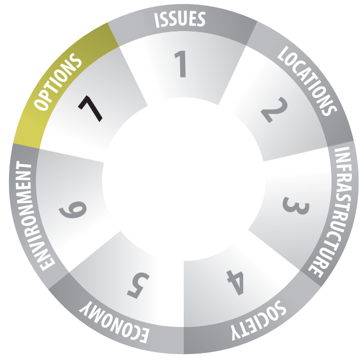
Community Mapping

By drawing on the map you started in Step 2, identify environmentally sensitive areas in your community, as well as, other areas where slope movement could have environmental impacts.

Final Checklist

	Have you identified environmentally sensitive areas in your community?
	Have you assessed how these areas might be affected by slope movement?
	Have you considered how slope movement might affect your local environment and fish and wildlife species?

Photo credit: Department of Environment and Conservation – Government of Newfoundland and Labrador



STEP 7: Identifying Adaptation Options for Your Community

This step will help you:

- Evaluate how your community has dealt with slope movement in the past; and
- Identify ways to reduce the negative impacts of slope movement.

Things to consider:

- **Infrastructure**
- **Technology**
- **Financial resources**
- **Human resources**
- **Policy and planning**
- **Emergency measures**
- **Education and awareness**
- **Other**

Adaptation Options

Here you will identify actions to deal with the impacts of slope movement in your community.

This step will help you identify adaptation options to reduce the impacts of slope movement. It may also help you determine the best solutions for your community while enhancing your ability to cope with future issues. The community mapping exercises that you have completed in this chapter will illustrate where slope movements could cause the greatest problems for your community. Key adaptation concerns and priority areas for planning may become apparent once you have had a chance to discuss the information you have collected.

Photo credit: Fire and Emergency Services, NL

Subsequent slope failure affected homes and businesses in Daniel's Harbour, NL.

Photo credit: Geological Survey of Newfoundland and Labrador

Fencing in Upper Island Cove, NL

Considering all of the information in steps 1 to 6, list the main slope movement concerns for your community.

Which past actions or measures have been successful in reducing the impacts of slope movement in your community? Please list.

What actions or measures were most effective?

What adaptation options would your community like to try? What are the barriers to trying these options?

Are there ways to overcome these barriers?

Potential Options

Slope movement impacts can be addressed in a number of ways. Six potential options are explained below and you will find more examples, in the form of case studies, in the Resource Guide at the back of the workbook.

1. **Infrastructure:** Adaptation options that may help decrease the likelihood and severity of slope movement include: installing drainage to direct water away from unstable slopes; building retaining walls at the base of slopes prone to slope failure; planting vegetation, such as grass and trees, to stabilize slopes; and installing proper fencing in areas prone to rockfalls and avalanches.

2. **Monitoring:** Monitoring for the purposes of predicting slope failure is difficult and unreliable. However, monitoring environmental variables such as precipitation and snow accumulation in areas where there has been a history of slope failure may provide useful information on slope movement in the future.

3. **Education:** Education is an important way to build awareness and encourage caution in areas that are vulnerable to slope movement. Also, encouraging awareness of what to do in the event of a slope movement can help people better prepare for and deal with the event if it does occur.

4. **Preventative measures:** Vegetation is important in providing strength to a slope so communities should ensure that trees and other vegetation are not removed from steep slopes. Similarly, beaches protect inland areas from flooding and erosion so communities should safeguard against material being removed from beaches.

5. **Preventative zoning and permitting:** Planning and development should include an assessment of areas that are vulnerable to slope movement. New structures should not be built close to cliff edges or below cliffs prone to rockfall and construction should not dig into the base of slopes. Discouraging development in areas that are prone to slope movement is the best way of ensuring the safety of people and the protection of infrastructure.

6. **Emergency measures:** Having an up-to-date emergency plan is critical in the event of a major slope failure.

Considering the above, please identify new adaptation options that may help address slope movement concerns in your community.

Please list the adaptation options you would like to pursue to address slope movement in your community:

1.

2.

3.

4.

5.

Not all of these options will have the same cost or require the same time, resources or personnel. Certain solutions will be more effective and have long-lasting impacts. In the conclusion of this workbook you can further consider the benefits and feasibility of pursuing each of these options and develop action plans for implementation.

CHAPTER 4

Drinking Water Supply and Climate Change

STEP 1: Understanding Drinking Water Supply in Your Community

Climate change will affect precipitation patterns, water temperature, and sea levels. These changes may impact drinking water quality and availability. For example, lower water levels and warmer water temperatures in a drinking water source can increase the risk of contamination. Also, rising sea levels can increase the risk of saltwater intrusion.

Many people do not know where their tap water comes from. This is especially the case in communities with groundwater supplies (drilled or dug wells) as the source water is not as visible as when it comes from rivers, ponds, reservoirs, or lakes. However, anything that occurs on the land can contaminate groundwater just as easily as it can contaminate surface water. Protecting public water supply areas is the first step in maintaining clean and safe drinking water for communities in Newfoundland and Labrador. The drinking water supply network contains the following three components:

The Water Source: Public drinking water supplies in Newfoundland and Labrador come from two types of sources: surface water (rivers, ponds, reservoirs and lakes) and groundwater (drilled and dug wells). Of the 489 public water supply sources in the province, 302 are surface water sources and 187 are groundwater sources.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

The drinking water source, Brigades Pond, for Southern Harbour, NL.

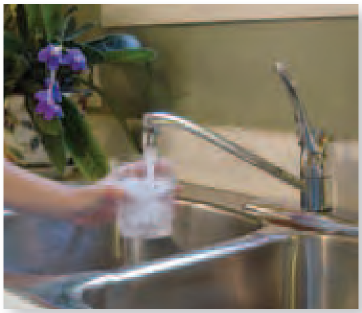


Photo credit: Paul Neary

The Drinking Water Treatment System: Drinking water treatment refers to the processes that remove contaminants or adjust aesthetic parameters in source water through filtration, the addition of chemicals, and other processes. Several water treatment strategies are used in the province; however, the most critical aspect of water treatment is disinfection. Chlorination is the most feasible and commonly used disinfectant in the province. When used in drinking water treatment, chlorine disinfects water and minimizes microbial growth in the water distribution system.

A water treatment plant may be necessary in some communities to address site-specific water quality problems. Water treatment plants use treatment processes such as coagulation, flocculation, sedimentation and filtration, in addition to disinfection. Small-scale drinking water treatment systems, called potable water dispensing units (PWDUs), can be a more feasible option for smaller communities with specific drinking water quality issues.

The Water Distribution System: The distribution system is the largest component of physical infrastructure that ensures drinking water safety. It includes all the pipes, valves, service lines, pumping stations, fire hydrants and storage facilities required to deliver clean, safe drinking water. Water distribution systems vary in size and type throughout the province and all of them require ongoing maintenance to ensure hydraulic capacity and safe drinking water.

The drinking water treatment building in Pouch Cove, NL.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

Each component of the water supply network can be vulnerable to changes in climate. Water sources can be depleted and water treatment requirements can change. Water distribution systems can be damaged by events such as flooding and freeze-thaw cycles and as piping ages, it becomes more prone to breaks and fractures compounding these issues.

Photo credit: Kimberly Bittermann

The drinking water distribution piping in St. George's, NL.

Factors Affecting Drinking Water Quality and Supply

Climate change can directly and indirectly affect your community drinking water source. Contaminants can be naturally occurring or they can enter your water source due to weather and to human activity.

Examples of contaminants:

Sediments: Sediments are particles of soil that can be carried downstream to the drinking water source through run-off, rain fall and erosion. An increase in sediment deposits in the drinking water source can lead to water contamination, thereby requiring additional disinfection and filtration.

Nutrients: Nutrients, such as nitrogen and phosphorus, occur naturally in water. Storm run-off and human activities, such as the release of sewage effluent, can increase the nutrient content of a water source and lead to an increase in algae growth; releasing toxins into surface water.

Salts and Metals: Salts and metals are inorganic elements that occur both naturally and from mining activities. These elements can contaminate deep groundwater. Contamination of drinking water from salts and metals can become an issue if shallow aquifers dry up and people drill deeper for groundwater supply sources.

Microbes: Microbes are disease-producing viruses and bacteria, such as E. coli 0157:H7 and Giardia, which can be dangerous sources of contamination. There are over 100 viruses originating from human and animal waste that can be transmitted through drinking water.

Disinfection by-products (DBPs): DBPs, such as trihalomethanes and haloacetic acids, are contaminants formed when chlorine reacts with organic matter such as decaying leaves. High levels of DBPs have the potential to cause health issues.

Potential Causes of Contamination

1. Climate and Weather

Flooding and storm surge: Drinking water can be contaminated from storm run-off, which can contain 1,000 times the normal level of disease-carrying microbes due to sewage contamination. As well, flooding and storm surge can damage the infrastructure of the water distribution system and can lead to power outages, shutting down pumping stations. For example, in September 2010, flooding from Hurricane Igor swept an entire disinfection building out to sea in Garden Cove, NL, leaving the community without clean drinking water.

Sea level rise: Sea level rise can cause saltwater intrusion, contaminating groundwater and surface water sources. Excessive pumping of groundwater wells near the coast can deplete aquifers and result in saltwater intrusion.

Temperature and precipitation changes: Temperature changes and changes in the timing and quantity of precipitation can affect the rate of surface water and groundwater recharge. Warmer winters with less snowfall or earlier spring melt can affect water level recharge as can drier summers or summers with rainfall that falls as intense bursts instead of steady rain. Climate change may not affect the overall amount of annual precipitation but it is likely to affect the timing, intensity, and type of precipitation. More intense precipitation can result in increased run-off, leading to higher levels of organic matter that can react with chlorine, and create DBPs. Warmer water temperature and increased levels of nitrogen and phosphorus can lead to algal blooms in drinking water supplies.

2. Human Activity

Urban and Cottage Development: Urban development often involves expanding paved or concrete areas at the expense of green space. This type of landscape change can result in increased flooding and run-off during a storm. Increased run-off can carry contaminants such as oil, chemicals, and microbes into drinking water sources. Additionally, the development of homes using individual groundwater wells and septic tanks can potentially result in an increase in nutrients in surface water or contamination of groundwater due to septic effluent. The construction of cabins and summer homes also has the potential to indirectly lead to drinking water contamination through an increase in septic waste and gasoline discharge from recreational boating.

Industrial Operations: Agriculture, mining, forestry and other industrial operations change topography and natural vegetation and can result in increased soil erosion and storm run-off, which can contaminate drinking water sources. Industry, especially mining and agriculture can also put stress on drinking water supplies through high water demand. Low water levels can change the water quality, increasing the concentration of contaminants.

Overuse of Aquifers: An aquifer can become depleted when the demand on the water supply is greater than the recharge rate. Dry summers can also have a negative impact on groundwater recharge, compromising groundwater availability. This is especially true for unconfined shallow aquifers that are located in thin sediment above bedrock.

Finally, the local infrastructure and water quality monitoring and maintenance can be one of the more significant factors affecting drinking water quality and supply for your community. Trained, qualified personnel help properly and effectively maintain system operations. Proper training is important in dealing with the aftermath of extreme weather events which can cause water to have increased levels of contaminants. Water loss due to leaky pipes or cross-contamination as a result of poorly maintained infrastructure can lead to water quality and supply issues and climate-related shortages of water may be compounded if leaks are not detected. In addition, aged sewer and water lines, or those in need of repair, are more vulnerable to damage from flooding and freeze-thaw cycles.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

Operator personnel listening for leak noise in Port-aux-Basques, NL.

Case Study: Skeletal Fluorosis in Maria, Quebec

Prior to the late 1970s, the small farming community of Maria, Québec relied on shallow wells as the source of their drinking water. As the town grew, water consumption increased, forcing farmers to drill deeper wells. During the late 1970s, two cases of skeletal fluorosis, a bone disease caused by consuming too much fluoride, were reported. An investigation revealed that the deeper wells tapped an aquifer that carried fluoride-rich water from the limestone highlands behind the town. The concentration of fluoride in the groundwater samples was seven times the maximum acceptable limit according to the Guidelines for Canadian Drinking Water Quality.

Please answer the following questions related to drinking water quality and supply issues in your community.

How have drinking water quality and supply issues impacted your community?

Maintenance of water distribution system infrastructure in Rocky Harbour, NL.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

What caused these issues?

How often has your community experienced drinking water quality and supply issues?

Do you think the occurrence of these issues will change in the future?

❑ Yes ❑ No

Place a check mark beside each question that you can answer with 'yes.' To address questions that you answered with 'no,' please refer to the Resource Guide at the back of this workbook for help.

Final Checklist

	Have you identified how drinking water quality and supply issues have impacted your community?
	Have you identified what caused the drinking water quality and supply issues in your community?
	Have you assessed whether drinking water quality and supply issues might occur more often in the future?

STEP 2: Identifying Locations Affected by Drinking Water Supply Issues in Your Community

To complete Steps 2-7, you will need a map of your community. Please refer to the Resource Guide at the back of the workbook to find out how to obtain a map.

This step will help you:

- Identify the areas within your community where drinking water supply issues may occur;
- Locate the components of the water distribution system in your community;
- Locate any private wells (both shallow and deep) in your community.

Things to consider:

- **Development**
- **Planning and zoning**
- **Recreation areas**
- **Industry**
- **Vegetation**
- **Drainage**
- **Rock type**
- **Sediment type**
- **Snow accumulation**
- **Other**

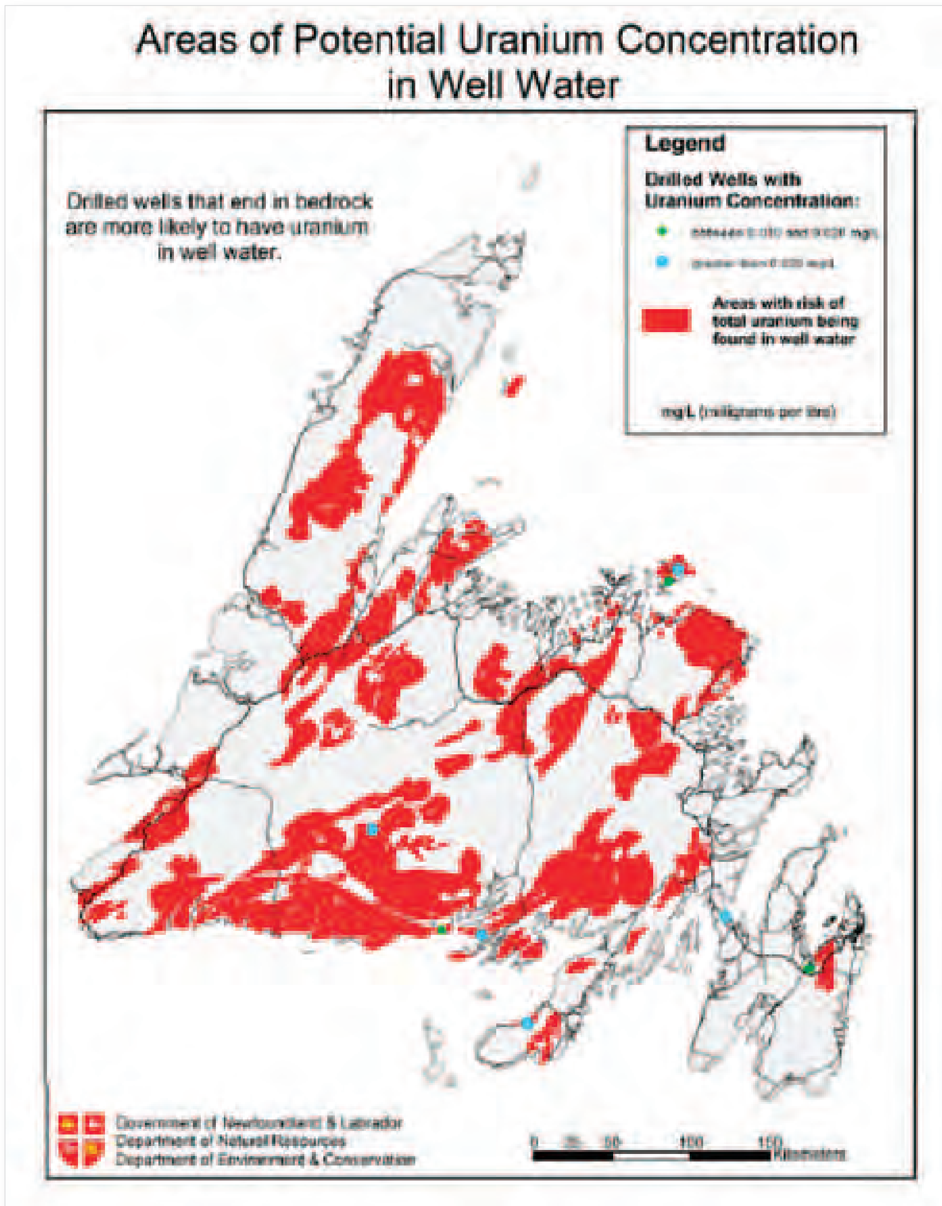
Location Assessment

Here you will determine where drinking water supply issues have occurred in your community and which components of your drinking water supply network could be at risk.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

The drinking water source in Clarke's Beach, NL.

Some components of your community's drinking water distribution system will be more vulnerable to contamination than others. For example, metal components will be more vulnerable to corrosion. Also, certain geographic areas have a greater likelihood of drinking water quality issues due to naturally occurring contaminants such as arsenic, fluoride, lead or uranium. Wells drilled in bedrock have a high incidence of containing elevated concentrations of these naturally occurring elements which can adversely affect water quality. The map below illustrates areas where elevated concentrations of uranium are likely in groundwater wells on the island of Newfoundland.



Taken from: www.env.gov.nl.ca/env/waterres/cycle/groundwater/well/uranium.html July 2012

Considering the Pollution Source

Pollution can be point source or non-point source. Point source pollution means the origin is a single source, such as a landfill or septic leak. Non-point source pollution means the origin is not restricted to a specific source; acid rain, forestry activities or pesticides could be considered non-point sources. Where are possible sources of pollution in your community? Could they cause drinking water quality issues?

Use Table 1 to identify factors that have affected drinking water quality and supply in your community.

Table 1: Factors that Affect Drinking Water

Factor	Check box if factor has affected drinking water quality or supply	Comments or information sources
Precipitation	☐	
Water temperature	☐	
Bedrock or sediment type	☐	
Pollution	☐	
Demands on water supply	☐	
Maintenance of water distribution system	☐	
Maintenance and operation of drinking water treatment system	☐	
Other	☐	

Please answer the following questions related to drinking water supply in your community.

What is the source of your community's drinking water supply?

Where is the drinking water supply network (source, treatment system, distribution system) located?

Can you locate any alternative water sources, such as private wells?

What areas of your community have been impacted by drinking water quality or supply issues?

Where did the issues originate in the drinking water supply network (source, treatment system, distribution system)?

Are there particular areas in your community that may be causing drinking water supply issues?

Do you expect that the location of drinking water supply issues will change in the future? If so, how?

Community Mapping

By drawing on your map, identify the areas in your community that have been affected by drinking water supply issues as well as where you think the problem originated in your drinking water supply network.

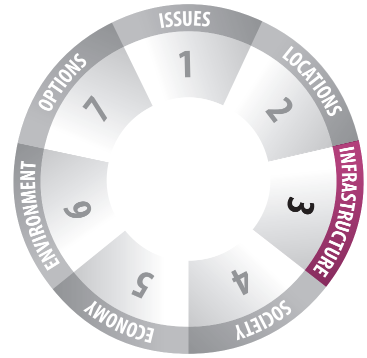
Final Checklist

	Have you identified the areas in your community that have caused or have been impacted by drinking water supply issues?
	Have you identified potential problems with your community's drinking water supply network?

Photo credit: Kimberly Bittermann

Community mapping in Fortune, NL.

STEP 3: Identifying Facilities and Infrastructure Affected by Drinking Water Supply Issues in Your Community



This step will help you:

- Identify key infrastructure in your community;
- Locate identified infrastructure; and
- Better understand the potential impact of drinking water supply issues.

Things to consider:

- Police and fire stations
- Hospitals and nursing homes
- Schools
- Public water fountains
- Parks
- Community and heritage buildings
- Power sources
- Water source
- Water treatment system
- Water distribution system
- Private wells
- Sewage and wastewater
- Other

Facilities and Infrastructure Affected

Here you will identify the location and characteristics of key infrastructure so you can determine where to focus your adaptation efforts.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

The pumphouse in St. Shott's, NL.

It is important to know the location of infrastructure and facilities that could be impacted by or that could cause drinking water supply issues in your community, as well as characteristics such as age and state of repair. You should also determine if they have been affected by or caused drinking water supply issues in the past.

Changes in climate and weather can have a serious impact on your community's drinking water supply network. For example, flooding can increase the number of contaminants entering the network, drought can reduce water availability and can change the concentration of contaminants in the water supply and freeze-thaw cycles can damage the infrastructure required to treat and distribute water.

The infrastructure required to operate the drinking water supply network can be damaged through storm activity or through on-going processes such as erosion or slope movement. Infrastructure can also be affected by a lack of water supply. As well, some facilities that are connected to the water supply network require water to operate but not necessarily of drinking water quality. These facilities could include fire stations, fish plants and power plants. While they do not require the same level of water quality, if there is only one water supply network in a community, any disruption in this network will affect all connected facilities.

Scaling on the inside of drinking water distribution piping in the Water Treatment Plant in Musgrave Harbour, NL.

Photo credit: Water Resources Management Division, Department of Environment and Conservation

The Drinking Water Distribution System

The drinking water distribution system includes extensive infrastructure, all requiring monitoring and maintenance. Infrastructure materials and electronic or motorized components must be able to withstand temperature fluctuations, dry or wet soil conditions and varying water flows. Freeze-thaw cycles can crack and break the pipes in the distribution system and corrosion can thin pipe walls causing metals (copper, lead and iron) to leach into the water, compromising water quality. Maintaining drinking water infrastructure in a community is dependent on factors such as the physical characteristics, size and location of the community, as well as, the financial and human resources available to that community.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

Gerry Lahey (Water Resources Management Division employee) demonstrating how to respond to a chlorine gas cylinder leak.

The Drinking Water Treatment System

The water treatment system also includes infrastructure components that require maintenance. Poorly maintained or outdated infrastructure and facilities can lead to breakdowns. Without an operational and reliable disinfection system, communities can be placed on boil orders until the system can be fixed or replaced.

As you go through this chapter, keep these questions in mind:

- What important drinking water infrastructure exists in your community?
- Is any infrastructure in need of repair, replacement or upgrades?
- Could the state of this infrastructure cause drinking water supply issues in your community?
- Who should be involved to address these concerns?

Use Table 2 on the next page to record information relating to the infrastructure in your community. Examples of key infrastructure include: police and fire stations; hospitals and nursing homes; water treatment and distribution systems; sewage and wastewater systems; power sources; schools, churches, heritage structures, community centres and other community buildings.

Please fill out Table 2 with information on infrastructure in your community.

Table 2: Inventory of Community Infrastructure

Infrastructure	Could it be affected by or cause drinking water supply issues? If yes, how?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

*A full size version of this table is available in the Resource Guide.

When were the water treatment and distribution systems installed?

Are there any components of these systems that are prone to failure?

If yes, please explain.

Has your community identified the steps necessary to address these concerns?

Please explain.

What infrastructure and facilities in your community require drinking water in order to operate?

How do you think drinking water infrastructure in your community could be affected by climate and weather-related issues?

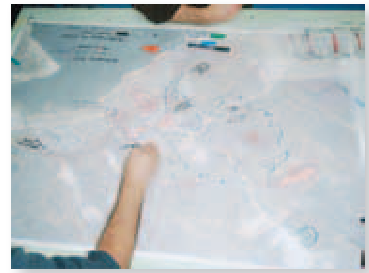


Photo credit: Melanie Irvine

Community mapping session.

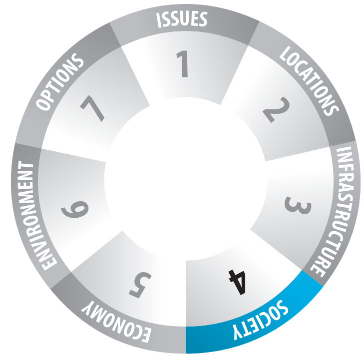
Community Mapping

By drawing on the map you started in Step 2, identify the location of infrastructure required for the drinking water supply network, as well as facilities that require water supply. Identifying areas where climate change issues are affecting water supply infrastructure or could affect it in the future is also important.

Final Checklist

	Have you identified infrastructure that has been affected by or has caused drinking water supply issues?
	Have you identified infrastructure that may be at risk to, or that may cause, drinking water supply issues in the future?

STEP 4: Identifying Individuals and Groups Most Affected by Drinking Water Supply Issues in Your Community and Those Able to Assist



This step will help you:

- Determine individuals and groups most impacted by drinking water supply issues and where they live; and
- Determine who can help.

Things to consider:

- **Elders and youth**
- **Special needs**
- **Literacy levels**
- **Emergency services**
- **Volunteer and community groups**
- **Recreation and cultural activities**
- **Isolated locations**
- **Other**

Social Assessment

Here you will identify the individuals and groups most likely to be impacted by drinking water supply issues, where they live and who can assist.

Climate change related impacts on drinking water can put people's health at risk. In the U.S., it was found that 50% of waterborne illness outbreaks in the last fifty years happened after a heavy rainfall. Increased rainfall can lead to contamination of water sources that were previously considered safe and can overload disinfection systems. Extreme weather events can damage drinking water infrastructure, knock out power sources and cause extensive flooding, increasing the risk of waterborne illnesses.

Photo credit: Kimberly Bittermann

An abandoned well with a spout.

Case Study: Hurricane Igor

In September 2010, Hurricane Igor left many people in need of emergency supplies, including clean drinking water. The Red Cross distributed 80,000 bottles of water to those communities. Extreme weather events, such as Hurricane Igor, can disrupt power and damage the infrastructure required for the water supply network. Working with emergency response organizations and having an up-to-date contact list can be crucial when identifying who is in need and how you can help.

Please answer the following questions related to the social implications of drinking water supply issues.

List individuals and groups who have been affected by drinking water supply issues in your community.

Are there obstacles to people receiving help during a disruption in the drinking water supply network (communication, transportation)?

The Salvation Army set up a mobile care unit to bring food and water to people who were left without power during Hurricane Igor.

Photo credit: Joe Gibbons, The Telegram.

Does your community have an up-to-date emergency plan?

❑ Yes ❑ No

If yes - Does this plan address potential barriers for people affected by drinking water quality and supply issues?

If no - Do you have the resources to create an emergency plan?

Are there important heritage or recreation areas in your community that have been affected by drinking water supply issues or may be affected in the future? If yes, please describe.

Are there any other ways that local lifestyles or culture have been or may be impacted by drinking water supply issues?

Many people were not vulnerable but became vulnerable when Igor came

-Anna Power, Canadian Red Cross

Photo credit: Water Resource Management, Department of Environment and Conservation, NL

A water storage tank in Bishop's Falls, NL.

There may be individuals or groups, both within your community and outside, such as those with first-aid training, emergency response experience, or amateur radio training who can help in the event of a drinking water supply issue. It is important to have up-to-date contact information for these individuals and groups in case of an emergency.

Please fill out Table 3 with information on agencies and individuals that could help in the event of a waterborne disease outbreak, water shortage, or contamination incident (or refer to your emergency plan if an up-to-date list already exists).

Table 3: Community Contact List

Agency/Person	Business phone #	Home phone #	Comments/Role

*A full size version of this table is available in the Resource Guide.

There may be other resources in your community that could be useful in the event of a drinking water supply problem. A few examples are listed in Table 4. Please complete the table and add any other resources that could be helpful if a drinking water supply issue occurs.

Table 4: Community Resource Listing

Resources	Owner (s)	Phone #	Comments
Emergency kits			
Generator (Note power output)			
Satellite phone			
Radio (VHF, two-way)			

*A full size version of this table is available in the Resource Guide.

Contaminated water may not affect everyone in your community to the same extent; those with weaker immune systems could experience more severe health issues.

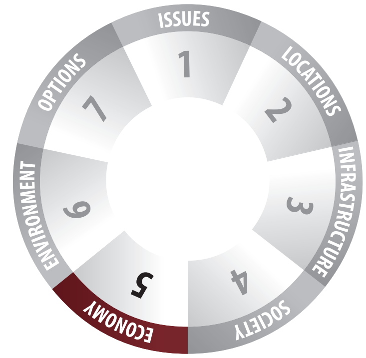
Community Mapping

By drawing on the map you started in Step 2, identify where people who are particularly susceptible to drinking water quality issues live, as well as the location of community services, volunteer groups or others who can help in the case of a drinking water issue.

Final Checklist

	Have you identified where people most susceptible to drinking water quality or supply issues live?
	Have you identified who can help during a drinking water quality or supply emergency?
	Have you considered other social impacts that drinking water quality or supply issues might have on your community?

STEP 5: Identifying Economic Impacts Caused by Drinking Water Supply Issues in Your Community



This step will help you determine:

- The economic sectors most important to your community;
- How drinking water supply issues may impact these sectors; and
- How drinking water supply issues could affect the financial resources of your community.

Things to consider:

- **Fishery**
- **Tourism**
- **Food and agriculture**
- **Manufacturing**
- **Stores and services**
- **Budget**
- **Health costs**
- **Other**

Economic Assessment

Here you will identify your community's key economic sectors and financial resources and assess how they could be affected by drinking water supply issues.

Drinking water supply issues can impact your local economy and will likely be a priority when considering adaptation options. It is also important to consider the financial resources required to respond to the impacts of sudden emergencies and ongoing drinking water quality and supply issues.

Photo credit: Fire and Emergency Services, NL

A chlorine leak at the pumphouse adjacent to the drinking water source in Williams Harbour, NL.

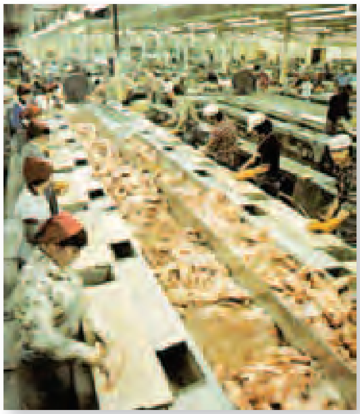


Photo credit: Department of Trade and Technology, NL, 1978

Case Study: The Fish Processing Industry

Newfoundland and Labrador's fishing industry has always been an economic mainstay for the province. The fish processing industry relies on water for operational purposes. The Towns of Cottlesville and Summerford run a shared water supply network that serves Breakwater Fisheries Limited's fish processing operations in Cottlesville. The fish processor is the largest taxpayer in the town and one of the most important employers in New World Island. One municipal leader explained that the water supply "was the key to getting a fish plant going …if the infrastructure were not in place we'd have no fish plant in Cottlesville." Maintaining freshwater supplies of sufficient quality and quantity is vital to this critical industry and to the economy of Cottlesville and New World Island.

If water supply shortages become an issue in the future, conflicts between water users (residents and industries) could increase.

Please answer the following questions related to drinking water supply issues and your economy.

What businesses, services and industries contribute most to your community's economy?

Are there any industrial users connected to your community's drinking water supply network and if so, who are they?

Have drinking water supply issues affected these businesses, services and industries in the past? If yes, how?

What businesses, services and industries are expected to be most important to your community in the future?

How could drinking water supply issues impact them in the future?

If applicable, what will happen to your tax base if these businesses, services and industries are impacted by drinking water supply issues?

Can you estimate the costs associated with addressing climate-related drinking water supply issues? What revenue sources exist to pay for these costs? What costs would have to be covered by your community?

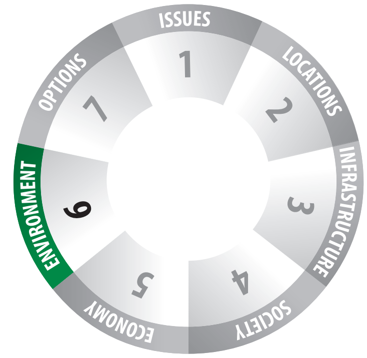
Community Mapping

By drawing on the map you started in Step 2, identify locations where key economic activities take place. This can help direct and guide decisions related to current and future drinking water supply issues.

Final Checklist

	Have you identified where your key economic activities take place?
	Have you determined how they may be impacted by drinking water supply issues?
	Have you attempted to calculate the financial costs to your community if a drinking water supply issue were to occur and how you would cover these costs?

STEP 6: Identifying Environmental Impacts Caused by Drinking Water Supply Issues in Your Community



This step will help you:

- Determine if drinking water supply issues could cause environmental problems; and
- Understand how drinking water supply issues could affect important species or natural areas.

Things to consider:

- **Hazardous and toxic sites**
- **Oil facilities**
- **Landfills**
- **Tailings ponds**
- **Sewage systems**
- **Streams, rivers, and lakes**
- **Fish and wildlife**
- **Parks and protected areas**
- **Sensitive habitats**
- **Other**

Environmental Assessment

Here you will consider how drinking water supply issues could affect the natural environment and identify sensitive areas that could be a planning priority in your community.

The issues examined so far in this chapter relate to the supply (quality and quantity) of freshwater for human consumption. However, freshwater quality and quantity issues can also have long-term effects on natural ecosystems and the species that inhabit those ecosystems.

This step will help you identify environmentally sensitive areas in your community that could be affected by freshwater quality and quantity issues. Changing precipitation patterns can lead to increased flooding or greater water scarcity. Flooding and droughts can affect ecosystems, fish and animal species, and vegetation. Also, temperature changes can impact the biodiversity of freshwater systems as most freshwater species are adapted to a relatively narrow range of temperature conditions. By identifying these sensitive areas, you may be able to find ways to minimize negative impacts.

Case Study: Atlantic Salmon

Increases in air and water temperatures often result in lower water levels and can restrict salmon from migrating along their usual routes, delaying or even preventing spawning. Snow is expected to melt sooner, which can reduce summer river flows and increase winter river flows. This increase in winter water levels can damage riverbed nesting habitats, destroying salmon eggs and juveniles, thus reducing populations.

Please answer the following questions related to the environmental impacts of water supply issues.

Do you think water supply issues could cause environmental problems in or near your community? Please explain.

Have you noticed any changes in aquatic ecosystems and biodiversity in your area?

What do you think caused these changes?

Photo credit: IUCN, 2009

Are there any endangered species or habitats in your community that may be threatened by water supply issues (quantity or quality)?

Are there concentrations of hazardous waste in your community?

❏ Yes ❏ No

If yes, are they stored safely?

❏ Yes ❏ No

Are there any freshwater sources at risk from the leaching of hazardous waste?

Do you have an environmental protection plan in place?

❏ Yes ❏ No

Do you have a watershed protection plan in place?

❏ Yes ❏ No

If you do not have these plans in place, you may want to consider developing them.

Community Mapping

By drawing on the map that you started in Step 2, identify environmentally sensitive areas in or near your community, including streams, wetlands or marshes, as well as other areas where freshwater issues could have environmental impacts.

Final Checklist

	Have you identified environmentally sensitive areas in your community?
	Have you identified how water supply issues could impact these areas?
	Have you considered how water supply issues might impact your local environment, fish and wildlife species?

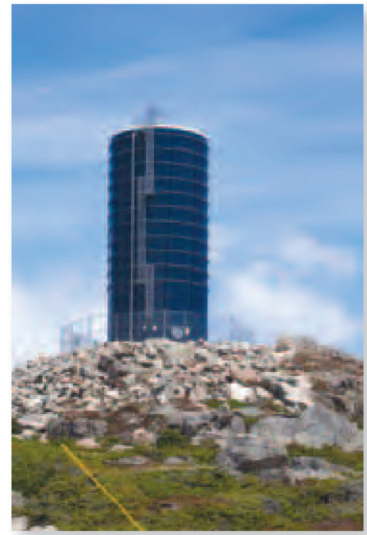
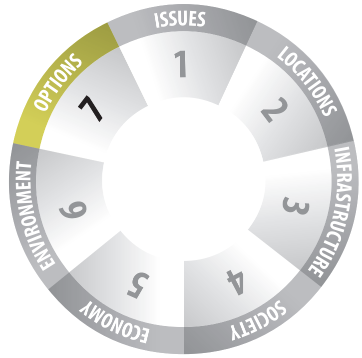


Photo credit: Water Resources Management Division, Department of Environment and Conservation,NL

A water storage tank in Ramea, NL.

STEP 7: Identifying Adaptation Options for your Community



This step will help you:

- Evaluate how your community has dealt with drinking water supply issues in the past; and
- Identify ways to reduce the negative impacts of drinking water supply issues.

Things to consider:
- **Infrastructure**
- **Technology**
- **Financial resources**
- **Human resources**
- **Policy and planning**
- **Education and awareness**
- **Emergency measures**
- **Other**

Adaptation Options

Here you will identify actions to deal with the impacts of drinking water supply issues in your community.

The Water Resources Act is the Province's legislation governing water resources and should be used as a preventative method to protect drinking water supplies and watersheds.

This step will help you identify possible adaptation options that can be implemented to reduce the impact of drinking water supply issues in your community. It will also help you determine the best solutions for your community while enhancing your ability to cope with future issues. The community mapping exercises that you completed in this chapter will illustrate where the main freshwater and drinking water supply issues occur in your community. Key adaptation concerns and priority areas for planning may become apparent once you have had a chance to discuss the information you have collected.

Considering all of the information in Steps 1 to 6, what are the main drinking water supply issues in your community?

Which past actions or measures were successful in reducing the impacts of drinking water supply issues in your community? Please list.

What actions or measures were most effective?

What adaptation options would your community like to try? What are the barriers to trying these options?

Are there ways that these barriers could be overcome?

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

A Water Resources Management Division operator trainer demonstrating how to properly handle and manipulate drinking water system equipment.

Potential Options

Drinking water quality and supply issues can be addressed in a number of ways. Four potential options are explained below and you will find more examples, in the form of case studies, in the Resource Guide at the back of the workbook.

1. **Infrastructure:** Adaptation options that may reduce the likelihood and magnitude of drinking water quality and supply issues include: changing the water treatment processes to ensure that adjustments can be implemented when water quality changes due to extreme events; installing disinfection equipment capable of responding to changing water conditions to ensure proper disinfection; and ensuring all the water system's components (hydrants and valves) are operational by enforcing proper operation and maintenance procedures (this is especially important during extreme weather events and would help prevent any reduction in water quality).
2. **Monitoring:** Monitoring environmental variables such as precipitation and snow accumulation can help in assessing when drinking water quality and supply issues may occur, allowing you to take preventative actions to minimize damages. In addition, monitoring of water quality can now be accomplished through on-line monitoring of parameters such as pH levels and turbidity.
3. **Education:** Education and awareness are critical in preparing for and dealing with drinking water quality and supply issues. Being aware of what to do in the event of a drinking water crisis can help your community be better prepared to deal with any issues that arise. It is particularly important to ensure that personnel employed in the drinking water sector have proper and up-to-date training and qualifications.
4. **Preventative zoning and permitting:** Planning and development should include consideration of the drinking water supply network. If your community's drinking water supply area is not protected, initiating this process would be a good place to start to ensure that development does not occur in that area. Maintaining a forested area (buffer zone) around a drinking water source can help improve water quality by keeping out contaminants such as agricultural run-off and disease-producing microbes. Discouraging development in areas that would affect drinking water quality and supply can help ensure the availability of clean, safe drinking water and the protection of system infrastructure.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

A protected wellhead with identification banding

There are 489 public water supply sources in the province. At the end of the 2010-2011 fiscal year, 315 sources were designated as protected public water supply areas.[1]

Considering the previous section, please identify adaptation options that can help address drinking water concerns in your community.

Please list the adaptation options you would like to pursue to address drinking water concerns in your community:

1.

2.

3.

4.

Not all of these options will have the same cost or require the same time, resources or personnel. Certain solutions will be more effective or have long-lasting impacts. In the conclusion of this workbook you can further consider the benefits and feasibility of pursuing each of these options and develop action plans for implementation.

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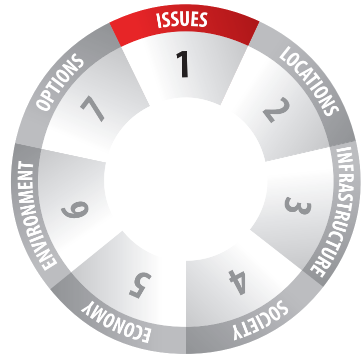
[1] *Drinking Water Safety in Newfoundland and Labrador Annual Report 2011. Department of Environment and Conservation.*



CHAPTER 5

Winter and Climate Change

STEP 1: Understanding Winter Conditions in Your Community

Winter weather in Newfoundland and Labrador can create some unique challenges for communities. Heavy snow fall and freeze-thaw events can damage property and infrastructure, cause power outages and creates hazardous driving conditions. In many parts of the province the winter season is becoming less predictable with more frequent temperature fluctuations. These changes in climate and weather patterns are expected to continue and become more severe. Changes in winter conditions may impact recreational and economic activities as well as public health and safety. Melting snow replenishes surface and ground water sources, so less snow cover may reduce the amount of water available during the rest of the year; impacting the agricultural sector as well as the public water supply.

As with all severe and hazardous weather, it is important to know what to expect and how to prepare. Also, understanding how winter conditions may change can help you prepare for the associated risks and may help minimize impacts.

**Please note that avalanches are covered in the Slope Movement Chapter of this workbook.*

Photo credit: Glen Groves

The Town of Bonavista, NL, after a snow storm.

Photo credit: Glen Groves

Snow accumulation after a snowstorm in Keels, NL in January 2005.

Types of Winter Conditions and Events

Winter is a naturally hazardous season in Newfoundland and Labrador due to its fluctuating temperatures and often severe weather events. The following is a list of winter conditions that your community may encounter:

Snow: Snow is a normal part of winter in this province but from year to year the amount can vary greatly. Heavy snowfall can reduce visibility, create hazardous road conditions, impact health and safety as well as local infrastructure. However, a winter with sufficient snowfall and consistently cold conditions can have a positive affect on local tourism and recreation. A snowfall warning is issued when 15 centimetres (cm) or more of snow is expected to fall within 12 hours or less.

Blowing snow: Blowing snow is snow driven by wind which can reduce visibility and cause deep snow drifts. This can make driving dangerous and it can also make it difficult for people to get out of their homes. A blowing snow warning is issued when visibility is reduced to near-whiteout conditions.

Snow Squall: A snow squall is a sudden, fairly heavy snowfall characterized by blowing snow, strong winds and reduced visibility. Intense and localized snow squalls can deliver significant snow accumulations in a relatively short period of time. A snow squall warning is issued for a localized, limited duration, intense snowfall that significantly reduces visibility and may be accompanied by strong, gusty winds.

Winter Storms: Winter storms are large-scale weather systems, hundreds of kilometres across, that can produce strong winds, heavy snowfall, freezing rain and cold temperatures. A winter storm warning is issued if (i) a major snowfall, 25 cm or more within a 24 hour period, is expected or (ii) significant snowfall, 15 cm or more within 12 hours or less, is expected and is combined with freezing rain, strong winds, blowing snow, or extreme wind chill. The mix of these winter weather conditions can pose a threat to public safety and property.

The economic consequences of winter storms can be severe as they may result in loss of work, damage to infrastructure and increased maintenance costs. Regular winter maintenance, such as snow clearing and road salting, is expensive and more frequent winter storms can quickly add to these expenses. Winter storm conditions are not restricted to the winter season as they can occur in the late autumn and early spring as well.

Blizzards: A blizzard is severe winter weather characterized by strong winds and heavy or blowing snow that causes low to zero visibility. A blizzard may be part of an intense winter storm or it may persist for a period of time on its own. When a blizzard creates hazardous weather conditions and a widespread reduction in visibility, a blizzard warning may be issued. Blowing snow and blizzards appear to be similar however a blowing snow event is less extreme in duration and visibility than a blizzard; as well, blizzards may be accompanied by a severe wind chill making conditions more dangerous.

Freezing Rain and Freezing Drizzle: Precipitation in the form of rain or drizzle that freezes on impact forming a glaze of ice on the ground and exposed objects. Driving and walking can be dangerous in such conditions. As well, ice coated utility lines or poles can break and collapse due to the excess weight of the ice. A freezing rain warning is issued when it is expected to pose a hazard to transportation or property or when it is expected for at least 4 hours. A warning is issued for freezing drizzle when it is expected for at least 8 hours.

Ice pellets: Ice pellets are raindrops that freeze before they reach the ground.

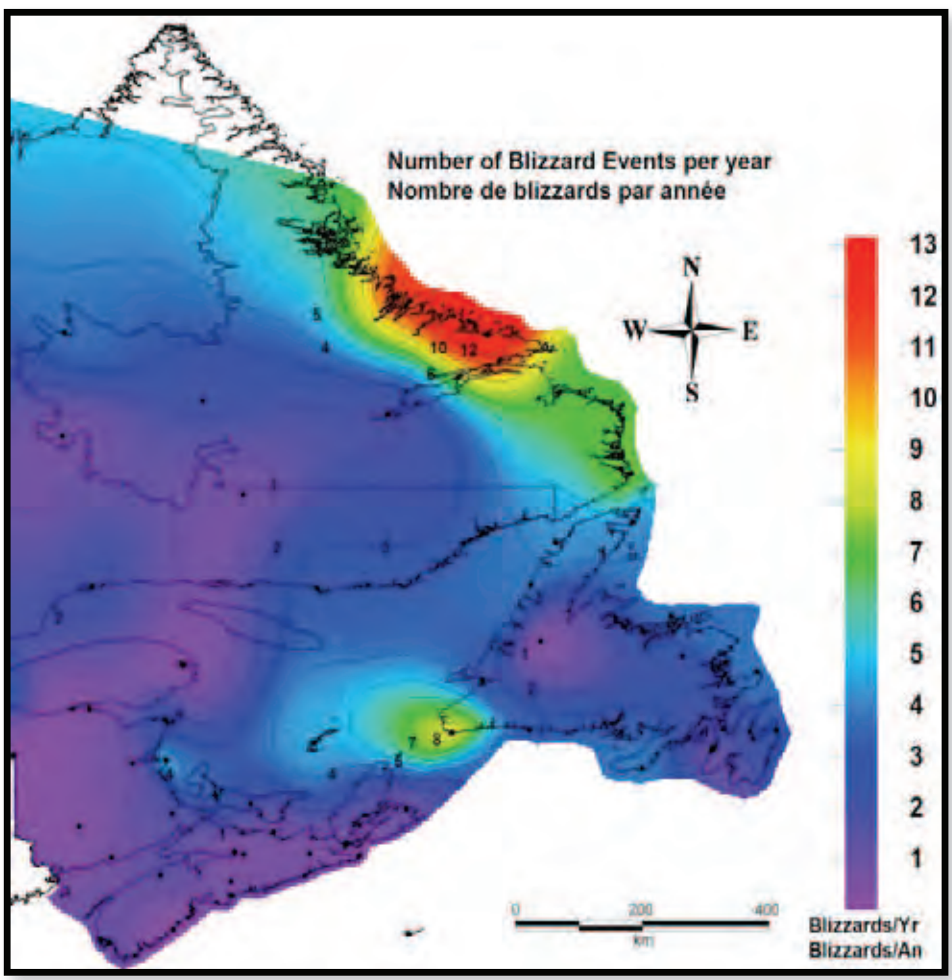


Figure source: Environment Canada, Government of Canada.

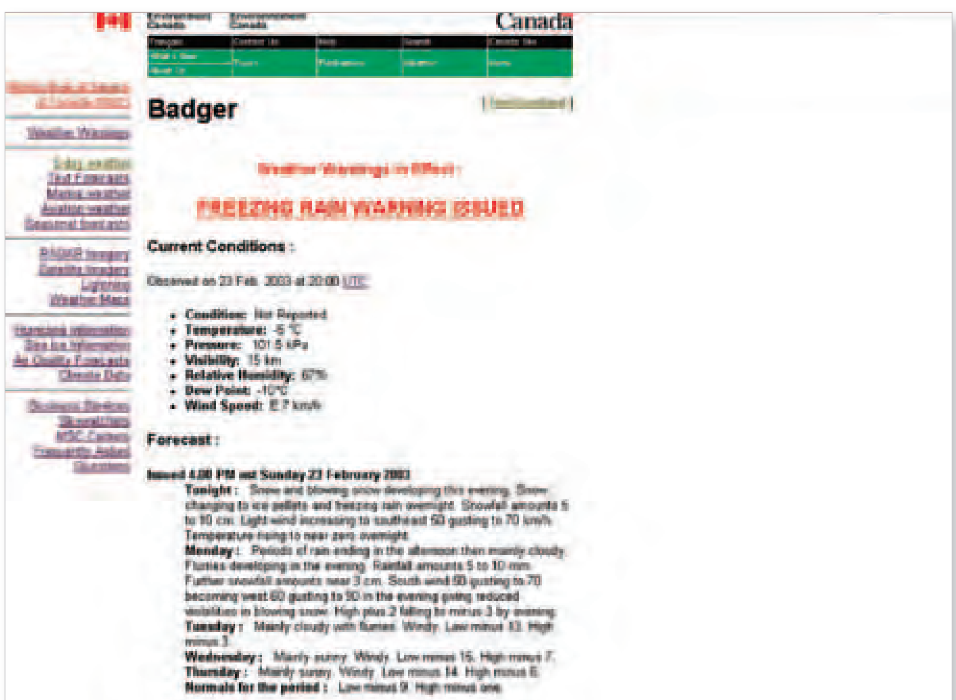
This map shows the number of blizzards per year in the province. Some areas in Labrador can experience over 10 blizzards per year.

Flash Freeze: A flash freeze warning is issued when significant ice is expected to form on roads, sidewalks or other surfaces over a considerable area due to the freezing of residual water from either melted snow or rain resulting from a rapid drop in temperature to below freezing.

It is important to be aware of winter weather in your community as roads can quickly become snow or ice-covered creating hazardous driving conditions. Since main highways and roads are usually given priority for salting and snow clearing, rural areas may experience delays in receiving these services during extreme weather events. As well, many rural communities have only one access road and can be located a great distance from emergency services. Severe winter weather can put these communities at an increased risk of being cut off from emergency and essential services.

Freeze-thaw Cycles: When winter temperatures fluctuate above and below 0°C it is referred to as a freeze-thaw cycle. These conditions can cause severe damage to pipes, communication networks, building foundations, infrastructure and roads.

Rain: Winter rainfall can be a significant event in Newfoundland and Labrador and can have serious impacts when it falls on snow or frozen ground. Rain water does not absorb quickly into frozen ground and can cause increased run-off and pooling which can lead to flooding. Snow melt during rainfall and rapid thawing of river ice can increase the extent of winter flooding. A rainfall warning is issued during the winter when 25 millimetres (mm) or more of rain is expected within a 24 hour period.



Screen shot of Environment Canada's Weather warnings.

Wind Chill: Wind chill is the actual temperature people experience when air temperature and wind are combined. Extreme wind chills can cause exposed skin to freeze very rapidly, leading to frostbite. It also speeds up the rate at which your body loses heat which can lead to hypothermia.

Wind: A wind warning is issued for sustained winds of speeds 80 km/h or more or gusts to 100 km/h or more that pose a significant threat to public safety and property.

Your community can be better prepared for winter weather hazards by having properly maintained infrastructure, as well as, effective communication procedures and emergency planning strategies. Public education and awareness campaigns are useful means of helping community members be better prepared for changing winter conditions.

Photo credit: www.clearroads.org/driver-safety-resources.html

Snow clearing operations.

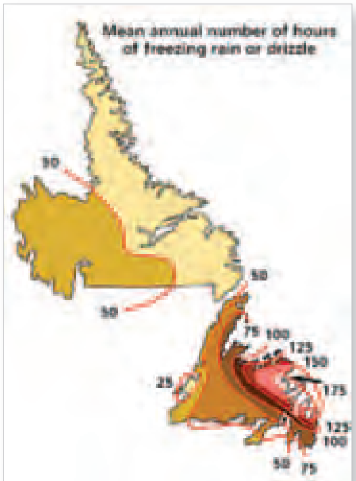


Figure from: www.heritage.nf.ca

This map shows the range of average annual freezing rain and drizzle hours across the province.

Case Study: Bonavista Ice Storm

In March 2010, the town of Bonavista was hit with an ice storm that left 4,000 people without power or telephone services. It was the worst ice storm that the town had experienced in 20 years. To cope with the power interruption, a back-up generator was used and the hospital prioritized its energy use to urgent and essential functions.

Please answer the following questions related to winter conditions and events in your community.

What types of winter conditions or events have affected your community?

How have these winter conditions or events affected your community?

Photo credit: Fire and Emergency Services , NL

Winter Conditions in the Future

Climate change projections indicate that extreme weather events will increase throughout all seasons. It is also projected that future warming will be greatest in the winter months and may result in greater snowfall amounts, intensified blizzards and blowing snow; more frequent and longer duration mid-winter thawing; more frequent freeze-thaw cycles; and degradation of permafrost.

Abnormally Mild, Snow-Deficient Winters

Winters on the Island portion of the province are relatively mild and rarely have prolonged periods with temperatures below minus 15 °C. A changing climate may bring milder winters resulting in less sea-ice, more freeze-thaw cycles and more frequent rain-on-snow events. This can create challenges for communities that rely on cold winters for transportation, recreation and tourism. Less ice cover makes the coast more vulnerable to erosion from wave action and storm surges. A lack of snow cover can lead to greater frost penetration while alternating mild-cold periods can result in more river ice jams and frost heaves. Milder temperatures can also result in increased amounts of freezing rain as well as an increase in the frequency of freezing rain, freezing drizzle and ice pellets.

Please answer the following questions related to winter conditions in your community.

What types of winter conditions do you think could be more problematic for your community in the future? Briefly describe.

Final Checklist

	Have you identified the types of winter conditions that have impacted your community?
	Have you identified how winter conditions might change in the future?

STEP 2: Identifying Locations Affected by Winter Conditions in Your Community

To complete steps 2- 7, you will need a map of your community. Please refer to the Resource Guide at the back of the workbook to find out how to obtain a map. This step will help you:

- Locate the areas within your community that are most affected by winter conditions.

Things to consider:
- **Landscape features**
- **Planning and zoning**
- **Development**
- **Power lines and grids**
- **Vegetation**
- **Elevation**
- **Snow accumulation**
- **Drainage**
- **Proximity to rivers and streams**
- **Other**

→ **Location Assessment** →

Here you will determine where winter conditions have affected your community and which areas could be at risk.

Certain areas of your community may be more vulnerable to winter conditions. Snow accumulation can vary due to differences in elevation and wind patterns as well as slope orientation. In addition, infrastructure built close to rivers and streams may be vulnerable to winter flooding.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

River flooding in Badger, NL.

Photo credit: Kimberly Bittermann

Community mapping in Logy Bay - Middle Cove - Outer Cove, NL.

Better signs and lighting may be necessary for streets that are particularly dangerous in the winter.

Please answer the following questions related to winter conditions and events in your community.

What areas of your community have been affected by winter conditions or events?

Table 1: Factors Influencing Winter Conditions

Factor	Check box if factor has influenced winter conditions	Comments or information sources
Topography	☐	
Drainage	☐	
Wind Direction and Speed	☐	
Precipitation	☐	
Land Use	☐	
Proximity to Rivers	☐	
Other	☐	

Do you expect that the locations affected by winter conditions or events will change in the future? If yes, how?

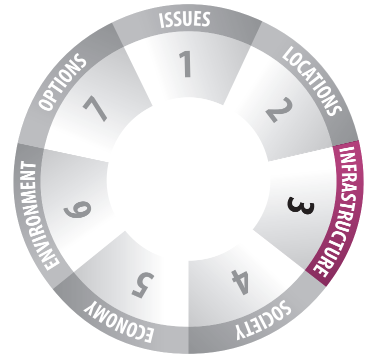
Community Mapping

By drawing on your map, please indicate the areas that are most affected by winter conditions or events.

Final Checklist

	Have you identified the areas most affected by winter conditions or events?
	Have you identified the areas that might be affected by winter conditions or events in the future?

STEP 3: Identifying Facilities and Infrastructure Affected by Winter Conditions in Your Community



This step will help you:

- Identify and locate key infrastructure in your community; and
- Better understand the potential impact of winter conditions on infrastructure.

Things to consider:

- Police and fire stations
- Hospitals and nursing homes
- Power sources
- Roads, bridges, culverts and trails
- Schools
- Community and heritage buildings
- Telephone wires and poles
- Roofing

Facilities and Infrastructure Affected

Here you will identify the location and characteristics of key infrastructure so you can determine where to focus your adaptation efforts.

Photo credit: Newfoundland Power

Ice storm in Heart's Content, NL.

It is important to know where your community infrastructure is located as well as its age and condition. Cold winter temperatures, combined with precipitation, can cause large heaves and cracks to form in roads creating safety hazards. Electrical and communication infrastructure, such as power lines and poles, may be especially vulnerable during ice storms and, if damaged, could result in extensive power outages for residents. Other hazards could include significant snow build-up on roof tops resulting in damage or collapse.

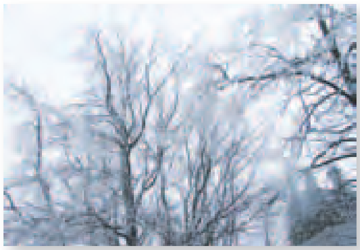


Photo credit: Fire and Emergency Services, NL

Case Study: Power Outages and Cancellations: Newfoundland Blizzard 2013

On January 11th, Southern and Eastern Newfoundland were struck by a raging blizzard which knocked out power to most of the island. Public services were shut down, ferry services and flights were cancelled, and schools across the region were closed. It was the heaviest snowfall to hit the region in seven years and, coupled with winds topping 130 km/h, it made for extremely hazardous driving conditions. St. John's received over 50 cm of snow, 70-90 cm fell in the Trinity Bay area and Gander had 30 hours of freezing drizzle. Due to the impact of the storm on Newfoundland and Labrador Hydro's Holyrood generating station, Grand Falls-Windsor and areas in western Newfoundland were affected by power outages even though they weren't exposed to blizzard conditions. The high winds also caused roofing to blow off several major businesses in the region.

> What important infrastructure exists in your community? Consider the following questions:
>
> - Is any infrastructure in need of repair, replacement or upgrades?
> - Does the state of this infrastructure increase the likelihood of winter conditions and events causing damage?
> - Who should be involved in order to address these concerns?

Use Table 2 to record information on key infrastructure in your community. Examples of key infrastructure include: police and fire stations; hospitals and nursing homes; water supply and treatment stations; sewage and wastewater systems; power sources; roads, bridges, culverts and trails; schools; churches; heritage structures; community centres and other community buildings.

Several days of freezing rain in March 2010 caused ice to damage power lines in Heart's Content, NL.

Photo credit: Fire and Emergency Services, NL

Table 2: Inventory of Community Infrastructure

Infrastructure	Will it be impacted by winter conditions? What type?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

*A full size version of this table is available in the Resource Guide.

Are there any buildings in your community with roofing that may not be able to handle a heavy snow load or is in need of repair?

❏ Yes ❏ No

If yes, please explain.

What is the current condition of roads and culverts in your community? Do you think they are able to withstand extreme snowfall, frequent snow-clearing measures and heavy machinery?

Have any buildings in your community been damaged by winter conditions? If yes, list examples. Do you think there is an increased risk of buildings being damaged by winter conditions or events in the future? Please explain.

Community Mapping

By drawing on the map you started in Step 2, identify the location of important infrastructure in the community that could be at risk. It is also important to identify drainage infrastructure such as the location of main culverts or drainage trenches.

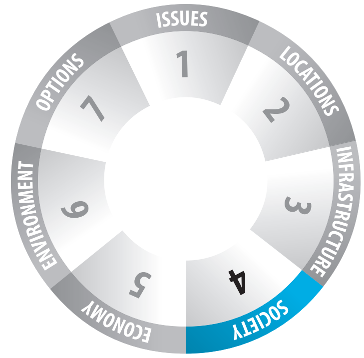
Final Checklist

	Have you identified the infrastructure that has been impacted by winter conditions or events?
	Have you identified what infrastructure will be at risk of being impacted by winter conditions or events in the future?

Ice storm in Gander Bay, NL.

Photo credit: Newfoundland Power

STEP 4: Identifying Individuals and Groups Most Affected by Winter Conditions in Your Community and Those Able to Assist



This step will help you:

- Determine who will be most impacted by winter conditions; and
- Determine who can help.

Things to consider:

- **Elders and youth**
- **Single parent households**
- **Special needs**
- **Literacy levels**
- **Emergency services**
- **Volunteer and community groups**
- **Recreation and cultural activities**
- **Isolated locations**
- **Other**

Social Assessment

Here you will identify the individuals and groups most likely to be impacted by winter conditions, where they live and who can assist.

Changing winter conditions and extreme events can have serious impacts on people, their homes, community infrastructure as well as a community's ability to respond to emergencies. Not everyone will be able to respond and react in the same manner, so understanding who may be most affected will help your community target important areas for investment and set priorities for planning. Volunteer groups and other forms of community support may be a resource you can draw upon to help residents respond and adapt to winter conditions or events.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

Preventing a river ice jam in Rushoon, NL.

Photo credit: Corrections in Canada
www.csc-scc.gc.ca

The ice storm of 1998 caused severe damage in Quebec, Ontario, New Brunswick and Nova Scotia.

Case Study: Ice Storm 1998

On January 5th, 1998, Quebec, Ontario, New Brunswick and Nova Scotia were affected by an extreme ice storm that lasted for several days, leaving millions of people without power. Power infrastructure was so extensively damaged that it took almost a month for power to be fully restored. The Canadian Armed Forces and local police assisted in bringing people to safety, providing medical care and cleaning up debris. This storm affected millions of Canadians, damaged infrastructure and had serious and long-lasting impacts on the regions dairy farms and maple syrup producers.

Please answer the following questions related to the social implications of winter conditions.

Who has been affected by winter conditions in your community?

Are there obstacles to these people receiving help during a major event (communication, transportation)?

Does your community have an up-to-date emergency plan?

❑ Yes ❑ No

Does this plan address potential barriers for people affected by winter conditions?

Do you have the resources to create an emergency plan?

Are there important heritage or recreation areas that may be affected by winter events and changing winter conditions?

Are there any other ways that local lifestyles and cultures have been or may be impacted by winter conditions or events?

How will you inform residents if there is a major blizzard or winter storm predicted for your community?

Other individuals in your community may be able to help, such as those with first aid training, emergency response experience or amateur radio training. It is important to have contact information for these individuals and groups in case of an emergency.

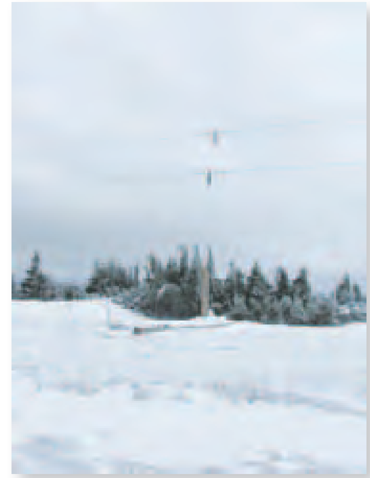


Photo credit: Fire and Emergency Services, NL

Ice build up caused this power line pole to snap off.

Please fill out Table 3 with information on agencies or individuals in your community that could help in the event of a major winter storm (or refer to your emergency plan if an up-to-date list already exists).

Table 3: Community Contact List

Agency/person	Business phone #	Home phone #	Comments/Role

*A full size version of this table is available in the Resource Guide.

There may be other resources in your community. A few examples are listed in Table 4.

Please complete the table by adding any other resources that are relevant to your community.

Table 4: Inventory of Community Resources

Resources	Owner (s)	Phone #	Comments
Snow blower or other rescue tools			
Backhoe			
Generator (Note power output)			
First aid experience			
Other (satellite phone, radio)			

*A full size version of this table is available in the Resource Guide.

Community Mapping

By drawing on the map you started in Step 2, identify any areas in your community where people most vulnerable live. Also identify the location of community services, volunteer groups or others who can help in case of an extreme weather event.

Final Checklist

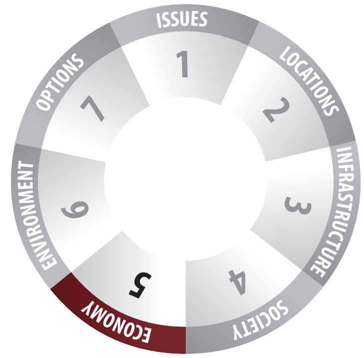
	Have you identified where people most vulnerable live?
	Have you identified individuals and groups in your community who may be able to provide assistance during an emergency?
	Have you considered other social or cultural impacts that changing winter conditions might have on your community?

Certain people in your community may have the ability, experience and resources to help others cope with the impacts of winter conditions or an extreme event.

Photo credit: Melanie Irvine

Community mapping in Ferryland, NL.

STEP 5: Identifying Economic Impacts Caused by Winter Conditions in Your Community



This step will help you determine:

- Your community's most important economic sectors;
- How winter conditions will impact these sectors; and
- How winter conditions could affect the financial resources of your community.

Things to consider:

- Fishery
- Forestry
- Tourism
- Food and agriculture
- Construction
- Manufacturing
- Transportation
- Retail and services
- Budget
- Insurance costs
- Other

Economic Assessment

Here you will identify your community's important economic sectors and financial resources and assess how they could be affected by winter conditions.

Changing winter conditions or an extreme event may have a negative impact on your local economy. It is important to assess the financial resources required to respond to the impacts of sudden, extreme winter events, as well as more typical on-going winter conditions. Changing ocean environments and sea ice conditions will affect vessels and shipping as well as site selection and long-term sustainability of the aquaculture industry.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

Extensive property damage occurred during a major winter flood in Badger, NL.

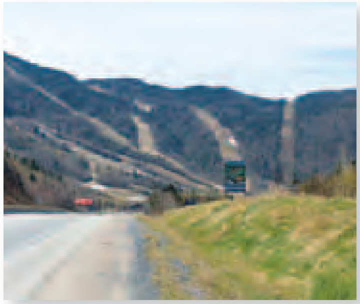


Photo credit: John Drover

Marble Mountain, NL in spring.

Please answer the following questions related to winter conditions and events and your economy.

What businesses, services and industries contribute most to your community's economy?

Have winter conditions or events impacted them in the past? If yes, how?

What businesses, services and industries are expected to be most important in the future?

How might changes in winter conditions and events affect them in the future?

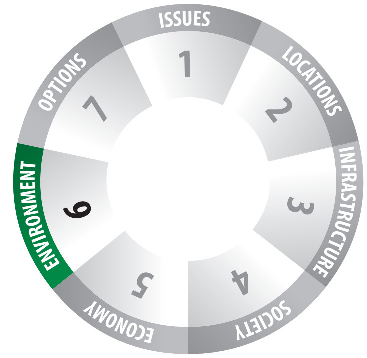
What will happen to your tax base if these businesses, services and industries are impacted?

Final Checklist

	Have you identified where your key economic activities take place?
	Have you determined whether these activities could be affected by winter conditions or events?
	Have you tried to assess the costs of winter conditions or events for your community and how you would cover these costs?

Photo credit: Newfoundland Power

STEP 6: Identifying Environmental Impacts Caused by Winter Conditions in Your Community



This step will help you:

- Determine if winter conditions could cause other environmental problems; and
- Understand how winter conditions could affect important species or natural areas.

Things to consider:

- **Hazardous and toxic sites**
- **Oil facilities**
- **Ports**
- **Landfills**
- **Mining sites and tailings ponds**
- **Sewage system**
- **Pests and diseases**
- **Agricultural runoff**
- **Fish and wildlife**
- **Sensitive habitats**
- **Exposed coastlines**
- **Other**

Environmental Assessment

Here you will consider how winter conditions could affect the natural environment and identify sensitive areas that could be a planning priority in your community.

Changing winter conditions and extreme events can have negative impacts on many species and their ecosystems. For example, ice storms may cause damage to forests through ice build-up, weighing down branches and causing them to bend or break. Ice storms can also change the tree species composition of a forested area, diminish stand growth and cause recently thinned stands and hardwood trees to be more vulnerable to the elements. Changing winter temperatures can also affect the survival rates and distribution of pests and diseases. This step will help you identify sensitive areas where these issues may occur and find ways to minimize the impacts.

Photo credit: Ted Pardy

Changing winter conditions due to climate change are affecting caribou migration.

Photo credit: www.clearroads.org/driver-safety-resources.html

Snow clearing / ice control equipment.

Please answer the following questions related to the environmental impacts of winter conditions and events.

Do you think that winter conditions or events could cause environmental problems in your community? Please explain.

Can you list any changes in winter conditions that could cause future environmental problems in your community?

Are there any species or habitats in your community that could be affected by winter conditions or events?

Has sea ice formation changed in your community? If yes, is your community experiencing increased coastal erosion due to less protection from sea ice in the winter months?

Are there concentrations of hazardous wastes or toxic sites in your community? Are the sites at risk from winter conditions or events such as storms, frost heaves or flooding?

❑ Yes ❑ No

Do you have an environmental protection plan in place?

❑ Yes ❑ No

If not, we recommend you consider developing one. Please see the Resource Guide for ideas.

Community Mapping

By drawing on the map you started in Step 2, identify any environmentally sensitive areas in your community. Also, it is important to identify any environmental issues that could be caused by changing winter conditions or extreme winter events.

Final Checklist

	Have you considered how winter events and changing winter conditions might impact your local environment and fish and wildlife species?
	Have you identified which areas of your community are environmentally sensitive?
	Have you identified the areas of your community that could be affected by winter events and changing winter conditions?

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

Measuring ice thickness in Rushoon, NL.

STEP 7: Identifying Adaptation Options for Your Community

This step will help you:

- Evaluate how your community has dealt with changing winter conditions in the past; and
- Examine the best options for reducing the negative impacts of changing winter conditions and extreme events.

Things to consider:

- **Infrastructure**
- **Technology**
- **Material resources**
- **Financial resources**
- **Human resources**
- **Policies and planning**
- **Emergency measures**
- **Transportation**
- **Communication**
- **Power**
- **Other**

Adaptation Options

Here you will identify actions to deal with the impacts of winter conditions and events in your community.

This step will help you identify a range of adaptation options to reduce the impact of winter events and changing winter conditions in your community. It will also help you determine the best solutions for your community and ways to cope with future winter conditions and events.

Photo credit: www.clearroads.org/driver_safety_resources.html

Photo credit: Newfoundland Power

Heart's Content, NL.

The community mapping exercises that you completed throughout this chapter can help illustrate the areas where winter conditions could cause the greatest problems. Key adaptation concerns and priority areas for planning may become apparent once you have had a chance to discuss the information you have collected.

Considering all of the information collected in Steps 1 to 6, list any winter conditions or events that impact your community.

What actions or measures have you taken that have been successful in reducing the impact of winter conditions and events in your community?

What actions or measures were most effective?

What adaptation options would your community like to try? What are the barriers to trying these options?

Are there ways to overcome these barriers?

Potential Options

There are a number of ways to reduce the impact of winter conditions and events on your community. Some options are explained below and more examples, in the form of case studies, are available in the Resource Guide.

- **Infrastructure:** While you can't control winter weather, you can prepare for changing winter conditions and extreme events and reduce impacts on your community. Some winter adaptation options could include:
  - implementing better road clearing and maintenance techniques;
  - installing snow fencing; or
  - providing extra support for unstable roofing.

- **Monitoring:** The monitoring of meteorological variables such as air pressure, relative humidity and temperature can help predict the occurrence of winter events. Environment Canada provides frequent updates on local conditions and forecasts.

- **Communication:** An effective warning or communication system should be put in place to help alert and inform citizens of a predicted storm.

- **Education:** Education is an important part of dealing with winter conditions and events. If people know what to do in the event of a blizzard, for example, they will be better prepared to handle the situation if it arises.

- **Technology:** Some technology options can be useful in the case of a major winter event. Having access to a community generator of sufficient size can provide emergency power for essential services in the event of a power outage. Low tech options like snow fencing and simple barriers can limit snow drifts and reduce white-out conditions on main roadways.

- **Planning:** Planning and development should include consideration of all possible winter conditions and events and how these conditions may change in the future. Communities that rely on winter tourism may need to shift their focus to another tourism season. Some communities may also need to reassess their annual snow clearing budgets as winter conditions become less predictable.
- **Emergency measures:** In the case of a major winter event, having an up-to-date emergency plan is critical.

Considering the alternatives discussed above, please identify any new adaptation options that may help to address winter conditions and events in your community.

River Ice in Rushoon, NL.

Photo credit: Water Resources Management Division, Department of Environment and Conservation, NL

List the options for adapting to winter conditions and events in your community that you believe should be pursued now or in the future:

1.

2.

3.

4.

5.

Not all of these options will have the same cost or require the same time, resources or personnel. Certain solutions will be more effective, and have long-lasting impacts. The conclusion of this workbook will help you further consider the benefits and feasibility of pursuing each of these options and develop action plans for implementation.

CHAPTER 6

Wildfire and Climate Change

STEP 1: Understanding Wildfire in Your Community

Fire is a natural process in many ecosystems. It is beneficial and necessary for maintaining a healthy forest as well as plant and animal diversity. Fire can also be an unnatural force caused by human activity and carelessness.

Communities built in or near forested regions will, at some point, have to deal with the threat of a wildfire. The number of wildfires that occur in Newfoundland and Labrador fluctuates on an annual basis; however, the province is seeing, on average, more than 150 wildfires each year.

Fire suppression is costing the province approximately $6 million per year. While fire occurrence and fire behavior varies from year to year, it is important to recognize that early detection can keep the cost of fighting wildfires to a minimum.

A wildfire is an unplanned and unwanted natural or human-caused fire, which requires suppression.

Photo credit: The Telegram - thetelegram.com

Local and provincial fire fighters worked together to suppress a wildfire near a residential area in Conception Bay South, NL.

Photo credit: The Telegram - thetelegram.com

A large grass fire near the School For The Deaf in St. John's, NL.

Factors that Influence Fire Behaviour

Fire behaviour refers to how a fire develops as well as how it reacts to the influences of fuel, weather and topography. Environmental factors that affect fire behaviour include:

Fuel: Wildfire fuel includes trees, grass, twigs, leaves and other combustible material. The moisture level of the fuel source will influence the likelihood and severity of a fire. For example, small dry twigs will burn much faster than large logs and dry fuel sources will ignite more easily and burn faster than wet fuel sources.

Weather: Aspects of weather, such as wind and moisture, can influence fire behaviour. Wind greatly affects how quickly a fire spreads and the direction in which it moves. Weather involving abrupt wind changes, such as cold fronts and sea and land breezes, can be particularly dangerous as it can suddenly change the fire's direction and behaviour. Warm, dry weather and long periods without rain can increase the likelihood of a wildfire developing. High temperatures will make a fire burn faster; however, high relative humidity and precipitation may slow down or extinguish a fire altogether.

Local topography: The shape of the landscape can influence the severity of a wildfire and the length of time that it burns. For example, wildfires will move and spread faster upslope and barriers such as creeks and roads can slow or extinguish them.

The fuel source, weather conditions and local topography all affect the likelihood and severity of a wildfire occurring; however, it is important to recognize that human carelessness causes most wildfires. Warm, dry weather can lead to extremely dry fuel sources but it also leads to an increase in outdoor recreational activities, which can result in more human-caused wildfires.

Please answer the following questions related to wildfire in your community.

How have wildfires had an impact on your community?

List the main causes of these wildfires.

Did weather conditions affect the severity of these wildfires?

Wildfire in the Future

In 1975, the Government of Newfoundland and Labrador increased its fire fighting capacity and took a lead role in forest fire management and suppression. As a result, the Province has improved its capability to suppress wildfires and reduce associated losses. The Forest Fire Protection Centre opened in 1986 in Gander, NL and has a provincial hose processing facility where hose is cleaned, tested, repaired and packaged for storage and shipment. New technology and equipment as well as improved education have contributed to better fire suppression techniques.

Nonetheless, due to a changing climate your community may see an increase in the number and severity of wildfires. Although most fires are caused by human activity, warmer, drier weather and changes in precipitation patterns may create more favourable conditions for wildfires.

Photo credit: Fire and Emergency Services, NL

Wildfire in Badger, NL.

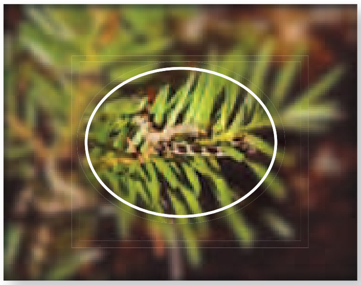


Photo credit: Forest Engineering and Industry Services Division, Department of Natural Resources, NL

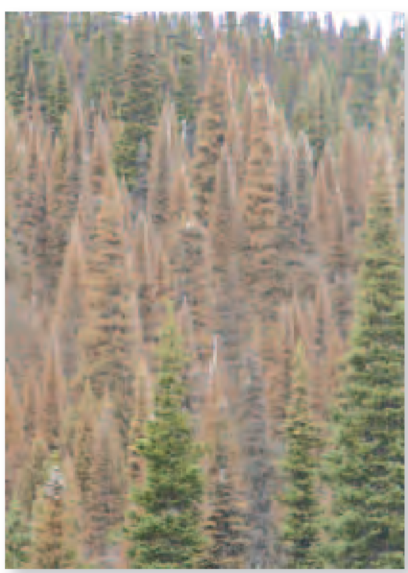
Eastern Hemlock Looper.

Case Study: Forest Pests - Insects and Tree Diseases

The relationship between climate, forest insects and tree diseases is complex. The distribution and impact of forest pests is closely related to seasonal temperatures and weather patterns. Increases in spring and summer temperatures may allow insects to become established in areas where they were previously non-existant or infrequent and milder winters may result in higher insect over-winter survival rates. Also, tree stands can become infected and damaged from disease spores which can be spread by splashing rain, often occurring in the spring or summer.

In Labrador, for example, there have been recent changes in populations of Eastern Hemlock Looper (EHL), a caterpillar that can destroy a healthy tree in a single year. Prior to 2006 only minor occurrences of EHL were documented but between 2006 and 2009 there was an unprecedented increase in populations and damage levels. Weather anomalies are suspected to have played a role in these population increases and subsequent damage.

On the West Coast of Canada, an increase in damage and mortality from the Red Band Needle Blight, a disease in Lodgepole Pines, has already been associated with increased rainfall during the summer. Climate change projections suggest that as average global temperatures warm, dry areas will become drier and wet areas will become wetter. If changes in weather patterns result in increased rainfall during the spring and summer more frequent infection and damage from tree diseases are expected. Increases in infection from a number of tree diseases (e.g. anthracnose, needle and shoot blights, Scleroderris canker, Cytospora canker) could occur in Eastern Canada if spring and summer precipitation changes in frequency and intensity.



Defoliation and mortality caused by Eastern Hemlock Looper.

Photo Credit: Forest Engineering & Industry Services Division, Department of Natural Resources, NL

Widespread mortality of trees in forested areas in or near your community will not only result in loss of habitat but will also increase the risk of wildfire. Dead trees and trees that have been damaged by insects or disease are a source of fuel for wildfires and increase the risk of a wildfire occurring.

Have you noticed changes in the frequency or severity of wildfires in or near your community? Briefly describe these changes.

Are weather conditions in your region becoming more favourable for wildfires?

❑ Yes ❑ No

Has the health of the forest changed?

❑ Yes ❑ No

Do you think these changes are due to insects, disease or drought?

❑ Yes ❑ No

Hot, dry summers create favourable conditions for wildfires.

Final checklist

Place a check mark beside each question that you can answer with 'yes'. If there are any questions that require a 'no' answer, use the Resource Guide, at the back of this workbook, to help you address them. After you have gathered more information, you should return to these questions to make sure each one has been properly addressed.

	Have you identified what has caused wildfires in your community?
	Have you identified how forested areas in or near your community might be more susceptible to wildfire in the future?

STEP 2: Identifying Locations Affected by Wildfire in Your Community

To complete steps 2 - 7, you will need a map of your community. Please refer to the Resource Guide at the back of the workbook to find out how to obtain a map.

This step will help you:

- Locate the areas within your community that are at risk of being affected by wildfire.

Things to consider:

- **Planning and zoning**
- **Development**
- **Vegetation**
- **Moisture content**
- **Topography**
- **Sediment type**
- **Snow cover**
- **Residential areas**
- **Other**

Location Assessment

Here you will determine where wildfires have occurred and which areas of your community could be at risk.

Certain areas of your community may be more vulnerable to wildfire such as forested regions and popular camping and bonfire sites.

Photo credit: The Telegram - thetelegram.com

A water bomber was brought in to the Southbrook subdivision in St. John's, NL to control a wildfire that came within yards of nearby homes.

Photo credit: The Telegram - thetelegram.com

Forestry Firefighters battle a blaze near Cochrane Pond Family Campground while campers were evacuated.

What factors have influenced wildfire in your community?

Table 1: Factors that Influence Wildfire

Factor	Check box if factor has influenced wildfire	Comments or information sources
Topography	❑	
Drainage	❑	
Season	❑	
Precipitation	❑	
Type of forest	❑	
Presence of disease pests	❑	
Planning, zoning and land-use	❑	
Other	❑	

Please answer the following questions related to wildfire in your community.

What areas of your community have been affected by wildfire? What areas are near forested regions?

Are there other areas in your community that may be prone to wildfire?

Are there popular camping and bonfires sites in or near your community?

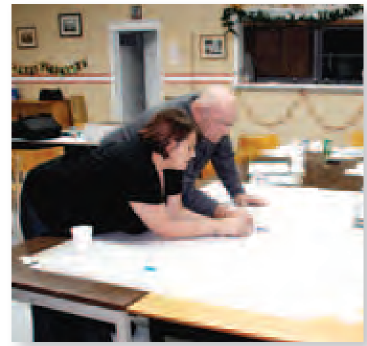


Photo credit: Kimberly Bittermann

Workshop participants from Fortune, NL map out areas of concern within their community.

Community Mapping

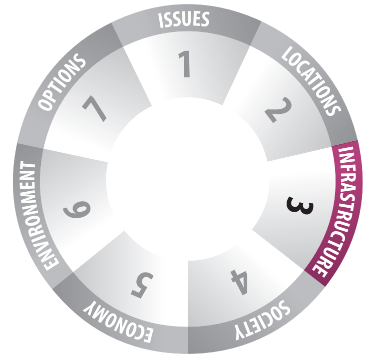
Do you know what areas in or near your community have been affected by wildfire? If yes, by drawing on your map, please identify these areas.

Do you expect the areas affected by wildfire to change in the future? If yes, how? What are some of the factors that you believe may lead to this change?

Final Checklist

	Have you identified where wildfires have occurred in the past?
	Have you identified where wildfires might occur in the future?

STEP 3: Identifying Facilities and Infrastructure Affected by Wildfire in Your Community



This step will help you:

- Identify key infrastructure in your community; and
- Better understand the potential impact of wildfire on infrastructure.

Things to consider:

- **Fire hall**
- **Fire hydrants**
- **Police stations**
- **Firefighting aircraft**
- **Hospitals and nursing homes**
- **Power sources**
- **Roads, bridges and trails**
- **Streams, ponds and lakes**
- **Parks**
- **Schools**
- **Community and heritage buildings**
- **Other**

Facilities and Infrastructure Affected

Here you will identify the location and characteristics of key infrastructure so you can determine where to focus your adaptation efforts.

It is important to be aware of the location of infrastructure and facilities that may be impacted by wildfire, as well as building material characteristics such as fire resistance. You should also determine if fire has damaged any facilities or infrastructure in the past and locate any infrastructure such as access roads, fire stations and fire hydrants that could be used to help minimize damage from future wildfires.

Photo credit: The Telegram - thetelegram.com

The town hall in Trepassey, NL was destroyed by fire in November, 2011. With no fire hydrants nearby, firefighters efforts were hampered.

Photo credit: The Telegram - thetelegram.com

Bob Ryan, a firefighter with the provincial Department of Forestry, douses smouldering hotspots in a wooded area of St. John's, NL.

As you go through this step, keep these questions in mind:

- What key infrastructure in your community would be vulnerable in the event of a wildfire?
- Is any infrastructure in need of repair, replacement or upgrades?
- Could the state of this infrastructure increase the risk of fire?
- What infrastructure is available for firefighting or repairing fire-related damage?
- Is this infrastructure in need of repair, replacement or upgrades?
- Who should be involved to address these concerns?

Examples of key infrastructure include: police and fire stations; fire hydrants and main water sources; hospitals and nursing homes; evacuation sites; roads and bridges; schools, churches, heritage structures, community centres and other community buildings.

Please complete Table 2 with information on infrastructure in your community.

Table 2: Inventory of Community Infrastructure

Infrastructure	Could it be impacted by wildfire? If yes, how?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

*A full size version of this table is available in the Resource Guide.

Are you aware of any infrastructure in your community that may pose a fire hazard due to its building material? For example, were non-combustible materials (stucco, brick) or combustible materials (wood, vinyl siding) used to construct the exterior walls of buildings? What can your community do to address these concerns?

Does your community have a fire department?

❑ Yes ❑ No

If no, do you have an arrangement in place with neighbouring communities to assist in the event of a wildfire?

❑ Yes ❑ No

Does the department that you rely on have the resources required to deal with a wildfire?

❑ Yes ❑ No

Are you aware of any infrastructure or facilities located in an area that may be vulnerable to wildfire? If yes, please explain.

Are there energy transmission lines or telecommunications infrastructure located in an area that may be vulnerable to wildfire?

❑ Yes ❑ No

Has your community considered how to address these concerns?

Community Mapping

By drawing on the map you started in Step 2, identify the location of important infrastructure in your community that may be at risk of wildfire. Identifying infrastructure that may be used during a fire is also important.

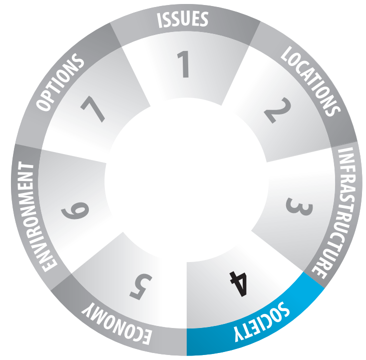
Final Checklist

	Have you identified infrastructure that has been impacted by wildfire?
	Have you identified infrastructure that may be at risk in the future?
	Have you identified infrastructure or facilities that may pose a fire hazard?
	Have you assessed your community's ability to respond to a fire?

Darryl Chubbs and Kenneth Roache with the St. John's Regional Fire Department work to extinguish a fire in a wooded area off Beothuck Street in St. John's, NL.

Photo credit: The Telegram - thetelegram.com

STEP 4: Identifying Individuals and Groups Most Affected by Wildfire in Your Community and Those Able to Assist



This step will help you:

- Determine individuals and groups most vulnerable to wildfire and where they live;
- Consider social or cultural impacts of wildfire; and
- Determine who can help.

Things to consider:

- **Elders and youth**
- **Single parent households**
- **Special needs**
- **Literacy levels**
- **Isolated locations**
- **Local fire department – training and resources**
- **Emergency services**
- **Volunteer and community groups**
- **Recreation and cultural activities**
- **Other**

Social Assessment

Here you will identify individuals and groups most likely to be impacted by wildfire, where they live and who can assist.

Photo credit: Fire and Emergency Services, NL

Emergency personnel in Badger, NL.

Photo credit: The Telegram - thetelegram.com

Members of the St. John's Regional Fire Department scramble down a steep hill in Shea Heights, NL to fight a grass fire that spread quickly due to dry conditions.

Fire can damage homes and infrastructure and the resulting smoke can be hazardous, especially for people with pre-existing respiratory illnesses. Educating people on the importance of staying inside during a fire can help minimize the impacts of smoke inhalation.

Not all members of your community will be able to respond to a wildfire in the same manner. It is important to recognize who may be most affected and to identify volunteer groups and other community support that may be utilized in the event of a fire.

Please answer the following questions related to the social implications of wildfire.

List individuals and groups affected by wildfire in your community.

Does your community have a communication plan to notify residents of wildfire?

Are there obstacles to residents receiving help in the event of a wildfire (communication, transportation)?

Is the 911 emergency telephone service available in your community? If not, are local emergency telephone numbers visible and known within your community?

If applicable, what type of training have firefighters in your community received? Is this training adequate?

Does your community have an up-to-date emergency plan?

❏ Yes ❏ No

If yes, does this plan address potential barriers to people receiving help in the event of a wildfire?

If no, do you have the necessary resources to create an emergency plan?

Are there important heritage or recreational areas that have been affected by wildfire in the past or may be affected in the future? If yes, please describe.

Are there any other ways that local lifestyles or culture have been or may be impacted by a wildfire?

Other individuals in your community may be able to help, such as those with first aid training, emergency response experience and amateur radio training. It is important to have up-to-date contact information for these individuals and groups in case of an emergency.

Please complete Table 3 with agencies or individuals that could help in the event of a wildfire (or refer to your emergency plan if an up-to-date list already exists).

Table 3: Community Contact List

Agency/person	Business phone #	Home phone #	Comments/Role

*A full size version of this table is available in the Resource Guide.

There are other resources that may be available in your community and could be useful if a wildfire occurs. A few examples are listed in Table 4. Please complete the table and add any other resources that may be helpful in the event of a wildfire.

Table 4: Inventory of Community Resources

Resources	Owner (s)	Contact/Phone #	Comments
Fire suppression equipment			
Personal protective equipment			
Fire hydrants/ tanker trucks/ portable pumps			
Firefighting Vehicles (fire trucks, rescue vehicles, equipment carrier)			
Appropriate facility to house vehicles and equipment			
Evacuation transportation/ evacuation plan			
First aid experience/ emergency training (level 1, breathing apparatus)			
Other (local radio, satellite phone)			
Updated emergency management			
An identified emergency operations centre			

*A full size version of this table is available in the Resource Guide.

Certain people in your community may require assistance in the event of an evacuation.

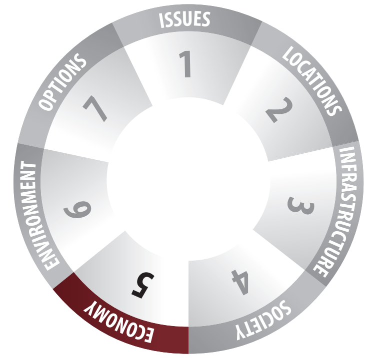
Community Mapping

By drawing on the map you started in Step 2, identify the areas in your community where people most vulnerable to wildfire live, as well as, the location of community services, volunteer groups or others who can help in case of a major event.

Final Checklist

	Have you identified where people most vulnerable to wildfire live?
	Have you identified who can help during an emergency?
	Have you considered other social or cultural impacts of wildfire on your community?

STEP 5: Identifying Economic Consequences of Wildfire in Your Community



This step will help you determine:

- Your most important economic sectors;
- How wildfire may impact these sectors; and
- How wildfire could affect the financial resources of your community.

Things to consider:

- **Fishery**
- **Forestry**
- **Tourism**
- **Food and agriculture**
- **Construction**
- **Manufacturing**
- **Transportation**
- **Retail and services**
- **Budget**
- **Insurance costs**
- **Other**

Economic Assessment

Here you will identify your community's key economic sectors and financial resources and assess how they could be affected by wildfire.

Wildfire can have serious economic consequences on communities, affecting local businesses and employment, as well as, damaging the infrastructure required for the local economy. It is important to consider the financial resources required to respond to wildfire along with the resources required to deal with the damage caused by a wildfire.

Photo credit: The Telegram - thetelegram.com

A wildfire near the Country Ribbon Chicken farm and the Cochrane Pond campground caused a precautionary evacuation of both facilities in July 2012.

Since the mid 1880's, many Newfoundland and Labrador communities have relied on forestry for economic growth. The province's lumber industry is currently worth millions of dollars annually. A wildfire can devastate the short-term and long-term stability of forestry based economies.

Case study: The "Bonavista North Fire"

Logging was a major industry in Bonavista North, NL during the first half of the 20th century. A pulp and paper company called Bowater employed hundreds of local residents and created a trade link between Newfoundland and Europe. On June 12th, 1961 a fire, known as the "Bonavista North Fire", swept through many of the communities in the Bonavista North Area.

Many homes and businesses were destroyed in the 18 settlements affected by the fire. It took 3 months to bring it under control, during which time, residents had to be evacuated and much of the areas timber stands were destroyed. Of the nearly 600,320 acres of land that was burned, approximately 333,310 acres was forested land. After harvesting the usable wood from the area, Bowater pulled its operations in 1967 and ended the commercial logging industry in Bonavista North.

The Canadian Forces were called in to help control the "Bonavista North Fire".

Photo credit: Department of Natural Resources, NL

Please answer the following questions related to wildfire and your economy.

What businesses, services and industries contribute most to your community's economy?

Has wildfire impacted them in the past? If yes, how?

What businesses, services and industries are expected to be most important in the future?

How could a wildfire impact them in the future?

Photo credit: Department of Natural Resources, NL

This aerial photo shows the wildfire that devastated the logging industry in Bonavista North, NL in 1961.

If applicable, what will happen to your tax base if these businesses, services or industries are impacted by wildfire?

Can you estimate the costs associated with addressing wildfire in your community? What revenue sources exist to cover these costs? What costs would have to be covered by your community?

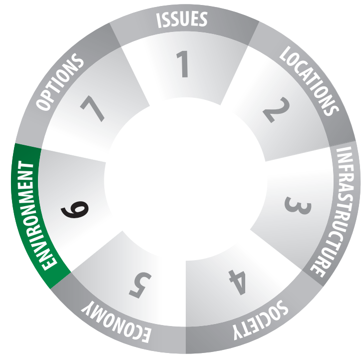
Community Mapping

By drawing on the map you started in Step 2, identify locations where your community's key economic activities take place. This information could help incorporate wildfire considerations into your planning processes.

Final Checklist

	Have you identified where your key economic activities take place?
	Have you determined if they could be impacted by wildfire?
	Have you attempted to calculate the financial costs associated with wildfire in or near your community and have you identified how you would cover these costs?

STEP 6: Identifying Environmental Impacts of Wildfire in Your Community



This step will help you:

- Determine if wildfire could cause other environmental problems; and
- Understand how wildfire may affect important species or natural areas.

Things to consider:
- Hazardous and toxic sites
- Oil facilities
- Ports
- Landfills
- Tailings ponds
- Pests and diseases
- Fish and wildlife
- Parks and protected areas
- Sensitive habitats
- Other

Environmental Assessment

Here you will consider how wildfire may affect the natural environment and identify sensitive areas that may be a planning priority for your community.

This step will help you identify environmentally sensitive areas in your community that could be affected by wildfire. By identifying these sensitive areas, you may be able to find ways to minimize negative impacts.

Photo credit: Nicole Rowsell

Woodpeckers, like the one in the centre of this picture, rely on dead or dieing trees for food and habitat. These natural areas are at increased risk to wildlife. Alexander Bay, NL.

Please answer the following questions related to the environmental impacts of wildfire.

Could a wildfire cause environmental problems in your community? If yes, please explain.

Are there endangered species or habitats in your community that may be threatened by a wildfire?

Red squirrel on the East Coast Trail, NL.

Photo credit: Kimberly Bittermann

Are there concentrations of hazardous waste in your community?

❑ Yes ❑ No

If yes, are they stored safely?

❑ Yes ❑ No

Could a wildfire increase the risk of hazardous waste being released into the local environment?

❑ Yes ❑ No

If yes, briefly describe how a wildfire could increase the risk of hazardous waste release.

Do you have an environmental protection plan in place?

❑ Yes ❑ No

If not, you may want to consider developing one.

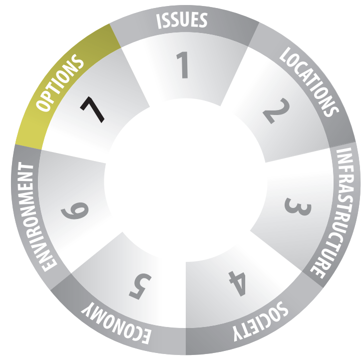
Community Mapping

By drawing on the map you started in Step 2, identify environmentally sensitive areas in your community, as well as other areas where wildfire could have environmental impacts. Examples include waste disposal sites, hazardous material storage sites and other areas that could be at risk if waste was released from these sites in the event of a wildfire.

Final Checklist

	Have you identified environmentally sensitive areas in your community?
	Have you assessed how these areas might be affected by wildfire?
	Have you considered how wildfire might affect your local environment and fish and wildlife species in the future?

STEP 7: Identifying Adaptation Options for Your Community



This step will help you:

- Evaluate how your community has dealt with wildfire in the past; and
- Identify ways to reduce the negative impacts of wildfire.

Things to consider:
- **Infrastructure**
- **Technology**
- **Financial resources**
- **Human resources**
- **Policy and planning**
- **Emergency measures**
- **Education and awareness**
- **Other**

Adaptation Options

Here you will identify actions to deal with the impacts of wildfire in your community.

This step will help you identify possible adaptation options to reduce the impacts of wildfire. It will also help you determine the best solutions for your community while enhancing your ability to cope with future issues. The community mapping exercises that you have completed in this chapter will illustrate where wildfires have the greatest impact in your community. Key adaptation concerns and priority areas for planning may become apparent once you have had a chance to discuss the information collected.

Photo credit: Christa Maloney

To control the spread of a wildfire near a residential area of St. John's, NL the properties were soaked by a water bomber.

Photo credit: Courtney Blundon

Threat of wildfire is increased when vegetation is permitted to grow close to transformers, poles and power lines.

Considering all of the information in steps 1 to 6, what are the main wildfire concerns for your community?

Which past actions or measures have been successful in reducing the impacts or occurrence of wildfire in your community? Please list.

What actions or measures were most effective?

What adaptation options would your community like to try? What are the barriers to trying these options?

Are there ways to overcome these barriers?

Potential Options

Wildfire can be addressed in a number of ways. Five potential options are explained below and you will find more examples, in the form of case studies, in the Resource Guide at the back of the workbook.

1. **Infrastructure:** There are a range of infrastructure adaptations that can help reduce the impact and threat of fire. Adaptations can be low-tech, simple solutions, or can require extensive investments and work. Examples of low-tech solutions include:
   - Managing combustible materials such as shrubs, trees and woodpiles by keeping them out of the immediate vicinity of homes and buildings within your community.
   - Using building materials and construction techniques that can prevent damage from fire. For example, metal roofs and asphalt shingles are fire resistant and wooden shingles are not. Building materials such as concrete, metal, brick and stucco offer superior resistance to wildfires whereas wood and vinyl siding offer very little protection; and
   - Contacting the utility company to remove vegetation that is touching transformers, power lines or poles.

2. **Training:** Training firefighters, either volunteer or paid, is an integral part of providing safe and effective fire suppression for your community.

3 **Monitoring:** Monitoring environmental variables, such as moisture levels and weather conditions, can help your community determine the level of wildfire threat and provide appropriate warnings, precautions and bans.

4. **Education:** Educating residents is an important part of building awareness around the dangers and impacts of wildfire in or near your community. Teaching residents about fire safety can help protect people, infrastructure and natural resources. Residents also need to be aware of any community emergency plans outlining emergency services and resources. If people know what to do in the event of a wildfire they will be better prepared to handle the situation if it arises.

5. **Preventative zoning and permitting:** Consideration of wildfire risks should be incorporated into community planning and decision making processes. When zoning and issuing permits for new developments, the potential for an increase in wildfire incidents along with the capacity of your fire suppression resources should be considered.

Considering the previous list of options, please identify new adaptation options that may help address wildfire concerns in your community.

Please list the adaptation options you would like to pursue to address wildfire concerns in your community:

1.

2.

3.

4.

5.

Not all of these options will have the same cost, or require the same time, resources or personnel. Certain solutions will be more effective or have long-lasting impacts. In the conclusion of this workbook you can further consider the benefits and feasibility of pursuing each of these options and develop action plans for implementation.

Conclusion

Adapting to Climate Change

This final chapter has been designed to help you develop adaptation strategies for your community. Sections A through G can help you prioritize your issues, identify possible adaptation options and manage your projects.

A. Determine priority level of each issue

B. Identify your adaptation options

C. Rank feasibility of adaptation options

D. Set your priorities

E. Manage your projects

F. Determine your next steps

G. Monitor your progress

As you work through this chapter please keep in mind that you can use the information gathered in Step 7 of any chapter in the workbook. As climate change advances and community priorities and resources change, you may wish to revisit these sections and update them.

Photo credit: Norm Catto

Coastal erosion in English Harbour, Trinity Bay, NL.

Photo credit: Kimberly Bittermann

Coastal Protection in Fortune, NL.

A. Determining Priority Level of Each Issue

If your community has multiple issues to address, it may be helpful to rank them according to which issue requires immediate attention. By considering the likelihood of an event occurring combined with its potential consequences, you can rank the level of priority as low, moderate, or high. Figure 1A contains examples of issues ranked by the likelihood of the event happening and the consequences of the event if it were to occur.

Use the examples supplied in Figure 1A to help assign a priority level to each issue. Consider the likelihood of an event occurring in combination with the potential consequences of that event. Rank each event in this manner using Table 1A as your working copy. Once established, these priority levels can be incorporated into your adaptation planning efforts.

Figure 1A: Determining Priority Level of Each Issue

	Consequence			
Likelihood	**Minor**	**Moderate**	**Major**	**Catastrophic**
Very Likely	Example: Boulders washing onto the road			
Likely				
Possible			Example: Winter river flooding (e.g Badger, NL 2003)	
Unlikely			Example: A combination of an extremely high tide, hurricane force winds and heavy rain	

Low **Moderate** **High**

Table 1A: Determining Priority Level Working Copy

Use this working copy to determine the priority level of each issue impacting your community.

	Consequence			
Likelihood	**Minor**	**Moderate**	**Major**	**Catastrophic**
Very Likely				
Likely				
Possible				
Unlikely				

*An additional working copy is provided for you in the Resource Guide

Low **Moderate** **High**

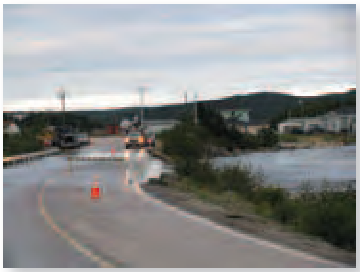


Photo credit: Fire and Emergency Services, NL

Flooding on the Burin Peninsula, NL.

B. Identifying Adaptation Options

Now that you have determined the priority level of each issue in your community, the next step is to further examine your options for reducing the impact on your community. Some ideas have already been presented in Step 7 (Identifying Adaptation Options for Your Community) at the end of each chapter of the workbook.

It is a good idea to explore ideas or options from other jurisdictions as you may be able to adapt an idea to fit your particular situation or location. There is a series of case studies at the back of this workbook that may help you get started. The more ideas you have at this point the better, as one solution or option may be more successful if used in conjunction with another option. Also, consider that some solutions or options may address more than one issue. Use Table 1B to write down your ideas, including those raised in previous workbook chapters. There are blank pages at the end of this chapter if you require more space.

Table 1B: Possible Adaptation Options

Issue	Possible Options
Example: Winter River Flooding	1. Stabilize river banks 2. Implement building set-backs 3. Monitor ice conditions on river, especially in spring
	1. 2. 3.
	1. 2. 3.
	1. 2. 3.

*A full size version of this table is available in the Resource Guide.

C. Ranking Feasibility of Adaptation Option

Once you have compiled your prioritized list of issues and possible adaptation options, it is important to consider the feasibility of each option by comparing the costs and benefits. Please use Table 1C on the following page to compare the options you have discussed and narrow down your choices based on practicality and availability of resources.

Photo credit: Community of Indian Bay, NL

How to use the Cost Benefit Analysis (Table 1C)

- To start, write down any expected benefits and possible negative results.
- In the cost column, please estimate or give a cost range for installing and implementing the adaptation option.
- Record how long it will take to implement the option in the time column.
- Give your adaptation option a "difficulty" ranking between 1 and 3; 1 (Easy - you have the staff, equipment and funding to implement), 2 (Moderate - you have some resources but need further assistance) or 3 (Difficult - all resources have to be obtained or further studies are required).
- Give your adaptation option an "effectiveness" ranking between 1 and 3; 1 (Very effective - option deals with the issue and provides a long-term solution), 2 (Effective - option addresses majority of the issue but may not be a long-term solution) or 3 (Somewhat effective - option deals with a portion of the issue and is not a long-term solution).

Photo credit: Community of Indian Bay, NL

In the early 2000s, when the cemetery in Indian Bay, NL flooded, the community used sand bags to decrease flood damage and weigh down the graves. This is a good example of an effective, low-cost adaptation option to reduce the impacts of flooding.

Table 1C: Cost/Benefit Analysis of Adaptation Options: Examples are taken from Table 1B

Adaptation Option	Expected Benefits	Negative Results	Cost $ (estimate/ range)	Time to plan and implement (days, months or years)	Difficulty Ranking (1 to 3)	Effectiveness Ranking (1 to 3)
Stabilize river banks	Less erosion of bank during spring run-off	N/A	Wide range of costs depending on materials used and length of river to be stabilized	Months	2	2
Implement building set-backs	Reduced property damage and long-term cost savings	Availability of land for development	Minimal	Months	1	2
Monitor ice conditions on river	Advanced warning of flood conditions	N/A	Commitment of personnel hours	Ongoing seasonal commitment	2	2

* There is a larger version of this table available in the Resource Guide

Difficulty Ranking

1 - Easy: Resources exist (staff, equipment and funding)

2 - Moderate: Some resources exist but further assistance is required

3 - Difficult: All resources have to be obtained, studies may be required

Effectiveness Ranking

1 - Very Effective: Option deals with the issue and provides a long-term solution

2 - Effective: Option addresses the majority of the issue but may not be a long term solution

3 - Somewhat Effective: Option deals with a portion of the issue and is not a long-term solution

D. Assigning Priority Levels to Adaptation Options

Using the Difficulty and Effectiveness rankings you determined in Table 1C, assign a priority level to each of your adaptation options using Figure 1D as a guide. Use the working copy (Table 1D) on the following page to arrange your options in the priority chart.

Figure 1D: Assigning Priority (Example)

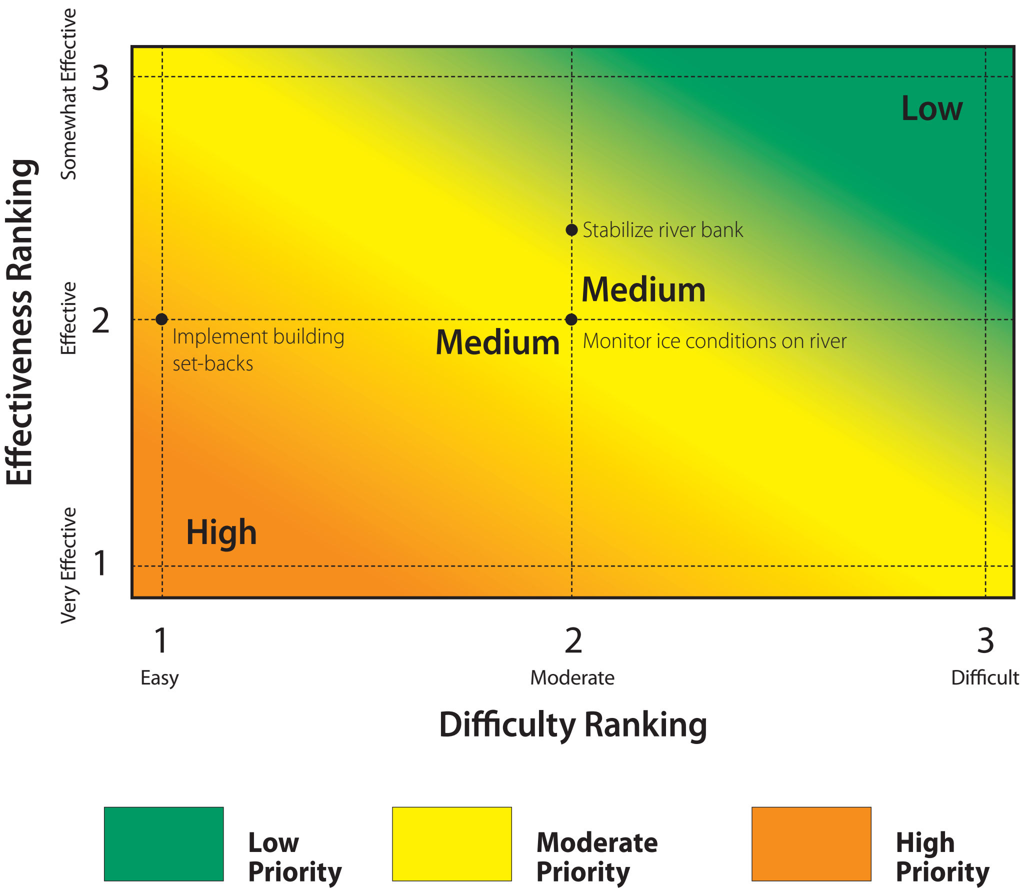
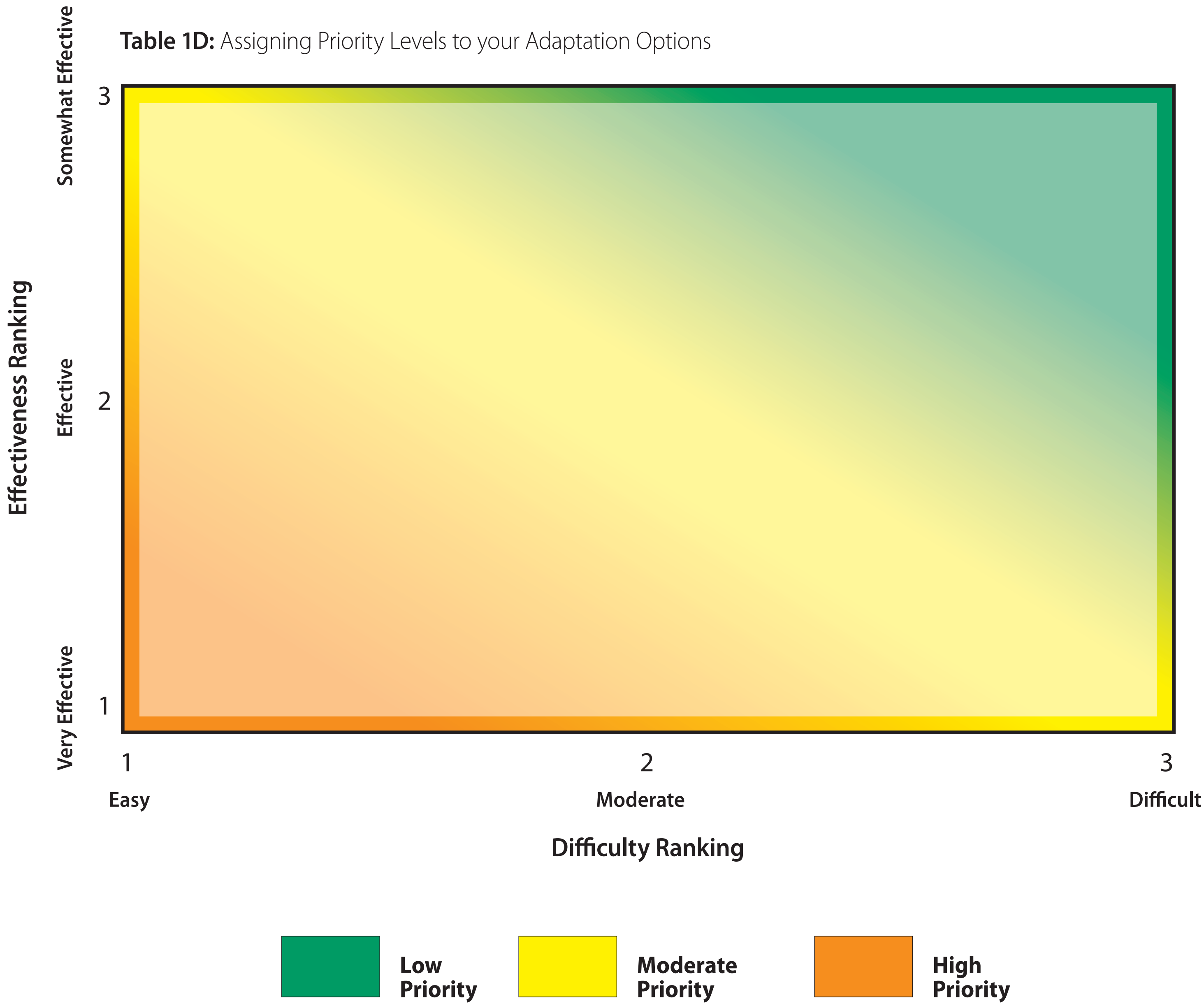


Photo credit: Courtney Blundon

Implementing building set-backs is one way to protect development along the coast. Brigus, NL.

Table 1D: Assigning Priority Levels to your Adaptation Options



Difficulty Ranking

1 - Easy: Resources exist (staff, equipment and funding)

2 - Moderate: Some resources exist but further assistance is required

3 - Difficult: All resources have to be obtained, studies may be required

Effectiveness Ranking

1 - Very Effective: Option deals with the issue and provides a long-term solution

2 - Effective: Option deals with the issue but is not a long-term solution

3 - Somewhat Effective: Option deals with a portion of the issue and is not a long-term solution

*An additional working copy is provided for you in the Resource Guide.

Priority Summary

Based on your priority level rankings in Table 1D, please fill in Table 2D with each of your identified adaptation options.

Record any reasoning you had for giving an option a particular ranking and add any other comments you feel are important.

Table 2D: Priority Summary

Adaptation Option	Priority Ranking from Table 1D	Reason/comments

Photo credit: Fire and Emergency Services, NL

Road damage caused by Hurricane Igor in Clarenville, NL.

E. Managing Your Project

Now that you have prioritized your adaptation options, you will need further information on how to implement these options. Choose the adaptation options that your community will most likely pursue, particularly those ranked as high or moderate priorities, and place them in Table 1E on the next page.

Create goals for each adaptation option; try to identify two or three. It is important to determine the organizations and individuals that should be involved in implementing the adaptation options and they should be given specific roles and responsibilities. Assigning clear timelines and milestones for each option can help ensure that your goals are met. In the column labelled 'Milestones', note the major milestones that will have to be completed to accomplish your goals. These milestones may include meetings, compiling research materials, hiring a contractor or purchasing equipment or supplies.

A preliminary budget is also an important piece of the planning process. This budget should include initial estimates of wages, equipment rentals, supplies, consultants and sub-contractors.

Indicators should be:

S pecific

Measurable

A chievable

R ealistic

T ime bound

To help track your progress, you can create indicators of success and add them to Table 1E. Essentially, they should be Specific, Measurable, Achievable, Realistic, and Time bound (SMART). An indicator can provide a simple and reliable way to measure success and can be quantitative (a measurable indicator eg. '20 loads of rock put in place') or qualitative (an indicator that is not easily measured eg. 'increased awareness of coastal erosion problems in the community'). The indicators will depend on the project and the particular aspects of the project that you feel represent success.

For example, roads near the coastline that are frequently damaged by storm surge and erosion can be protected with the installation of groynes. An indicator of success in using coastal protection as an adaptation measure could be to track road repairs before and after installation of the groynes.

Culverts blocked by debris may cause flooding during times of heavy rainfall.

Photo credit: Department of Municipal Affairs, NL

Table 1E: Tracking Success

Adaptation Option	Goals	Roles/Responsibilities of Organization and Individuals	Milestones	Budget	Timelines	Indicators
	1. 2. 3.					
	1. 2. 3.					
	1. 2. 3.					
	1. 2. 3.					

*Table has been modified from Centre of Indigenous Environmental Resources Inc. (2006).

F. Determining Your Next Steps

When this chapter is complete, your community leaders will have the information they need to make a decision on what adaptation options to pursue.

List the adaptation options that your community is committed to pursuing.

1.

2.

3.

4.

5.

Coastal erosion on a, now abandoned, road near O'Donnells, St. Mary's Bay, NL.

Photo credit: Norm Catto

For each of the adaptation options you have listed on the previous page, identify 2-3 next steps required for project completion. Use Table 1F to list the options, next steps, the organizations or individuals taking responsibility for these steps and assign a completion date.

Table 1F: Tracking Next Steps

Adaptation Option	Next Steps (2-3)	Organization/ Individual Responsible	Date of Completion

Photo credit: Department of Municipal Affairs, NL

Deteriorated culvert requires replacement.

G. Monitoring Your Progress

It is important to monitor progress while working to implement the adaptation options that your community has decided to pursue. Monitoring progress will help community members stay on track with ongoing projects and maintain focus on addressing impacts while at the same time meeting the needs of the community. Throughout the year, look closely at any community projects or initiatives to make sure the goals remain relevant and manageable. Check your milestones and timelines in addition to arranging meetings with the organizations and individuals involved in the projects.

Projects that are nearing completion or those that have been completed should be assessed to ensure they are meeting expectations in reducing climate change impacts. There will be unexpected outcomes as these adaptation options are implemented so it is important to keep good records.

The tables and figures presented in this chapter can serve as helpful tools when comparing actual results with those indicated during the planning process.

By monitoring your progress you may find that an adaptation option is not meeting expectations; such as, not meeting the goals, causing unexpected results, costing too much or requiring resources that are not available. Depending on the type of project, you may need to modify the project scope, apply for more funding or seek additional resources.

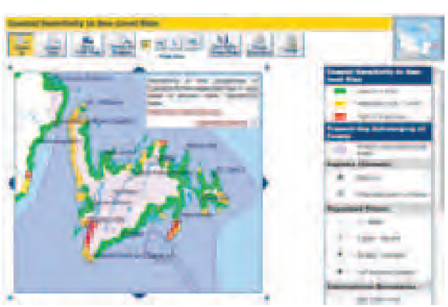
The issues affecting your community today may change in the future. However, with the implementation of effective adaptation options and proper planning, you will have helped your community become more resilient to climate change.

Properly designed infrastructure. Fortune, NL.

Photo credit: Department of Municipal Affairs, NL

SECTION A:

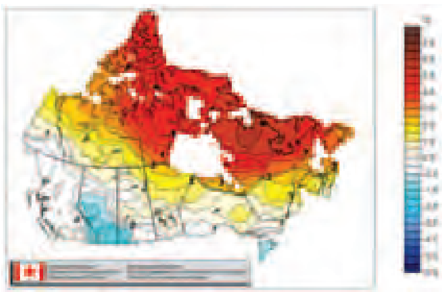
Sources of Information and Technical Support

Topic Area and Weblink	Description	Contact and related information
I want to do some mapping…	**The Basics:** You can do a lot with a simple paper map. When you're gathering local information from residents and groups it's helpful to have a map handy to make notes on. Consider getting a larger-sized version laminated so it can be reused: you can mark on it with china markers (grease pencils), non-permanent markers and/or sticky-notes. Clear plastic overlays (i.e. Mylar) are useful if you want to save the information to consult later. **Geographic Information Systems (GIS)** store data tied to specific locations in a digital format and are used to visualize, modify and interpret the data. In much the same way that Mylar overlays can be used to overlay a variety of information on paper maps, a GIS organizes data in layers that can be turned on and off to create a detailed picture of an area and help identify areas of vulnerability. Increasingly, public agencies and larger local governments are developing in-house GIS capacity, often putting selected content on-line for public use (e.g. the City of St. John's).	
Base map resources	**Where to find basic maps and area images**	
Atlas of Canada Natural Resources Canada atlas.nrcan.gc.ca/site/english/index.html  *On-line Topographic Maps:* atlas.nrcan.gc.ca/site/english/maps/topo/map **MapsNL** www.mapsnl.ca	**The Atlas of Canada** is a comprehensive on-line collection of Canadian maps and related information available for public use. The website is user-friendly and interactive. It is easy to navigate to specific regions, and there are a number of different maps available. There are a number of thematic maps on climate, climate change, and adaptation and vulnerability. They include topics like natural hazards, hydrology, projected climate change impacts (coastal sensitivity to sea-level rise), and natural resource-related information (forest areas and their fire sensitivity). **Topographic maps** show the shape of the land, including elevation changes. The maps have contour lines, which are lines that connect contiguous points of the same altitude. You can view topographic maps online and download high-quality print-ready copies. You can also buy paper copies of the standard map sheets (referred to using their National Topographic System or NTS number) from various map distributors. **MapsNL** is the Government of Newfoundland and Labrador's on-line map portal and search tool for provincial geographic imagery (**See Air photos**). Electoral district, municipal boundary and local road map detail is available down to 1:1,000 scale. The site also provides a topographic base map viewer with layers that can be turned on and off and used to produce and print simple reference maps.	Topographic map sheets can be purchased at: **Air Photo & Map Library Howley Building** Higgins Line St John's, NL A1B 4J6 Tel: 709-729-3304 **Cansel/Wade** 210 Kenmount Road John's, NL A1B 3P9 Tel: (709) 722-8772 Toll-free: 1-888-222-6735 Fax: (709) 722-7125 www.cansel.ca

Topic Area and Weblink I want to do some mapping… **Base map resources** cont'd	**Description**	**Contact and related information**
GeoGratis Natural Resources Canada (NRCan) geogratis.gc.ca/geogratis/en/index.html	**GeoGratis** is a portal provided by the Earth Sciences Sector (ESS) of Natural Resources Canada. For users with some GIS capacity, it provides geospatial data in a variety of formats at no cost and with few restrictions on its use.	
National Air Photo Library Natural Resources Canada (NRCan) www.nrcan.gc.ca/earth-sciences/home (select 'Satellite and Photographic Imagery') **Air Photo & Map Library** Government of Newfoundland & Labrador www.geonl.org/mapguide/AirPhotoIndex **Memorial University** www.library.mun.ca/qeii/maps/airphotos.php	**Air photos** and satellite imagery are valuable sources of geographic information. Since air photos have been taken at regular intervals in some parts of the country since the 1920s, they can provide information about how areas have changed over time. You can use air photos in conjunction with maps and/or other GIS content, to help identify and track potential hazards for a given area. The National Air Photo Library has over six million aerial photographs, roughly half of which can be ordered online through the Natural Resources Canada website. Memorial University also has extensive air photo collections.	**Air Photo & Map Library** **Howley Building** Higgins Line St John's, NL A1B 4J6 Tel: (709) 729-3304 **Map Library** Queen Elizabeth II Library Memorial University St. John's, NL A1B 3X9
Google Earth© earth.google.com	**Google Earth**© is a well-known brand of user-friendly computer software used to view an extensive worldwide array of satellite images, maps and street view content. You can download a free general use version. Detail varies with location: in general, the larger the community, the better the resolution (the degree to which one can zoom in on the image).	
Thematic map resources	**Resources offering consolidated map content on a variety of subjects**	
Community Accounts Newfoundland and Labrador Statistics Agency nl.communityaccounts.ca	**Community Accounts** is an innovative online information system providing a free and reliable source of community, regional and provincial data. Users can custom-generate a wide variety of tables and illustrative graphics. You can compile key social and economic indicator data in a simple print format using the system's Well-Being account. There is information on 400 communities, in addition to 80 local areas and 20 economic development areas. If you'd like help using Community Accounts, you can use interactive web tutorials on the site or on YouTube.	**Community Accounts Administrator** Economics and Statistics Department of Finance Government of Newfoundland and Labrador P.O. Box 8700 St. John's, Newfoundland and Labrador Canada A1B 4J6

Topic Area and Weblink I want to do some mapping… **Thematic map resources** cont'd	**Description**	**Contact and related information**
Land Use Plans and Development Regulations Local Municipal Council and/or Department of Municipal Affairs *Areas subject to Federal-Provincial Flood Risk Mapping:* www.ma.gov.nl.ca/ma/for/flood_policy/risk.html (select 'Satellite and Photographic Imagery') See **Newfoundland and Labrador Water Resources Portal** (below) for additional details on obtaining these maps.	**Land Use Plans** are policy documents crafted to guide development in a given municipality or region. **Development Regulations** (also referred to as zoning) are the rules crafted to interpret and implement the Plans. Each include maps illustrating the areas corresponding to the policies and zoning, respectively. Not every municipality in Newfoundland and Labrador has these development control tools but where available, they provide a good deal of local information and offer a means to record areas vulnerable to flooding and other hazards. Newfoundland and Labrador, in conjunction with the federal government, has formally identified and mapped areas across the province that are subject to flooding. These flood risk areas affect 32 municipalities; 4 local service districts; 6 unincorporated communities; and an uninhabited area on the Trans Canada Highway. (Note: Not every place in the Province that has experienced localized flooding has been formally mapped). The **Provincial Flood Risk Policy** restricts new buildings and land use to areas that are not at a high risk of flooding. In lower risk areas, the policy requires development to be designed with an appropriate level of protection to ensure the risk of damage from flooding is minimized. Any development within a flood risk area should not impede water flows or exacerbate flood risk elsewhere.	**Department of Municipal Affairs** Municipal Engineering and Planning Branch Main Floor (West Block) Confederation Building P.O. Box 8700 St. John's, NL A1B 4J6 Tel: (709) 729-5334 Fax: (709) 729-7491
Natural Risks and Hazards in NL Department of Natural Resources www.nr.gov.nl.ca/nr GeoScience OnLine gis.geosurv.gov.nl.ca Agrifoods Soil Maps www.nr.gov.nl.ca/nr/agrifoods/maps/index.html Forestry Management Areas and Plans www.nr.gov.nl.ca/nr/forestry/manage/district.html	Through its **Mines and Energy Branches** and the **Forestry and Agrifoods Agency**, the **Department of Natural Resources** delivers a variety of supports and services to industry and the public. The Geological Survey of NL has established the interactive **GeoScience OnLine** map system. In addition to a series of thematic options (e.g. surficial geology, elevation model), the layers document a variety of mineral sector activities along with other land uses of interest (i.e. forest access roads, public water supplies).	**Mines and Energy Branches** Natural Resources Building 50 Elizabeth Avenue P.O. Box 8700 St. John's, NL A1B 4J6 Tel: 1-709-729-2920 Fax: 1-709-729-0059 **Forestry and Agrifoods** Agency Headquarters Fortis Building P. O. Box 2006 Corner Brook, NL A2H 6J8 Tel: 1-709-637-2339 Fax: 1-709-637-2461 Email: webmasteragric@gov.nl.ca

Topic Area and Weblink I want to do some mapping… **Thematic map resources** cont'd	**Description**	**Contact and related information**
Coastal and Ocean Information Network for Atlantic Canada (CoinAtlantic) Atlantic Coastal Zone Information Steering Committee (ACZISC) coinatlantic.ca	**ACZISC** (est. 1992) is a multi-sectoral, multidisciplinary organization promoting regional cooperation in integrated coastal and ocean management, coastal mapping and geomatics. It publishes a monthly e-newsletter "Coastal Update" and maintains the **COINAtlantic** Search Utility, a data warehouse tied to a GIS mapping engine. It provides an exceptional and growing array of consolidated environmental information (e.g. sub-watershed boundaries, bathymetric profiles) for use by coastal zone managers and the general public. An excellent **Quick Start Tutorial** is available in their Help section.	**ACZISC Secretariat** Dalhousie University 6414 Coburg Road PO Box 15000 Halifax, NS B3H 4R2 Tel: (902) 494-7162 Fax: (902) 494-1334 Email: ACZISC@dal.ca
Newfoundland and Labrador Water Resources Portal maps.gov.nl.ca/water *Flood Risk Mapping:* www.env.gov.nl.ca/env/waterres/flooding/frm.html	The **Newfoundland and Labrador Water Resources Portal** has a wide variety of water resources data including drinking water quality and treatment, boil water advisories, and protection areas for ground and surface water supplies. **Flood Risk Public Information Maps** (as described in **Land Use Plans and Development Regulations** section above) are available for many communities in Newfoundland and Labrador. The flood risk areas are defined based on detailed hydrological studies. The resulting maps show two flood zone areas, flooding of a return period of 20 years (or floods which have a 5% chance of occurring each year) and flooding with a return period of 100 years (or floods which have a 1% chance of occurring each year). You can view these maps online and download them from the website. Paper maps (2' x 3') are also available from each of the Department's regional offices (St. John's, Grand Falls-Windsor, Corner Brook and Happy Valley-Goose Bay).	St. John's - Headquarters **Water Resources Management Division** Department of Environment and Conservation P.O. Box 8700 4th Floor, West Block, Confederation Building St. John's, NL A1B 4J6 Tel: (709) 729-2563 Fax: (709) 729-0320 Email: water@gov.nl.ca
Canadian Ice Service (CIS) www.ec.gc.ca/glaces-ice	The **Canadian Ice Service**'s website provides detailed ice and iceberg mapping and publishes ice hazard bulletins on a daily basis. You can also find a seasonal outlook and historical data, which allows you to see if sea-ice levels have been increasing or decreasing for a particular region.	**Canadian Ice Service** 373 Sussex drive. Ottawa, Ontario K1A 0H3

Topic Area and Weblink I want to do some mapping… **Thematic map resources** cont'd	**Description**	**Contact and related information**
Climate Trends and Variations Bulletin www.ec.gc.ca/adsc-cmda  The national average temperature departures for the winter of 2010-11	The **Climate Trends and Variations Bulletin** summarizes recent climate data and presents it in a historical context. It looks at the national temperature and precipitation then highlights interesting regional data. The bulletin places the most recent season and year in historical context by using historical climate records and data sets from weather stations across Canada. This information can help you establish the direction of a variety of kinds of climate change in your area as you're working on your local adaptation plan. For example, the first Bulletin of 2012 examines how the average temperature and precipitation levels of the prior winter compares to the historical record. The map to the left illustrates the national average temperature for that period was 2.5°C above normal, making it the sixth warmest winter since national record keeping began in 1948. Newfoundland and Labrador, denoted by the black circle on the map, was on average 3.0 - 6.5°C above normal.	**Environment Canada Atlantic Regional Office** 45 Alderney Drive Dartmouth, Nova Scotia B2Y 2N6 Tel: (902) 426-7231 Fax: (902) 426-6348 Email: 15th.reception@ec.gc.ca
Canadian Climate Change Scenarios Network (CCCSN) cccsn.ca	The **CCCSN** supports climate change impact and adaptation research throughout the country by providing climate change scenario information for decision-making and policy development. The Network's website provides a user-friendly portal to climate modeling tools and Canadian research on climate change and adaptation. The user is able to select specific regions (by postal code or community name) and generate reports including maps of future climate scenarios.	**Adaptation and Impacts Research Section** (AIRS) Atmospheric Science and Technology Directorate Science and Technology Branch Environment Canada 4905 Dufferin Street Toronto, Ontario M3H 5T4 Fax: (416) 739-4297
Topic Area and Weblink	**Description**	**Contact and related information**
I need more data…	In addition to the mapping resources, you may want greater detail about certain features of an area's population, infrastructure, economy, climate, and the ways conditions may be changing over time. There are lots of places you can go to get reliable public data on these kinds of topics. You'll find some good starting points listed below.	
StatCan Statistics Canada www.statcan.gc.ca	The **StatCan** online database contains a wide variety of statistical information at the community, provincial, territorial and national level drawn from data collected every five years through the national census. In addition to community profiles, the website offers many thematic reports you may find useful in local adaptation planning. The Department's Atlantic regional offices (Halifax and St. John's) periodically hold workshops for individuals wishing to learn how to collect, interpret and work with statistical data.	**Statistics Canada** 150 Tunney's Pasture Driveway Ottawa, Ontario K1A 0T6 Tel: 1-800-263-1136 Fax: 1-877-287-4369 Email: infostats@statcan.gc.ca

Topic Area and Weblink I need some more data…cont'd	**Description**	**Contact and related information**
Public Sectors Accounting Board (PSAB) www.psab-ccsp.ca/ www.ma.gov.nl.ca/ma/for/psab/index.html	The **PSAB** website provides new requirements for inventory and reporting on all infrastructure, its age and book value. More importantly your town's own PSAB records will provide information relevant for assessing vulnerability to climate-related issues.	**The Public Sector Accounting Board** c/o The Canadian Institute of Chartered Accountants 277 Wellington Street West Toronto, Ontario M5V 3H2 Tel: (416) 977-3222 Fax: (416) 977-8585
Weather Office Environment Canada www.weatheroffice.gc.ca *Historical Climate Data:* www.climate.weatheroffice.gc.ca/Welcome_e.html	The national **Weather Office** website provides information on a range of weather-related topics, including current weather conditions and forecasts, historical weather, marine information and radar and satellite images. The Office maintains a **National Climate Data and Information Archive** that provides access to historical climate and weather data. The record varies with location but dates back a hundred years in some cases. The archived data may be searched by location (province, town) and for different time periods (annually, monthly and daily). The climate summaries contain values of various climatic parameters, including monthly averages and extremes of temperature, precipitation amounts, degree days and wind speeds. Climate normals (averages) are used to summarize or describe the average climatic conditions of a particular location.	**Environment Canada** National Inquiry Response Team 77 Westmorland Street Suite 260 Fredericton, New Brunswick E3B 6Z3 Fax: (506) 451-6010
Canadian Tides and Water Levels Data Archive Fisheries and Oceans Canada www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/twl-mne/index-eng.htm DFO – Newfoundland & Labrador Region www.nfl.dfo-mpo.gc.ca	The Canadian Historical Tide and Water levels Data Archive holds over 500 million records, with the earliest dating back before the turn of the 20th century. The data – much of which is available on-line – includes observed tidal highs and lows, and water levels. Data is recorded at an interval as short as 15 minutes, but daily and monthly means are also available. In this province, data is collected by three stations on the Island (Port Aux Basques, Argentia and St. John's) and one in Labrador (Nain). You can use these records to investigate storm surge trends and conditions leading to coastal flooding episodes.	**Fisheries and Oceans Canada** Communications Branch P.O. Box 5667 St. John's, Newfoundland and Labrador A1C 5X1 Tel: (709) 772-4423 Fax: (709) 772-4880 Email: info@dfo-mpo.gc.ca
Hydrometric Data – Water Quantity Water Survey of Canada Environment Canada Stream Flow Data: www.ec.gc.ca/rhc-wsc Newfoundland and Labrador Department of Environment and Conservation Stream Flow Data: www.env.gov.nl.ca/env/waterres/cycle/hydrologic/info.html List of Sampling Stations in NL www.env.gov.nl.ca/wrmd/ADRS/v6/Graphs_List.asp	The **Water Survey** is responsible for collecting and interpreting water resource data across the country. Flow rates and water levels are useful for resolving issues on infrastructure, land use planning and sustainable water use. Water quantity data are also used in hydrological monitoring, which is important for forecasting floods and to predict the impacts of changing flow rates on human and economic activity (e.g. agricultural needs). You can also find stream flow data on the Department of Environment and Conservation website, but this information is not quality-controlled and therefore is not as accurate as the data provided on Environment Canada's website. However, you can use the province's Sampling Station List, to narrow down the station search terms for use on the Water Survey site: www.wsc.ec.gc.ca/applications/H2O/HydromatD-eng.cfm	**Environment Canada** National Inquiry Response Team 77 Westmorland Street Suite 260 Fredericton, New Brunswick E3B 6Z3 Fax: (506) 451-6010

Topic Area and Weblink	Description	Contact and related information
I have some other questions about…	Climate change adaptation touches on virtually every aspect of our communities and the environment. Fortunately, there are people throughout government and numerous non-governmental organizations who are working on various aspects of the adaptation challenge.	
Local Government in Newfoundland and Labrador *Department of Municipal Affairs* www.ma.gov.nl.ca/ma/index.html *Listings of local governments in NL:* www.ma.gov.nl.ca/ma/municipal_directory/index.html *Urban and Rural Planning Act, 2000* www.assembly.nl.ca/Legislation/sr/statutes/u08.htm *Municipalities Newfoundland & Labrador* www.municipalitiesnl.com	The **Department of Municipal Affairs** manages a variety of training and support-oriented activities for individuals engaged in local government roles, funds capital works for municipal infrastructure development, and through its Urban and Rural Planning Division, supports communities implementing land use plans pursuant to the *Urban and Rural Planning Act, 2000.* **Municipalities Newfoundland & Labrador** (MNL) was formed in 1951 to represent the interests of the growing number of municipal councils in the province. MNL is governed by an eleven-member Board of Directors representing seven regions as well as small town and urban constituencies. Member services include a province-wide municipal general insurance program, a free legal telephone referral program, an air travel discount program, and an exclusive debt collection service. MNL undertakes considerable advocacy and policy efforts on behalf of its members.	**Department of Municipal Affairs** Municipal Engineering and Planning Branch Main Floor (West Block) Confederation Building P.O. Box 8700 St. John's, NL A1B 4J6 Tel: (709) 729-5334 Fax: (709) 729-7491 **Municipalities NL** 460 Torbay Road, St. John's, NL A1A 5J3 Tel: (709) 753-6820 Fax: (709) 738-0071 Toll Free: 1-800-440-6536 Email: mnl@municipalitiesnl.com
Adaptation Planning Initiatives Local governments for sustainability (ICLEI) www.iclei.org ICLEI Canada www.icleicanadaorg	**ICLEI** is an international association of local governments and organizations who have made a commitment to sustainable development. The association provides consulting, training and information services to support local government sustainability projects. The organization's Adaptation Initiative provides a five-milestone framework to assist local governments with the creation of climate adaptation plans. The Initiative offers tools and support to help communities integrate adaptation planning with other key planning processes. You can download free copies of the Initiative's *Changing Climate, Changing Communities* guide and workbook.	**Fisheries and Oceans Canada** Communications Branch P.O. Box 5667 St. John's, Newfoundland and Labrador A1C 5X1 Tel: (709) 772-4423 Fax: (709) 772-4880 Email: info@dfo-mpo.gc.ca
Municipal Planning in Canada Canadian Institute of Planners (CIP) www.cip-icu.ca Atlantic Planners' Institute (API) www.atlanticplanners.org	Representing planners in Canada, the **CIP** administers a professional certification system and offers professional development activities and a variety of member services. The Atlantic Planners' Institute is CIP's regional chapter for the four Atlantic Provinces. The Newfoundland and Labrador Branch of the API hosts a Lunch and Learn series in St. John's.	Dalhousie University's School of Planning is Atlantic Canada's only accredited planning school. They offer undergraduate and graduate degrees in the planning field. www.architectureand planning.dal.ca/planning

Topic Area and Weblink I need some more data…cont'd	**Description**	**Contact and related information**
Drinking Water Quality Health Canada www.hc-sc.gc.ca See also **Newfoundland and Labrador Water Resources Portal** RES'EAU-WaterNET www.reseauwaternet.ca/	In Canada, the responsibility for making sure drinking water supplies are safe is shared between the provincial, territorial, federal and municipal governments. The provinces and territories are responsible for providing safe drinking water to the public, while municipalities usually oversee the day-to-day operations of the treatment facilities. **Health Canada**'s Water Quality and Health Bureau plays a leadership role in science and research. Its mandate and expertise are to protect the health of all Canadians by developing the Guidelines for Canadian Drinking Water Quality in partnership with the provinces and territories. **RES'EAU-WaterNET** is devoted exclusively to the objective of developing innovative and affordable solutions for providing drinking water to small, rural and First Nations communities.	**Health Canada** Atlantic Regional Office Suite 1917 1505 Barrington Street Halifax, NS B3J 3Y6 Tel: (902) 426-2038 Fax: (902) 426-3768 RES'EAU-WaterNET Email: info@reseauwaternet.ca
Emergency Preparedness Fire and Emergency Services-Newfoundland and Labrador (FES-NL) www.gov.nl.ca/fes *Public Safety Canada (PS)* www.publicsafety.gc.ca Canadian Risks and Hazards Network (CRHNet) www.crhnet.ca	**Fire and Emergency Services-NL** (FES-NL) is responsible for the province's emergency management strategy. In collaboration with agency partners and stakeholders, FES-NL prepares for and responds to emergencies, disasters and fires. **Public Safety Canada** was created in 2003 to ensure coordination across all federal departments and agencies responsible for national security and the safety of Canadians. The **CRHNet** is a not-for-profit organization that was established in 2003 to promote and strengthen disaster risk reduction and emergency management in Canada. The Network is a space where hazard researchers, educators and emergency management practitioners can share knowledge and innovative approaches to reducing disaster vulnerability.	**Fire and Emergency Services** - NL P.O. Box 8700 St. John's, NL A1B 4J6 Email: fes-nl@gov.nl.ca **Public Safety Canada** Regional Office – NL John Cabot Building, 8th floor 10 Barter's Hill Place P.O. Box 668, Station 'C' St. John's, NL A1C 5L4 Tel: (709) 772-5522 Email: BOX-NL@ps-sp.gc.ca Toll-free (national): 1-800-830-3118
Transportation www.tw.gov.nl.ca	The **Department Transportation and Works** is responsible for the construction and maintenance of the provincial highways; the provision of the provincial ferry services; the management of the provincial government fleet of light vehicles and heavy equipment; the operation and maintenance of the provincial government air ambulances and water bombers; and the construction and management of provincial government buildings.	**Department of Transportation and Works** P.O. Box 8700 Prince Philip Drive Confederation Building St. John's, NL A1B 4J6 Tel: (709) 729-2300 Email: tw@gov.nl.ca
Fisheries and Aquaculture www.fishaq.gov.nl.ca Canadian Fisheries and Aquaculture statistics www.dfo-mpo.gc.ca/stats/stats-eng.htm	The **Department of Fisheries and Aquaculture** fosters the development of the province's fishing and aquaculture industries - a $1 billion sector in Newfoundland and Labrador.	**Department of Fisheries and Aquaculture** P.O. Box 8700 St. John's, NL A1B 4J6 Tel: 1-709-729-3723 Email: fisheries@gov.nl.ca

Topic Area and Weblink I need some more data…cont'd	**Description**	**Contact and related information**
Tourism, Culture and Recreation www.tcr.gov.nl.ca/tcr Detailed Statistical Information: www.tcr.gov.nl.ca/tcr/stats/index.html	The **Department of Tourism, Culture and Recreation** has the mandate to support sustainable economic growth in tourism and cultural industries, support the arts , preserve cultural heritage and historic resources and recognize their importance, and promote participation in recreation and sport. You can get detailed information about their programs on their website.	**Department of Tourism, Culture and Recreation** P.O. Box 8700 St. John's, NL A1B 4J6 Tel: (709) 729-0862 Fax: (709) 729-0870 Email: tcrinfo@gov.nl.ca
Government of Newfoundland and Labrador www.gov.nl.ca	For information on topics not addressed above, you can contact the province's Communications Branch staff. You can also use the Government of Newfoundland and Labrador's main website as a starting point for finding information on useful resources and information offered by various departments and branches.	**Communications Branch** 10th Floor, East Block Confederation Building St. John's, NL A1B 4J6 Email: info@gov.nl.ca
Atlantic Climate Adaptation Solutions Association (ACASA) www.atlanticadaptation.ca	The Atlantic Regional Adaptation Collaborative Program (ACASA) produced many tools & reports. This site houses all the products produced. Climate data, case studies, flood risk mapping, assessments, regional reports, etc.	**Policy & Planning Division** **Department of Environment and Conservation** Tel: (709) 729-0027
Climate Change, Energy Efficiency and Emissions Trading. www.gov.nl.ca/exec/cceeet www.turnbackthetide.ca	The Office of Climate Change, Energy Efficiency & Emissions Trading (CCEEET) is responsible for strategy and policy development on climate change and energy efficiency. Turn Back the Tide is a public awareness campaign focused on creating awareness and inspiring action on climate change and energy efficiency.	**Office of Climate Change, Energy Efficiency and Emissions Trading** Tel: (709) 729-1210 climatechange@gov.nl.ca
Charting Our Course: Climate Change Action Plan 2011 www.exec.gov.nl.ca/exec/cceet/publications/climate_change.pdf	The Action Plan, developed by CCEEET, establishes the Provincial Government's approach to climate change. It sets out government's vision and goals alongside commitments for action across the economy.	**Office of Climate Change, Energy Efficiency and Emissions Trading** Tel: (709) 729-1210 climatechange@gov.nl.ca

SECTION B: Potential Funding Sources

Funding Agency and Website	Description	Contact and related information
I need help with financial resources…	This section provides an overview of potential funding sources for adaptation options in Newfoundland and Labrador. The first part lists funding sources municipalities can apply to directly, while the second part lists organizations that municipalities may be able to partner with to apply for funding. Many of the organizations listed also offer expertise on adaptation issues.	
	Programs available to municipalities	
Federation of Canadian Municipalities www.sustainablecommunities.fcm.ca	The **Green Municipal Fund** (GMF) is administered through the Federation of Canadian Municipalities (FCM). FCM provides funding to three types of environmental initiatives: plans, studies and projects. Grants are available for sustainable community plans, feasibility studies and field tests, and a combination of grants and loans are available for capital projects. The GMF application process is open year-round to all municipal governments and their partners. At the GMF website you can complete a short questionnaire to help determine your eligibility before you apply. Alternatively, you may begin directly with the GMF Application Form.	**Green Municipal Fund Federation of Canadian Municipalities** 24 Clarence Street, Ottawa, Ontario K1N 5P3 Tel: (613) 907-6208 Email: mf@fcm.ca
Agriculture Canada www.agr.gc.ca **Canadian Agricultural Adaptation Program** www.agr.gc.ca/caap	The **Canadian Agricultural Adaptation Program** (CAAP) is a five-year (2009-2014) program to help the agri-food and agri-based products sectors prepare for and adapt to climate change. CAAP funding is $163 million over five years and is available for eligible projects. You can find details on eligibility and how to apply in the online CAAP National Application Guide	**Canadian Agricultural Adaptation Program** (CAAP) 1341 Baseline Road, Tower 7, Floor 8, Room 242 Ottawa, ON K1A 0C5 Toll Free (general): 1-877-290-2188 Tel (Newfoundland and Labrador): 1-709-747-4874 Email (general): caap-pcaa@agr.gc.ca Email (Newfoundland and Labrador): info@nlfa.ca

Funding Agency and Website I need help with financial resources… *cont'd*	**Description**	**Contact and related information**
Atlantic Canada Opportunities Agency (ACOA) www.acoa-apeca.gc.ca	The **Building Canada Fund** is a cost-shared program that provides funding for the development of municipal infrastructure in smaller communities. The Government of Canada contributes on average one third of the total eligible costs of the project and the provincial government and municipality provide the remainder. The Department of Municipal Affairs (*see below*) is involved in the administration of this program and a number of other jointly-funded Federal-Provincial programs.	**Regional Office** John Cabot Building 11th Floor 10 Barter's Hill PO Box 1060, Stn. C St. John's, NL Canada A1C 5M5 (Courier Address: A1C 6M1) General Enquiries: Tel: (709) 772-2751 Fax: (709) 772-2712 Toll-free: 1-800-668-1010
Department of Municipal Affairs www.ma.gov.nl.ca/ma/funding/index.html	The **Department of Municipal Affairs** supports the financial stability and viability of municipalities and the efficient and effective delivery of municipal services. It assists municipalities in meeting their infrastructure needs and provides financial and administrative tools to support sound municipal governance. In addition to **Municipal Capital Works** program funding, the Department administers numerous other infrastructure and planning oriented programs that may be applied to adaptation-related initiatives.	**Department of Municipal Affairs** 4th Floor (West Block) Confederation Building P.O. Box 8700 St. John's, NL A1B 4J6 Email: MAinfo@gov.nl.ca
	Programs available to other potential partner organizations	
Environment Canada www.ec.gc.ca/iea-aei	The **Atlantic Ecosystem Initiatives** (AEI) is a successor to the Atlantic Coastal Action Program (ACAP) established in 1991. It encompasses a network of community-based environmental NGOs across Atlantic Canada. Each participating site/region has developed its own environmental management plans and objectives. Officially, there are no new regional ecosystem initiatives in Newfoundland and Labrador; just the four legacy ACAP organizations: **Northeast Avalon ACAP** (NAACAP) in St. John's; **ACAP Humber Arm Environmental Association** in Corner Brook; **Labrador Southeast Coastal Action Program** (LSCAP) in Port Hope Simpson; and **Central Labrador Environmental Action Network** (CLEAN) in Happy Valley-Goose Bay. The Province is also well-represented in the **Atlantic Coastal Zone Information Steering Committee** (ACZISC), one of the current AEI Ecosystem Initiatives (*see Section C listing*).	**Ecosystems and Sustainable Communities Office** Environment Canada Email: aei-iea@ec.gc.ca

Funding Agency and Website I need help with financial resources… *cont'd*	**Description**	**Contact and related information**
Federal research funding organization collaboration www.science.gc.ca	The Government of Canada is trying to improve the coordination of its research funding programs, activities and policies (*see NSERC, SSHRC and Memorial University entries below*). This has created several avenues for private and/or public sector players to partner with academic institutions on research of mutual benefit. The subject directory on this website is a useful starting point for searching collaborative research areas. Funding priority areas may be expected to shift over time but the site also serves as a portal for up-to-date information on targeted research areas.	Email: information@science.gc.ca
Natural Sciences and Engineering Research Council of Canada www.nserc-crsng.gc.ca *NSERC Collaborations* www.nsercpartnerships.ca	**NSERC** is federally funded agency that supports post-secondary research in science and engineering. The funding programs support scientific research, technology advancement, and product development. Collaboration between the public and private sectors and between universities and companies is encouraged.	**NSERC Atlantic Regional Office** 100 des Aboiteaux Street, suite 1300 Moncton, NB E1A 7R1 Tel: (506) 854-8154 Fax: (506) 854-7981 Toll-free: 1-877-767-1767 Email: nserc-atlantic@nserc-crsng.gc.ca
Social Sciences and Humanities Research Council www.sshrc-crsh.gc.ca **SSHRC Priority Area - Canadian Environmental Issues** http://www.sshrc-crsh.gc.ca/funding-financement/programs-programmes/priority_areas-domaines_prioritaires/environment_research-recherche_environnement-eng.aspx	The **Social Sciences and Humanities Research Council** (SSHRC) is a federal agency that promotes and supports postsecondary-based research and training in the humanities and social sciences. Through its programs and policies, SSHRC enables research excellence in Canada, and facilitates knowledge-sharing and collaboration across research disciplines, universities and society.	**Social Sciences and Humanities Research Council** 350 Albert Street P.O. Box 1610 Ottawa, ON K1P 6G4 Canada Email (Partnerships): strategic@sshrc-crsh.gc.ca
Research at Memorial University www.mun.ca/research **Yaffle** yaffle.ca	Memorial University's **Office of Vice-President (Research)** is responsible for promoting and enhancing the university's broad range of research activities across all academic disciplines; building partnerships; and enhancing the dissemination, application and commercialization of research results generated at Memorial. **Yaffle.ca** is Memorial University's online connecting tool. The Yaffle search tool allows users to browse researcher interests, expertise, existing projects and upcoming research opportunities involving Memorial University faculty, students and associates. One of its most significant jobs is to provide a way for people from outside Memorial to ask for research help from the university.	**Office of Vice-President** (Research) A-2021, Arts & Administration Building Memorial University of Newfoundland St. Johns, NL A1C 5S7 Tel: (709) 864-2530 Fax: (709) 864-2552 Email: vp.research@mun.ca **Yaffle Support** Email: support@yaffle.ca Tel: 709-864-3576

SECTION C: Other Climate Change Adaptation Resources

<table>
<tr><th>Topic Area</th><th>Description</th><th>Contact and related information</th></tr>
<tr><td>Other Climate Change Adaptation Resources</td><td colspan="2">This is a listing of other toolkits and associated websites that contain useful information and examples.</td></tr>
<tr><td>Adapting to Climate Change: A Risk-based Guide for Ontario Municipalities (2006)

www.nrcan.gc.ca/earth-sciences/projdb/pdf/176a_e.pdf

Bruce, J. P., Egener, I. D. M., & Noble, D.</td><td rowspan="2">The Ontario Ministry of Municipal Affairs and Housing, together with Natural Resources Canada and the Institute for Catastrophic Loss Reduction, supported the initial development of this guide to help Ontario municipalities understand and manage risks associated with climate variability and change. A shorter national version followed with additional support from the Provinces of Alberta and British Columbia.

These guides include useful templates and tools for use in adaptation planning and decision-making, several of which were used in the adaptation workbooks compiled for Newfoundland and Labrador. Some of the content is based on Canadian Standards Association practice as noted in the Chapter 6 Synthesis (www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/assessments/211) of From Impacts to Adaptation: Canada in a Changing Climate (see listing below).</td><td rowspan="2">Canadian Standards Association

155 Queen Street Suite 1300
Ottawa, Ontario
Canada, K1P 6L1

Tel: (613) 565-5151
Fax: (613) 565-5743
Email: climate.change@csa.ca
Email: ghgregistries@csa.ca
www.csa.ca

The Canadian Standards Association is a not-for-profit membership-based association serving business, industry, government and consumers. The CSA works in Canada and around the world to develop standards that address real needs, such as enhancing public safety and health.</td></tr>
<tr><td>Adapting to Climate Change: A Risk-based Guide for Local Governments
Volume 1 (2010)

www.nrcan.gc.ca/sites/www.nrcan.gc.ca.earth-sciences/files/pdf/projdb/pdf/ris_e.pdf

Black, R.A., Bruce, J. P. & Egener, I. D. M.</td></tr>
<tr><td>From Impacts to Adaptation: Canada in a Changing Climate 2007 (2008)

www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/assessments/132

Lemmen, D.S., Warren, F.J., Lacroix, J., and Bush, E., eds. Government of Canada</td><td>Considerable research has been done on Canadian climate change impacts. This information was brought together in this exhaustive assessment report that highlights key issues facing each region of the country in a policy-relevant manner. It includes examples of recent and ongoing adaptation initiatives.

You can download this report or order print copies. It is one of a series of Climate Change Impacts and Adaptation publications listed at www.nrcan.gc.ca/earth-sciences/products-services/publications/climate-change/279</td><td>Also in this on-line resource:

Risk Management Tools

www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/295</td></tr>
</table>

Topic Area	Description	Other contact information
Municipal Resources for Adapting to Climate Change (2009) www.fcm.ca/Documents/reports/PCP/Municipal_Resources_for_Adapting_to_Climate_Change_EN.pdf Federation of Canadian Municipalities Researched by ICLEI Canada and the Clean Air Partnership (CAP)	This resource guide is intended to provide information to Partners for Climate Protection (PCP) members and other municipal officials who wish to undertake adaptation planning. The PCP program is a partnership between the Federation of Canadian Municipalities and ICLEI — Local Governments for Sustainability. PCP is the Canadian component of ICLEI's Cities for Climate Protection (CPP) Campaign, which involves more than 900 communities internationally. In Canada, over 180 municipal governments are involved in the PCP program, which uses a five-milestone framework to guide communities in assessing and reducing greenhouse gas emissions.	**Partners for Climate Protection FCM's Green Municipal Fund** Federation of Canadian Municipalities 24 Clarence Street Ottawa, Ontario K1N 5P3 Tel: (613) 907-6370 Fax: (613) 244-1515 E-mail: pcp@fcm.ca www.fcm.ca/gmf
A Practitioners Guide to Climate Change Adaptation in Ontario's Ecosystems (2011) ontario.ca/s364 Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) www.climateontario.ca & Ontario Ministry of Natural Resources (OMNR) www.mnr.gov.on.ca	This guide introduces the concepts of climate change adaptation, vulnerability and risk, and identifies ways that climate change adaptation plans can be integrated into decision-making processes. Both the OCCIAR and the OMNR maintain extensive on-line libraries of other climate change-related materials. Through their **Climate Change Adaptation Community of Practice**, the OCCIAR has also been facilitating the training of adaptation practitioners across a number of sectors.	**Climate Change Adaptation Community of Practice** (CCACoP) The OCCIAR has established an interactive online community to address climate change adaptation. In the CCACoP, researchers, experts and practitioners can ask questions, generate ideas, and communicate with others working in the field of climate change adaptation. The OCCIAR facilitates regular webinars and other knowledge-sharing events for CoP members. CCACoP website: www.ccadaptation.ca
Climate Change Adaptation Planning - A Handbook for Small Canadian Communities (2011) www.planningforclimatechange.ca/wwwroot/dsp_Library.cfm Bowron, B. and Davidson, G.	This handbook is intended to help small Canadian communities prepare and implement a climate change adaptation plan. The handbook helps community members 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, but larger municipalities may also find it useful.	**The Canadian Institute of Planners** (CIP) has consolidated information and publications regarding climate change-related projects undertaken by their professional membership. These are available on the Planning for Climate Change website. www.planningfor climatechange.ca

Topic Area	Description	Other contact information
Climate Change Planning Tools for First Nations: Adapting to Climate Variability and Change (2006) www.cier.ca/information-and-resources/publications-and-products.aspx?id=412 Centre for Indigenous Environmental Resources (CIER)	This set of six short guidebooks outlines every step in the process of undertaking and implementing a community adaptation plan. The guides suggest activities to involve members of the community in setting and achieving priorities. They are available in French and English. Although written for aboriginal communities, these guides can be useful for any municipality. The CIER has an extensive list of useful reports and community resources addressing sustainability and adaptation themes.	**Centre for Indigenous Environmental Resources** A national, First Nation-directed environmental non-profit organization, established in 1994 by a group of First Nation Chiefs from across Canada. Their programs address climate change, building sustainable communities, protecting lands and waters, and conserving biodiversity. www.cier.ca
Canadian Communities' Guidebook for Adaptation to Climate Change (2008) Including an approach to generate mitigation co-benefits in the context of sustainable development. www.forestry.ubc.ca/Default.aspx?alias=www.forestry.ubc.ca/aird Bizikova L., T. Neale and I. Burton Environment Canada and University of British Columbia	This guidebook, published by the University of British Columbia (UBC), is intended to help those who are looking for ways to reduce the impacts of climate change (increasing heat waves, water shortages, intense storms and sea-level rise) while decreasing greenhouse gas emissions and ensuring sustainable development for their communities. UBC's **Sustainable Development Research Institute** (SDRI) has been conducting collaborative scientific research projects on climate change impacts and adaptation, and linking them with sustainable development staff at Environment Canada's **Adaptation and Impacts Research Section** (AIRS) work with many UBC faculty on interdisciplinary research projects.	**Adaptation and Impacts Research Section** (AIRS) Environment Canada 4905 Dufferin Street Toronto, Ontario M3H 5T4 Tel: (416) 739-4271 Fax: (416) 739-4297
Resource Binder on Climate Change (2006) www.arcticathabaskancouncil.com/aac/files/climate_change/Resourcebinderfinal.pdf Fleischmann, M. Arctic Athabaskan Council (AAC)	This binder-format resource guide is a compilation of material prepared for for the Arctic Athabaskan Council. It highlights the particular political context for climate change adaptation in the Western Arctic and introduces numerous tools to assist with risk assessment and adaptation. The Arctic Athabaskan Council (AAC) is an international treaty organization established to defend the rights and further the interests of American and Canadian Athabaskan member First Nation governments in the eight-nation Arctic Council and other international forums.	**Arctic Athabaskan Council** 2166-2nd Avenue Whitehorse, Yukon Y1A 4P1 Tel: (867) 393-9214 Fax: (867) 668-6577 www.arcticathabaskan council.com

Topic Area	Description	Other contact information
12 Steps to Developing an Effective Emergency Management Plan (undated) www.gov.nl.ca/fes/emo/12Stepswithtemplate.pdf Fire and Emergency Services Newfoundland and Labrador **(www.gov.nl.ca/fes)**	This manual and its companion DVD were designed to assist Councils and Emergency Management Coordinators develop emergency plans. Useful worksheets are included throughout. The FES provides links to this manual and other municipal training resources at the following link: www.gov.nl.ca/fes/emo/municipalplanning.html	**FES-NL** also offers a training program in *Basic Emergency Management, Emergency Operations Centre Management, Incident Command System, and Exercise Design* and facilitates training courses through the Canadian Emergency Management College (CEMC) in Ottawa. This training, including courses through CEMC, is offered at no cost to municipalities.
Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments (2007) cses.washington.edu/cig/fpt/guidebook.shtml Center for Science in the Earth System (The Climate Impacts Group) Joint Institute for the Study of the Atmosphere and Ocean University of Washington King County, Washington	This guidebook is designed to help local, regional and state governments prepare for climate change by recommending a detailed, easy-to-understand process, based on familiar resources and tools. It was written by Climate Impacts Group and ICLEI – Local Governments for Sustainability. **The Climate Impacts Group** (CIG) focuses on the intersection of climate science and public policy – conducting research aimed at understanding the consequences of climate fluctuations for the US Pacific Northwest, and promoting the application of this information in regional decision making.	**Climate Impacts Group** Box 355672 Seattle, WA USA 98195-5672 Tel: (206) 616-5350 Fax: (206) 616-5775 Email: cig@uw.edu
Climate Witness Community Toolkit (undated) assets.panda.org/downloads/cw_toolkit.pdf McFadzien, D., Areki, F., Biuvakadua, T., & Fiu, M. World Wildlife Fund (WWF)	This toolkit was developed by the WWF to help local communities in the Pacific region identify and participate in appropriate adaptation measures. It guides community facilitators through the process of collecting climate change information and in developing appropriate community responses. The toolkit is comprised of a series of participatory activities which are broken down into segments to be carried out over a two-day period. These include data collection, analysis and the production of a community action plan. Although the toolkit is aimed at southern communities, much of this information would suit many communities in Newfoundland and Labrador.	**World Wildlife Fund** www.wwf.org South Pacific Programme Regional Office Address: 4 Ma'afu Street, Suva, Fiji. Postal Address: Private Mail Bag, GPO, Suva, Fiji Tel: (679) 3315 533 Fax: (679) 3315 410 email: infor@wwfpacific.org.fj www.wwfpacific.org.fj

Adapting to Climate Change: An Introduction for Canadian Municipalities (2010) www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/municipalities/373 Richardson, G. R. A. Natural Resources Canada	This document provides municipal decision-makers and staff with information to help them understand the need for climate change adaptation and how to put adaptation measures in place. The book includes 11 case studies that illustrate how municipalities of varying sizes from across the country are taking adaptation action.	
Globally the 'green economy' is growing rapidly presenting economic opportunities for communities across the province. The Green Economy encompasses activities, products, or systems that reduce non-renewable energy and raw materials consumption and reduce or eliminate harmful emissions/discharges and their impact on the environment.	It is estimated that with the right supports, the green economy in this province could grow by 30% by 2020. Sectors that offered the greatest opportunities include sustainable resource management, green building, waste management and recycling and sustainable tourism. Newfoundland and Labrador is well positioned to achieve success in the green economy which was estimated to be worth $4.3 trillion in 2010/11 and is expected to achieve significant growth by 2020 (UK Dept. for Business, Innovation & Skills, 2011).	www.unep.org/greeneconomy/ www.greeneconomynet.ca/ www.turnbackthetide.ca/for-businesses/green-economy.shtml

SECTION D: Definitions

Adaptation: Adjustment in natural or human systems in order to reduce or avoid harm or benefit from opportunities in response to actual or expected climatic changes.

Avalanche: Fast downslope movement of snow.

Beach: Shoreline constructed of sediment.

Blizzard: Severe winter weather characterized by strong winds and heavy or blowing snow that causes low to zero visibility.

Boulder: Eroded and transported mass of rock, greater than 256 mm in diameter.[1]

Breakwater: A structure which provides protection to the shoreline by interfering with wave action.[2]

Coastal flooding: Inundation of low-lying area along the shoreline.

Clay: Fine-grained sediment, less than 0.004mm in dimension, finer than silt.[3]

Climate: General pattern of meteorological elements, such as temperature and wind, over 30 years or more.

Climate change: A long-term alteration in the climate.

Climate scenario: A description of possible future climate conditions for an area.

Climate variability: Variations of the climate on scales beyond that of individual weather events.

Cobble: Eroded and transported mass of rock, between 64 and 256 mm in diameter.

Creep: The slow movement of sediment or rock down a slope due to gravity.[4]

Dike: An artificial wall or barrier used to confine water to prevent flooding.

Erosion: The removal of sediment or rocks by water, wind, gravity or ice.

Fetch: The distance of open water that wind can blow over. A long fetch creates larger and stronger waves.[5]

Flooding: Inundation or submergence of an area of land by water from a lake, stream, ocean or other source.

1 R.O. van Everdingen, Multi-Language Glossary of Permafrost and Related Ground-Ice Terms. (Calgary, AB: University of Calgary, 2005), 310 pp.

2 Maryland Department of Natural Resources, Shore Erosion Control Guidelines. (Annapolis, MD: National Ocean and Atmospheric Administration, 2006), 36 pp.

3 Van Everdingen, Multi-Language Glossary of Permafrost and Related Ground-Ice Terms.

4 M.J. Batterson, S.J. McCuaig, and D. Taylor, Mapping and Assessing Risk of Geological Hazards on the Northeast Avalon Peninsula and Humber Valley, Newfoundland. (St. John's, NL: Newfoundland and Labrador Dept. of Natural Resources, Geological Survey, 2006) Report 06-1:147-160.

5 Van Everdingen, Multi-Language Glossary of Permafrost and Related Ground-Ice Terms.

Flood fringe: Designated zone of 1:100 flood recurrence (1% statistical chance of flooding in a given year).

Floodway: Designated zone of 1:20 flood recurrence (5% statistical chance of flooding in a given year).[6]

Flow: A type of slope movement where the material behaves like thick fluid.

Freezing rain: Rain that freezes when it comes into contact with a cold surface.

Gravel: Gravel particles are larger than sand. Gravel includes granules, pebbles, cobbles, and boulders.

Groyne: Infrastructure erected to interfere with sediment transport along a shoreline, usually aligned at 90° to the shoreline.

Hail: Ice that is 5 mm or more in diameter. Hail often occurs when there are large highly developed clouds. [7]

Hazard (natural): The danger or risk of a naturally occurring event that could have a negative effect on people or the environment.

Hurricane: Tropical cyclones with maximum sustained surface winds of at least 119 kilometres per hour in the Western Hemisphere.[8]

Land subsidence: The sinking or settling of land. This can be in response to numerous factors including the lowering of groundwater level, removal of underlying supporting materials, or earth movements, as well as those long-term gradual movements associated with crustal rebound following melting of the ice sheets at the end of the last ice age.[9]

Ice storm: A type of winter storm that consists of freezing rain. Ice can build up on the surface of trees, buildings, cars, and power lines with damaging effects.

Longshore drift: Movement of sediment along the shoreline by waves and currents.[10]

Mitigation: Actions which reduce the severity of climate change, such as lowering greenhouse gas emissions.[11]

Risk: A combination of the likelihood and the consequences of an adverse event.[12]

6 M. Batterson and D. Liverman, Past and Future Sea-Level Change in Newfoundland and Labrador: Guidelines for Policy and Planning. (St. John's, NL: Dept. of Natural Resources Geological Survey, 2010) Report 10-11:129-141.

7 J.E. Oliver, (Ed.), Encyclopedia of World Climatology. (Dordrechi, Netherlands: Springer, 2005), 854 pp.

8 Oliver, (Ed.), Encyclopedia of World Climatology.

9 Ecology Dictionary [on-line]. Last accessed 26 March 2012 at www.ecologydictionary.org.

10 Maryland Department of Natural Resources, Shore Erosion Control Guidelines.

11 IPCC, Climate Change 2007: The Physical Science Basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate change. S. Solomon, , D. Qin, , M. Maning, Z. Chen, M. Marquis, K. B. Averyl, M. Tignor and H.L. Miller (Eds.) (New York: Cambridge University Press, 2007):1-18

12 Batterson, McCuaig and Taylor, Mapping and Assessing Risk of Geological Hazards on the Northeast Avalon Peninsula and Humber Valley, Newfoundland

Rockfall: Downslope movement of blocks of rock. Rockfalls often occur as a result of freeze-thaw action, erosion or human actions.[13]

Saltwater intrusion: Saltwater entering into a freshwater aquifer (groundwater source) in coastal or inland areas.

Sand: Sand is larger than silt, but smaller than gravel. The grains are between 0.06 and 2 mm in diameter.[14]

Sea level rise: The position of the sea surface relative to adjacent land. Sea level rise is caused by a combination of thermal expansion and glacial melt both of which are a result of warmer air and ocean temperatures. When calculating sea level rise, post glacial subsidence and rebound of the land must also be considered.

Seawall: Infrastructure creating a division between land and water to prevent erosion.[15]

Silt: Silt is smaller than sand but larger than clay, and is between 0.004 and 0.6 mm in diameter.[16]

Slope movement (also called Mass movement): The downslope movement of material including sediment, bedrock, vegetation, and snow. The following are types of slope movement:

Rockfalls - the downslope movement of boulders either by free fall, rolling or sliding[17]

Landslides - the downslope movement of unconsolidated material. When a landslide is rapid it is called a debris flow and when it is slow it is called creep.

Avalanches - the rapid, downslope movement of snow and ice which may also include sediment, rock, and vegetation.

Snow storm: Winter storm with snow and/or sleet and cold temperatures.

Storm surge: A storm surge is defined as the elevation of the water resulting from meteorological (wind and pressure) effects on sea level. The storm-surge elevation is the difference between the observed water level during the storm and the level that the tide would normally rise to in the absence of storm activity.[18]

13 Batterson, McCuaig, and Taylor, Mapping and Assessing Risk of Geological Hazards on the Northeast Avalon Peninsula and Humber Valley, Newfoundland .

14 Van Everdingen, Multi-Language Glossary of Permafrost and Related Ground-Ice Terms.

15 Maryland Department of Natural Resources, Shore Erosion Control Guidelines.

16 Van Everdingen, Multi-Language Glossary of Permafrost and Related Ground-Ice Terms.

17 Batterson, McCuaig and Taylor, Mapping and Assessing Risk of Geological Hazards on the Northeast Avalon Peninsula and Humber Valley, Newfoundland.

18 D. L. Forbes, G. S. Parkers, G.K. Manson, and L. Ketch. "Storms and Shoreline Retreat in the Southern Gulf of St. Lawrence," Marine Geology 210 (2004):169-204.

Submergence: Submergent coasts are coastal areas that are now underwater due, in large part, to rising sea levels.[19]

Tide: The rising and falling (vertical movement) of the ocean level due to gravitational forces of the moon and sun and the rotation of the earth. Many places have two high tides and two low tides per day, but some areas only have one.[20]

Vulnerability: A function of the risk level of, and ability to cope with, an impact.

Weather: Immediate and short-term conditions of the atmosphere.[21]

19 Maryland Department of Natural Resources, Shore Erosion Control Guidelines.

20 Maryland Department of Natural Resources, Shore Erosion Control Guidelines.

21 H. J. de Blij, Physical Geography: The Global Environment (Toronto, ON: Oxford University Press, 2005).

SECTION E: Chapter Tables

Chapter 1

Table 2: Inventory of Community Infrastructure

Infrastructure	Could it be impacted by flooding? If yes, how?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

Table 3: Community Contact List

Agency/Person	Business phone #	Home phone #	Comments/Role

Table 4: Inventory of Community Resources

Resources	Owner (s)	Phone #	Comments
Boat			
Backhoe			
Generator (Note power output)			
Grader			
Satellite phone			
Other			

Table 2: Inventory of Community Infrastructure

Infrastructure	Could it be affected by coastal vulnerability?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

Table 3: Community Contact List

Agency/Person	Business phone #	Home phone #	Comments/Role

Table 4: Inventory of Community Resources

Resources	Owner (s)	Phone #	Comments
Boat			
Backhoe			
Generator			
Grader			
ATV			
Truck			
Satellite phone			
Other			

Chapter 3

Table 2: Inventory of Community Infrastructure

Infrastructure	Could it be impacted by slope movement? If yes, how?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

Table 3: Community Contact List

Agency/Person	Business phone #	Home phone #	Comments/Role

Table 4: Inventory of Community Resources

Resources	Owner (s)	Phone #	Comments
Large shovels or other rescue tools			
Backhoe			
Generator (Note power output)			
Other (satellite phone, radio)			

Table 2: Inventory of Community Infrastructure

Infrastructure	Could it be affected by or cause drinking water supply issues? If yes, how?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

Table 3: Community Contact List

Agency/Person	Business phone #	Home phone #	Comments/Role

Table 4: Inventory of Community Resources

Resources	Owner (s)	Phone #	Comments
Emergency kits			
Generator (Note power output)			
Satellite phone			
Radio (VHF, two way)			

Chapter 5

Table 2: Inventory of Community Infrastructure

Infrastructure	Will it be impacted by winter conditions? What type?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

Table 3: Community Contact List

Agency/Person	Business phone #	Home phone #	Comments/Role

Table 4: Inventory of Community Resources

Resources	Owner (s)	Phone #	Comments
Snowblower or other rescue tools			
Backhoe			
Generator (Note power output)			
First aid experience			
Other (satellite phone, radio)			

Table 2: Inventory of Community Infrastructure

Infrastructure	Could it be impacted by wildfire? If yes, how?	Who is responsible? (name, email, phone number)	Comments (age, level of maintenance, past problems, material used)

Table 3: Community Contact List

Agency/Person	Business phone #	Home phone #	Comments/Role

Table 4: Inventory of Community Resources

Resources	Owner (s)	Contact/Phone #	Comments
Fire suppression equipment			
Personal protective equipment			
Fire hydrants/ tanker trucks/ portable pumps			
Firefighting Vehicles (fire trucks, rescue vehicles, equipment carrier)			
Appropriate facility to house vehicles and equipment			
Evacuation transportation/ evacuation plan			
First aid experience/ emergency training (level 1, breathing apparatus)			
Other (local radio, satellite phone)			
Updated emergency management			
An identified emergency operations centre			

Case Studies

Flooding and Culvert Maintenance: Bay Bulls, NL

The town of Bay Bulls is taking a proactive approach to reduce its vulnerability to flooding. During storms or heavy rains, municipal staff and volunteers are on call to check and clear culverts. During Hurricane Igor, town representatives actively checked and cleared culverts, calling on maintenance crews when necessary.

Not only is the Town of Bay Bulls taking a proactive approach by monitoring culverts during heavy rain, the town has also replaced culverts or installed larger ones to accommodate the extra runoff from new development. In one area where a culvert was deteriorating, the town council installed a new culvert alongside the existing one to accommodate the extra flow.

Photo credit: Kristina Turner

The new culvert that was installed alongside the existing one on Cemetery Lane, Bay Bulls, NL.

The Town of Grand Bank, NL took a similar approach during a storm in the early 2000s, when a blocked culvert caused a road washout. A local backhoe owner dug a trench to divert water, saving several houses in the area from serious flooding. The makeshift ditch was filled in again later.

The State of Nevada, U.S.A, has taken another approach to reducing flooding caused by blocked culverts. They produced a pamphlet for door-to-door distribution explaining to residents what culverts are, why it is important to keep them unobstructed, and ways to clear them.

The pamphlet notes that obstructed culverts can cause property damage, restrict vehicle access, and cost residents money. Simply shoveling debris away from the opening of the culverts can reduce vulnerability to flooding. The pamphlet also suggests calling the county road department if a sediment build-up is occurring. It used photographs to illustrate the difference between a properly functioning culvert and a poorly maintained one.

This culvert in Bay Roberts is properly maintained and was installed to replace a culvert damaged by Tropical Storm Chantal.

Photo credit: Kimberly Bittermann

Road washout on the Bonavista Peninsula during Hurricane Igor.

Photo credit: Fire and Emergency Services, NL

For additional information:

Prepare for Summer Flash Floods: Keep Your Culvert Clean. (Reno, NV: Buckbrush Flood Safety Coalition and University of Nevada Cooperative Extension).

Available on-line at: www.unce.unr.edu/publications/files/nr/2000/SP0005.pdf

Town of Bay Bulls
Tel: (709) 334-3454
Website: www.baybulls.com

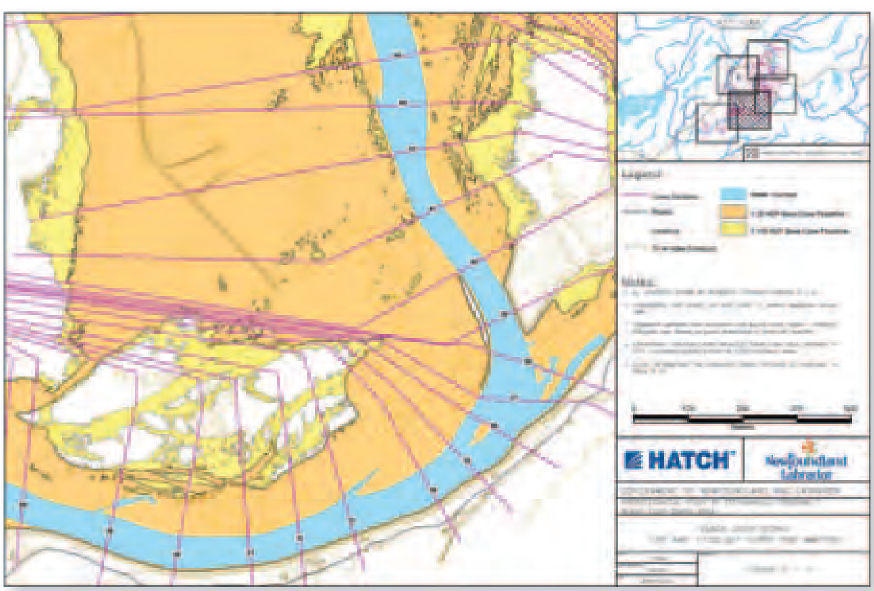
Douglas County Office of the University of Nevada Cooperative Extension
1329 Waterloo Lane, Gardnerville
P.O. Box 338
Minden, NV 89423-0338
Tel: (775) 782-9960
Email: cobournj@unce.unr.edu

River Flooding: Mapping in Truro, NS

Truro is located on the south side of the Salmon River floodplain, and was among the many Bay of Fundy region communities hit hard by the infamous Saxby Gale of 1869. The town has continued to be vulnerable to flooding and the risk of flooding is expected to worsen due to rising sea levels and the increasing severity of storms.

Truro has two ongoing adaptation strategies to help reduce its vulnerability. Provincial staff regularly check and increase the height of the dykes in the area as part of regular maintenance activities in order to help prevent future flooding. Truro is also increasing its flood preparedness through planning and development control measures. The Town of Truro and the County of Colchester began this process by commissioning a joint study of the Truro floodplain in 1997. The following year, a Joint Planning Advisory Committee for Flood Risk Management was established in response to one of the report's recommendations. The Committee was tasked with developing an inter-municipal planning strategy and a land use by-law for flood risk areas. Their draft plan was completed in 2000 and addressed land use in flood risk areas, the maintenance of natural drainage flows, and community flood protection.

Research is a key component of Truro's approach to adaptation, in particular, gathering more precise information regarding local topography and elevations, historic storm surges and tidal data. Natural Resources Canada collected elevation data for Truro in 1998 using LiDAR (Light Detection and Radar), a remote sensing system that scans spot heights to generate very detailed digital terrain profiles. These 3-D maps can be overlaid by multiple tidal and storm surge scenarios to help determine the susceptibility to flooding in the area. One scenario illustrated what would happen to the town if it experienced the same combination of 2-metre storm surges and high tides that hit the area in 1869; this version of the map showed that most of the local dykes would be inundated, and that large areas of the community would flood.



An example of LiDAR Imagery used in Flood Risk Mapping for the community of Black Duck Siding, NL

For additional information:

Nicole, Amber. *Changing Climate, Changing Coasts: Report from the June 6th 2007 Learning Circle on Climate Change Impacts and Adaptation in Nova Scotia* (Halifax, NS: Ecology Action Centre – Coastal Issues Committee, 2007) pp. 19-21.

(Available on-line at: www.ccns.chebucto.org/ChangingClimate.pdf)

Ecology Action Centre – Coastal Issues Committee
2705 Fern Lane, Halifax, Nova Scotia
Canada B3K 4L3
Tel: (902) 442 - 5046
Fax: (902) 405 - 3716
E-mail: coastal@ecologyaction.ca
Website: www.ecologyaction.ca/coastal_issues/coastal_issues.shtm

Coastal Flooding: Risk Mapping in Annapolis Royal, NS

Annapolis Royal is a coastal community located on the southern shore of the Bay of Fundy. The low elevation of the townsite combined with rising sea levels, make it increasingly vulnerable to flooding. Climatic changes have also increased the likelihood of intense storm surges and coastal erosion in the region.

Annapolis Royal, N.S.

Photo credit: Trish Fry

In 1998, a citizen-based group known as the Clean Annapolis River Project (CARP), a member of the Atlantic Coastal Action Program network, began an assessment of Annapolis Royal's vulnerability to storm surge. The Tidal Surge Project identified and gathered information on potential threats to the town, including floods during times of extreme tides and storm surges, so that appropriate response plans and procedures could be put in place. The study determined that while a tidal surge during a severe storm was an infrequent event, it remained a threat to coastal zones in the region, especially if it were to coincide with an unusually high tide.

CARP mapped areas at risk for potential flooding using storm surge scenarios and sea level rise predictions. The group gathered background information by searching records from museums, newspapers and historical societies to see what types of events occurred in the past and to estimate changes over time in local climate and tidal factors. This information was overlaid on terrain elevation maps to determine the locations most at risk from tidal surge flows and flooding. Once these potential flood risk zones were identified, CARP was able to further evaluate possible implications for people and infrastructure in the region.

Photo credit: Trish Fry

Picture taken from the Annapolis Royal Boardwalk, Annapolis Royal, N.S.

The results of the project were presented to the citizens through public forums, which were followed in the spring of 1999 by a mock disaster that engaged local fire, medical and emergency response teams. By allowing residents to see first-hand the effect that a flood might have on their area, the exercise helped them find ways to minimize damage in the event of an emergency. In response, people took additional adaptive measures. One homeowner raised his home by more than half a meter once he understood the risk of flooding. It was also discovered that, although the community fire station sat on a rise above projected floodwater levels, during a flood that land would become an island, isolated from the rest of the town. To deal with this, the Fire Department distributed rescue equipment previously stored in the fire station to other locations, and purchased a boat.

In 2005, due to CARP's original Tidal Surge Project, a team of scientists from the Applied Geomatics Research Group (AGRG) at the Centre of Geographic Sciences in Lawrencetown, Nova Scotia developed high-resolution maps. These maps provided a more accurate visualization of future flooding scenarios, enhancing disaster planning in Annapolis Royal. Municipal staff use these maps to inform potential developers of storm surge risks. The town is also working with other stakeholders in the Fundy region to develop a coordinated approach to dealing with flooding and to prioritize regional actions on climate change and storm surge. Annapolis Royal has already significantly reduced its vulnerability to storm surge flooding, but it continues to fine-tune its plans as estimates of sea-level-rise improve.

For additional information:

Richardson, G. R. A. "Preparing for Storm Surges in Annapolis Royal, Nova Scotia." *Adapting to Climate Change: An Introduction for Canadian Municipalities*. (Ottawa, ON: Natural Resources Canada, 2010) pp. 30-31.

(Available on-line at: www.nrcan.gc.ca/earth-sciences/climate-change/community-adaptation/municipalities/373)

Town of Annapolis Royal
Tel: (902) 532-3146
E-mail: cao@annapolisroyal.com

Clean Annapolis River Project
Tel: (902) 532-7533
E-mail: carp@annapolisriver.ca

Coastal Erosion: Infrastructure Adaptations in Ferryland, NL

The community of Ferryland, on the Avalon Peninsula, has a history of coastal vulnerability. Flooding and coastal erosion have damaged roads and homes, and threatened to isolate part of the community.

A narrow peninsula juts out from the southern side of the town protecting Ferryland Harbour to the north from the full force of ocean waves. The narrowest part of the peninsula, known locally as the Pool, is at particularly high risk of erosion. The Colony of Avalon, an archeological site that dates back to the 1600s, is located there along with several houses and the Folk Arts Center. A single access road crosses the Pool and continues east to the Ferryland Lighthouse at the very end of the peninsula.

Coastal protection in Ferryland, NL. The armour stones in the foreground were installed early in 2010 as a temporary measure.

Photo credit: Kimberly Bittermann

During the winter months, the Pool Road has been subject to flooding and erosion; storm waves regularly wash onto it, damaging the pavement and washing part of it out to sea. Serious road damage and flooding occurred during a December storm in 2009. The spray from waves during that storm reached the second floor windows of many coastal buildings. After that storm, $120,000 was spent to armour the beach with large stones and to erect a heavy fence line along the road. However, the road continues to be a source of concern both for the welfare of Pool area residents and the operation of Ferryland's key tourism assets: it was damaged again during a storm on Christmas Eve in 2010.

In recent years, the severity and number of storms appears to be increasing in Ferryland. To reduce the impact of future coastal storms, the town council hopes to repair and improve its existing shoreline protection with capital infrastructure assistance from the Department of Municipal Affairs. A new 190-metre long seawall is proposed to protect the Pool Road. The seawall would be constructed using a combination of large rocks and timber cribwork at an estimated cost of one million dollars.

Photo credit: Melanie Irvine

A December storm in 2010 damaged this road in Ferryland, NL.

For additional information:

Director of Communications
Department of Municipal Affairs
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River Bank Erosion: South-Central Newfoundland

Construction projects can destroy large areas of vegetation and habitat. In 2004, Memorial University's Botanical Garden partnered with Newfoundland and Labrador Hydro to assist in the re-vegetation of the Granite Canal Fish Habitat Compensation Facility (FHCF) following a large hydroelectric development in south-central Newfoundland. The re-vegetation was initiated in order to provide cover for the new fish habitat and to stabilize the stream banks.

Planting the stream banks of the Granite Canal Fish Habitat Compensation Facility (FHCF).

Photo credit: MUN Botanical Garden

When choosing plants for re-vegetation, it is important to select species that establish quickly and develop strong and widespread root systems to stabilize soils. Before the project started, staff from the Botanical Garden did extensive research to better understand local soil composition, nutrients and conditions, as well as the local climate.

From among the plants that grew in the region, the staff selected species which grew best in re-constructed soils. Of the 100,000 native plantings the Botanical Garden staff used, 75,000 were alder seedlings and the rest were a mixture that included ground juniper, red-osier dogwood, bearberry, pearly everlasting, aster, lance-leaved goldenrod and rough-leaved goldenrod, all of which were grown at the Botanical Garden. Although there are several different microclimates in Newfoundland, and therefore different varieties of vegetation, all of the plants used in the FHCF project should survive in most regions of the province.

Photo credit: Melanie Irvine

Granite Canal Fish Habitat Compensation Facility (FHCF).

For additional information:

MUN Botanical Garden
306 Mt. Scio Rd., St. John's, NL
Tel: (709) 864-8590
E-mail: mbishop@mun.ca
Website: www.mun.ca/botgarden/plant_bio/research/site_rehab.php

Streamside Stabilization: Bioengineering in Victoria, BC

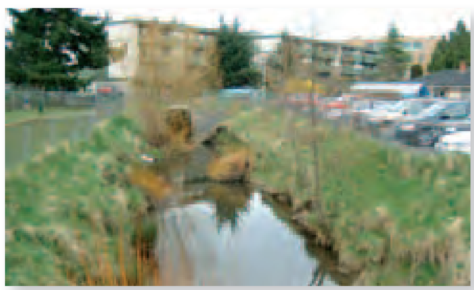
Bioengineering involves using plants to build structures that reduce, prevent or repair erosion. Weaving 'living' fences and planting native vegetation to achieve stream bank stabilization is growing in popularity. As the Bowker Creek Initiative demonstrates, it is an effective, biologically sound and relatively inexpensive stabilization measure that many community members can get involved in.

Photo credit: Rob Miller

Volunteers stabilizing banks along a section of Bowker Creek in 2008 using willow wattle fencing.

Urbanization in Victoria, British Columbia has contributed to persistent erosion throughout the Bowker Creek watershed, leading to flooding, flow management and water quality problems. The grassroots Friends of Bowker Creek Society was founded in 1998 to raise awareness about this urban creek and advocate for multi-jurisdictional watershed planning and restoration. In 2002, three municipalities and a variety of community partners were brought together by the Capital Regional District to examine these issues and launch a watershed management planning process. The resulting Bowker Creek Watershed Management Plan (2003) was established and continues to guide the collaborative watershed governance model of the current Bowker Creek Initiative.

The Management Plan recommended stabilizing the banks of Bowker Creek using living fences. This technique typically involves weaving live willow cuttings, but cottonwood and dogwood cuttings can also be used. At first, the woven structure helps prevent soil from washing away. As the vegetation grows, creating a more naturalized riverbank environment, the plant roots further secure the soil and enhance its water storage capacity.



St. Patrick's school demonstration project prior to restoration in 2005 (left) and with well-established vegetation in 2008 (right).

Photo credit: Bowker Creek Initiative

In 2005, the Capital Regional District worked with special interest groups, residents, and engineering and restoration professionals to complete a demonstration project using this technique. A 48-metre section of the hardened and eroding creek bank was reconstructed using heavy machinery. Volunteers created planting terraces by weaving live willow wattle fencing. Students from the nearby St. Patrick's School helped plant other native vegetation and played a key role in its subsequent monitoring and care.

In 2008, another smaller project was undertaken on another portion of the Creek which did not require heavy machinery and placement of rocks.

Numerous Bowker Creek monitoring indicators were recommended by the Management Plan and were later described in detail by the Bowker Creek Blueprint, including several that track ongoing bank stabilization progress.

For additional information:

Bowker Creek Initiative
Tel: (250) 360-3302
Website: www.bowkercreekinitiative.ca

Westland Resource Group. *Bowker Creek Watershed Management Plan.* (Victoria, BC: Capital Region District, 2003)

(Available on-line at www.bowkercreekinitiative.ca/plans-strategies/documents/plan_BowkerCreekWater.pdf)

Bowker Creek Initiative. *Bowker Creek Blueprint: A 100-year action plan to restore the Bowker Creek watershed.* (Victoria, BC: Bowker Creek Initiative, 2010).

(Available on-line at www.bowkercreekinitiative.ca/plans-strategies/stormwatermanagement.htm)

The Friends of Bowker Creek Society
E-mail: bowkercreek@shaw.ca
Website: members.shaw.ca/bowkercreek/index.htm

Wildfire: Prescribed Burns in Terra Nova National Park, NL

Prescribed burns are controlled forest fires set deliberately to try to reduce the likelihood of wildfires and disease, and to encourage new growth. On July 16, 2008, park wardens carried out a prescribed burn at Terra Nova National Park. The process they followed required prior approval by the Canadian Environmental Assessment Agency. Only certain areas were allowed to be included in the burn and it could take place only under certain weather conditions.

Photo credit: Melanie Irvine

Terra Nova National Park, NL.

To prepare for the burn, park wardens set fire to an 800-metre firebreak line situated on an isthmus between Park Harbour and Field Harbour, following the natural drainage of the land. Prior to this, hikers were told to avoid the area, and pumps and sprinklers were placed along firebreaks to soak and protect adjacent forest not included in the burn. As well, a Canadian Coast Guard crew was required to be on hand to monitor burn sites from the water.

On the day of the prescribed burn, a helium balloon was released into the sky to track wind, and a test patch was burned on the northeastern edge of the peninsula. After it was declared a success, the prescribed burn began.

Terra Nova National Park, NL.

Photo credit: Melanie Irvine

The fires were lit line by line against the wind and slope of the land. Afterwards, the prescribed burn site was monitored and any fire, smoke or hotspots outside it were immediately extinguished. The next day, the burnt area was left to smolder and an area of forest surrounding it was soaked again with water.

For additional information:

Button, L. "Terra Nova brings down boreal forest in the name of ecology." The Packet, July 21, 2008.

Canadian Environmental Assessment Agency website. *Field Harbour Prescribed Burn - Terra Nova National Park of Canada* (Environmental Assessment Screening Report, June 11, 2006).

(Available on-line at: www.ceaa.gc.ca/052/details-eng.cfm?pid=13185)

Terra Nova National Park of Canada
General Delivery
Glovertown, NL A0G 2L0
Tel: (709) 533-2801
Email: info.tnnp@pc.gc.ca

Canadian Environmental Assessment Agency
22nd Floor, Place Bell
160 Elgin Street
Ottawa ON K1A 0H3
Tel: (613) 957-0700
Toll free: 1-866-582-1884

Climate Change and Economic Opportunities: Corner Brook, NL

Like most communities, Corner Brook is facing many challenges due to climate change. The city however, is looking for ways to take advantage of the opportunities offered by warming temperatures and decreasing occurrence of sea ice.

Projected climate change may affect the formation of sea ice, leaving harbours along the coast ice-free for longer periods. While this will negatively affect communities that depend upon ice for winter activities, for Corner Brook there could be some advantages. Less sea ice could have a positive effect on marine transportation and the oil and gas industry in the region. As a result of the decrease in sea ice, a new winter ferry service between Corner Brook and Labrador is being piloted by the provincial government. This could bring more tourists to the area, which could translate into significant economic benefits. Less sea ice also benefits the Corner Brook Pulp and Paper mill by reducing the amount the mill needs to spend on ice-breaking services.

The warming temperatures may provide other economic opportunities such as an extended construction season and longer growing seasons for local farmers. A warmer climate may also allow local farmers to grow more varieties of produce.

Figure 1 and Figure 2 illustrate the difference between former and projected growing degree days for Corner Brook. Comparing Figure 1 growing degree days from 1961-1990, to the Figure 2 growing degree days modeled for 2041-2070, shows that there may be a significant increase in the number of growing degree days in the future.

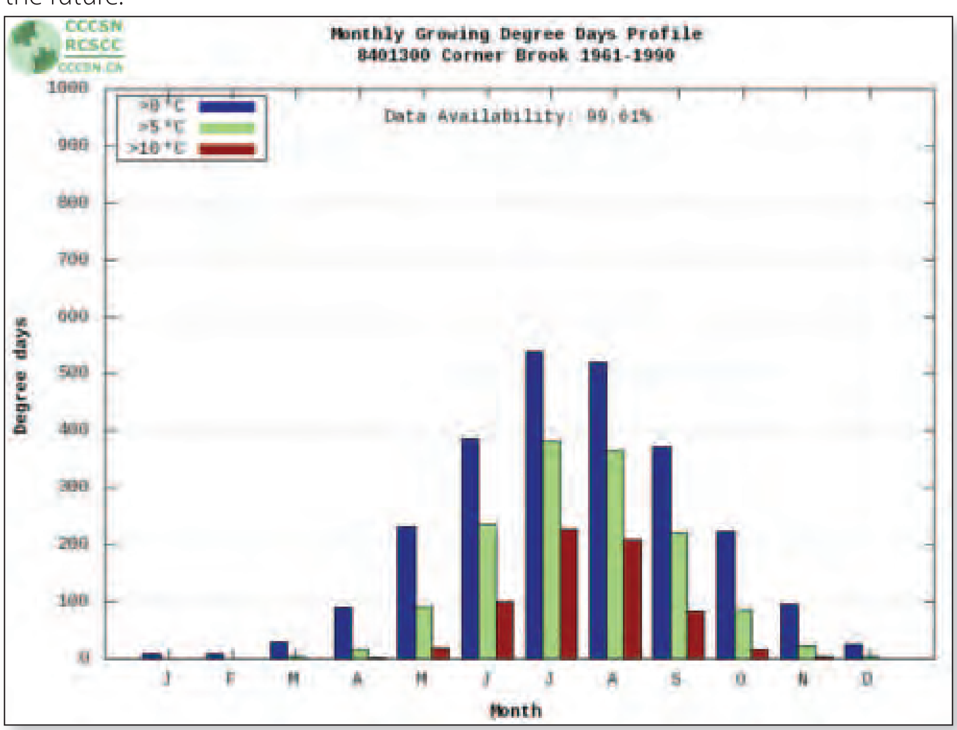
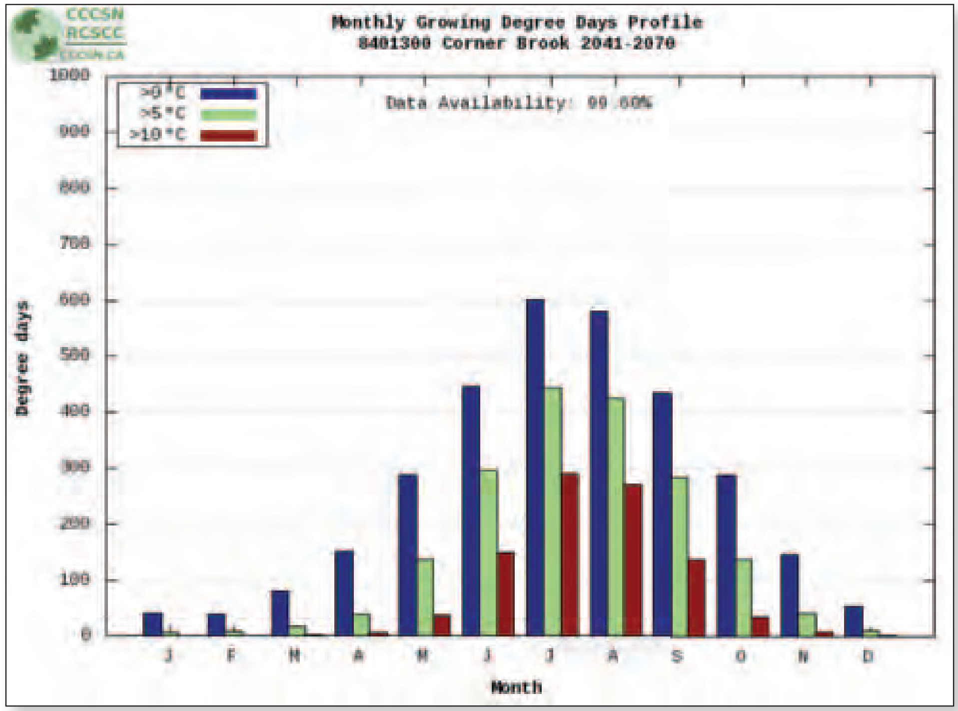


Figure 1: Monthly growing degree days profile for Corner Brook from 1961-1990.

Figure 2: *Monthly growing degree days profile modeled for Corner Brook for 2041-2070.*



Corner Brook Area Growing Degree Days: Baseline scenario (previous page) compared with a climate change scenario (upper graph) based on a balanced emphasis on all energy sources. Source: Generated by Canadian Climate Change Scenarios Network [on-line].

Public Education and Awareness Tools: The Southern Gulf of St. Lawrence

Since climate change affects everyone, public education and awareness are important considerations when developing a plan to deal with the impacts of climate change. Educating the public about potential hazards and ways to avoid them can help reduce risks in your community.

There are various ways to educate the public about the hazards of climate change. You can use brochures, leaflets and newsletters to outline risks and suggest ways to cope with them. You can also present information through public media outlets such as your local radio and television stations or through web-based news providers. Workshops, conferences, training programs and online courses are other ways of providing information to the public.

The Southern Gulf of St. Lawrence Coalition on Sustainability (Coalition-SGSL) uses many methods to inform the public of coastal erosion hazards and to suggest preventative actions. They produce and distribute a variety of print materials and maintain a website where these documents are available for download. One good example is a recent brochure describing the effects of coastal erosion on people and habitat: it identifies regional hazards related to coastal erosion and provides suggestions on how to plan for the future to minimize their impacts. Since printed material may not be an effective form of communication for all residents, Coalition-SGSL is exploring the option of using radio broadcasts as a way to reach a greater percentage of the population.

Geographic Information Systems (GIS) are proving to be very useful aids to public education. With GIS software, different scenarios can be illustrated using maps and other imagery to show the public where risks may be present. The Province of Prince Edward Island used GIS to help predict areas at risk of coastal flooding. Flooding scenarios were layered over maps of Charlottetown to determine areas at-risk. These maps are being used for planning and adaptation purposes and one has been mounted on the city's website to raise public awareness of flood zones.

For additional information:

Southern Gulf of St. Lawrence Coalition on Sustainability (Coalition-SGSL)

Website : www.coalition-sgsl.ca

Coastal Erosion Monitoring and Education Program (CEMEP)
webpage: coalition-sgsl.ca/CEMEP.php

Southern Gulf of St. Lawrence Coalition on Sustainability. *Coastal Erosion: Impacts on People and Habitat*. (Shippegan, NB: Universite dé Moncton, Campus de Shippegan). Brochure.

(Available online at coalition-sgsl.ca/webcura/files/242078_cemepbrochure.pdf)

McCulloch, M., Forbes, D.L., Shaw, R.W. and CCAF A041 Scientific Team. *Coastal Impacts of Climate Change and Sea-Level Rise on Prince Edward Island - Synthesis Report*. (Ottawa, ON: National Research Council of Canada, 2002).

(Available online at: www.nrcan.gc.ca/earth-sciences/projdb/pdf/56a_e.pdf)

City of Charlottetown
Website: www.city.charlottetown.pe.ca
See also: www.city.charlottetown.pe.ca/maps/city_flood_risk_areasb.pdf

Logy Bay - Middle Cove - Outer Cove Case Study

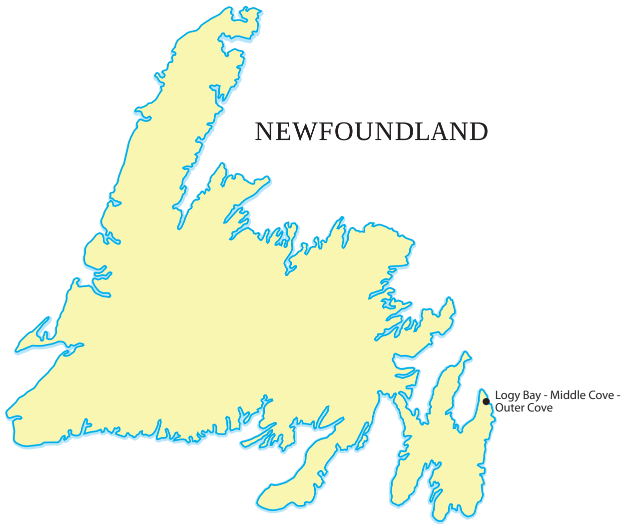


***Figure 1:** Location of Logy Bay-Middle Cove-Outer Cove*

The Community

Logy Bay-Middle Cove-Outer Cove (LBMCOC) is located on the northeast side of the Avalon Peninsula, near the City of St. John's (Figure 1). These three communities have been an amalgamated municipality since 1986, but permanent settlement began in the early 1800s by Irish immigrant fishermen and farmers.

The area has retained a predominantly low-density, rural residential character despite its proximity to the city. It is also a regional tourism destination: Middle Cove's pebbly beach attracts thousands of visitors annually. Many people also visit the area to hike the East Coast Trail and tour Memorial University's Ocean Sciences Research Centre.

Climate Change and Community Vulnerability

LBMCOC has a maritime climate, with short, cool summers and long winters. Regional climate projections indicate that there may be an increase in annual average temperatures, the number of frost-free and growing degree days, as well as an increase in precipitation amounts throughout the year and heavy rain events. Data from an Environment Canada climate station that existed in the community from 1969-2004 suggest there was a slight warming trend in LBMCOC over that period. Residents say they have noticed an increase in rain, especially heavy rain events in the fall, and that annual snow amounts seem more variable than in the past.

Members of the community have identified several areas of concern, including rogue waves and bluff erosion at Middle Cove (Figure 2); historic landslides in Outer Cove; upstream development impacts on river water quality and quantity; and an increase in the number and intensity of fall and winter season

Photo: Norm Catto

***Figure 2:** Waves are causing ongoing erosion along slopes in front of the beach at Middle Cove.*

Figure 3: The Savage Creek Bridge over Outer Cove Brook floods regularly, as seen here following Hurricane Igor. The bridge is slated for replacement.

Photo: Adele Carruthers

storm events. More variable winter conditions, with increased temperature fluctuations, may create challenges for community snow clearing, making it necessary for them to change techniques. Freeze-thaw cycles already contribute to potholes and other road deterioration throughout the community and these conditions are expected to worsen in years to come.

Relative sea level is rising by approximately 3mm annually on the Avalon Peninsula; this is one of the most significant natural risks for Northeast Avalon communities. Increased wave action and precipitation may accompany more frequent, intense storms, increasing the risk for areas that are vulnerable to coastal erosion.

Dr. Norm Catto of Memorial University of Newfoundland, has evaluated shoreline sensitivity to erosion and petroleum contamination throughout the Northeast Avalon. He found that Middle Cove and Outer Cove are highly sensitive to erosion with moderate vulnerability to petroleum spills.

There have been many instances of river flooding in Logy Bay-Middle Cove-Outer Cove. Outer Cove was included in a 1996 flood risk study completed under the Canada-Newfoundland Flood Damage Reduction Program. The resulting Flood Information Map designated three, highly localized inland 1:20 year flood zones, noting that they were a consequence of undersized culverts and high flows attributed to heavy rain or snow melt.

Over the last decade, members of the community have reported an increase in the extent of flooding during the spring thaw, and more severe flooding during major storms. Access routes have increasingly been affected: for example, Hurricane Gabrielle caused the closure of the Savage Creek Bridge over Outer Cove Brook in 2001, and the bridge has flooded regularly since then (Figure 3).

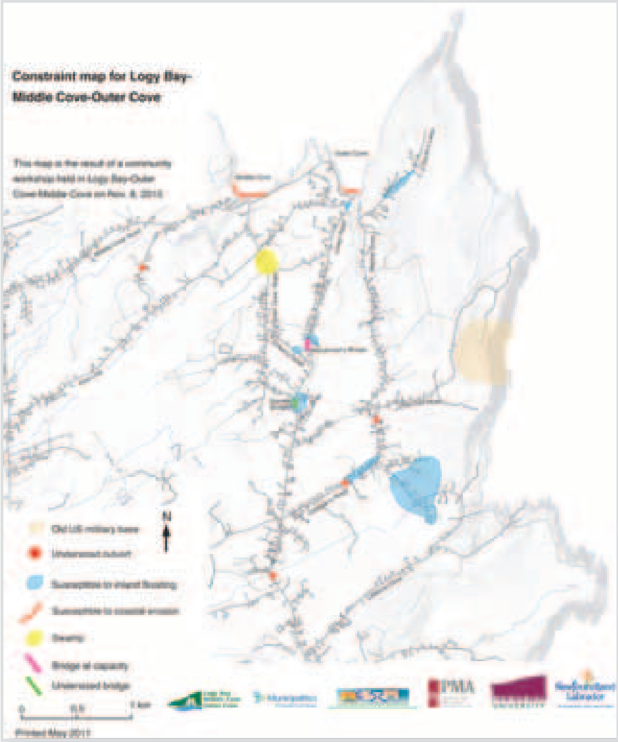


Photo: Adele Carruthers

***Figure 5:** Constraint map for Logy Bay- Middle Cove-Outer Cove.*

The 1996 flood risk mapping study identified several culvert upgrades needed to address flooding in Outer Cove; some infrastructure improvements have since been made. Historically, heavy rains coupled with an accumulation of debris at bridges and culverts have resulted in flooding. Increasingly; however, local flooding is being attributed to increased development which accelerates runoff to generate flash stormwater flows, overloading the older LBMCOC drainage infrastructure. During a regional forum on climate change adaptation, hosted by Municipalities Newfoundland and Labrador in St. John's in 2009, LBMCOC town representatives noted that some of their flooding concerns may be originating with development 'upstream' in the neighbouring City of St. John's. Projected increases in rainfall and extreme events (fall storms) may compound these problems in years to come.

Local Climate Change Adaptation to Date

In May of 2010, the town council agreed to participate in the piloting of a climate change vulnerability assessment and adaptation planning workbook. Researchers completed the work through the summer and fall. In November, a team from Memorial University and the Department of Environment and Conservation held a community workshop to complete a vulnerability assessment on flooding.

Participants discussed key climate-related issues affecting LBMCOC and mapped vulnerable areas (Figures 4-5). Feedback on the session was positive: participants indicated that they had found it productive.

From Jan. to March 2011, the research team investigated assessment and adaptation options and presented the findings to committee and community members in April 2011. The town, in consultation with the Water Resources Management Division of the Newfoundland and Labrador Department of Environment and Conservation, commissioned a study to update local flood risk maps and assess community drainage infrastructure.

Culvert maintenance and replacement with new and/or larger culverts has helped mitigate some flooding issues. Residents often clear culverts that are blocked with debris, or they notify the town if they need help.

In the event of major flooding, road or bridge closures could isolate areas in the community. One piece of infrastructure in particular, the Savage Creek Bridge located at Logy Bay Road and Outer Cove Brook, would be impassable. This is the shortest route between Logy Bay and Middle Cove-Outer Cove; if emergency vehicles were forced to use an alternate route, it would significantly increase their response time.

The town council has concluded that they must be proactive concerning the things they can control within their municipal boundaries. Their experiences with adaptation planning highlighted the importance of identifying the impacts of future development in order to prioritize capital works projects. Their existing municipal plan also makes reference to preventing development in sensitive areas, like wetlands, and protecting waterways.

As well, through their emergency planning, they have identified strategies for communication in the event of a flood.

Next Steps and Opportunities

The community plans to evaluate the following adaptation options:

- Rezoning vulnerable areas;
- Lining ditches with rock and material designed to reduce the velocity of flows;
- Diverting flows from waterways that are more susceptible to damage from flood events (e.g. damming, storing overflow);
- Establishing more routine checks on existing culverts and bridges to keep the areas clear of debris and tree falls; and
- Investigating a municipal wetlands stewardship agreement with the Department of Environment and Conservation.

The town will also continue to seek improved inter-municipal policies and cooperation with the City of St. John's, especially since the City is undertaking a municipal plan review in 2012-13. Upcoming regional land use planning processes for the Northeast Avalon may also present the town with opportunities to address flooding and other development related issues.

In early 2012, an up-to-date municipal flood risk study will be available for LBMCOC. A contracted engineering firm, guided by the Water Resources Management Division of the Department of Environment and Conservation (Gov NL) and paid with Gas Tax funds, will provide a detailed assessment of infrastructure and vulnerable areas throughout the town. The town council will use that information to amend their municipal plan and regulations by designating 'no-build' and conservation zones; establishing a zero net run-off policy; and otherwise managing development to reduce flood risks into the future.

Photo Credit: Kimberly Bittermann

For further information:

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Policy and Planning Division
Department of Environment and Conservation
Government of Newfoundland and Labrador

P.O. Box 8700
St. John's, NL A1B 4J6

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Website: www.env.gov.nl.ca

August 2012

Everyone's a winner – Alternate route planning for the Cain's Quest Endurance Race

An Economic Driver

Promoted as a feature opportunity for adventure tourism, Cain's Quest Endurance Race across Labrador is the longest snowmobile endurance race in Canada. Since its inception in 2006, it has brought attention and investment to the region and has grown in participation, international status and prize money.

Photo Credit: sgc-sleditor.blogspot.com

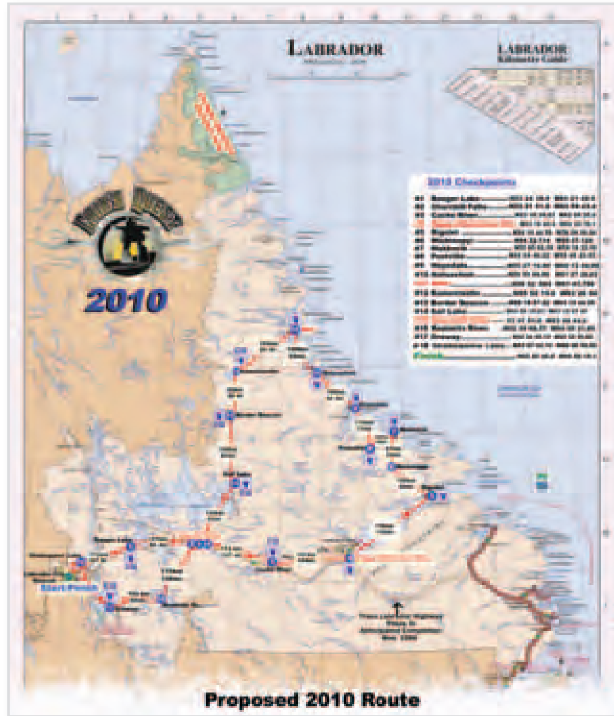
The start line for Cain's Quest 2012 in Labrador City, where according to Todd Kent, Co-Chair, Cain's Quest Committee, 35 teams embarked on "one of the biggest snowmobiling events on the globe".

From hotels to restaurants, gas stations and supply stores, Cain's Quest continues to rev the economic engine of Labrador in the winter season.

The Honourable Keith Hutchings, Minister of Innovation, Business and Rural Development, Press Release 2012

Climate Casualty

A snowmobile race of the length and calibre of Cain's Quest relies entirely on safe ice and snow conditions in order to operate. The 2010 race route was set to take participants from the start point in Labrador City to Happy Valley-Goose Bay, along the coast of Nunatsiavut and then back across the interior to Labrador City. Unfortunately, the winter of 2010 was abnormally warm, which had a major impact on accessibility along the 2010 race route, and 8 weeks before the race date the organizers were forced to cancel.



The traditional route for the Cain's Quest Endurance Race starts in western Labrador, crosses the interior, heads north on the coastal ice and then returns along an inland route to Labrador City.

No one knows the full impact of the race cancellation on the local economy, but it was clear that for its national and international reputation the event could not sustain a second cancellation. The added fact that the local organizing committee took a loss of $75,000 on the cancellation meant that it was more important than ever that the race go ahead in 2011.

For the past two weeks, ice conditions along the coast have been steadily deteriorating and rivers and lakes have been opening up. Organizers feel that…it would be unsafe to proceed as planned...

Cain's Quest press release, February 17, 2010

Planning for Uncertainty

With early indications of a late and potentially mild winter for 2011, the Cain's Quest Committee set about planning an alternate route. Key to the new route were reliable, safe travel conditions, especially on ice, and the availability of a layover checkpoint that had the capacity to host all of the racers, volunteers and media. The selected route covered 2300 km from Labrador City to Kuujjuaq, Nunavik, the layover checkpoint, and back through a major checkpoint in Schefferville, Quebec.

Initially the alternate route for 2011, unsafe travel conditions forced the Cain's Quest Committee to select the Kuujjuaq route over the traditional one.

By the time of the race in March 2011, conditions along the North Coast had failed to improve and the Kuujjuaq route was activated. One of the consequences of adopting a largely remote route was the requirement for all racing teams to carry their own fuel – normally fuel was available at communities checkpoints – making the race markedly more difficult than in previous years. The response from participants, however, was incredibly positive.

The weather can really get in your way, but you just have to adapt.

Todd Kent, Co-Chair, Cain's Quest Committee

The additional cost to create an alternate race route for 2011 was minimal and primarily in staff hours, whereas the benefits were substantial and incremental – for example, a hybrid course containing components of the traditional and alternate routes was adopted for Cain's Quest 2012. The sensitivity of annual outdoor winter events to weather conditions appears obvious, but then who would believe that March snow/ice conditions would be unsafe for snowmobiling in Labrador! Changing climate in Labrador will mean more seasonal variability and unusual weather conditions – planning for such variability is key to successful adaptation.

Information Sources

Thanks to Todd Kent (Cain's Quest Committee).

For more information:

Policy and Planning Division
Department of Environment and Conservation
Government of Newfoundland and Labrador

P.O. Box 8700
St. John's, NL A1B 4J6

Tel: (709) 729-0027

Website: www.env.gov.nl.ca

August 2012

Adapting to Climate Change: Slope Movement Corner Brook, Newfoundland and Labrador

Figure 1: Location of Corner Brook, NL

The Community

Corner Brook is located at the mouth of the Humber River on the Bay of Islands in Western Newfoundland (Figure 1). Permanent European settlement began in the steep-sided river valley in the mid-1800s. In 1956, it was amalgamated with the neighbouring communities of Corner Brook East, Corner Brook West and Curling to become the City of Corner Brook.

Today, Corner Brook is the major service centre for the western half of the island of Newfoundland. It is the second most populated area of the province after the Northeast Avalon Peninsula. Close to 20,000 people live in the city and nearly twice that number live within easy commuting range. The mill is still a prominent local employer, but according to Statistics Canada, more people now work in health care and social services than in any other sector.

Corner Brook promotes itself as a year-round tourism destination. The Marble Mountain ski resort is an important regional attraction, and snowmobilers and skiers enjoy the backcountry outside the city.

Climate Change and Community Vulnerability

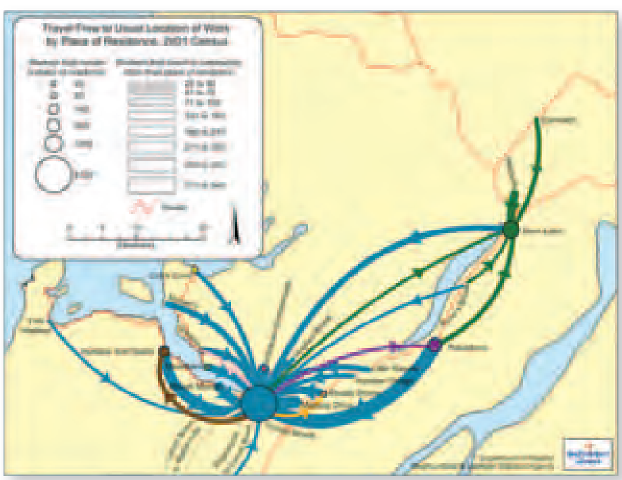
Corner Brook has a semi-maritime climate with warm, relatively dry summers, and winters with plenty of snow. Climate models indicate that there will be increased rain in the area in coming years and residents are already reporting more frequent storms and heavy rain. Other projected regional climate changes include: warmer average temperatures; more variable conditions, including more rain-on-snow events; and more frequent and extreme storms. Consequently, researchers expect there to be more frequent river flooding and slope instability in the area.

Climate change scientists expect rising sea levels, compounded by storm surges and high tides, to increase coastal vulnerability in the area; flooding and erosion have already impacted low-lying areas. Heavy rain, including rain-on-snow events, has caused flooding along the four main watercourses in the city. Also, building construction and paving on higher ground have increased water run-off volumes and triggered flooding below in areas where the drainage infrastructure was unable to cope with the heavier flows.

For the Corner Brook area, projected climate changes could have advantages as well as disadvantages. Research suggests that while there will be a net increase in regional snowfall, there will also be a trend towards more frost free days and milder winters. These conditions could lead to extended growing and construction seasons. As well, a decrease in the extent and duration of sea ice could create the potential for marine travel to Labrador. More variable winters, however may create challenges for snow clearing and increase the incidence of freeze-thaw damage to roads. Winter tourism may also be affected by the changing conditions.

Corner Brook is sensitive to slope movement. The urban area has a bowl-like topography with many steep slopes. Records show that since the late 1800s, landslides, rockfalls and avalanches in Corner Brook and the Humber Arm area have repeatedly caused major property damage and even fatalities. As the city continues to expand, developers are finding it more difficult to obtain land that is not affected by slope movement issues. Development below slopes comprised of loose sediment or fill are at a heightened risk from slope failure.

Changes in the regional climate will likely increase the risk of slope movement in the future: freeze-thaw cycles can destabilize boulders; heavy rainfall can add weight to slopes leading to failures; and heavy snowfall can cause avalanches. Human activity and the pressure of development can further increase the risk of slope movement. Buildings and other infrastructure constructed on slopes can destabilize terrain and cause slope failure. Similarly, snowmobile use on steep, snowy areas can (and has) caused avalanches in areas surrounding the city.



Data source: Department of Finance, Newfoundland and Labrador Statistics Agency.

***Figure 2:** Travel flows to and from work in the Corner Brook area.*

Slope movement has occurred throughout the city and along the local coastline, including Curling, Riverside Drive, Hillview Road and Humbermouth. While not all events have serious consequences, slope movements can be disruptive and dangerous. For instance, Riverside Drive has been closed twice because of slope movement: in 1994, construction work on the Trans-Canada Highway triggered slope failure and flooding, causing a landslide, and in 1995, heavy rain triggered a rockfall. On both occasions people were unable to use this normally busy roadway to travel to Corner Brook for work and other essential services (Figure 2).

Local Climate Change Adaptation to Date

In the past, the city has tried to reduce the impacts of slope movements using engineered adaptations such as retaining walls, gabion baskets (thick wire containers filled with stone and stacked against a slope), and drainage trenches. Since 1995, this has included a program of active remediation to protect the Riverside Drive area from slope failure (Figure 3).

Particular locations at risk of slope movement in Corner Brook may not change significantly in the future, but the risk of slope movement occurring at these locations may increase. The municipal plan for the City of Corner Brook (1994-2004) prohibits development on lands with natural environmental hazards such as poor drainage, flood susceptibility, erosion, steep slopes or any other physical condition that could endanger human life and property.

Although development controls within the city have become more stringent over time, Corner Brook still has to cope with aging infrastructure built in accordance with former building standards, terrain and drainage conditions. As a result, older

Data source: N. Catto.

***Figure 2:** Remedial measures – Humber Road, Riverside Drive area, Corner Brook. The city installed a storm drain (lighter disturbed ground to left) following a slope failure triggered by a single rain-on-snow event in March 2003.*

parts of Corner Brook may be at increased risk. Repairing, upgrading and maintaining retaining walls and other forms of slope stabilization can be costly for residents and the city.

Corner Brook has an up-to-date emergency plan. In the event of a disaster, the area is well-served by emergency, police, ambulance and health services.

Corner Brook was among the communities consulted in the earliest stage of developing the climate change vulnerability assessment workbook, "7 Steps to Assess Climate Change Vulnerability in Your Community." As an urban municipality, Corner Brook is responsible for a large portfolio of infrastructure which poses challenges for adaptation planning. At a 2009 climate change adaptation workshop, city staff expressed interest in obtaining updated flood risk mapping and better criteria to support risk assessment. Despite having in-house planning capability, the city must sometimes bring in external expertise to help it address some of the challenges created by climate change.

As part of an adaptation planning workshop in September 2010, residents, municipal and provincial government staff, representatives from Sir Wilfred Grenfell College and local environmental organizations identified areas vulnerable to flooding and to slope movement. Participants agreed that further mapping, technical support and provincial guidelines were needed to support local decision makers. They also noted that the public's reluctance to accept that climate change is having a direct effect on issues such as flooding and slope movement presents a significant challenge for municipal officials.

Next Steps and Opportunities

During the piloting of the vulnerability assessment workbook, representatives of the City of Corner Brook and other workshop participants suggested ways to improve climate change adaptation planning. City staff expressed a need for more data regarding the local physical environment, particularly in the form of geotechnical analyses and updated flood risk mapping. Workshop participants suggested that more in-depth information would help city staff make more informed development decisions and would also help the staff explain these decisions to permit applicants. Another suggestion was to develop tougher standards to guide how development permits get approved in Corner Brook. As conditions change, it will become increasingly important for city staff to enforce regulations and regularly examine properties with steep slopes to ensure that proper drainage and stabilization requirements are met.

Workshop participants noted that disseminating knowledge and information is critical. Residents need information on how climate changes are affecting their city, how those changes may impact their day-to-day lives, and what they can do to prepare. Participants suggested that city staff explain drainage and slope movement to residents in an easy-to-understand way: for example, by hosting focus groups and workshops, and creating print materials that outline factors to consider when choosing a safe place to build or develop. They also recommended that, when doing community education and outreach, city staff try to include banks, financiers, insurance firms and other companies and organizations that can influence residential development practices.

Data source: Kimberly Bittermann.

Figure 2: *Community mapping in Corner Brook*

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August 2012

Adapting to Climate Change: Coastal Flooding Ferryland, Newfoundland and Labrador

***Figure 1:** Location of Ferryland*

The Community

The Town of Ferryland is located 65 km south of St. John's on the east side of the Avalon Peninsula between Calvert Bay and Aquaforte Harbour (Figure 1). The local population was 465 in 2011, a decrease of 12% since 2006. The area's long history includes occupation by the Beothuk, and visits by French, Spanish and Portuguese migratory fishermen through the 1500s. Sir George Calvert, the first Lord Baltimore, established the year-round European settlement of Avalon here in 1621.

Today, this rich history plays a major role in Ferryland's local economy. The Colony of Avalon, which includes an ongoing archaeological dig and local artifacts dating back to the 1500s; the Ferryland Museum; the Holy Trinity Church, built in 1865; the Ferryland Lighthouse and associated picnic enterprise, all contribute to the town's appeal as an important tourism destination in the region. Police and medical services for the Southern Shore are based there as well.

Climate Change and Community Vulnerability

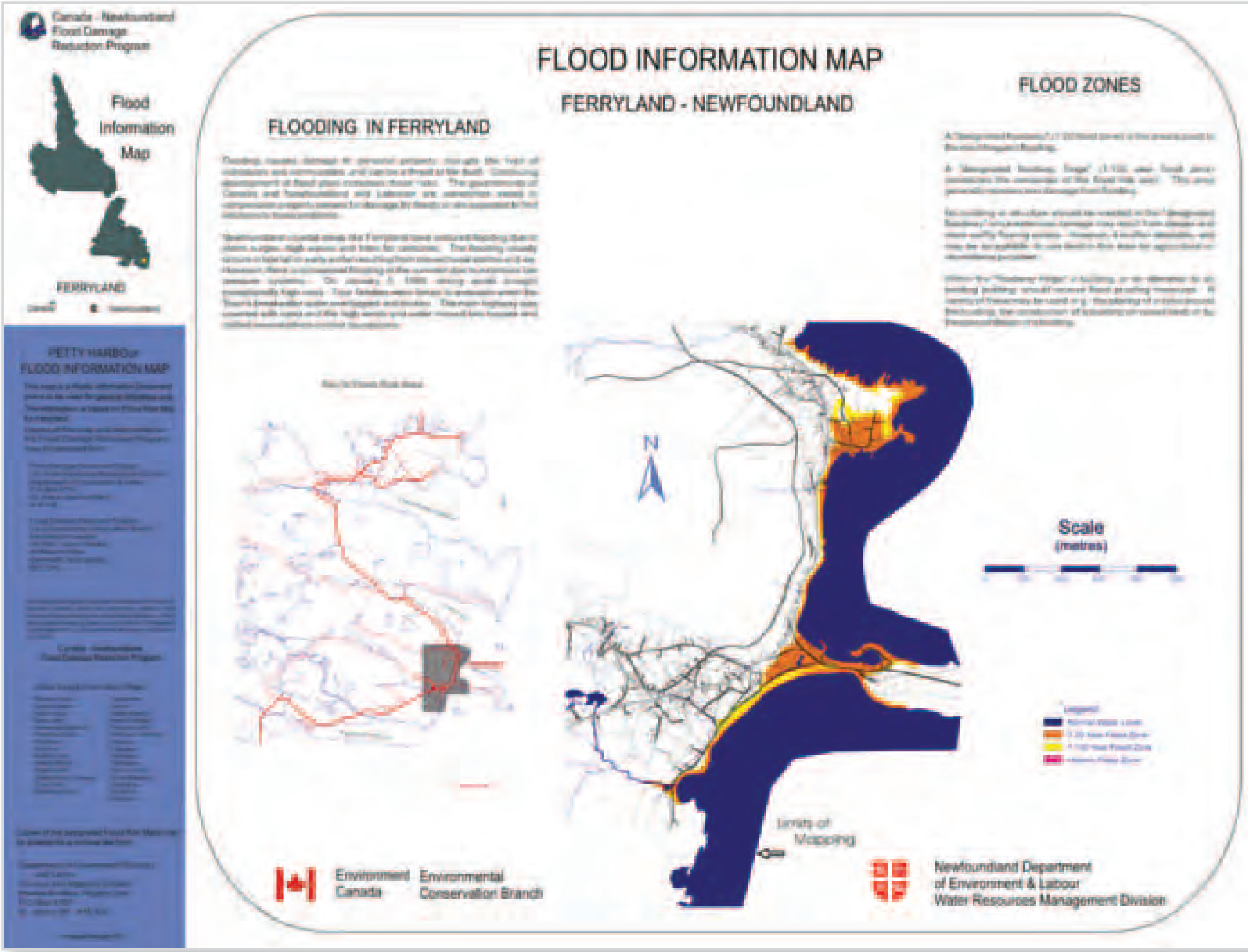
Ferryland has a strong maritime climatic influence, with short, cool summers and long winters.

Residents describe the winters as becoming warmer, milder and generally producing less snow than in the past. Since the 1950s, it has rarely snowed before December, with most of the heavy snow occurring from January to March. In recent years, however, there has also been an increase in rain and sleet during the colder months. There are stronger winter storms and more damaging waves. At present, based on tide gauge data, the rate of sea level rise is estimated at 3 mm per year1. The sea level is especially high when there is a northerly wind. Residents of Ferryland describe their summers as cooler with increased precipitation. They also describe greater rainfall in the spring and fall.

There has been more surface water in areas where haying used to occur, suggesting that the water table has increased. Heavy runoff can colour the town's drinking water since the municipal treatment system, developed in 1990, does not have a means to remove sediment. It isn't unusual for Ferryland to be placed under a few short-term boil water advisories in a given year. They are typically caused by electrical failures or heavy rains.

Land-based flooding occurs in the community, especially at the areas locally known as Arthur's River and Merrymeeting. It is caused mainly by snowmelt and blocked drainage ditches. A bridge near Calvert frequently floods during heavy rains, but water levels quickly recede when precipitation ceases. Heavy rains also caused a landslide near Calvert at least 20 years ago, blocking the Southern Shore Highway. Minor rockfalls have occurred along the former railbed in Ferryland but, overall, slope movement is not a great concern in the community.

[1] *N. R. Catto, Coastal Erosion in Newfoundland, (St. John's, NL: Department of Geography, Memorial University, 2011).*



Source: www.env.gov.nl.ca/env/waterres/flooding/ferryland_pi_map.pdf

***Figure 2:** Ferryland Flood Information Map (1997)*

The community's coastal issues are also beginning to affect its key tourism attractions. A narrow peninsula that juts out from the southern end of the town (Figure 2) protects Ferryland Harbour to the north from the full force of Atlantic Ocean waves, that run up instead at the 'Backside' of this natural breakwater. The backside is the narrowest part of the peninsula, and the town has tried to protect it by introducing a variety of engineered erosion control measures over the last couple of decades. The Colony of Avalon, the Folk Arts Centre and several houses are located a short distance away beside the traditional anchorage known as the Pool. A single access road runs from the Southern Shore Highway past the Pool and continues east to the Ferryland Lighthouse at the very end of the peninsula.

The Pool Road has been subject to more intense coastal flooding and erosion, particularly during the winter months. On January 5, 1989, strong winds and high seas created storm waves large enough to overtop the peninsula at Backside, damaging the road. Four families had to be evacuated from the Pool area. When the combined action of wind and water moved two houses and shifted others on their foundations. The storm also deposited sand and water on the adjacent Southern Shore highway. On record there are only two other storms that compare to the 1989 storm; one in October of 1955 and another in January of 1977.

Engineers completed flood risk mapping for Ferryland as part of the Canada-Newfoundland Flood Damage Reduction Program. The resulting map, produced

Photos: N.R. Catto

***Figure 3:** Storm damage, 2004 (Left), temporary wooden barrier, in place after storm in Dec. 2009 (right).*

in 1997, was based on the prior thirty years of water level and meteorological data. It designates narrow 1:20 year and 1:100 year flood zones along the entire shoreline of the community. The engineers also mapped more extensive floodplains, to the north side of the Ferryland Harbour and in the Backside/Pool area.

Local Climate Change Adaptation to Date

Coastal flooding and erosion are key concerns for Ferryland, with the Backside, the Pool and the Avalon archaeological site at greatest risk.

Ferryland residents observe that stronger waves and higher tides are contributing to more serious coastal issues. The Town of Ferryland lacks the financial resources needed to keep pace with increasingly frequent infrastructure damage. In February 2004, nearly one-third of the 165-metre seawall running along Pool Road had to be replaced due to damage from a powerful storm.

In December 2009, a storm washed away 150 metres of cribbing and a section of the same road. In April 2010, Ferryland received $120,000 from the province to repair the seawall and the Pool Road in time for the tourism season. The town installed armour at the time, but this proved insufficient; high seas washed the road out again on Christmas Eve. In addition to these cost-shared public measures, local adaptations to coastal flooding have included the relocation of several private residences.

During a regional forum on climate change adaptation, hosted by Municipalities Newfoundland and Labrador in late 2009, Ferryland's mayor expressed interest in piloting a climate change vulnerability assessment workbook, '7 Steps to Assess Climate Vulnerability in Your Community'.

On November 18, 2010, the town hosted its own adaptation workshop with the help of a facilitating team from Memorial University and the Department of Environment and Conservation.

Six community members, including the mayor, town clerk, members of council and residents, attended to identify, discuss and map local coastal issues. Participants discussed key climate-related issues affecting Ferryland and mapped at-risk areas. The participants also examined ways in which coastal issues could change in the future. The workshop concluded with a discussion of potential adaptation options.

Feedback on the session was positive; participants indicated that they had found it productive and informative. Mayor Leo Moriarty said, "It was a good process to go through, no matter what your local issues may be. For us, it was more than 'the breakwater is gone again.' It helped focus our attention on the causes and longer term solutions."

Next Steps and Opportunities

The Town of Ferryland completed a municipal sustainability self-assessment in 2008. While financially stable and maintaining satisfactory fire protection, emergency response, drinking water, and waste management systems, the community did not have an emergency preparedness plan. Since serious storm events can flood and/or damage the Pool Road, the community recognized that its plan would need an emergency scenario that addressed the possibility of the peninsula being cut off from services. Similarly, it would need to address the needs of a growing number of potentially vulnerable older residents. The town completed its Emergency Plan in the fall of 2011.

Ferryland residents have also identified the need to prevent ATV use along beach areas, in order to decrease rates of coastal erosion. The town also noted that while the local Flood Information Map still accurately portrays the areas most at risk of flooding,

what is referred to as a 1:20 year flood return rate may need to be adjusted downwards to reflect more frequent flooding events.

The severity and number of storms is thought to be increasing in the region around Ferryland. Prior to the 2012 tourism season, the town once again repaired and improved its existing shoreline protection, with capital infrastructure assistance from the Department of Municipal Affairs. The town constructed a new 190-metre long seawall to protect the Pool Road, using a combination of large rocks and timber cribwork. In 2012, the town was also completing a review of its municipal plan, which will include consideration of climate change impacts and adaptation requirements.

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August 2012

Adapting to Climate Change: River Flooding Indian Bay, Newfoundland and Labrador

Figure 1: Location of Indian Bay, NL

The Community

The Town of Indian Bay is a small rural community located on the northeast coast of the island portion of the province (Figure 1). Early European occupation in the area dates back to the 1700s; permanent settlement began after 1800. The early settlers were loggers, fishermen and trappers. By the 1900s, logging was the main occupation in the region; however, an extensive forest fire in 1961 resulted in a near collapse of the industry. Commercial logging has resumed in the Indian Bay watershed, but is no longer a major source of employment in the area.

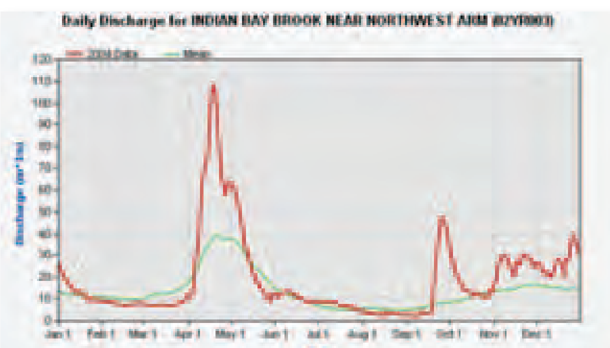
Like many rural communities, Indian Bay is facing the challenges posed by an aging, declining population. Fortunately, Indian Bay enjoys a rich natural and cultural heritage, making it a popular cottage, hunting and fishing area for local residents and visitors.

Climate Change and Community Vulnerability

Indian Bay typically has cold winters, warm summers and late springs. The extended spring season is due to the moderating effects of the cold North Atlantic Ocean and the persistence of sea ice. Residents feel the climate is changing: they describe wetter springs; shorter, drier summers; and milder winters with decreased snowfall and a shorter period of snow cover. Data collected from an Environment Canada climate station located in the town indicate that both annual and summer temperatures have increased since 1986. According to Environment Canada weather data from Gander, spring rains in the region have increased since the 1940s. These conditions have contributed to river flooding becoming the key climate change-related concern for the municipal staff, councillors and residents of Indian Bay. Some residents believe that certain infrastructure, like the bridge over Indian Bay Brook, may be contributing to flooding upstream. Also, the water levels in the area are no longer controlled by Bowater, a logging company that operated in the area, as their dams and gates were removed in 1967. These factors, in addition to increased water flows, could be contributing to more frequent and intense flooding in the area.

In addition to river flooding, other climate change-related concerns include coastal erosion, drinking water contamination, changing winter conditions and wildfires. Local residents believe rising sea levels, higher tides and severe storms such as Hurricane Igor have contributed to coastal erosion on the eastern shoreline of the town. Some residents are concerned that their drinking water could become contaminated by increased human activity in the backcountry and by a rise in water temperatures in the summer which could, for example, create more favorable conditions for algae growth. While warmer winters could reduce home heating costs, these warmer conditions could also lead to less snow-pack, thinner ice, and more frequent freeze-thaw cycles. In turn, these conditions may limit access to cabins and fishing areas as well as have a negative impact on backcountry safety. Finally, with drier summer conditions, residents also fear a recurrence of the disastrous 1961 wildfire, especially since the town is not equipped to deal with fires of that magnitude.

Regional trends in the last decade indicate an increased frequency of river flooding with the events now occurring approximately every two years. Minor floods were recorded in 2001, 2008 and 2010, with major floods in 2004 and 2007. Daily discharge data from 2004 (Figure 2) illustrate a typical peak in annual flows; in the spring of that year, rapid snowmelt and rain caused significant flooding. Important infrastructure and heritage areas at risk during floods include: the bridge and highway over Indian Bay Brook, the water pump house and treatment unit, the houses upstream of the bridge, the town church, the historic and current graveyards, the town park, and the campground.



Data source: Environment Canada

***Figure 2:** Daily discharge for Indian Bay Brook near Northwest Arm for January – December 2004 compared to the average for 1981-2009. Note the spring peak in discharges.*

Local Climate Change Adaptation to Date

In May 2010, the Town of Indian Bay agreed to participate in piloting a climate change vulnerability assessment workbook, '7 Steps to Assess Climate Change Vulnerability in Your Community' that was being led by Memorial University of Newfoundland (MUN) and the Newfoundland and Labrador Department of Environment and Conservation. The purpose of the pilot project was to test and further develop an adaptation planning workbook. From May through December 2010, a MUN research team gathered emergency and sustainability plans, maps, infrastructure and environmental studies, and relevant climate data.

The researchers also recorded local knowledge, interviewing long-term residents and seniors, the mayor, the town clerk and water personnel. They interviewed engineers and a geologist who was familiar with the area. The town hosted a workshop in December 2010 with the help of a facilitating team from MUN and the Department of Environment and Conservation. During the workshop, council members and residents used the adaptation planning workbook and the information gathered by the MUN research team to assess the vulnerability of the town. The research team then presented the information gathered and the results of the workshop to the community in April 2011.

In recent years, the citizens of Indian Bay have adopted a proactive approach to flooding, using sandbags and other low-cost strategies to minimize damage. Any time there is potential for flooding, residents monitor water levels, place sandbags and plywood around buildings and the graveyard (Figure 3), and use water pumps. Word-of-mouth is used to inform residents about potential flooding. These strategies have minimized flood damage successfully and, to a certain extent, protected infrastructure and the historic graveyard. If the extent of flooding increases, these

Photo: The Town of Indian Bay

Figure 3: *Sandbags have been used to minimize flood damage to the cemetery.*

strategies may not be sufficient, and the town would not have the resources necessary to implement more effective, long-term adaptation measures.

In the event of a major flood, road or bridge closures could isolate the community. If the Indian Bay Brook Bridge were to sustain major damage during a flood, people would be unable to reach nearby communities. Residents would have to travel significantly further to the Town of Gander to access regional services, work and shopping. To address the possibilities of emergencies caused by events such as floods or fires the Town of Indian Bay worked with the neighbouring Town of Centreville-Wareham-Trinity, in conjunction with this adaptation planning exercise, to complete an Emergency Response Plan (ERP). The ERP contains a section which lists, in detail, the actions that first responders should take to protect people, property and transportation routes in the event of a serious flood.

Next Steps and Opportunities

Through the climate change adaptation pilot project, the Town of Indian Bay identified several adaptation options:

- Strengthen restrictions and enforcement efforts related to woodcutting along the river bank;
- Plant supportive vegetation along the river bank to decrease erosion rates;
- Monitor conditions (water flows, erosion rates, tides) in the area and assess any changes over time;
- Install infrastructure such as a wall to protect the river bank, a dam to control water flow or culverts to divert water overflow; and
- Commission an engineering or hydrological assessment to determine current and future flood risks and the feasibility of adaptation options.

As a small rural community the Town of Indian Bay does not have the staff or the expertise to assess the feasibility of various adaptation options and lacks the financial resources needed to create and implement climate change adaptation plans. Therefore, unless the town collaborates with other partners, it may be limited to implementing the cost-effective measures that it has used in the past.

The Town of Indian Bay can make use of their existing local and regional partnerships with groups, such as the Indian Bay Ecosystem Corporation, the Kittiwake Economic Development Corporation and the neighbouring Town of Centreville-Wareham-Trinity to plan and carry out adaptation efforts. In 2010, the Town of Indian Bay partnered with Town of Centreville-Wareham-Trinity to prepare an Integrated Community Sustainability Plan (ICSP). In the ICSP they proposed that both communities prepare and implement a Natural Resources Stewardship Plan. In February 2012, the town of Indian Bay asked the Wildlife Stewardship Program, under the Department of Environment and Conservation, to draft a proposal for a Wetlands and Coastal Stewardship Agreement that would include management areas along the Indian Bay River. Through this agreement the town may find opportunities to reduce the impacts of flooding, such as land-use restrictions and re-vegetation.

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August 2012

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When the Tap Runs Dry – Climate Variability and Community Water Supply

Freshwater Demand and Supply

Port au Choix on the Northern Peninsula of Newfoundland has a flourishing tourism industry and a world-class fish plant, both of which are key components of the local economy. Although many external factors can affect the year-to-year performance of both industries, no one in the community thought that their operation might depend on the availability of tap water – until the summer of 2009.

Although Port au Choix has limited freshwater sources to supply local demand, it is rare for these sources to drop to extremely low levels. But a combination of reduced winter snowfall and a summer drought brought the town exceptionally close to a water crises.

The water supply for Port au Choix consists of three linked, precipitation-fed ponds and three artesian wells. The combined supply must support all of the homes and businesses in town, as well as the fish plant. Parks Canada independently supplies its Interpretation Centre with water from one of the three ponds.

It's just inconceivable to people like ourselves who've grown up in these rural areas and who've really not been exposed to those issues [drought] and never had really to pay for it [water]. We think it's an endless supply. We're surrounded by it - by lakes and ponds and the whole nine yards. So in our head, we can't run out.

Carolyn Lavers, Mayor of Port au Choix

Photo credit: M.A.P. Renouf

The Port au Choix Interpretation Centre serves 15,000 visitors each summer. Without running water it is unable to operate for health and safety reasons

Coping with Circumstances

In the summer of 2009, when both the interpretation centre and the fish plant were operating near full capacity, critically low levels in the town water supply resulted in a crisis. The winter of 2008-09 had been unusually warm with very little snow and both the spring and summer had been unusually dry. Faced with a tough choice – the closure of the fish plant and water rationing for residents or the closure of the Interpretation Centre – the Town finally decided to draw down on the Parks Canada water supply, leaving it temporarily without water and visitors.

Fortunately, the rains came sooner than later and water levels rose. The town had dodged the crisis, the fish plant remained open and residents were spared the worry and concern of water rationing. But according to the mayor, "people have always assumed that a freshwater supply would be there for them and this is something that will need to change".

Photo credit: Shirley Alyward

Extremely low water level in the pond that supplies water to the Parks Canada Interpretation Centre at Port au Choix (summer 2010).

Photo credit: M.A.P. Renouf

Known as the "fishing capital" of Western Newfoundland, Port au Choix boasts a large fishing fleet and a modern shrimp processing plant. The plant is a heavy user of freshwater in its fish processing operations.

Normally Nature will give us enough, but we had the very minimum of snow that winter and very low rain, so we didn't really have anything coming from Nature to replenish it.

Carolyn Lavers, Mayor of Port au Choix

Planning for Future Uncertainty

In the wake of the close call in 2009, Port au Choix councilors and Parks Canada took steps to reduce their exposure to future seasonal variability in precipitation by:

- Fixing the leak in the current town water supply to maintain its maximum storage capacity;
- Deepening the water intake in the supply pond for the Interpretation Centre so that a water source could be maintained during low water levels;
- Exploring new sources of groundwater, although newly drilled wells have produced brackish water, suggesting that the current use is at capacity; and
- Discussing alternate freshwater sources; for example, partnering with the neighbouring community of Port Saunders for access to their substantial water supply.

Photo credit: Shirley Alyward

In response to the 2010 summer water shortage, Parks Canada upgraded their supply facilities to operate effectively during low water levels.

Information sources

Thanks to Carolyn Lavers (Mayor, Port au Choix), Millie Spence (Manager, Port au Choix Interpretation Centre) and participants of the Adapting to Climate Change on the Great Northern Peninsula: Municipal and Regional Perspectives workshop held in Hawke's Bay, November 2010.

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Stockpiling Firewood – Coping with Unpredictable Sea-Ice Conditions

Lucky Coincidence

The winter of 2009/10 was anomalously warm in Nunatsiavut. It rained most of February instead of snowing, melting the snowpack, turning river, lake and sea ice to slush, and isolating coastal communities. The warm weather created numerous challenges for the northern communities which are adapted to cold winter conditions. One of those challenges was accessing the wood required to keep homes warm. Routes that were typically accessible by snowmobile and komatik, were no longer usable due to the warm conditions.

There was a lucky coincidence that year however, which ensured residents had enough wood to heat their homes. In 2009/10 there was also a public health scare associated with the H1N1 virus. In response to this scare, Provincial Government Ministers decided to barge firewood to isolated communities on the Labrador Coast. They feared that widespread infection would restrict normal firewood collection and by providing firewood, Government would guarantee the basic necessity of home heat during the Labrador winter. Construction of the Trans Labrador Highway, south of Happy Valley–Goose Bay, meant that there was abundant wood available for shipping. Thankfully, the H1N1 outbreak in Labrador was not as serious as first feared and the stockpiled wood was not in immediate demand. It was needed that winter however, when the conditions were too warm for traditional snow routes to be used to access firewood.

Photo credit: Gus Dicker

Above-freezing February temperatures in 2010 in Nain, Nunatsiavut, left skidoos stuck in the slush, hampering sea-ice travel along the coast and reducing accessibility to firewood and country food.

Sea Ice – the Weak Link in Firewood Collection

While some North Coast communities have firewood in fairly good abundance nearby, others do not. Hopedale, for instance, is mostly surrounded by winter sea ice and residents must travel more than 70 kilometres by snowmobile and komatik to collect quality firewood. As winter is the preferred season to collect firewood, the melted snow and softened sea ice of winter 2009/10 prevented many communities from accessing their wood sources.

It was a lucky coincidence then that communities had stockpiled firewood to tie them over until seasonably cold temperatures returned and sea ice travel was once again possible. The government decision to re-run the firewood subsidy program in fall 2010 was again farsighted because freeze up was delayed that following winter and communities could not access their firewood across open water. Unfortunately, winter conditions took longer to establish in 2010/11 and the stockpiled firewood did not last. Residents

The additional stress that climate change and anomalous winter events are placing on vulnerable Nunatsiavut households is striking. Coping on an annual basis is no longer adequate; long-term visions for climate change adaptation must be developed and energy security within homes is a critical component of this adaptation.

Tom Sheldon, Nunatsiavut Government

resorted to extreme measures to heat their homes, including burning furniture and clothing and using electric stove ovens as heat sources.

From Coping to Adaptation

Warmer Labrador winters are anticipated during the next several decades as part of the changing climate. The unusual winters of 2009 and 2010 are therefore likely to become the new normal winter condition over time. Nunatsiavut residents will need to adjust to this new reality to maintain or improve their living standards.

In the short term, stockpiling firewood is an effective coping strategy for heating homes, but is not sustainable or cost-effective going forward. In the long term, an effective adaptation strategy is needed that would provide Nunatsiavut homes with an adequate and dependable source of heat (e.g., electricity), independent of local sea ice conditions and firewood availability. Such adaptation planning is part of a broadly based community sustainability program, one element of which is the "InosiKatigeKagiamik Illumi: Healthy Homes" initiative that will design and build climate adapted, healthy homes in Nunatsiavut.

Photo credit: Rudy Riedlsperger

Hauling firewood across the ice and snow near Makkovik, February 2012.

Information sources

Thanks to Ron Bowles (Deputy Minister of Labrador Affairs), Collin Carroll (Director of Forestry for Labrador), Tom Sheldon (Director, Environment Division, Nunatsiavut Government), Wayne Piercy (AngajukKâk for Hopedale), and Rudy Riedlsperger (MA candidate, Memorial University).

Photo credit: Rudy Riedlsperger

Access to good quality wood, such as a forest burn area, may mean a trip of several hours that has to be repeated many times to secure enough firewood. With a powerful snowmobile, between 15 and 20 logs can be hauled at a time over the snow and ice trails. A typical family might need 200 to 250 logs to heat their home over the course of the year.

Photo credit: Rudy Riedlsperger

Houses in Nunatsiavut are heated by three main energy sources: wood, oil, and electricity. Access to firewood varies by community and depends on winter trail conditions. Cost depends on travel distance and fuel prices. The monthly cost of furnace oil per household in winter is over $600. Electricity is the preferred energy source for a variety of reasons from comfort to efficiency; however, according to homeowners, it is not necessarily available because of the limited supply capacity of the diesel-powered generators in communities.

Taking Advantage of Warmer Winters – Re-Thinking Snow-Clearing Contracts

Winters are Changing

Moderate to heavy snowfall typically characterizes Newfoundland and Labrador winters. Snow clearing contracts for important transportation routes are usually tendered on a per-season basis, with the assumption that snowfall frequency and amount require fairly consistent effort throughout the winter months. In some recent winters, however, snowfall amounts have been lower and the duration of the snow-clearing season shorter.

Although the Parks Canada Interpretation Centre at Port au Choix is only open seasonally, the road to the centre must be snow-cleared to allow access for emergency vehicles.

In response to these variable conditions, some organizations and small municipalities have changed their snow-clearing tender requirements to better reflect winter snow conditions. One example is Parks Canada at Port au Choix on the Northern Peninsula. Following the unusually mild and largely snow-free winter of 2009, local Parks Canada manager, Millie Spence, decided that a more cost-effective tendering strategy would be to switch from a seasonal to an hourly rate.

To make the transition to the new tendering system, Millie calculated the number of hours required for snow clearing in a heavy snowfall year – 70 hours – and then asked contractors to bid on an hourly rate based on a potential 70-hour season. This flexibility in snow-clearing contracts ensures that roads are maintained snow-free under a wide range of seasonal snow conditions and takes advantage of cost savings associated with mild winters.

The new tendering system has been very successful and much more cost-efficient than the previous one that was based on seasonal contracts.

Millie Spence, Parks Canada

Incorporating Flexibility in Planning

Adapting to increased seasonal variability, especially in winter, means being more flexible in how operations and infrastructure are planned. This is critical at the community and small municipality level where budgets are smaller and there is normally less capacity to absorb major change.

Adjusting the tender requirements for snow clearing is one example of flexible planning. Another was the decision by a Northern Peninsula municipality to replace their old snow-plough truck with one that could handle both snow-ploughing and ice-control, as they realized that with milder winters, they were spending much more time sanding and salting community roads than on snow-clearing.

Information sources

Thanks to Millie Spence (Parks Canada Interpretation Centre, Port au Choix) and participants of the ***Adapting to Climate Change on the Great Northern Peninsula: Municipal and Regional Perspectives*** *workshop held in Hawke's Bay, November 2010.*

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August 2012

Municipality of the Town of Yarmouth Climate Change Case Study

Key facts

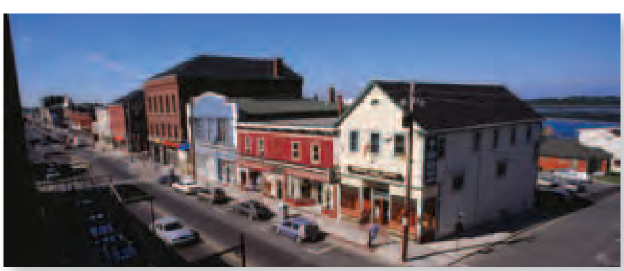
Population	6,761
Total private dwellings	3,539
Land area (km^2)	1,056

Yarmouth Harbour stretches 7.2 km along the town's western coastline.

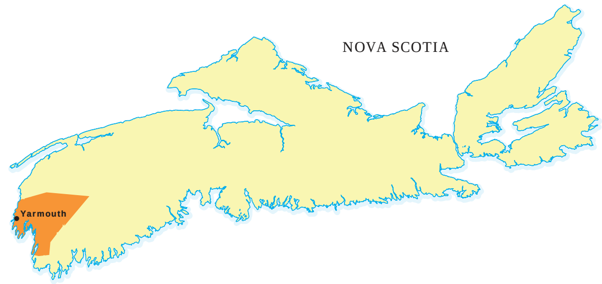
The Municipality of the Town of Yarmouth is the regional hub of southwestern Nova Scotia. The heart of the Yarmouth's economy is its waterfront, home to fisheries and marine-based industries. This includes two major fish plants, port facilities, and a ferry terminal. A wastewater treatment plant at one end allows for a commercial clamming industry.

The Town of Yarmouth is highly sensitive to extreme weather events, and officials, staff and residents have a heightened awareness about the potential impacts on infrastructure and property from increased storm activity, storm surge and sea level rise.

Storms have washed out bridges; stream overflow has affected sewers, Milton Dam, the wastewater treatment plant, and the Town's primary waterway, Broad Brook.



One block below Main Street (pictured) is Water Street, which experiences flooding usually more than once every year.



Critical Issue: Waterfront Infrastructure

Yarmouth is very sensitive to impacts on its coastline. Waterfront infrastructure – within 6 meters of sea level – accounts for $22.8 million of a total estimated infrastructure value of $36.5 million. This infrastructure is vulnerable to both sea level rise and storm events, including:

- 4.1 cm average sea level increase per decade, historically
- up to 173 cm total relative change projected by 2100
- 481 cm CGVD28 water level during Groundhog day storm, 1976 (bench storm event)
- 603 cm CGVD28 projected worst case scenario

The Municipality partnered with the Atlantic Climate Adaptation Solutions (ACAS) Program to help examine these issues in further detail and prepare for change.

Dalhousie University School of Planning also conducted many climate change impact studies relevant to Yarmouth through the ACAS project. Through a local inventory of social assets at risk, for example, Dalhousie identified Yarmouth South as the Town's most vulnerable population. This vulnerability is magnified by southern area's flooding problems from heavy rainfall (as water makes its way through the Broad Brook watershed system). The study suggested that upgrades to the storm water system throughout Yarmouth South could help minimize these impacts. Other potential impacts identified by Dalhousie included:

- employment/income loss from waterfront businesses affected by sea-level rise and storm surges events.
- access to the Regional Hospital may be impacted as sea-level rise and storm surge events impact the Milton Bridge and the Milton Dam.

Sea level rise

Historical (century)	Projected 2020s	Projected 2050s	Projected 2080s
+41 cm	+15 cm (±3)	+43 cm (±15)	+83 cm ± (36)

The Cape Forchu Lightstation stands watch over Yarmouth's coastline.

Through its involvement with the ACAS Mentor project, The Town of Yarmouth established a Climate Change Action Plan (CCAP) Committee to develop its Municipal Climate Change Action Plan. Committee membership was comprised from:

- Town Planner
- Town Engineer
- GIS Technician
- CAO
- Waterfront Development
- Emergency Measures Office
- Councilor
- Planning Advisory Committee Member
- Director of Finance
- Tusket River Environmental Protection Association (TREPA)

Water Street beautification investments are vulnerable to coastal impacts.

Working collaboratively, the CCAP Committee identified a number of adaptation options for consideration in response to storm surges and sea level rise, including:

1. Amendments to MPS/LUB to safeguard developments
2. Study of Waste Water Treatment Plant
3. Redevelopment plan for upgrades of Milton Dam
4. Redevelopment plan for upgrades of Milton Bridge
5. Plan to safeguard Water Street developments, such as upgrades to seawalls and creation of retention ponds in strategic locations
6. Study and implement environmental safeguards for storm sewer outfalls into Yarmouth Harbour and the lake system.
7. Revise Emergency Management Plan in light of potential effects
8. Cooperative work with the Municipality of the District of Yarmouth to minimize impacts

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Municipality of the Town of Cumberland Climate Change Case Study

Key facts

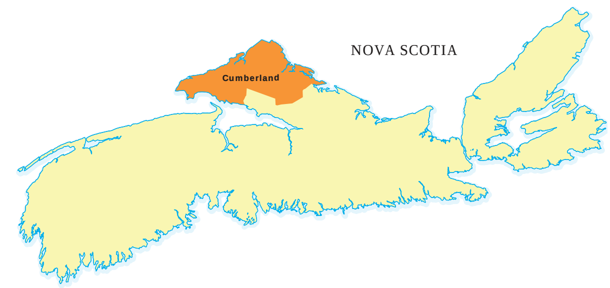
Population	31,353
Total private dwellings	18,422
Land area (km^2)	4,273

Cumberland County is bounded by water on three sides, including the Bay of Fundy (pictured here, near Parrsboro).

The Municipality of the County of Cumberland (Cumberland County) is a large area of nearly 9 million acres with a relatively low population density (roughly seven people per km^2). Land use includes rural residential, a number of agricultural practices, as well as forestry, mining, commercial and industrial. The largest residential centres in the area are Amherst (population 9,811), Springhill (3,868), Parrsboro (1,305) and Oxford (1,151).

Cumberland County is surrounded by water on three sides: the Bay of Fundy, the Northumberland Strait, and Chignecto Bay. Not surprisingly, Cumberland County's core climate change concerns relate to coastal vulnerability - low lying coastal areas on all three coastlines are particularly vulnerable to changes in sea level rise, storm surge, and coastal erosion.

Residents have experience with flooding and extreme weather events along the coastline, stretching back to the famous Saxby Gale of 1869 that created the highest tide ever recorded in the world – reportedly



reaching 21.6 meters in the Bay of Fundy – and flooding the Chignecto Isthmus.

Cumberland County is also vulnerable to saltwater intrusion into private wells in coastal areas and inland flooding from increased extreme rainfall events – the River Phillip can experience flooding during heavy rainfall.

Critical Issue: Flooding in the Chignecto Isthmus

Nova Scotia's most important connection to Canada is through the Chignecto Isthmus. Both road and rail lines cross the low-lying Isthmus, supporting 98% of all interprovincial imports – an estimated $10.78 billion annually. The area is vulnerable to rising sea levels and storm surges from both the Bay of Fundy and the Northumberland Strait.

A system of agricultural dykes, the CN Railway and the Trans-Canada Highway (Hwy 104) protect the Isthmus, but flooding does happen during large storm events – and climate change will increase the frequency, duration and intensity of these floods if action is not taken.

Both municipal and provincial levels of government appreciate the need to assess the flood risk along the Chignecto Isthmus and look at practical options and opportunities to adapt.

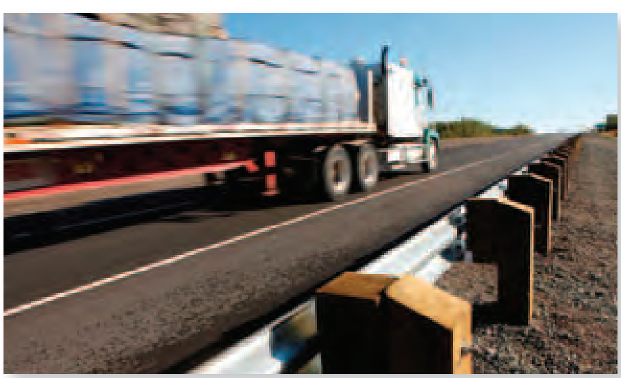
New Brunswick Nouveau
Newfoundland Labrador
Natural Resources Canada
Ressources naturelles Canada
Prince Edward Island Canada
NOVA SCOTIA

Responding to its involvement with the Atlantic Climate Change Solutions (ACAS) Program, Cumberland County created a Municipal Climate Change Action Plan (MCCAP) Working Group that included both staff and councillors, led by a contracted planner/mentor to design the overall workshop framework, facilitate meetings, and record proceedings.

The Working Group identified the critical need to involve other levels of government considering climate change impacts and action planning. Many vulnerable infrastructure assets and land uses are outside of municipal jurisdiction, such as:

- TransCanada highway
- Road network
- Dykes
- Agricultural lands
- Marshlands + wetlands
- Lands below the high water mark
- Forestry
- Regulation of water supply
- Regulation of sewage treatment

The Working Group endorsed a focus on strategic steps to enable greater planning coordination among many parties – because in many cases the authority, expertise, coordination and analysis required are beyond the capacity of the municipality.



Highway 104 traverses the county but is under provincial authority.

December 2010 storm surge at Lorneville, on the Northumberland Strait.

In the case of the Chignecto Isthmus, for example, the Working Group suggested a coordinated project such as an Integrated Climate Change Adaptation Master Plan for the Tantramar Marshlands with a phased approach using sea level rise horizon timelines might engender this level of coordination. The focus cannot simply be the adaptation plan itself – rather it should be a plan for how to work together.

Sea level rise

Historical (century)	Projected 2020s	Projected 2050s	Projected 2080s
-	+15 cm (±3)	+42 cm (±15)	+105 cm ± (48)

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Municipality of the District of Lunenburg, Nova Scotia Climate Change Case Study

Key facts

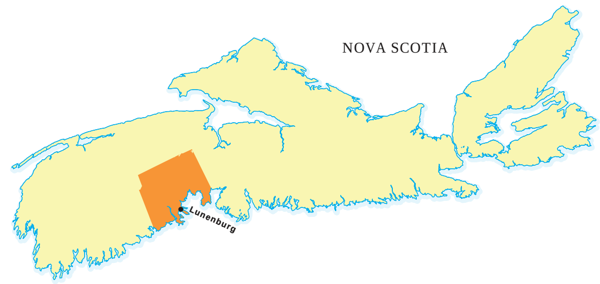
Population	47,313
Total private dwellings	25,263
Land area (km^2)	2,910

'Old Town' Lunenburg is a designated UNESCO World Heritage site with a coastal, tourism-based economy.

The Municipality of the District of Lunenburg (MODL) is a large rural municipality located on Nova Scotia's south shore, encompassing the towns of Bridgewater, Lunenburg, and Mahone Bay. It consists of over 130 communities historically rooted in land and sea-based resources, and is Nova Scotia's third largest community in terms of total property assessment.

MODL residents have already identified a number of potential climate change risks – such as overland flooding from storm surge, increased rates of coastal erosion, and migration or loss of socially valued beaches, and to some degree, sea level rise.

Less apparent impacts, but equally important, include inland and down-river flooding due to short intensity precipitation events, increased duration and frequency of water deficits, freeze-thaw cycles during warmer winters disrupting the winter survival of fruits and other flora, saltwater intrusion into drinking water supplies, continued stress on and possible loss of numerous sea-based species, and stress to forest health and maturation.



Critical Issue: Rural collaboration

MODL is not a single community so much as a grouping of many. And many of these communities were established early in the history of European settlement in Nova Scotia – consequently, very little public land exists in the municipality. As well, only 11.5% of the municipality has land use planning.

Dalhousie University School of Planning has identified this as a challenge in relation to climate change. Private landowners have created or altered land levels along the coastline before seeking a development permit – and the municipality has no jurisdiction over changing land levels until they receive a permit application. The authority to disallow the altering of coastal habitat lies at the provincial level – not with the municipality.

The province also maintains many of the roads travelled by commuters within the municipality. In fact, because of its relatively close proximity to HRM, there are so many commuters that only 32.7% of the population works in the Municipality.

As well, MODL does not own or operate any central water supply: wells on individual lots are the normal sources of drinking water and this is likely to continue.

As adaptation efforts require coordination, MODL recognizes the critical importance of coordinating information and planning efforts among different levels of government and residents.

As part of the Atlantic Climate Change Solutions (ACAS) Program, MODL is collaborating with the Province in a project to test drive a Municipal Climate Change Action Plan (MCCAP) Guidebook for use by Nova Scotia municipalities. MODL established a MCCAP Committee consisting of three councillors and a team that includes:

- Senior Planner (lead)
- Municipal Engineer
- Director of Planning and Development Services
- Municipal Engineer
- Engineering Technician and Assistant Emergency Coordinator
- Regional Emergency Management Coordinator
- Chief Administrative Officer
- Planning Technician

The team has already identified a number of recommendations, including collaboration between Town of Bridgewater, Mahone Bay, and the Municipality of the District of Chester around:

- climate change issues and hazards,
- affected locations, and
- facilities, infrastructure and service delivery

LIDAR data indicates the area's vulnerability to sea level rise.

Sea level rise

Historical (century)	Projected 2020s	Projected 2050s	Projected 2080s
+32 cm	+15 cm (±3)	+43 cm (±15)	+83 cm ± (36)

MODL already has experience in acquiring relevant climate information, having investigated the potential impacts of flooding and storm surge in the coastal area of Kingsburg in 2006. This began the municipality's collection of LIDAR data.

Blue Rocks, like many MODL communities, has much of its infrastructure directly along the coast.

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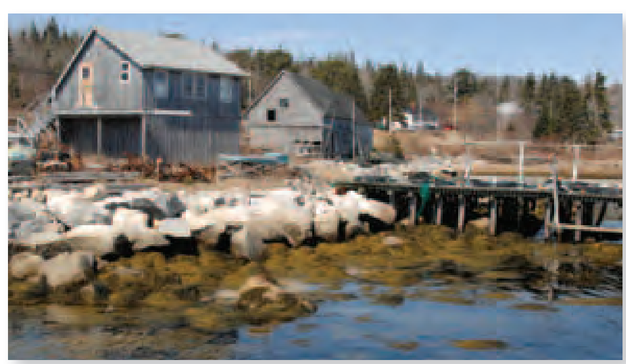


Halifax Regional Municipality, Nova Scotia Climate Change Case Study

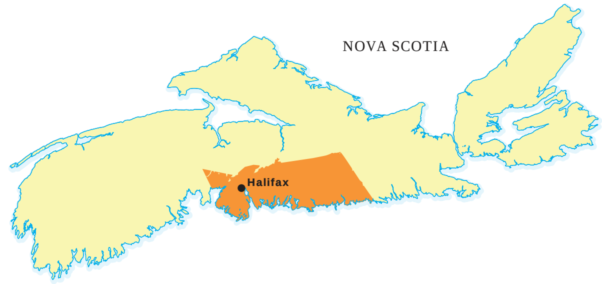
Key facts

Population	390,096
Total private dwellings	177,160
Land area (km^2)	5,490

HRM's waterfront infrastructure includes container facilities, defense, refineries, shipyards, and many tourism-based businesses, making it vulnerable to coastal impacts (inset).

Halifax Regional Municipality (HRM) is the largest population centre in Atlantic Canada and a major economic hub for government services and private sector companies. Economic underpinnings include the Department of National Defence, three levels of government, and the Port of Halifax. Agriculture, fishing, mining, forestry and natural gas extraction are major resource industries found in the rural areas of HRM.

As an urban centre and coastal municipality, HRM is vulnerable to many climate impacts, including sea level rise and increased frequency and intensity of extreme weather events. Also critical are the secondary impacts of storm surge and heavy rainfall on coastal erosion, coastal inundation, inland flooding, wet weather sewage flows and stormwater flows.



Residents are very aware of a number of recent extreme weather events, including:

- Hurricane Juan (September 2003): a category two storm that resulted in 8 deaths, and an estimated $300 million in damages.
- "White Juan" (February 2004): a blizzard dropping a record-breaking 100 centimeters of snow and costing over $5 million in unbudgeted snow removal and damages.

Extreme Rainfall

Historical (century)	Projected 2020s	Projected 2050s	Projected 2080s
-	+5%	+9%	+16%

HRM has partnered with all levels of government and the private sector to develop Climate SMART, a fully integrated planning approach that addresses the impacts of climate change. The program supports a wide range of adaptation and mitigation activities, including models to determine potential climate change impacts.

Critical Issue: Extreme Rainfall

HRM can expect an increase in the intensity and frequency of extreme weather events, including storms and rainfall. Increasing bursts of extreme rainfall have the potential to overwhelm conventional storm water systems.

HRM suffered enormous tree loss from Hurricane Juan.

As part of its Climate SMART adaptation efforts, HRM is building a hydrological systems model of the Halifax Harbour drainage basin. The proposed LiDAR-based GIS model will consider urban storm water runoff under different climate change scenarios, allowing HRM to plan more resilient future development.

Trees – the forest canopy –can influence storm water flow rates in the HRM watershed; the model must therefore consider the impacts of both removing and adding forest.

In basic terms, land covered in buildings and pavement translates into faster water run-off into the existing stormwater system of streams and sewers, making overflow more likely. Land with some degree of forest canopy slows water run-off; this canopy also helps mitigate the effects of greenhouse gas emissions by sequestering carbon dioxide.

Benefits of this model include:

- improved ability to assess urban forest in all of the HRM watersheds and potential impacts of forest management options on flooding.
- create a methodology to potentially assess the rest of the Halifax Harbour drainage basin and other areas.
- a methodology that could become part of a wider tool set to help municipalities conduct more accurate storm water vulnerability assessments and more strategic adaptation plans for forest watersheds.

HRM's Urban Forest Master Plan includes the following targets for forest canopy:

North End: 70%

Stadacona: 20%

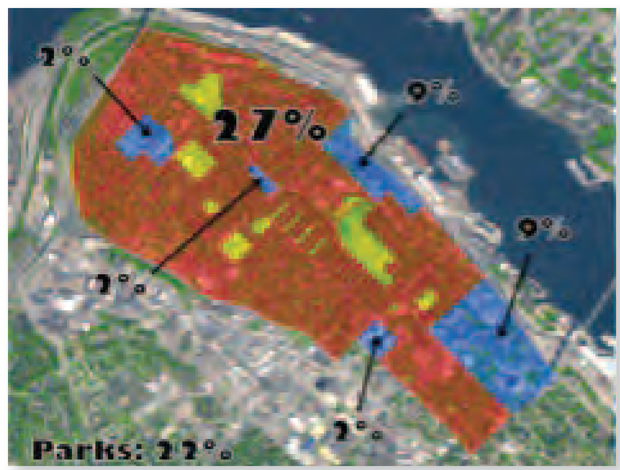
Mulgrave Park: 20%

NSCC: 20%

Novalea Centre: 20%

Oland Brewery: 20%

Parks: 40%



Current levels of forest canopy in Halifax's North End neighbourhood.

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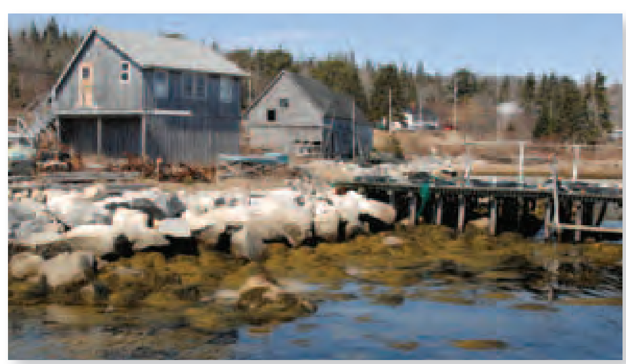
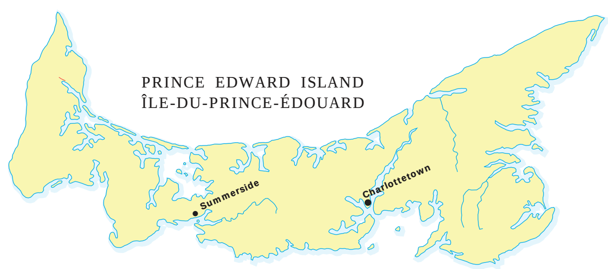


Climate Change and Saltwater Intrusion in a Small Municipality

Community Context

Summerside is the second largest city in Prince Edward Island (population 14,751). It is a coastal community located on an isthmus in the narrowest part of the province.

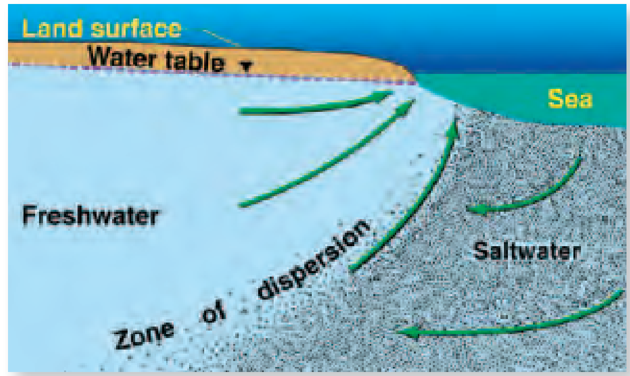


Summerside, like the rest of Prince Edward Island, gets its drinking water from groundwater sources. Municipal wells provide drinking water to residents, business and industry in the area.

Groundwater supplies are more than adequate in the area, with the sandstone aquifer that underlies all of Prince Edward Island, being highly productive in most areas. Water quality, however, has been a concern in Summerside. Saltwater infiltrated two municipal supply wells in the west end of the city (Northumberland Street / Duke Street) in the late 1950s and early 1960s. Over-pumping of the municipal supply was considered the cause of the saltwater intrusion. Both wells were abandoned as a result.

Climate Change and Community Vulnerability

Coastal drinking water supplies in Summerside are vulnerable to saltwater intrusion due to a number of factors. Climate change is causing sea levels to rise around Prince Edward Island. Current scenarios suggest a rise of 1 metre over the next 90 years. Rising sea level could push the boundary between saltwater and fresh water further landward affecting wells near the shore.



Climate change could also affect the rate and amount of rain and snow that recharges the aquifer. Amounts of precipitation (rain and snow) will increase by 5 – 10 per cent by 2100. However, this doesn't mean that there will be more water available when it is needed. Rain will likely fall in short, intense events, which are less likely to be absorbed into the ground. Warmer summers will lead to greater evapotranspiration and greater demand for irrigation in agricultural areas around Summerside. This will put more pressure on groundwater supplies. Either lower rates of recharge to groundwater supplies or greater groundwater withdrawals could pull saltwater landward into fresh water portions of the aquifer.

Modeling the Risk of Saltwater Intrusion

Like other municipalities across Canada, the City of Summerside is considering how they can adapt to climate change. In 2010, the City of Summerside decided to assess the potential vulnerability of their drinking water supplies to sea level rise.

The City of Summerside, led by Saint Francis Xavier University and the Atlantic Climate Adaptation Solutions Association (ACASA), assessed the risk of saltwater intrusion using a program of test drilling and a 3-dimensional (3D) computer model (ModFlow) to examine the potential impacts of future climate change scenarios. Scenarios included changes in sea level, climate change alterations to the hydrological cycle (groundwater recharge) and rates of groundwater extraction.

Six wells were drilled near the coast to gather data to support the model. Water samples from varying depths were analyzed and the saltwater / freshwater interface was identified and mapped.

The study found that sea level rise will likely cause only a slight push of saltwater into the groundwater aquifer. However, water demand, resulting in the pull of saltwater into the groundwater aquifer, is more likely to cause significant salt water intrusion. Excessive water demand may adversely affect the supply of freshwater currently tapped by municipal wells and require the identification of new well water sources.

Next Steps

Water demand, rather than sea level rise, is the key risk factor for future saltwater intrusion in Summerside. Maintaining modest water demand will help ensure that Summerside has an adequate supply of freshwater in the future. Summerside should be able to safely develop new well fields provided pumping is restricted to moderate quantities. Other recommendations include:

- Identify any existing high capacity water users, including those not supplied by the City of Summerside's municipal water supply. This will help determine the full extent of water demand on the Isthmus.
- Promote water conservation measures to minimize water demand.
- Conduct regular monitoring of water quality and water levels, including the test wells used in this project to track changes in the position of the saltwater / freshwater boundary.
- Restrict the location of new wells in areas prone to saltwater intrusion.

Impacts of coastal erosion on the location of the saltwater / freshwater interface were not considered in this study, however would be expected to have similar impacts as sea level rise Erosion essentially moves the shoreline further inland, pushing the saltwater / freshwater interface landward.

This study has allowed the City of Summerside to better understand their risk and vulnerability to saltwater intrusion. However, understanding how climate change will impact the municipality is a continuous process and will require on-going assessment and regular review.

Partners

- St. Francis Xavier University (Dr. Grant Ferguson[i] and Brian Hansen)
- PEI Environment, Labour and Justice (George Somers and Yefang Jiang[ii])
- DJardine Consulting (Don Jardine)
- Natural Resources Canada
- City of Summerside (Phil Hardy and Tony Gallant)

For more information on this project, please visit www.atlanticadaptation.ca

i Current Address: University of Saskatchewan
ii Current Address: Agriculture and Agri-Food Canada

Coastal Climate Change in Prince Edward Island: Shoreline Protection

Context

Prince Edward Island is well-known for its beautiful sandy beaches and red sandstone cliffs.

Much of PEI's 3,300 km of coastline is exposed to open waters in the Gulf of St. Lawrence and Northumberland Strait. Waves, winds and storms (like tropical storms, hurricanes, and surges) constantly reshape the coastline. Erosion is common. Across Prince Edward Island, the shoreline erodes at a rate of almost 30 cm each year.

Much of Prince Edward Island's population lives near the shore. Homes and cottages, as well as infrastructure like roads, bridges, utilities, and parks, are all vulnerable to an encroaching shoreline. Provincial and municipal development set-backs and buffer zones are designed to ensure properties are located at safe distances from the coast. In provincial planning areas, these setbacks are 60 feet or 60 times the annual erosion rate. Some municipalities have more restrictive set-backs. However, these set-backs will only protect properties for a period of time. In many places, these set-backs or safety margins are gone and infrastructure is at risk .

Climate Change and Increased Vulnerability

Prince Edward Island is already experiencing greater rates of erosion. In the last 10 years, erosion rates have increased to 40 cm per year. More intense and frequent storms, rising sea levels (1 cm/year) and less sea ice are all contributing to greater rates of erosion. Extreme weather events (e.g. hurricanes, winter storms, storm surge), which account for the most dramatic losses of shoreline, will occur with greater frequency and intensity in the coming years. Rising sea level will mean deeper water which causes larger, more

damaging waves. Sea ice, which protects the shoreline from waves and wind, will be less common because of warming temperatures. Frequent freeze-thaw processes can also reduce bank stability.

Shoreline Protection

Communities, developers, and individuals with infrastructure at risk along the coast are faced with some tough decisions. Do you protect the shoreline or retreat and abandon the infrastructure? Abandonment and re-naturalization of the coast is considered by some the only "correct" approach. However, it is not always practical. Shoreline protection, on the other hand, can be costly (sometimes over $1,000 per linear metre). It requires significant investment and on-going maintenance. As well, it is not a permanent solution for areas experiencing significant erosional pressures. Communities and individuals need to weigh all options and make strategic decisions about how to live with our coasts.

If after weighing all the options, shoreline protection is considered most appropriate, a couple of different approaches can be used. Most shoreline protection approaches in Prince Edward Island maintain the existing shoreline (this is sometimes called "hold the line"). Using this approach, shoreline protection structures are built along the existing waterfront or coastline. In a few places in Prince Edward Island, shoreline protection has been placed further offshore. This approach, called advance the existing shoreline ("advance the line"), creates sheltered waters that can minimize the effects of storm surge events.

Whether maintaining the existing shoreline or advancing it, three different types of shoreline protection systems can be used. Keep in mind; all shoreline protection efforts require government approval in the form of a watercourse / wetland and buffer zone alteration permit.

Hard Protection – Hard shoreline protection includes man-made structures designed to armour the shoreline, protecting it from wave action and over-topping. Hard protection includes structures like sea walls and bulkheads built of armour stone, concrete or piling. Examples on Prince Edward Island include the aging seawall below Water Street in Victoria-by-the-Sea, and the armour stone installed along boardwalks in Charlottetown and Summerside. Some hard protection systems are unattractive and reduce bird and wildlife habitat. Hard protection systems can also reduce or eliminate any sand or shallow beach that may have been present previously. Using durable material and ensuring that the structure is high enough to prevent overtopping from rising sea level and storm surge is essential.

Soft Protection – Soft shoreline protection tries to minimize wind and waves while increasing sediment stability and/or amount of sand to maintain desired beaches and dunes. Examples on Prince Edward Island include the beach below the Souris Causeway, where a series of wooden snow fences have been installed at 30 degree angles to trap windblown sand and 'build' a dune to protect and build up inland areas. Fences and windbreaks provide artificial barriers to wind and sand providing a temporary barrier until the dune system can be stabilized with natural vegetation.

Hybrid Protection – Hybrid shoreline protection combine hard with soft protection systems, whereby structures act as artificial headlands that limit sediment loss. Examples on Prince Edward Island include the Links at Crowbush Cove (a golf course), where its famous dunes were rebuilt using a low-lying armour stone core buried in a reconstructed sand dune system. The dune systems were then stabilized with

marram grass. While severe storms can still wash away the dune sand, the underlying armour stone remains in place to protect landward infrastructure. Maintenance is required to replenish the dune after severe storm events. The increasing frequency and severity of storm events could ultimately make holding this position cost-prohibitive.

Next Steps / Recommendations

Adaptation to climate change will require a wide range of approaches that are suited to each situation. No matter the choice, one should consult with qualified professionals who are knowledgeable in the areas of coastal processes, engineering, and climate change design criteria. As well, one should consider more than just a single property or structure when making decisions about coastal hazards as shoreline protection can influence neighboring properties.

Resources

Shoreline Erosion www.gov.pe.ca/environment/shoreline-erosion

Contractor Licensing Program www.gov.pe.ca/environment/contractor-licensing-program

For more information on this project, please visit www.atlanticadaptation.ca

Coastal Climate Change in Prince Edward Island Parks: Retreat or Protect?

Context

Prince Edward Island has many parks, including the Prince Edward Island National Park and 26 provincial parks. Most of these parks are located along the coast

and offer beautiful beaches, nature trails, outdoor recreation, and interpretive programs. Some parks also have camping facilities. Each year, these parks attract thousands of visitors and residents alike and are an important driver of the Island's economy.

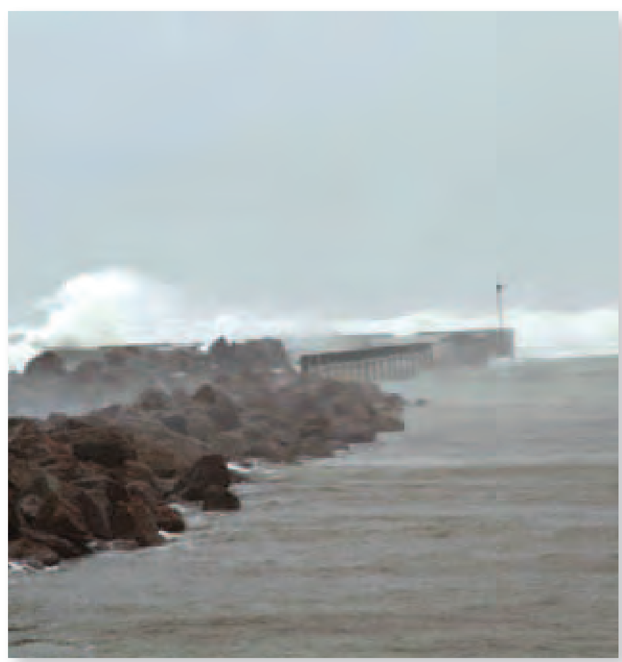
Coastal parks are subject to the natural processes along the coast. Soft, mainly sandstone bedrock overlain by glacial deposits is one of the most sensitive environments to coastal erosion in Canada. Waves, winds and storms (like tropical storms, hurricanes, and surges) constantly reshape the coastline and erosion is common. Many coastal parks are also low-lying and vulnerable to flooding during storm surges

Climate Change and Increased Vulnerability

Climate change will bring more intense and frequent storms, rising sea levels and less sea ice. These will contribute to coastal flooding and erosion. Extreme weather events (e.g. hurricanes, winter storms, storm surge), which account for the most dramatic losses of shoreline and flooding, will occur with greater frequency and intensity in the coming years. Sea level will rise by 1 metre by the end of the century, flooding low lying areas. Rising sea level will also give rise to larger, more damaging waves. Sea ice, which protects the shoreline from waves and wind, will be less common because of warming temperatures.

Adaptation Efforts in Coastal Parks

Since many of our parks were established (up to 80 or 90 years ago), there have been many efforts to adapt to a dynamic coastal environment. Shorelines have been protected using armour stone, gabions, sea walls, breakwaters, rock revetments and other hard protection methods. More recent efforts have focused on enhancing natural protection systems like sand dunes or a combination between hard and soft protection.



PEI National Park – Planned Retreat

The PEI National Park, established in 1937, is located on the North Shore of Prince Edward Island, extending from the Cavendish Sandspit in New London Bay to Blooming Point and a separate section on the Greenwich Peninsula. It covers over 27 square kilometres, including about 60 km of shoreline. The Park has a diverse mix of coastal features, including beaches, dunes, marsh lands, and high cliffs. Erosion and storm surge damage is common in the park and has forced the abandonment of campgrounds (Robinson's Island), parking lots (Dalvay) and roads. In some areas of the park, erosion is averaging 1 metre per year. However, over 10 m of shoreline and dunes have eroded during single storm events.

Parks Canada have used a variety of methods such as armour stone, rip rap, gabions, sea walls and breakwaters to protect some of their beaches and infrastructure such as beach access ramps and stairs, board walks, parking lots, camp grounds and road ways. However, erosion and flooding pressures were too great in some locations (e.g. Robinson's Island).

Protection efforts proved ineffective and costly. Instead, the current management plan for the park is focused on allowing natural processes to occur in their coastal areas. This is despite the fact that most of their infrastructure are in vulnerable areas. Since 1974, Parks Canada has purchased an additional 12.5 km^2 of land to provide room for them to move with a gradually encroaching shoreline. They have also established a series of erosion monitoring locations along the coastline to determine the average rates of erosion and to establish trends for future planning.

Jacques Cartier Provincial Park

Jacques Cartier Provincial Park is located in Kildare, on the North Shore of western Prince Edward Island. In operation since the early 1960's, the Park has a beautiful beach and campground. The shoreline has a small bank (about 1 metre high) separating the park from the beach.

Storm surge and erosion have changed the Park significantly. Estimates in the 1980s suggested that over half of the original land area of the park had eroded (about 41 hectares). In the last several years, shoreline retreat in the area is happening at a rate of 2 metres each year. Infrastructure has been affected. Campsites have been moved further inland. Some have been abandoned. Electrical and water services to the campsites have been damaged. Sand is deposited on the campsites as the shoreline tries to move landward.

There is no management plan for erosion and flooding at Jacques Cartier Provincial Park. Instead, damaged infrastructure is repaired and campsites and access roads moved as needed. Annual surveys are conducted to monitoring the rate of erosion.

Panmure Island Provincial Park – Protect

Panmure Island Provincial Park, opened in the 1960s, is located on the eastern shore of Prince Edward Island. The Park lies to the southeast of a causeway linking Panmure Island to Prince Edward Island. Popular with both locals and tourists, Panmure Island Provincial Park is noted for its beautiful sand dunes, beaches and scenery.

Sand dunes in the park and a portion of the roadway were eroded during a major storm surge on December 26, 2004. Shoreline protection was considered necessary to protect the causeway and the park from future storms. However, a traditional hard protection system (armour stone, rip rap, etc.) would detract from the beauty of the beach and its tourism appeal. Instead, a combination of hard and soft protection was used. An armour stone revetment system was installed buried along the northeast end of the causeway to protect the roadway and dune system. Dunes were rebuilt on top of the revetment and marram grass replanted.

This approach requires on-going maintenance as sometimes the dunes need to be replaced after storms (this happened on January 2, 2010). However, the roadway is protected and the aesthetic appeal of the area remains.

Resources

Other approaches to coastal change can be found in some of the reference materials cited below:

Hawaii Coastal Erosion Management Plan (COEMAP) http://hawaii.gov/dlnr/occl/documents-forms/policies-plans/coemap.pdf

UK Planning policy on development and coastal erosion, case study policy research http://www.communities.gov.uk/documents/corporate/pdf/1802350.pdf

For more information on this project, please visit www.atlanticadaptation.ca

Adapting to Climate Change: Flooding Grand Bay-Westfield, New Brunswick

Figure 1: Location of Grand Bay-Westfield

The Community

Grand Bay-Westfield is located on the western shore of the lower Saint John River in southern New Brunswick. Although the town is inland, its climate is influenced by the cool waters of the Bay of Fundy. The Saint John River, as it passes the town, has a significant tide. The town lies on the boundary between the Fundy Coastal ecozone and the more continental Valley Lowlands ecozone.

The area was settled by United Empire Loyalists who were given land grants along the river at the end of the American Revolution in 1783. Their farm and logging operations relied on the river for transport until the railway opened in 1869.

Grand Bay-Westfield – like many New Brunswick communities – was hit by the historic Saxby Gale in October 1869. Storm flooding overturned the engine intended to lead the first run of rail cars on their newly constructed local line to Fredericton Junction. As a result, a replacement engine had to be brought from Saint John for the opening festivities. By World War I, the area was growing in popularity as a summer destination. In 1921, a major fire destroyed more than 100 buildings. Cottagers and permanent residents returned to the area and quickly rebuilt it, leading to the distinct architectural style the community is known for today.

By 2011, Grand Bay-Westfield was home to 5,117 people. Many residents commute to work in Saint John, Fredericton and the New Brunswick Power facilities at Lepreau, but the town is also an important service centre for the surrounding area. The Province provides a cable ferry service across the Saint John River from Brundage Point (also the location of the town's River Centre) to the Kingston Peninsula. The River Centre is a Stonehammer Geosite, part of North America's first UNESCO designated Geopark.

Climate Change and Community Vulnerability

Grand Bay-Westfield is experiencing many of the climate changes documented elsewhere in southern New Brunswick, including rising temperatures, increased annual precipitation, less snowfall, extreme rainfall events, and warmer winters. Residents describe much stronger winds, more intense storms and rainfalls, and shorter winters that start later and bring much less snow. They say that none of their seasons are as well defined as they once were, and offer examples that range from 'yo-yoing' winter temperatures and green Christmases, to river ice that forms later, breaks up earlier, and is much thinner than it used to be.

The impacts of these changes are wide-ranging; while not all of them are negative, there are definitely trade-offs. For instance, residents need to heat their homes fewer days each year, but those savings may be offset by the increasing number of days they use their air conditioners. More intense storms are also increasing the number of power outages. A shorter winter season means less time for ice fishing and snowmobiling, but the regional warming trend is extending the local golf and growing seasons. Area residents rely on private wells for their drinking water; their reports suggest that well water levels are up due to increased rain. However, sediments carried in the runoff from Base Gagetown into the Nerepis River by those same rains, produce murky chocolate-coloured waters downstream in Grand Bay-Westfield. The extra sediment is making river bottoms muddier and filling in some coves.

The town experiences river flooding in the spring, when meltwater and ice break-up increase river flows. While these flood cycles enrich local marshlands, ice jams occasionally lead to more significant flooding and property damage. In the spring of 1889, a serious ice jam destroyed the original wooden Nerepis Bridge, as well as portions of the local railbed. Similar conditions led to serious property losses in 1936 (Figure 2). Significant spring flood events also occurred in 1973, 2005 and 2008.

Since the 1920s, sea-levels in the area have risen 23.5 cm. Fluctuating temperatures may continue to trigger ice jams, but the degree of infrastructure damage they cause could be lessened in future by declining amounts and duration of river ice. River levels year-round are much higher than they used to be though. Increasingly, heavy rains are triggering flash flooding, eroding banks, overflowing ditches, washing out roads, and damaging adjacent properties. In the past, river flooding affected mostly private properties, but more intense rains are increasing localized flooding, creating potential problems for municipal infrastructure throughout the town.

Photo Credit: Town of Grand Bay-Westfield

***Figure 2:** Infrastructure damaged in Westfield by a river ice jam on the Lower Saint John River in the Spring of 1936*

Local Climate Change Adaptation to Date

Its history of flooding has already led Grand Bay-Westfield to make a number of adaptations. The town prides itself on having excellent emergency plans and preparations in place. In addition to its Emergency Response Plan, the town has also developed detailed plans to deal with more serious floods and storms. The town periodically updates all these plans and keeps its contact list current by sending out regular update requests; in the event of an emergency, first responders can count on having an up-to-date resident contact list on file. The provincial Emergency Measures Organization (EMO) also has a very effective flood information service that broadcasts peak-of-flood notifications for the Saint John River through the internet and local media.

The town maintains a municipal watch list that identifies areas flooded in the past. Most of these sites have been subject to river flooding; they lie along the Nerepis and Saint John rivers and include a trailer park, the Brundage Point River Centre and ferry dock, a riverside subdivision dating from the 1960s, and some low-lying waterfront roads. The town has also identified areas subject to localized flooding. Localized flooding tends to result from a problem with the town's drainage infrastructure: for example, when the river level rises above an outflow or a culvert gets clogged with debris. The Town of Grand Bay-Westfield conducts regular inspections of its drainage systems to ensure they are clear and in good repair.

In 2012, the Atlantic Regional Adaptation Collaborative (RAC) included Grand Bay-Westfield, along with Saint John, Rothesay and Quispamsis in a pilot initiative called the Lower Saint John River Project. As part of this project, Grand Bay-Westfield agreed to participate in a test application of a flood risk assessment workbook developed by Memorial University in Newfoundland and Labrador as a component of a larger adaptation planning workbook. In February 2012, a facilitator presented the flood assessment workbook at a local adaptation planning workshop. At this workshop, the facilitator also introduced participants to a LiDAR (Light Detection and Ranging) based wet-areas map developed by the University of New Brunswick's Forestry and Environment Department for the RAC project (Figure 3). The Wet Areas Mapping (WAM) system used the detailed elevation maps produced with LiDAR data to identify the corridors along which flooding would occur under varying conditions. According to the workshop facilitator, participants were positive about the flood assessment risk workbook, but it was the WAM-produced high-resolution wet-areas map that made it much easier for people to visualize potential flood risks. One participant remarked, "If the LiDAR tool is available for us to use, we'll use it."

Within two weeks of the adaptation planning workshop, Grand Bay-Westfield's Development Officer was able to review a development application using the LiDAR-based wet-areas map. The Planning Advisory Committee and Public Works Department now use it to check sites and to support their interpretation and their decisions. The staff is also using the map to help other people, such as prospective buyers, understand the potential constraints of specific properties.

The town's Public Works Commissioner and Fire Chief also moved quickly to demonstrate the new map to their Emergency Management Committee. As a result, when the town receives a forecast water level for St. John River flooding from the provincial EMO, the town will be able to use the map to determine what effect that level will have on the local landscape.

Next Steps and Opportunities

Grand Bay-Westfield town staff have provided an in-depth demonstration of the LiDAR-generated wet-area map to their town council. The staff would like to expand the use of LiDAR mapping: for example, the tool could be used to provide information for drainage infrastructure maintenance and upgrades by identifying problematic culverts, likely stream channels, and locations where new storm sewers are required. Similarly, when the town is planning its development control measures, it could use the wet-areas map to help decide where building setbacks need to be increased or where development should be limited or revised. The staff also would like to use the map to facilitate the town's dealings with engineers and other contracted professional staff.

Photo: Jae Ogilvie and Paul Arp, Forest Watershed Research Centre, Faculty of Forestry & Environmental Management, University of New Brunswick (http://watershed.for.unb.ca)

***Figure 2:** Wet Areas Mapping (WAM) of the community's golf course illustrating flow channels with the greatest likelihood to conduct stormwater during (top) the dry period of late summer, and the wettest weather (bottom) in the spring.*

The Emergency Management Committee plans to use the LiDAR-derived wet-areas map to model emergency flood scenarios for preparedness training purposes. The Committee also plans to approach the provincial Emergency Measures Organization (EMO) to arrange for the use of an emergency radio channel to broadcast continuous flooding information when electricity is lost and residents are unable to access the EMO's website or other news outlets.

Finally, the Town of Grand Bay-Westfield is very conscious of the need to develop an in-house public education program to inform residents about the risks of flooding in their community. The town staff also plan to make greater use of resources such as the provincial Department of Environment's NB Climate Change presentation, as well as LiDAR modeling tools like WAM.

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July 2012

Adapting to Climate Change: Coastal Flooding Tantramar Marshlands, New Brunswick

***Figure 1:** Location of Sackville and the Tantramar Marshes*

The Area

The Tantramar River drains into the Cumberland Basin of the Bay of Fundy in southeastern New Brunswick, near the border with Nova Scotia. Its tidal marshlands—known as the Tantramar—are a rich cultural and ecological feature of the region. A system of historic dykes protects the farmland in the area. The earliest of the dykes were developed by Acadian colonists between 1671 and their expulsion from the region in 1755.

Sackville is the largest community within the Tantramar marshlands. In 1762, the Town of Sackville held its first local government meeting. The community got off to a slow start due to a huge storm that breached the dykes and temporarily prevented the resettlement of the land formerly owned by the Acadians. However, settlers from New England soon occupied the former Acadian farms; by 1815, the English had constructed a new canal to drain additional marshlands for hay growing.

In 1843, Mount Allison University was established in Sackville. The university has grown to become a major local employer. The area is also known for the international radio towers the Canadian Broadcasting Corporation has operated in the marshlands since 1943. While agricultural land use has been declining in this part of Westmorland County since the 1970s, the remaining cultivated and pasture lands occupy a substantial portion of the Tantramar marshes.

Climate Change and Community Vulnerability

Projected regional climate change impacts include relative sea level rise, changing precipitation patterns, increasing temperatures and an increase in the frequency of extreme weather events. Researchers expect climate change to impact agricultural production in the area. While increased temperatures might lengthen growing seasons, farm animals and crops may not respond well to altered temperature ranges and there are concerns over the spread of invasive species and unfamiliar pests and diseases.

The Tantramar—like many parts of New Brunswick—was hit by the historic Saxby Gale in October 1869; while the area's flood mapping has referred to the extraordinarily high water levels that resulted at the time, development has continued to occur in the Saxby Gale floodplain. There have been several serious storm events over the last decade, including two in 2010 that extensively damaged coastal infrastructure and terrain in the nearby Port Elgin area. There is growing public awareness and concern about the potential impacts of climate change on the Tantramar.

The combination of rising sea levels and increasingly frequent and more powerful storm surges is expected to substantially increase the extent of coastal

Photo Credit: Courtesy of J. Bornemann

***Figure 2:** Tantramar marsh study area. Note the current 1:10 year storm flood extent (area in blue)*

floodplains throughout the province. Currently, one in ten-year storm water levels would be expected to overtop existing dykes and cause extensive flooding in the Tantramar (Figure 2)[1]. Researchers expect a 1-metre sea level rise to affect much of the region by 2100: if this happens, the flooding levels reached at the height of a record storm-surge event in January 2000 (then considered a 100-year return period event) could occur every three to five years[2].

Climate change could also impact regional transportation systems. There are two ground transportation routes on the isthmus between New Brunswick and Nova Scotia, but the Tantramar route is by far the busier. Traffic volume on the Trans-Canada Highway reaches 13,500 vehicles per day;[3] substantial flows of passengers and freight move through the same corridor by rail. Serious flooding of the Tantramar marshlands could lead to transportation disruptions, with economic consequences affecting multiple sectors across the entire Atlantic region.

Local Climate Change Adaptation to Date

The New Brunswick Department of Agriculture, Aquaculture and Fisheries currently maintains the Tantramar area dykes. Historically, dykes helped control lowland flooding, making it possible to bring more land into productive use. Over time, the function of the dykes has expanded. Today they protect not only the agricultural lands, but also the Town of Sackville and the essential transport corridors between Nova Scotia and the rest of Canada (both CN Rail and the Trans-Canada Highway). In fact, the rail line sits on top of the dykes in some sections along the bay (Figure 3).

In October 2011, researchers from Mount Allison University and the University of New Brunswick reported on a series of climate change related projects at a meeting in Sackville, New Brunswick. Residents were particularly concerned about the findings regarding the potential impact of climate change on the area's historic dykes. Researchers expect rising sea levels and increasingly frequent and more powerful storm surges to cause both greater dyke erosion and a heightened risk of failure, resulting in more flooding. Researchers found that 89% of the area's existing dykes, which range in elevation between 7 and 12 metres above sea-level (averaging 8.6 metres) would be overtopped in a current one-in-ten year storm surge event. The erosion rates would be greatest in dykes closest to the coast and in those bare of vegetation.

The researchers recommended some short-term adaptation options including updating emergency response plan scenarios to include dyke system breaches; making improvements to the dykes, especially by vegetating exposed sections; and conducting public outreach to raise awareness of the potential risks. Suggested longer-term adaptations would build on these efforts by: using regulations to prevent further development of areas at risk of

Photo Credit: R. Chiasson

***Figure 3:** The CN Rail line runs on top of some of the dykes in the Tantramar.*

flooding; relocating or replacing vulnerable infrastructure; and by identifying which dykes to raise in order to better protect critical infrastructure that cannot be moved. Researchers proposed restoring salt marshes as a means of introducing a natural buffer zone to absorb the most powerful and erosive storm waves[4].

Researchers from the University of New Brunswick have prepared Wet Areas Mapping (WAM) for many flood zones in the Maritime region. Working with finely-textured LiDAR (Light Detection and Ranging) base map data, they generated a variety of potential inland flood scenarios for the Tantramar area: these were presented at the Sackville meeting (Figure 4). The researchers set up flooding scenarios of varying severity and identified the potential network of stream channels that could result, along with the associated flows into existing drainage infrastructure; they also looked at the potential impact on critical utilities such as powerlines and pipelines in the area. The researchers also assessed the degree of potential terrain saturation or 'wetness' that could lead to further damage from erosion and slumping. Their modeling identified locations where breaches would likely appear in residential and agricultural ditches, as well as in several culverted stream crossings along the length of the Trans-Canada Highway.

Next Steps and Opportunities

Staff from the Town of Sackville and provincial and federal government departments are reviewing the outcomes of the Wet Area Mapping (WAM) and flood modeling done for the area. It will take the various levels of government some time to make the appropriate adjustments to land use plans and regulations, public education campaigns, capital works and maintenance processes, and other operations that could be affected by the increased flooding scenarios.

After better understanding the extent of the flood risk to agricultural lands in the Sackville area, researchers recognized the need for further investigation of the climate change impact on agricultural production in the Tantramar region. The research findings could be used to evaluate the merits of saving agricultural lands experiencing flooding versus allowing them to revert to salt-marsh. More information would also help planners assess the relative costs and benefits of engineered adaptations in upland and lowland settings. The development of an agricultural adaptation strategy for the Tantramar Region is underway, taking these questions into account. Researchers also plan to interview local farmers to gain a better understanding of what they are already experiencing and how they are adapting, or planning to adapt to climate change.

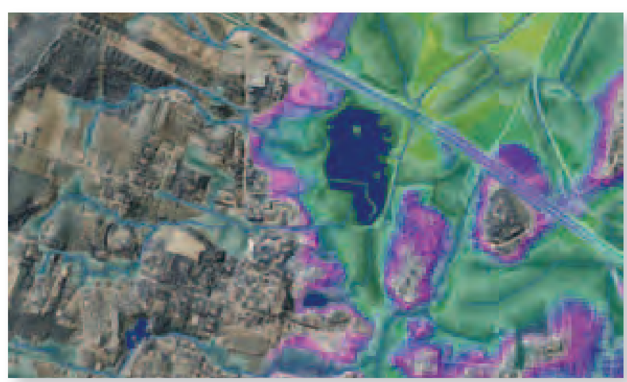

Photo Credit: M. Castonguay, J. Ogilvie. and P. Arp. Faculty of Forestry and Environmental Management, University of New Brunswick, 2011.

***Figure 4:** Inland flooding potential for Sackville, NB illustrated using wet areas map and flow network (blue channels).*

Mount Allison University is also conducting further research to study the public perception of risk, and assess the social and economic vulnerability of the Tantramar community to coastal flooding. The vulnerability assessment will involve a preliminary analysis of the costs and benefits associated with a number of community adaptation strategies—factors that also commonly inform decision-making. The use of visualization tools— for example those based on LiDAR modeling—to illustrate flooding scenarios appears to be very helpful in enabling people to understand the seriousness of the projected climate change impacts[5].

In order to improve transportation sector planning, researchers are constructing an interactive model of the New Brunswick-Nova Scotia transportation corridor. By providing researchers with a better understanding all the economic consequences of climate change impacts over time, the model will make it possible to measure and compare the long term costs and benefits of various adaptation options.

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[3] *Y. Yevdokimov, Economic Evaluation of Climate Change Impacts on New Brunswick-Nova Scotia Transport Corridor. Environmental Trust Fund Project Report No. 110128. (Fredericton, NB: University of New Brunswick, 2012).*

[4] *D.J. Lieske and J. Bornemann, Coastal Dykelands in the Tantramar Area*

[5] *D. J. Lieske, Assessing and Visualizing Community Vulnerability in the Face of Sea Level Rise, Presentation, (Department of Geography and Environment, Mount Allison University, Sackville, NB, 2011).*

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