Municipal Climate Change Action Plan for the Town of Lunenburg

Final Report

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131267.00 ● Final Report ● February 2015

ISO 9001
Registered Company

Prepared for:
Town of Lunenburg

Prepared by:
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2 February 2015

Mr. Marc Belliveau, Town Engineer
Municipality of the Town of Lunenburg
PO Box 129
119 Cumberland Street
Lunenburg, NS B0J 2C0

Dear Mr. Belliveau:

RE: Municipal Climate Change Action Plan for the Town of Lunenburg - Final Report

CBCL Limited is pleased to provide this update to the final report for the Climate Change Action Plan for the Town of Lunenburg.

The update was necessitated by the receipt of more proximate information on the chart-to-geodetic vertical datum conversion factor used in the study. Based on the information we had at the time, the previous version of the study used extreme water levels that were overestimated by 0.388m.

While the general results of the report remain unchanged, we have revised the maps and supporting text in the report to ensure that the Town is using the most accurate information available as it moves forward with its decision making.

We have also made some revisions to the sections on snow-loading and winter road maintenance to expand information in those sections as a result of requests for clarification.

Thank you again for the opportunity to work on this interesting and important project for the Town. We trust these updates will help to ensure that the document proves useful.

Yours very truly,

CBCL Limited

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Attachment

Project No: 131267.00

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Executive Summary

Executive Summary

The Town of Lunenburg Municipal Climate Change Action Plan (MCCAP) is divided into two sections: Section 1 **Adaptation** and Section 2 **Mitigation**. The Town has prepared this plan to proactively consider climate change impacts and hazard risks within Town boundaries. Across Nova Scotia, coastal communities can expect a rise in sea level, changes to precipitation patterns, amounts and intensities, warmer temperatures, and more frequent severe weather events like storms, floods and droughts (SNSMR, 2011a). Although planning for a changing climate cannot prevent changes in Lunenburg, it is useful for anticipating potential hazard risks and impacts. Planning enables the Town to better respond to climate change, reduce risk, minimize damage, and enhance resident safety. Of utmost importance is limiting the damage to critical municipal infrastructure including water, wastewater and roads. The purpose of this MCCAP is to proactively plan for climate change and identify where adaptation and mitigation measures are necessary to improve public safety and community sustainability.

The Province requires the preparation of MCCAPs for the transfer of the Gas Tax Funds which provide financial assistance for municipalities to invest in environmentally sustainable infrastructure projects.

The MCCAP builds on existing information, including:

- the Town's Inventory of the Build Environment at Risk to Sea Level Rise and Storm Surge (Forbes J. and Wightman J., 2013); and
- Scenarios and Guidance for Adaptation to Climate Change and Sea-Level Rise - NS and PEI Municipalities by William Richards and Réal Daigle (2011, August).

The MCCAP planning process determined that the primary hazard risk of concern in Lunenburg is flooding from sea level rise and storm surge impacts on its waterfront infrastructure.

Recommended Adaptive Actions:

- Design and implement a flood management program in the Victoria Rd. / Hall St. Area;
- Continue with Planning for flood management in the vicinity of Victoria Rd. and Falkland St.;
- Ensure Critical infrastructure has back-up power;
- Account for sea level rise in shoreline infrastructure design and maintenance;
- Continue storm sewer separation from sanitary sewer;
- Begin preparations to relocate important facilities;
- Consider additional emergency preparations;
- Establish coastal and floodplain setbacks;
- Organize a process to collect municipal staff knowledge about locations of climate change;
- Implement monitoring at Dares Lake;
- Review municipal structures for snow loading;
- Work with other municipalities, provincial agencies and organizations to have Annual regional meeting that discusses climate change issues and allows the sharing of information on how to address these issues;

- Implement a program requiring the provision of climate change reviews and stormwater management plans for development; and
- Implement an education program to education the public about climate change issue in the Town and what the Municipality is doing about it.

Recommended Mitigative Actions:

- Install a Direct Digital Control (DDC) or Supervisory Control and Data Acquisition (SCADA) system to improve monitoring and the efficiency of operations of Town facilities including buildings and the water and waste water pump inventory;
- Add insulation to older Municipal buildings such as the Electrical Utility building, Public Work building and the Angus Walters House;
- Consider switching to alternative heating fuel such as natural gas, propane and wood; and
- Ensure regular maintenance of the vehicle fleet and regularly review that the right-sized vehicles are being used for their intended purpose.

SECTION 1 ACTION PLAN - ADAPTATION

Section 1 of the MCCAP outlines Lunenburg's plan for climate change ***adaptation***. Climate change adaptation refers to:

> "Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Various types of adaptation exist, e.g. anticipatory and reactive, private and public, and autonomous and planned. Examples are raising river or coastal dikes, the substitution of more temperature-shock resistant plants for sensitive ones, etc." (SNSMRa, 2011: 3).

Adaptation approaches include *preserving* natural resource and habitat lands, *avoiding* development in areas at risk of hazard, *protecting* areas where hazard risk would be exacerbated by development, *accommodating* and tolerating climate change impacts, and *managing retreat* where it becomes necessary to relocate public and private assets at risk of severe risk climate change impacts, especially in coastal areas (SNSMRb, 2011).

Developing the Adaptation Plan for Lunenburg was a six-step process, and the findings of each step are detailed in the sections below:

1. Establishing an Adaptation Committee;
2. Identifying Climate Change Issues & Hazards;
3. Identifying Affected Locations;
4. Assessing Vulnerability of Facilities and Infrastructure;
5. A) Identifying Who Will Be Most Adversely Affected;
5. B) Identifying Potential Economic Implications;
5. C) Identifying Potential Environmental Issues; and
6. Determining Priorities for Adaptation.

1.1 Step One: Adaptation Committee

The Lunenburg Adaptation Committee was formed in late 2013 and represents a diverse range of expertise and experience. The Adaptation Committee (hereafter referred to as the Committee) is comprised of the following representatives from Council, town staff, and other local organizations:

Table 1.1: Adaptation Committee Members

Name	*Position*
Bea Renton	Chief Administrative Officer
Peter Haughn	Deputy Chief Administrative Officer
Marc Belliveau	Town Engineer
Peter Baker	Public Works Superintendent
Elana Wentzell	Finance and Accounting Director
Donnie Parks	Fire Hall Superintendent
Bruce Parks	Emergency Management Coordinator
Robin Scott	Recreation Director/Co-ordinator of Special Events

1.1.1 Adaptation Committee Mandate and Terms of Reference

The mandate of the Adaptation Committee is to oversee the preparation of a Municipal Climate Change Action Plan by early 2014. The Committee retained the consulting services of CBCL Limited to produce the MCCAP. The Committee has worked with the consultant to assess hazards, potential impacts, affected locations, risk severity, frequency and area, and rank municipal concerns in terms of priority.

1.1.2 Stakeholder Consultation

The Adaptation Committee and consulting team focused on talking to key informants and reviewing documents prepared by stakeholders (*see citations throughout and list of references*), rather than holding broad public consultation, which was not Provincially required for this planning process. Key Municipal staff sit on the Adaptation Committee, enabling important contributions and insights throughout the planning process.

1.2 Steps Two and Three: Hazards, Impacts and Affected Locations

The goal of **Step Two** is to identify climate change impacts and hazards. To achieve this goal, local weather-related and climate events in the past, as well as evidence from recent climate change scenarios (Richards and Daigle, 2011, Forbes and Wightman, 2013) were assessed to determine the potential climate change hazards and impacts for Lunenburg. Which of these potential climate changes could exacerbate or cause current and future potential hazards were then identified. Which changes in the climate could potentially bring opportunities to Lunenburg were also considered. The objective of Step Three is to identify locations within the Town of Lunenburg municipal borders that have been impacted by climate events or hazards in the past, and where they may occur in the future. In determining potential affected locations, the Committee considered local topography, geology, flood risk areas, erosion prone areas, hazard prone areas, cultural and historic sites, existing land uses and future land use zoning in these locations.

Steps Two and Three were conducted simultaneously and the findings are thus combined below. To methodologically guide the Committee's discussion on the current and potential future impacts of climate change related hazards, a Climate Change Hazard Impact Matrix was established and is included as *Appendix A*. The following sections describe anticipated climate changes for the Lunenburg area and discuss past and potential hazards, anticipated impacts, and possible locations under section headings that correspond with the matrix in Appendix A. Potential benefits to climate change are also discussed in the following sections.

1.2.1 Past and Existing Weather Events and Climate Related Issues

During a site visit on 31 January 2014, key stakeholders were interviewed. The stakeholder's observations on the impacts of past weather events was compiled in the following list.

1.2.1.1 Flooding

All stakeholders interviewed described flooding of the Victoria Road area as the top concern in terms of climate change impacts (Figure 1.1). In the recent past, the area is described by different stakeholders as being flooded between "once every two years" to "three to four times a year", reportedly due to a combination of high tide, storm sewer backup, and possibly frozen ground. An apparent increase in the intensity of storms was reported. It was noted that the storm surge can overtop the imitation wharf at Tannery Road and Buenavista Court which covers the storm outfall that services the area.

This flooding causes Victoria Street to be closed and the Municipality sometimes has challenges to get warning barriers up quickly enough and keeping them in place and the extent of the flooding can change quickly.

Figure 1.1: Victoria Road/Hall Street intersection looking Northeast, with the 'Blue Building' near the Community Centre in the background – Note the wetland on the left. This road regularly floods, experiencing temporary closures.

As shown in Figure 1.2, the area includes a number of important community facilities that are immediately adjacent to the area that floods. These facilities include:

- the 'Blue Building' on Victoria Road, which is used as storage space for public works, the electric utility and the fire department;
- the Community Centre, which also acts as an emergency shelter. The building was recently wired to allow a backup generator to be connected in the case of an electrical power outage. There is a large trailer mounted generator available at the 'Blue Building', which is capable of supplying complete power to the whole facility;

- the ambulance base. Victoria Road is the most direct link between the ambulance base on Hall Street and the main centre of population in the Town. Flooding of Victoria, Knickle and Tannery Roads could cut off the ambulance base, which has no alternate route to get to New and Old Towns; and
- Bluenose Academy. While it is a little further away from the area currently affected by flooding, it is immediately adjacent to the Community Centre.

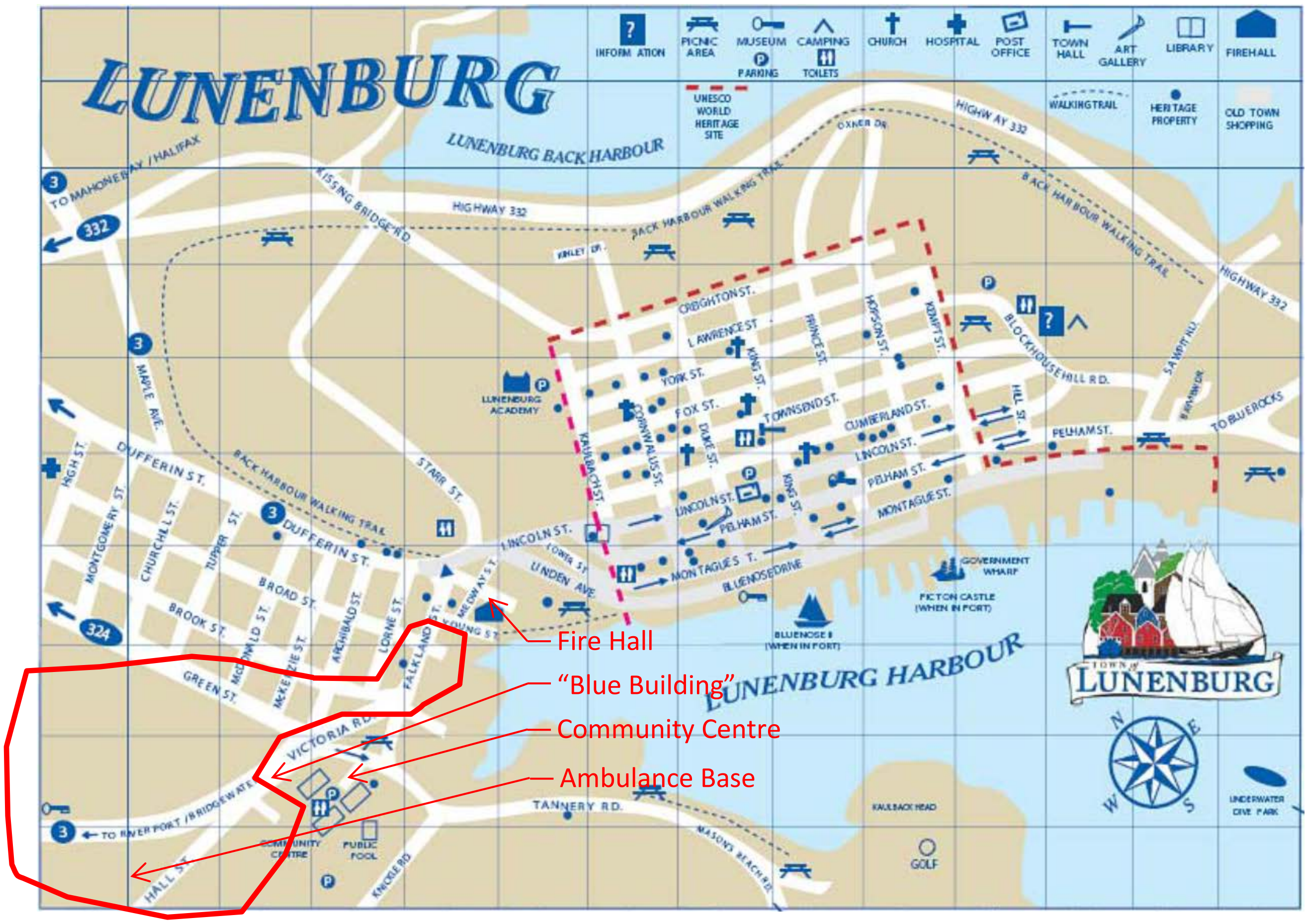

Figure 1.2: Lunenburg Town Map (Victoria Road area (circled) was described as particularly sensitive to flooding by local stakeholders)

Other streets to have experienced recent flooding include Dufferin Street, McDonald Street, McKenzie Street, Archibald Street, Brook Street, Montague Street (source: Town Council meeting minutes, 17 Sep 2012) which are located near Victoria Road and/or along the waterfront. Most Town sewers are combined storm and sanitary pipes, which increases basement flooding risks in low-lying areas during heavy rain storms. Separation is conducted as funding permits.

Fortunately, the Fire Station (see Figure 1.3), while it is near the waterfront, is situated on some higher ground and is not projected to be directly affected by sea level rise.


Figure 1.3: Fire station on Medway St. looking Southeast

1.2.1.2 Ice and Snow Loads

Heavy ice storms and hurricanes are known to interrupt electrical supply if trees or large limbs fall on the lines. Spruce and pine trees are reported to be difficult to deal with in snow, ice and wind conditions as they bend and touch wires and there are more of these types of trees planted the area known as Garden Lots, which is outside of the Town boundary. Given concerns with the age and condition of trees throughout the Municipality, the Town has recently completed a tree assessment project and has instituted a program to remove seven to eight trees of concern per year.

1.2.1.3 Water Supply

The water treatment plant is located at 524 Northwest Rd. The pumphouse is located at Dares Lake, to the northwest of the Town. There are no reported problems with water supply from the lake. During period of high flows, the lake used to flood some adjacent private land, but the Town has remedied this situation by setting the spillway lower.

1.2.1.4 Fire and Emergency Response

Town Public Works staff indicated that the water table may be getting higher because fire hydrants are unable to drain properly and are freezing more often. However, the Town has instituted a program of plugging the gravity drains on problem hydrants and pumping them dry to ensure proper operation.

The stakeholders noted that getting volunteers for fire and emergency is not presently an issue. The fire hall is located near the waterfront at the edge of the flood-prone area (see Figure 1.2). Flood mapping presented in the following sections indicate the station itself is outside the flood risk area, however flooded streets to the south may cut off access to that direction.

1.2.2 Anticipated Climate Changes for Lunenburg

Local climate science experts Richards and Daigle (2011) developed climate scenarios and climate change best estimates for representative communities across Nova Scotia and PEI. The climate scenarios consider both the current climate and possible future climate situations. For the Town of

Lunenburg, the closest representative community/climate station analyzed by Richards and Daigle is Bridgewater. A complete table showing the climate scenario data for Bridgewater can be found in Appendix B. The climate scenarios indicate in general, coastal communities across Nova Scotia can anticipate higher sea levels and storm surges, as well as warmer temperatures and increased precipitation amounts and intensities (Richards and Daigle, 2011).

1.2.3 Sea Level Rise and Storm Surge

The IPCC Fourth Assessment Report (AR4) cites updated information on global sea-level rise over the past 50-100 years and provides estimates of potential rise in mean sea level over the coming 100 years. For the global ocean as a whole, the latest literature assessed in AR4 indicates that sea level rose 0.17 ± 0.05 m during the 20th century, an increase over the rate in the 19th century, and slightly less than the mean rate of 1.8 ± 0.5 mm/year observed from 1961 to 2003.

In Nova Scotia, the sea level rose about 0.30 m in the twentieth century due to the rise in water level plus land subsidence (i.e., sinking of land surface, as currently occurring in NS due to post-glacial ocean loading of the continental shelf). The rate of global mean sea level rise is accelerating in the 21st century due to global warming impacts, notably the melting of polar ice caps. A report from the Arctic Monitoring and Assessment Program (AMAP, May, 2011) warns that the potential global mean sea level rise may range from 0.9 m to 1.6 m by 2100 if the melting of polar ice caps continues as predicted. In September 2013, the Intergovernmental Panel on Climate Change (IPCC 2013) indicated that the current consensus is as follows:

- the likely range of global mean sea level rise for 2081-2100 relative to 1986-2005 is estimated from 0.26 m (lower bound value for low emission scenario) to 0.98 m (higher bound estimate for high emission scenario);
- there is currently insufficient evidence to evaluate the probability of specific levels above the assessed likely range;
- there will be regional differences, with the northeastern coast of North America potentially experiencing a sea level rise rate higher than the global average (Sallenger et al., 2012); and
- sea level rise will continue for centuries after global temperature have been stabilized. Several meters of sea level rise must be expected over the next few centuries.

The storm surge and sea level rise and estimates provided by Richards and Daigle for NS Municipalities (2011) and used by Forbes and Wightman for Lunenburg (2013) are consistent with the above sources, and will be used throughout the present assessment. By 2100, the total sea level in Lunenburg areas is anticipated to rise approximately 1.06 m ± 0.48 m.

Sea-level changes are driven by a combination of local, regional, and hemispheric factors. Each coastal area responds differently to a particular combination of these factors, and the change in sea-level varies along Nova Scotia's coastlines. Total sea-level rise is the net sea-level rise based on estimated sea-level rise and subsidence of a particular region.

Based on estimates of crustal subsidence in coastal areas around Nova Scotia, Table 1.2 quantifies the total predicted sea-level rise for various communities in the area, including Lunenburg.

Table 1.2: Estimates of Anticipated Changes in Total Sea-Level in Metres

Location	***Sea-Level Rise (2100)***	***Crustal Subsidence (2100)***	***Total Change (2025)***	***Total Change (2055)***	***Total Change (2085)***	***Total Change (2100)***
Halifax	0.90 ± 0.43	0.16 ± 0.05	0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Lunenburg	0.90 ± 0.43	0.16 ± 0.05	0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Liverpool	0.90 ± 0.43	0.16 ± 0.05	0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Yarmouth	0.90 ± 0.43	0.16 ± 0.05	0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48

(Adapted from Scenarios and Guidance for Adaption to Climate Change and Sea-level Rise, W. Richards, August 2011)

Rising seas will permanently flood land that is less than 1.06 m above mean sea level (provided it is not protected by a higher sea wall or other structure). Storm surges will cause temporary flooding, but may still inflict major damage. A rise in sea level can geographically extend the impact of tides and storm surges (Government of Nova Scotia, 2009a), increasing the frequency and severity of coastal flooding. Residents need only consider the extent of previous surges and floods (i.e. high water mark), and then envision how much farther a similar surge/flood event would extend with a 1.06 m increase in sea level. For example, a storm surge that has a 1% chance of happening in 2000 (100 yr. return period) will have a 10% (10 year return period) chance of happening each year by mid-century. By the end of this century, a 1 in 100 year storm could reach land that is less than 3.25 m ± 0.68 m CD in the Lunenburg area (Table 1.3). Table 1.3 provides additional information on sea level rise and storm surge (m CGVD28) scenarios for Lunenburg at different points in the future. See Section 1.3 for a more detailed discussion of sea level rise and storm surge impact on Lunenburg infrastructure.

Table 1.3: Sea Level Rise and Storm Surge (m CGVD28) Scenarios for Lunenburg from Forbes and Wightman (2013)

Parameter	***2000***	***2025***	***2055***	***2085***	***2100***
Total Sea Level Rise (m)		0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Extreme Total Sea Level (m CGVD28)					
HHWLT	1.24	1.39 ± 0.03 **1.42 (Sc. 1A)**	1.67 ± 0.15	2.07 ± 0.36	2.30 ± 0.48 **2.78 (Sc. 2A)**
10- Year Return Period	1.95 ± 0.20	2.10 ± 0.23	2.38 ± 0.35	2.78 ± 0.56	3.01 ± 0.68
25- Year Return Period	2.05 ± 0.20	2.20 ± 0.23	2.48 ± 0.35	2.88 ± 0.56	3.11 ± 0.68
50 – Year Return Period	2.12 ± 0.20	2.27 ± 0.23	2.55 ± 0.35	2.95 ± 0.56	3.18 ± 0.68
100- Year Return Period	2.19 ± 0.20	2.34 ± 0.23	2.62 ± 0.35	3.02 ± 0.56	3.25 ± 0.68
Benchmark storm: Hurricane Juan (1.63 m surge)	2.87	3.02 ± 0.03 **3.05 (Sc. 1B)**	3.30 ± 0.15	3.70 ± 0.36	3.93 ± 0.48 **4.41 (Sc. 2B)**

Note: the above estimates were converted from Daigle and Richards estimates using a 1.188 m conversion factor from the local Chart Datum to the Geodetic Datum CGVD28 (source: DFO, December 2014)

Figure 1.4 is a map illustrating areas affected by projected sea level rise scenarios. Scenarios 1A and 1B are based on projected scenarios for the year 2025, while scenarios 2A and 2B are based on projected scenarios for the year 2100. Using the precautionary principle, this study examines the worst case scenario as the basis for description and decision-making.

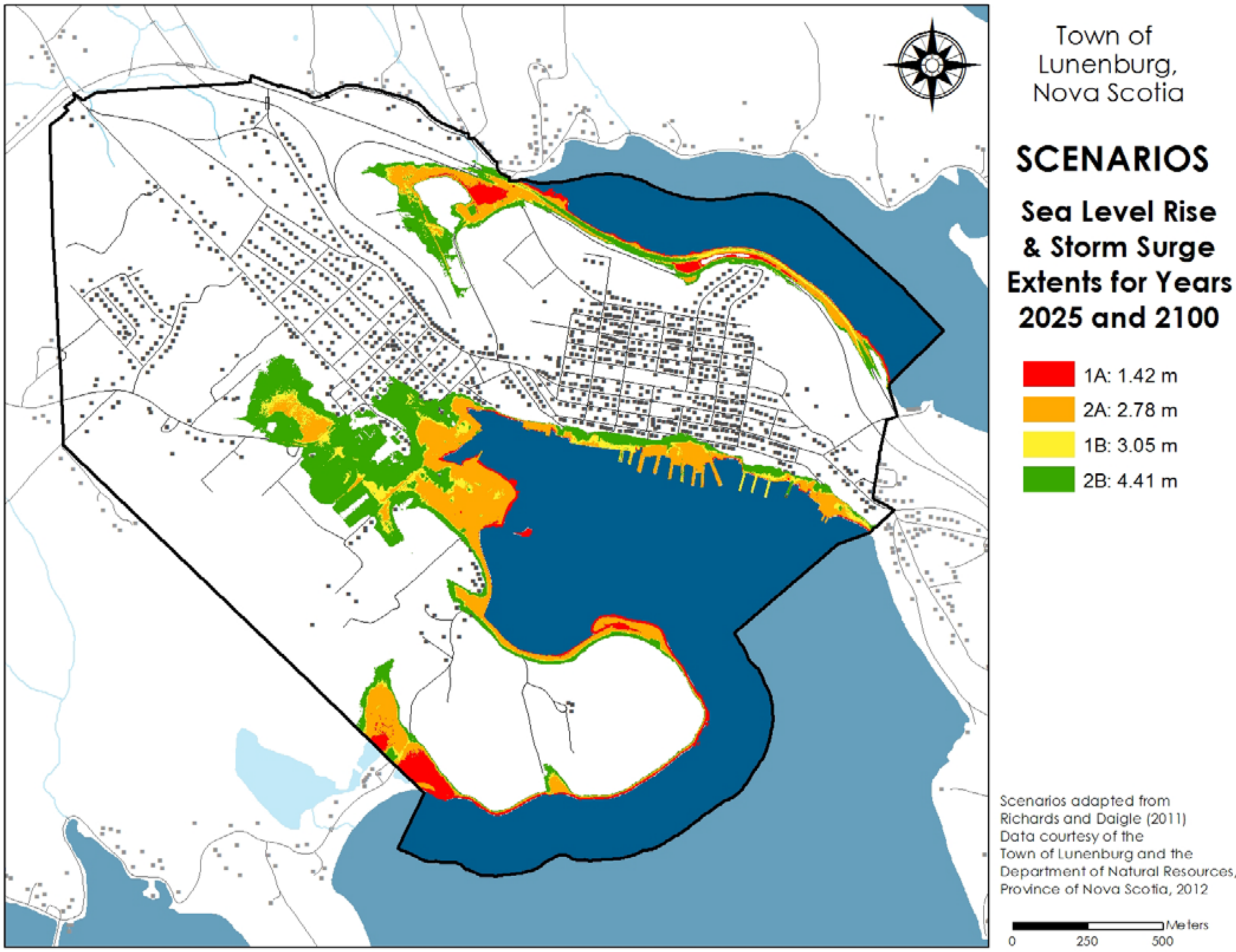

Figure 1.4: Sea level rise and storm surge extents for scenario 1 (2025) and scenario 2 (2100), cases A (extreme sea level rise) and B (extreme sea level rise + storm surge) (reproduced from Forbes and Wightman, 2013)

Sea level rise can also have an impact on storm events such as erosion, increasing the flooding extent, and beach migration (Government of Nova Scotia, 2009b). An accelerated rate of erosion is likely along coastal areas, prompting the need for further consideration of retreat or protection options.

In summary, the identified hazards of the gradual predicted increase in sea level are:

- increased erosion;
- permanent inundation;
- more extreme flooding events;
- salt water intrusion; and
- damage to infrastructure.

Figure 1.5 shows water levels reached on 16 February 2014 along Tannery Rd. This was an extreme high tide event which overtopped the waterfront retaining wall. There was no wind or storm surge that would have caused more extensive flooding by this high tide event. With climate change, sea level rise will cause this extreme high tide event to get higher and the increased frequency of storms and storm surges will cause water levels to be even higher.

Figure 1.5: Oceanfront Water Levels along Tannery Rd., 16 Feb. 2014

1.2.4 Erosion and Landslides

Landslides are considered of minor, rare, and small hazard risk in the Town of Lunenburg. Coastal erosion is a major concern and could cause the following impacts:

- damage to property and infrastructure;
- water contamination / siltation;
- habitat disruption;
- road and access disruptions; and
- slumping in banks along the river.

Figure 1.6 shows areas susceptible to erosions within the year 2100 sea level rise and storm surge scenario.

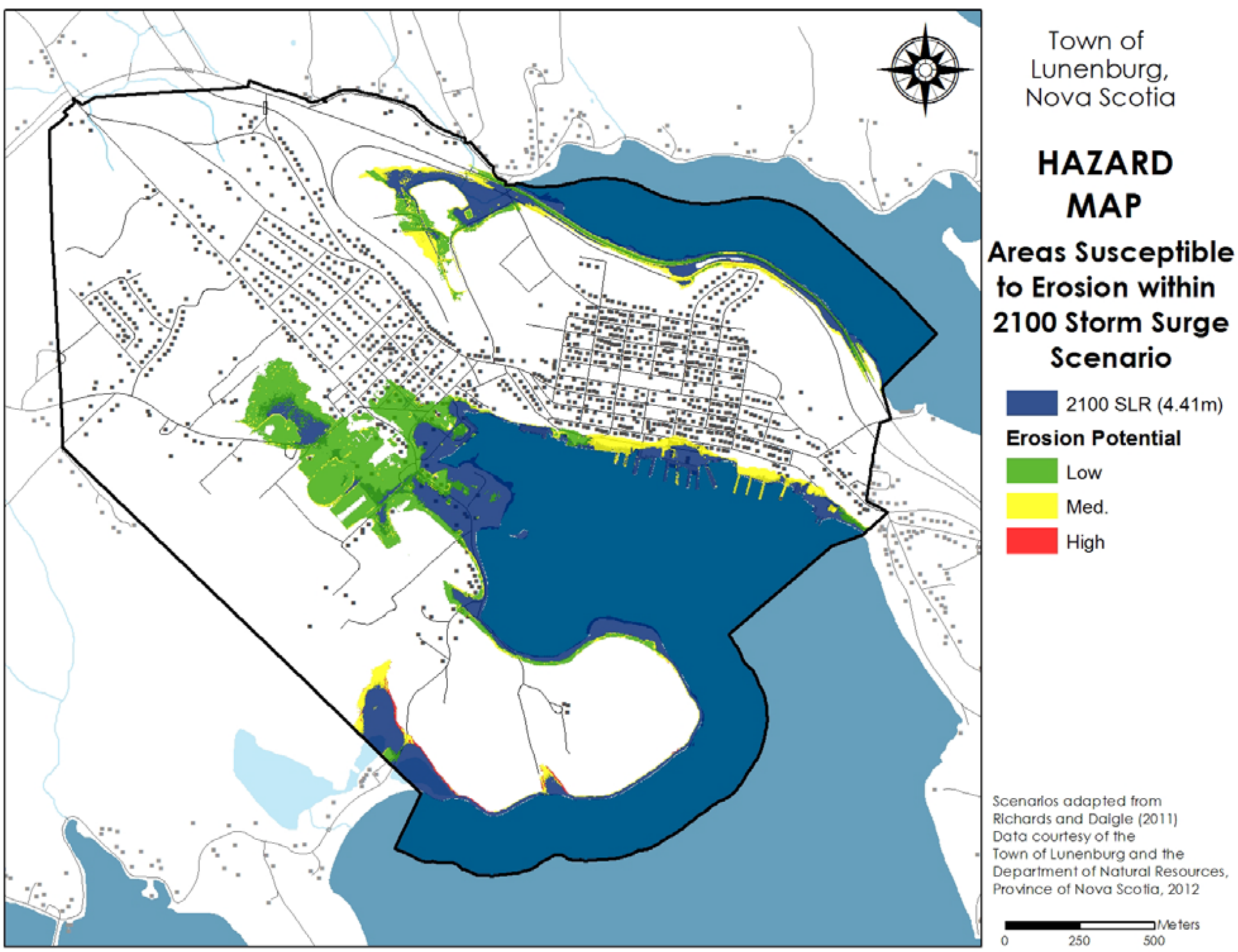

Figure 1.6: Erosion hazard map (reproduced from Forbes and Wightman, 2013)

1.2.5 Increased Precipitation Amounts and Intensity, and Flooding

In Lunenburg, the hazard risks associated with increased precipitation amounts and intensities, and the potential stormwater flooding are of concern. With climate change, increased amounts of precipitation and more intense rainfall events are anticipated. A 5% increase in the amount of rain by the 2020s, 9% by the 2050s, and 16% more rain by the 2080s can be expected (Richards and Daigle, 2011). Heavy, sudden storms are concerning, but smaller slow moving storms can also bring heavy amounts of rainfall and pose flood risks (SNSMR, 2011b).

Warmer Winters and More Rain

With increased temperatures, warmer winters with fewer cold (less than -10°C) and very cold days (less than -20°C) can be expected. Richards and Daigle (2011) observe that precipitation is likely to increase most during the winter months, so more days with rain and less with snow can be expected. Winter precipitation brings concern about freezing rain and icy road conditions. Freeze-thaw cycles can also put stress on the built environment, such as concrete structures and asphalt roads, potentially resulting in cracks and potholes. As the climate warms over the long term, freeze-thaw cycles will decrease, but in the short and mid-term communities can anticipate freeze-thaw cycles as a potential impact in the winter months (Richards and Daigle, 2011). A potential benefit of less snow is that the Town's budgetary needs for snow clearing will eventually decrease. However, the requirement for salting and sanding of roads may escalate due to increased amounts of freezing rain and changes in the freeze-thaw cycles. Fluctuating winter climate conditions will also impact the timing and intensity of snow melt and spring run-off, which may impact the timing and intensity of potential flooding.

Potential Impacts - Increased Precipitation Amounts and Intensity, and Flooding

The impacts of increased precipitation amounts and intensities and flood include:

- overflowing of the storm sewers and of the sanitary sewer system sections that are still combined with storm, resulting in basement flooding for properties in low-elevation areas;
- damage to property and critical infrastructure (e.g., water, power, see further discussion in see Section 1.3);
- disruption of roads;
- isolation and limits to access;
- evacuation;
- water contamination;
- freezing rain/ icy road conditions;
- impact on septic systems and sewage treatment;
- habitat disruption; and
- fatalities and injury.

Flooded roads would impede access to and from homes, businesses and emergency services. For example, residents may be unable to access homes or the hospital, and emergency service providers may be cut off from accessing homes and other affected locations. In an intense rain or coastal flooding event, floodwaters would likely contain debris and contaminants. Heavy rains will increase runoff and may place a strain on culverts and the storm water drainage system which would be exacerbated by blocked culverts. Flooding, debris, contaminants and runoff will disrupt natural stream and wetland habitats. Depending on the severity of the rain and flooding, there could be potential impacts on septic systems. High, fast river waters and floods also have the potential to cause injury or result in fatalities (e.g., from drowning).

Past and Anticipated Future Flood Locations

Locations mapped as vulnerable to sea level rise in previous figures are all potential flood locations. The high tide and storm surges may impact upstream area through a backwater effect that prevents sufficient drainage of streams and sewer systems. The Victoria Road area is of the highest concern.

1.2.6 Hurricanes, Lightning & Wind

Storms and hurricanes can bring high winds and lightning, which can damage property and critical infrastructure by hitting these directly, or hitting a tree and causing broken limbs and branches to fall and cause damage. These hazards can impact any location in the municipality. Power and communications lines are especially vulnerable to high winds. Historical "climate normals" for nearby Halifax, NS (1970-2000) show a yearly average wind speed of 16.8 km/hr, and the wind direction most frequently South. The maximum hourly wind speed was recorded in 1964 at 89 km/hr, and the maximum gust speed was recorded in 1976 at 132 km/hr (Climate Canada, 2013).

Potential Impacts – Hurricanes, Lighting and Wind

The potential impacts of hurricanes, lightning and wind include:

- direct hits and fallen tree limbs and branches;
- damage to power & communication lines and other critical infrastructure;
- disruption of roads;
- limits to access;
- damage to private property;
- injury or fatalities; and
- lightning – fires.

The Town of Lunenburg has the capacity to clear roads and minimize disruption by cleaning up fallen tree limbs and branches and other debris following a storm with high winds. Wet soil conditions can compound the impacts of storms, lightning and wind, as root systems and tree stability may be affected. Depending on where a tree limb falls or lightning strikes, private properties and municipally-owned buildings may be damaged. Fallen tree limbs and lightning strikes have the potential to injure people or cause fatalities, depending on when and where the damage occurs. Lightning strikes have the potential to cause fires in either treed areas or buildings.

Power Outage

Damage to power lines could cause far-reaching power outage affecting Lunenburg residents, businesses, infrastructure and services depending on where and which lines were damaged. The following possible major effects of power outage include:

- loss of heat/ cooking; lighting;
- loss of water-pumps;
- food shortages/spoilage;
- traffic lights;
- loss of communications;

- fuel shortage; and
- money shortage.

1.2.7 Warmer Summers and Droughts

Even through increased amounts of precipitation can be expected as a result of climate change, soil conditions can still be very dry because of warmer temperatures and increased evaporation (Richards and Daigle, 2011). Lunenburg will be highly affected by increased temperatures. This is likely to increase the number “cooling degree days” within a year and lead to more energy used to run air conditioners. Hot days (exceeding 30°C) currently about six per year are projected to increase to almost 32 days per year by 2080. Very hot days (exceeding 35°C) currently zero per year are projected to increase to 2.6 per year (Richards and Daigle, 2011).

Potential Impacts – Warmer Summers and Droughts

- surface water recharge reduction;
- habitat disruption (e.g., low water levels in streams, ponds and wetlands, risk of fire); and
- loss of agricultural productivity.

Lunenburg’s primary concern about warmer summers is the risk of drought and placing strain on the Town water supply. While Dares Lake is not currently experiencing any issues, the dramatic increase in hot days and variations in precipitation could cause lower levels in the future. Strain on the water supply would likely occur in the hottest times of the summer, especially August. Falling water levels in streams, ponds and wetlands will disrupt habitat for plant species and wildlife. The Committee considers risk of forest fire to be very low, given the limited amount of forested areas within Town boundaries. There is little agricultural activity within the Town’s borders; however, it is worth noting that the growing season is expected to be lengthened by approximately one to two months by the end the century (Richards and Daigle, 2011). This will require adaptation from farmers and even backyard gardeners in terms of the crops grown and will affect the need for irrigation and watering.

The Town of Lunenburg, and other maritime municipalities will need to adapt to warmer temperatures and Council may need to consider actions like issuing heat health alerts, and providing public air-conditioned cooling centres and special monitoring and services for vulnerable groups like young children and seniors. Drought conditions may also require restrictions on household, lawn and gardening water uses. Warmer municipalities across Canada can provide examples for these measures, so Lunenburg will not have to reinvent the wheel as the climate gets warmer over time. A potential benefit of warmers summers is an extended tourism season, which will have positive economic impacts throughout Nova Scotia.

1.2.8 Earthquakes

Earthquakes in Nova Scotia are of such a low magnitude that they are rarely felt. Earthquakes are measured according to seismic energy on a Magnitude scale of 1-9. Earthquakes in the Magnitude of 1-3.5 are “recorded on local seismographs, but generally not felt” (NRCAN 2014a). Table 1.4 presents a search of the NRCAN (2014b) earthquake database which shows eight low-magnitude

(1.6-3.2 MN) earthquakes in the Bridgewater-Lunenburg area between 1985[1] and 2013 (see Figure 1.7 below).

Table 1.4: NRCAN Earthquake Database ,1985-2013

Date	***Lat***	***Long***	***Mag***	***Region and Comment***		
2007/07/16	44.297	-64.742	3.2MN	Felt	in	Bridgewater
2007/06/11	44.351	-64.700	2.8MN	15	km	W from Bridgewater
2007/12/11	44.425	-64.799	1.7MN	23	km	W from Bridgewater
2002/06/20	44.455	-65.227	2.3MN	60	km	W from Bridgewater
2003/01/24	44.600	-64.988	2.9MN	45	km	NW from Bridgewater
2003/01/21	44.623	-64.950	2.4MN	45	km	NW from Bridgewater
2003/02/09	44.671	-65.033	1.6MN	50	km	NW from Bridgewater
2003/01/16	44.683	-64.924	2.3MN	50	km	NW from Bridgewater

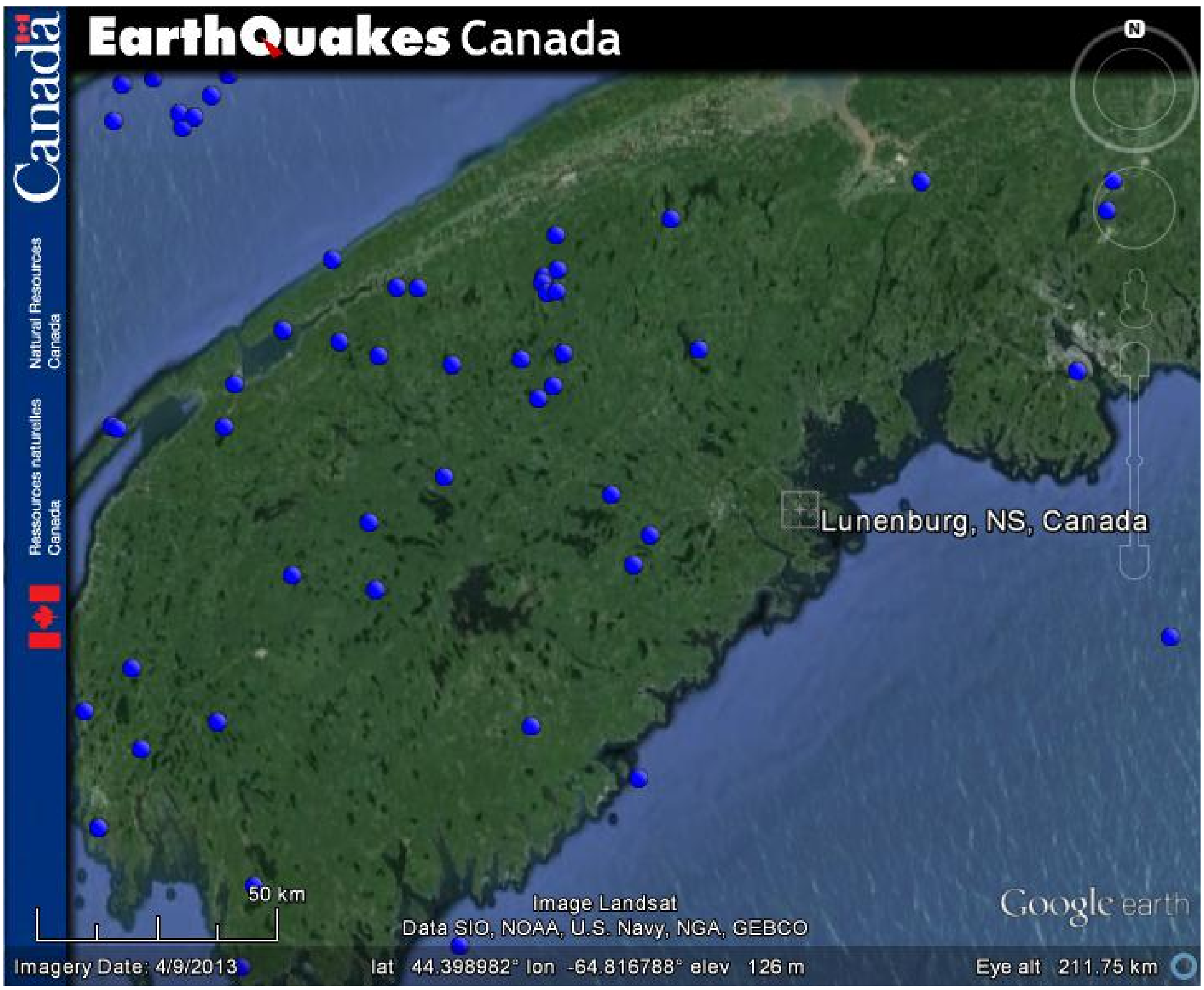

Figure 1.7: Earthquake locations near Lunenburg, NS 1985-2013 (NRCAN, 2014)

[1] Earliest date in the historical database for the Lunenburg area search.

Climate change does not affect earthquakes. Earthquakes are considered a low, and rare risk within the Town of Lunenburg currently, and in the long term. Given the historically low magnitude of earthquakes in the region, feeling an earthquake and any resultant damage is highly unlikely.

1.2.9 Information Gaps

Generally the following information is lacking relating to hazards caused by climate change:

- Accurate erosion rates and erosion maps for the Town's shorelines;
- Some storms deposit large amounts of rain in localized areas which may not be measured by Environment Canada as they don't have enough stations in place to cover the geographic area accurately. Therefore, weather extreme data from Environment Canada may not be dependable to be used for prediction of a maximum rain event; and
- The closest tide gauge is located in Halifax Harbour. A tide gauge should be located within the Harbour to accurately document the return frequency of high water events and associated probabilities of coastal flooding damage.

1.3 Step Four: Facilities, Infrastructure and Service Delivery

The objectives of step four are to identify the key facilities and infrastructure in the Town of Lunenburg boundaries, to determine whether some will be more affected than others, and to evaluate the impact of climate change on the delivery of municipal services.

The following discussion represents the potential extra impact of climate change on facilities, infrastructure and service delivery in addition to regular maintenance, retrofits and renewal. In addition to the following discussion, Appendix C includes completed Infrastructure Risk Assessment Spreadsheets, using the framework established by Service Nova Scotia and Municipal Relations. The spreadsheets assess the potential risk posed to each municipal infrastructure by potential climate change impacts.

1.3.1 Stormwater, Roads, Bridges and Culverts

The Town of Lunenburg maintains all roads within Town boundaries. Stormwater in the central area of Lunenburg is directed into the Harbour. Lunenburg monitors and maintains culverts throughout town.

As noted above in Section 1.2.1, the area in the vicinity of Victoria Street and Hall Street are already regularly affected by flooding related to heavy precipitation when high tides and storm surges back up the outfall at Tannery Road and Buenavista Court. Dufferin Street, McDonald Street, McKenzie Street, Archibald Street, Brook Street, and Montague Street are also affected by flooding. With climate change, the frequency of this flooding is projected to increase. The Town is aware of this issue and has begun investigations to look for solutions.

As shown on Figure 1.8, it is anticipated that all of Bluenose Drive, Montague Street at Prince Street, the Highway 332 bypass from west of Kissing Bridge Road to Sawpit Road, and Starr Street up to the vicinity of the proposed dog park will also be affected by more frequent flooding.

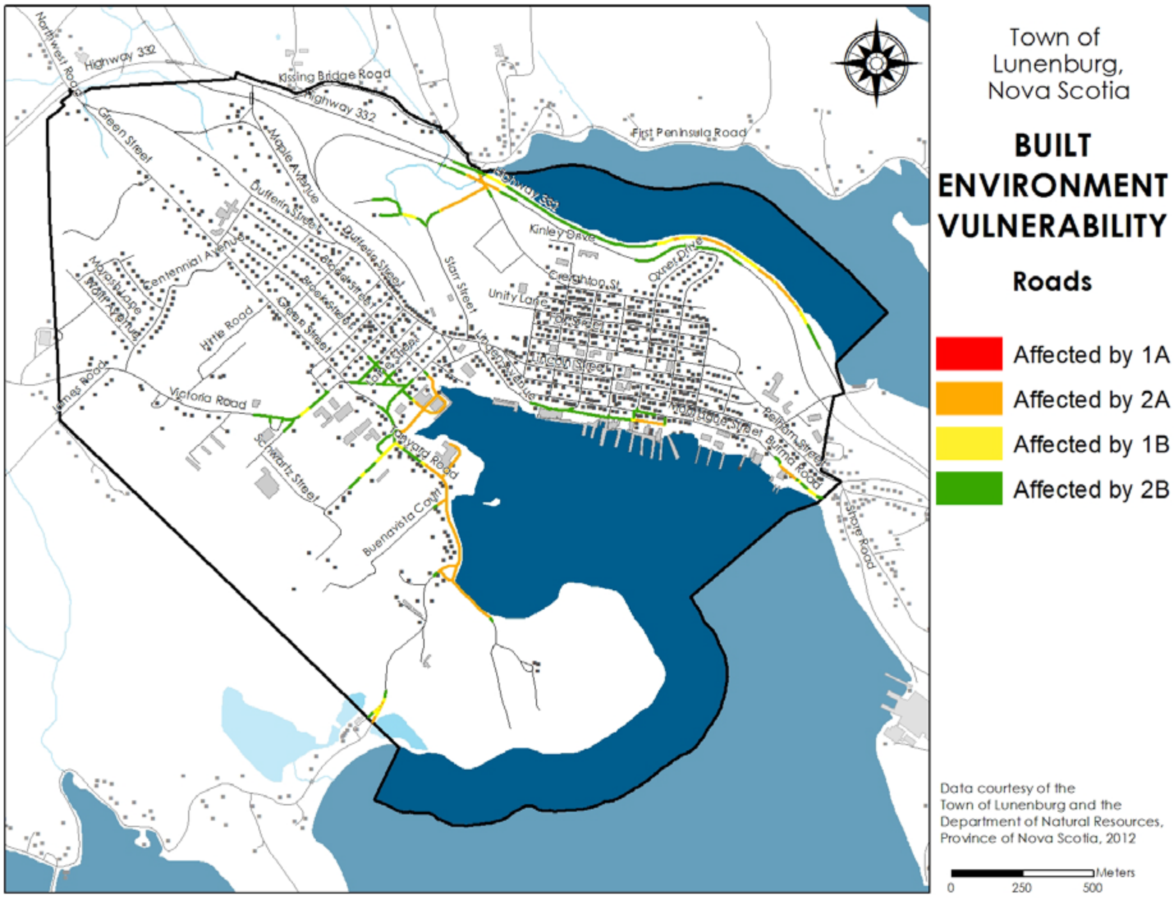

Figure 1.8: Built environment vulnerability map: Roads (reproduced from Forbes and Wightman, 2013)

1.3.2 Emergency Facilities and Other Buildings

Figure 1.9 highlights buildings that will be affected by sea level rise and storm surge under different scenarios. As noted in Section 1.2.1, the area around Victoria Street and Hall Street already experiences regular flooding that causes the closure of Victoria Street up to three to four times per year. The area contains the Community Centre, which acts as a shelter in an emergency situation, the "Blue" Building which is used to store materials for the Municipality and the Electrical Utility, as well as a number of businesses and residences. This flooding will be exacerbated by climate change.

As noted in Section 1.2.1, the ambulance base (see Figure 1.10) is located near this area on Hall Street. While the building will not be affected by flooding, Victoria Road is anticipated to flood more frequently and the area affected by flooding is expected to increase in size cutting off access from the ambulance base to other portions of the Town during extreme events

While it is not currently experiencing issues, it is anticipated that future flooding due to climate change will affect the Bluenose Academy, the public school located at the corner of Knickle and Tannery Roads. The Angus Walters House at 8 Tannery Road and the adjacent Annex are both municipally owned buildings in the area will be affected.

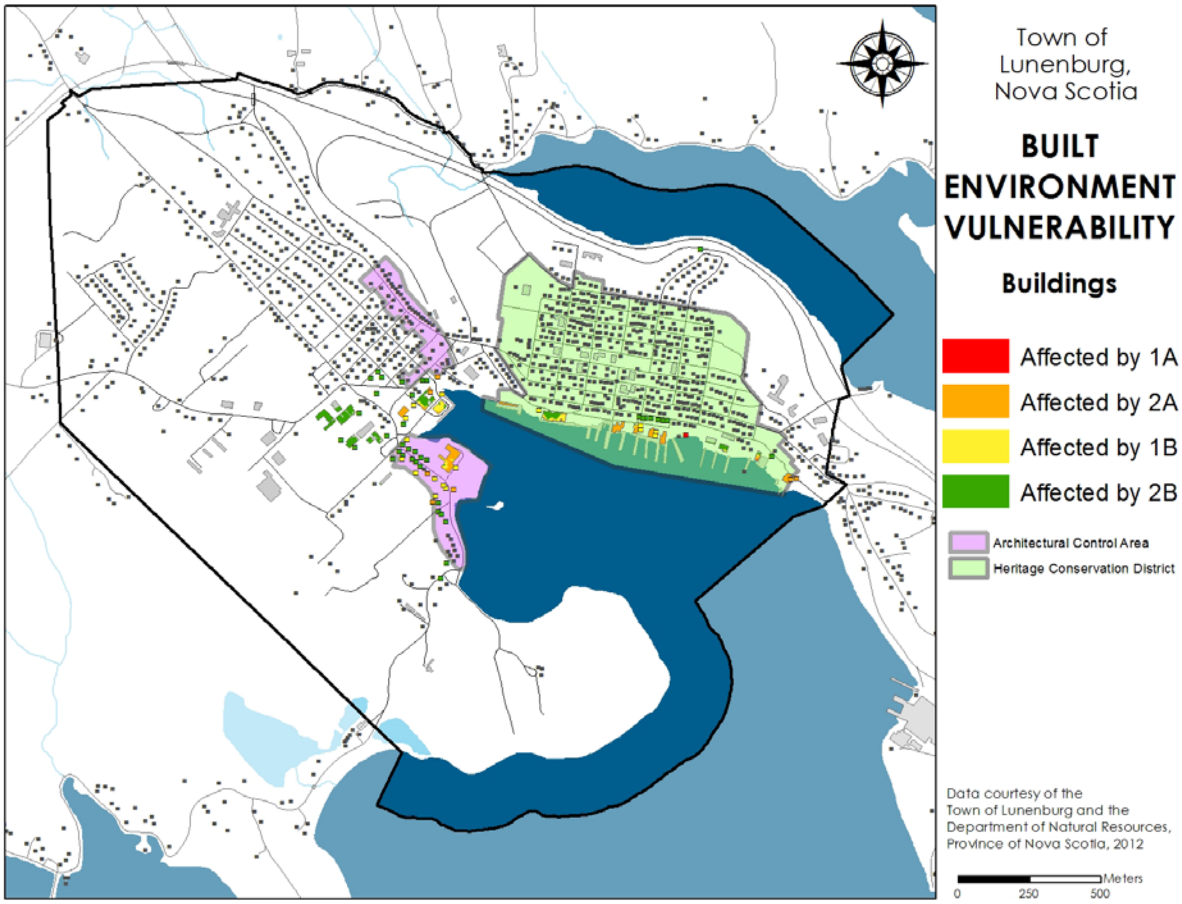

Figure 1.9: Built environment vulnerability map: Buildings (reproduced from Forbes and Wightman, 2013)

Figure 1.10: Ambulance base on Hall St., looking Northeast down towards Victoria Road.

The entire waterfront area of Old Town will be significantly affected by sea level rise and storm surge. Figure 1.11 provides a dramatic photo-illustration of the anticipated impact. While most of the buildings and other structures in the area are not owned by the Town, they are key to the identity of the community and are the basis of the tourism industry, which provides significant employment, income, and tax revenue in the Town.

Figure 1.11: Photo-illustration (looking East) showing the waterfront flooding extent for scenario 2B (source: The Chronicle Herald, using a photo provided by Communications Nova Scotia).

In addition, many of the waterfront industries across the harbour including ABCO and Lunenburg Marine Railway (LIFE Plant #2), where the Bluenose II was re-built would be impacted negatively affecting employment in the area.

Figure 1.12 shows parcels of land in Lunenburg that will potentially be impacted under differing climate change scenarios. Without attention to the storm drainage system in the area, private residences in the lower portions of McDonald Street, McKenzie Street, Archibald Street, Brook Street, and Montague Street will experience increased flooding. As noted in Section 1.3.1, the Town is aware of this issue and has begun investigations to look for solutions.

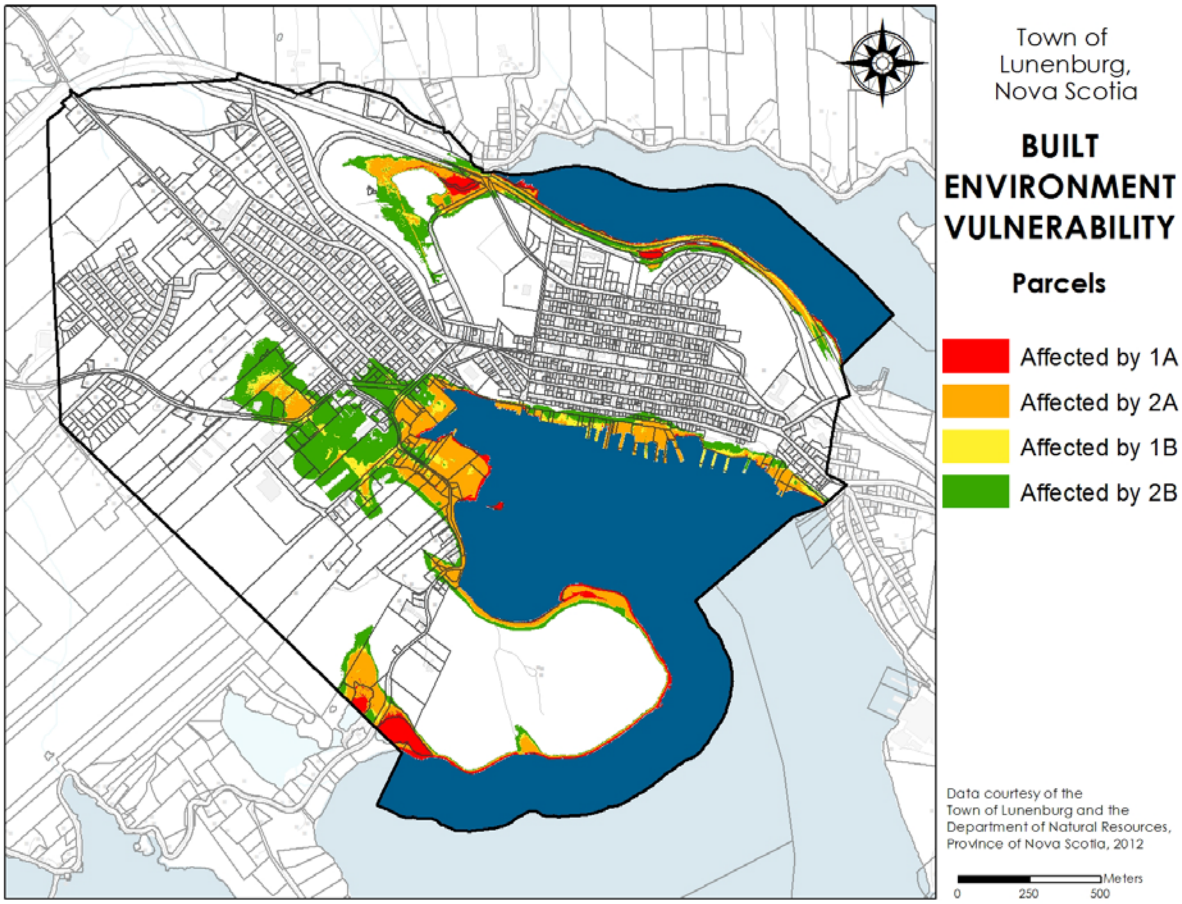

Figure 1.12: Built environment vulnerability map: Land Parcels (reproduced from Forbes and Wightman, 2013)

1.3.3 Sewer and Water Utilities (Lines and Hydrants)

Figure 1.13 illustrates sewer and water utilities in Lunenburg that will potentially be impacted under differing climate change scenarios.

As noted in Section 1.2.1, the Town does not currently experience issues with water supply. Potential impacts related to droughts affecting water supply in the future are noted in Section 1.2.7. Ensuring the cleanliness and safety of the public water supply and minimizing disruptions to the distribution system are top priorities. Climate change-induced droughts, insufficient recharge, and severe flooding could impact the water supply. As the water supply system is pressurized, temporary flooding in vulnerable areas should not affect supply lines significantly.

As noted in Section 1.2.1, the Town has been experiencing more frequent issues with the freezing of fire hydrants and has instituted a program of draining the hydrants to avoid this problem. As this maintenance only needs to be done on an annual basis or after a hydrant is used in the winter, it does not constitute a major issue.

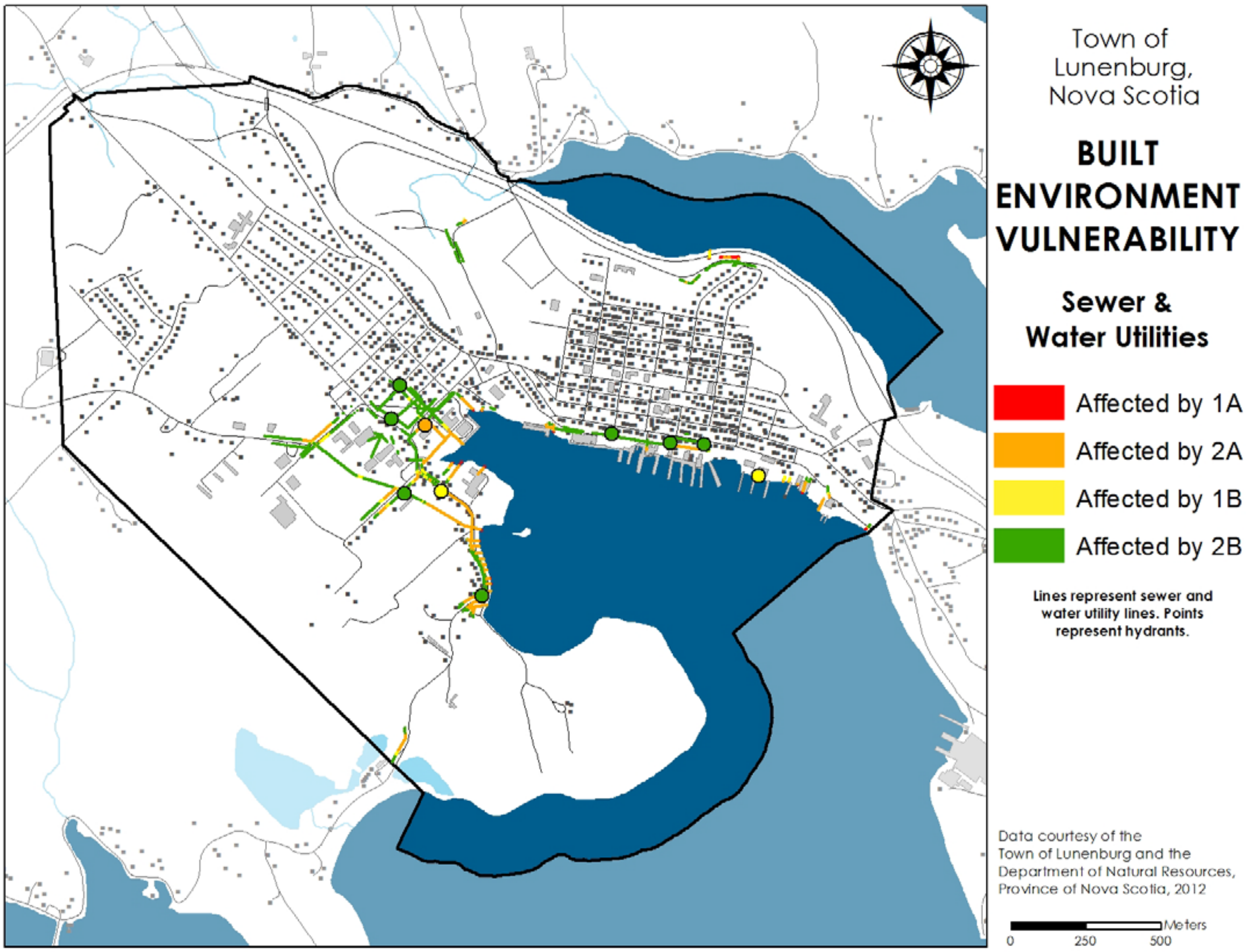

Figure 1.13: Built environment vulnerability map: Sewer and Water Utilities (reproduced from Forbes and Wightman, 2013)

1.3.4 Wastewater Collection and Treatment

As noted on Figure 1.13, it is anticipated that there will be flooding experienced at the head of Back Harbour and the mapping indicates that the sewage treatment plant is likely to be affected. Many of the Town's sewage lift stations will likely be flooded. The sewage treatment plant does not have a back-up power supply and only the lift station at Tannery Road can be connected to a generator. With a loss of power to the Town, some or all of the lift stations and the sewage treatment could cease functioning. Depending on the length of the outage, overflows of sewage into potential vulnerable areas could occur.

The Municipality also has a salt shed and a fire fighters training centre located adjacent to the sewage treatment plant, and these facilities also may be affected by flooding.

1.3.5 Power Utilities and Supplies
The electrical substation supplying the Town is located adjacent to the sewage treatment plant and the mapping indicates that it is likely to be impacted by flooding.

Other risks to electrical supply and potential impacts are discussed in Sections 1.2.1 and 1.2.6. The extent of impact from a power outage depends on which part of the power supply system is impacted. For example, if the substation were affected, there would be more serious impacts than from a single power line being impacted during a storm.

1.4 Step Five: Social, Economic and Environmental Considerations

1.4.1 Social Considerations
According to the 2011 census[2] the Town of Lunenburg Census Area has a population of 2,313 people with 1,035 males and 1,278 females. The population has declined by nearly 10% over the last decade from 2,568 in 2001. The median age is approximately 53 with more than 84% of the population over 19 and approximately 40% of the population over 60 years of age. These statistics are significantly higher than the Provincial averages of 79% over 19 years old, about 24% over 60 and a provincial median age which is closer to 43 years of age.

The official employment rate[3] for the Town of Lunenburg is 50.8% with a slightly above average unemployment rate of 11%, compared to the Nova Scotia average of 10%. According to 2006 statistics, the median income for fully-employed residents was $21,386 – lower than the Provincial median of $24,030.

Vulnerability to the associated impacts of sea level rise, notably, to the implications of storm surge events becoming more frequent and more damaging to buildings and infrastructure, varies throughout the community. Certain populations within the community may also be more vulnerable to the impacts of climate change, than would be their neighbours.

Low-income and disabled residents are more vulnerable to climate change hazards and impacts. REMO Lunenburg recommends that all households have 72 hours of resources on hand for emergencies, like food and water. Having these resources available is challenging for residents with tight budgets and fixed incomes. Developing a central registry or list of community leaders from

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[2] Statistics Canada. 2012. Lunenburg, Nova Scotia (Code 1206006) and Lunenburg, Nova Scotia (Code 1206) (table). Census Profile. 2011 Census. Statistics Canada Catalogue no. 98-316-XWE. Ottawa. Released October 24, 2012. http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/index.cfm?Lang=E (accessed February 17, 2014).

[3] http://www.novascotia.ca/finance/communitycounts/profiles/community/default.asp?gnum=mun62&gview=3&glevel=mun

local churches, charities, service clubs, etc., who could help communicate with, provide shelter and other assistance, and relocate people such as seniors, low-income households, special needs residents and other marginalized populations should be considered. Provincial departments and social services may be able to play a role in developing these resources.

As the Municipality has an aging demographic, the development of adaptation measures was focused primarily on emergency services delivery and associated planning. The Regional Peacetime Emergency Plan (prepared by REMO) and the Integrated Community Sustainability Plan (ICSP) are the key instruments in addressing climate related social impacts. Adaptation measures include:

- education on how to prepare for weather related emergencies;
- use of a communications strategy as a tool for the dispersal of information regarding emergency preparedness;
- identification of access routes and other roads that are vulnerable and may impede emergency services access; and
- identification of community resources that could be utilized in the event of climate change emergencies and the development of plans and lines of communications to enable access to and management of these resources in an emergency situation.

Social media has had a growing significance in assisting municipal communications, however, due to literacy concerns and limited access to computers, radio announcements and other means of communication (e.g., word of mouth, phone calls, etc.) still remain important in the case of a climate related emergency event.

1.4.2 Economic Considerations

Lunenburg's economy is service-based, with the service sector employing nearly 70% of the working population in health, education, business and social services and many tourism related activities. The municipality has over 200 businesses and community organizations listed in their Business and Service Directory some of whom are seasonal, open only during popular tourist periods. Much of the town is zoned as residential; however, many homes operate as bed & breakfasts or double as home businesses.

The downtown includes retail shops, banks and services like restaurants and accommodations with most businesses oriented to tourists. The downtown area could become impacted by overloaded culverts and coastal inundation; especially the commercial properties situated near the water off of Bluenose Drive. Many of the Town's civic and cultural infrastructure including public utilities could also be damaged or made inaccessible during a major flood event.

Almost all industrial areas are located on low lying coastal areas and are directly threatened by 100-year floods. According to a 2011 Flood risk assessment of Lunenburg (*Lidar Processing and Flood Risk Mapping for Coastal Areas in the District of Lunenburg,* T. Webster, K McGuigan and C MacDonald, 2011) all property between Falkland Street, Tannery Road and the coast would be completely inundated, while flooding could extend beyond Victoria Road and Hall Street. Wharves and jetties are also of particular concern for wave damage during hurricane events.

Lunenburg is a service hub for its surrounding rural neighbours. If there were a flood or other severe climate related event, impacts would be felt not just by the 2,300+ residents, but many neighbouring residents in who rely on the town for shopping, work, health, education and other services and who would travel into the town for emergency services.

In terms of the fiscal sustainability, a severe climate related event could put serious strains on the municipality's budget. Depending on which facility or infrastructure component was affected, the cost of repair or replacement could be beyond the Town's capital budget capacity and strain the Town's ability to respond to the crisis.

1.4.3 Environmental Considerations

The Town of Lunenburg is located in the South-Shore Eco-District (SSED). Similar to the neighbouring LaHave Drumlins Eco-District with shallow stoney till and predominately coniferous forests the SSED, has a distinct bio-diversity and climactic variance associated with the land's immediate proximity to the ocean.

Scenarios that model future temperature and precipitation rates for the South Shore of Nova Scotia have generally predicted that there will be hotter summers and wetter winters than has been experienced in the past. The Town is already susceptible to a number of extreme weather events, including intense snow and rainstorms, storm surges, and seasonal flooding.

The warmer temperatures and increased precipitation amounts and intensities that can be expected with climate change will inevitably impact the environment and natural habitats around Lunenburg . These impacts could include:

- changes in species composition including loss or reduction in existing species and the introduction of new species to the area and possibly an increased incidence of agricultural/forestry-related pests and diseases;
- variations in wetlands conditions including water levels and extents;
- changes in coastal erosion and sedimentation as a result of increased soil saturation, wave damage exacerbated by reduced sea ice), and freeze-thaw cycles;
- inland erosion due to a longer growing season increased rainfall intensities and more freeze-thaw cycles, which may lead to increased top soil erosion, stream back erosion, and sedimentation in local watercourses affecting fish and other aquatic habitat;
- changes in ocean temperatures, salinity and other water composition factors may lead to changes in fish species and stocks; and
- an increased possibility of forest fires, which will become a more prominent concern during hotter drier summers.

1.5 Step Six: Priorities for Action

The objective of step six is to prioritize the climate change adaptation issues that pose the greatest current and future risk, identify courses of action, and develop and approach to integrate adaptation priorities into municipal planning documents. Adaptation options are generally identified in the following general categories:

- protect;
- accommodate;
- retreat;
- planning, which should help to avoid issues in the future; and
- public education, which will help to ensure that people are aware of potential issues.

General options for actions are provided in Table 1.5 which presents each category along with objectives, responses and examples. The functionality and life-cycle costs of the options can be compared against the value of services provided. The examples provide an idea of the range of actions that are available and some are more easily implemented than others. However, the range is presented to enable people to consider potential actions as the impacts from climate change increase.

Table 1.5: General Climate Change Adaptation Options, with a Focus on Sea Level Rise

Adaptation option	***Objectives***	***Response***	***Examples***
Protect	Increase robustness and prevent loss	Advance the line	• Build a barrage across the mouth of the harbour
		Hold the line	• Step-up maintenance • Build additional protective structures (hard structures such as breakwaters, seawalls and/or soft solutions such as beach nourishment)
Accommodate	Increase flexibility	'Raise' the line	• Raise structures • Flood-proof buildings and ensure back-up power generation
	Improve awareness and preparedness	Community focused adaptation	• Flood mapping • Modification of land use/building code • Hazard insurance
Retreat	Tolerate the loss	Retreat the line	• Relocation/abandonment of infrastructure in highly vulnerable areas • Phasing out/banning development • Withdrawal of government subsidies
		No intervention	• Monitoring only
	Reverse maladaptive trend	Sustainable adaptation	• Wetland restoration
Planning	Try to avoid problems in the future	Do not place facilities / infrastructure in areas that are vulnerable	• Create municipal zoning that does not allow development in vulnerable areas • Review potential climate change impacts when deciding where to locate a facility
Public Education	Ensure that people are aware of the potential issues	Inform people of the potential impacts of climate change	• Provide targeted workshops for land-use planners and other decision-makers

The following sections of this chapter outline specific actions that the Town can take to address climate change issues. These actions are developed in the context of the current situation and projections of what the future may bring. They should be revisited on a regular basis, perhaps every five years in conjunction with the updating of the Municipal Planning Strategy to ensure that they remain relevant and address an up-to-date understanding of potential climate change impacts.

Practically, in order of priority, the Town needs to:

- look after the infrastructure, facilities, and programs for which it is directly responsible;
- advocate for other levels of government and utilities to look after infrastructure for which they are not responsible, but which plays a major role in the operations of the Town or life of Municipal residents; and
- inform the public of climate change issues that may affect them and their decision-making as well as the climate change adaptation and mitigation efforts being undertaken the Town.

Based on these criteria, the following provides a listing of recommended actions that may be undertaken.

1.5.1 Design and Implement a Flood Management Program in the Victoria Rd. / Hall St. Area

The Town should keep records of when this area floods. The records can be relatively simple but should include information on the date and duration of the flood, weather conditions at the time, information on the soil conditions (e.g., saturated, frozen, etc.), tide conditions at the outfall, how long the road was closed, etc. This information should be supported by photographs showing the extent of the flooding and other relevant issues. This information will be useful to determine if changes in the frequency, duration and extents of the flooding are occurring and will help improve designs when the roads in the area need to be rebuilt. The information will also assist with determining when facilities such as the emergency shelter in the Community Centre, the ambulance base, and the 'Blue Building' need to be relocated (see Section 1.5.6).

The Town should also consider implementing a flood management plan for the area. Possible solutions include:

- purchasing land in the area to develop the wetland into a retention pond;
- raising the road surface;
- implementing low impact design approaches for new development in upstream areas (see Appendix D) to limit or reduce overland flows to the area; and
- retrofitting developed area with features to limit stormwater run-off (see Appendix D) to also limit or reduce overland flows to the area.

Proposed solutions should be designed by professionals with experience in these techniques.

1.5.2 Continue with Planning for Flood Management in the Vicinity of Victoria Road and Falkland Street

The Town is already begun a process to consider how to limit flooding in the low-lying portions of Victoria Road, McDonald Street, McKenzie Street, Archibald Street, Brook Street, and Montague Street. To complement any hard infrastructure solutions proposed, the Town should consider the implementation of low impact development techniques (see Appendix D).

1.5.3 Ensure Critical Infrastructure Has Back-Up Power

The Community Centre (emergency shelter) can be hooked into back-up power and the Town owns a large generator capable of powering these facilities.

The Town should review water treatment and supply systems, sewage treatment plant and lift stations, and buildings / facilities that will be used in an emergency event to ensure that they either have back-up power permanently available or have ability to be hooked into a back-up generator with sufficient fuel supply.

1.5.4 Account for Sea Level Rise in Shoreline Infrastructure Design and Maintenance

Sea level rise and storm surge impacts must be included in any design or maintenance project on waterfront or shoreline infrastructure. The Town's historic Front Harbour is central to its identity and prosperity. Where retreat or abandonment is not an option (as presumably the case for the Front Harbour's historic infrastructure), protection and adaptation of municipal infrastructure will require a combination of the following factors:

- increased maintenance;
- raising of existing structures (e.g. wharf decks), depending on its intended lifetime; and
- flood-proofing infrastructure that cannot easily be raised.

These requirements should be included in the commissioning of infrastructure works by the Town.

However, many of the historic resources in the waterfront area are owned by the Waterfront Development Corporation (WDCL). Give the importance of these facilities to the character and economic viability of Lunenburg, the Town should liaise with WDCL to ensure that they are developing plans for dealing with climate change impacts on their facilities. The Town and WDCL should seek opportunities to collaborate on climate change adaptation efforts to protect the waterfront area.

1.5.5 Continue Storm Sewer Separation from Sanitary Sewer

Combined sewers put additional stress on sewage collection and treatment systems as the precipitation adds dramatically to flows in sewer, through lift stations and into the sewage treatment plant. This can lead to releases of untreated sewage into the environment as the capacity of these systems is overtopped. The Town has been making progress on separating storm and sanitary sewers and should continue this program.

1.5.6 Begin Preparations to Relocate Important Facilities

Given their location, the Town should begin preparations to enable the relocation of the following facilities:

- emergency shelter (the present location in the Community Centre is in flood zone);
- ambulance base (exit roads could be cut-off by flooding); and
- public services located in 'Blue Building' on Victoria Road, used as storage space for public works, the electric utility and fire departments (site and building could be flooded).

The facilities do not need to be replaced immediately, but their relocation will become more urgent as time passes. A practical approach would be acquire or obtain the right of first refusal on lands in safe areas that could accommodate these facilities to ensure that they can be relocated to better locations. These buildings have a useful life and will need to be replaced at some point. Rather than replacing them in the same location, they could then be relocated to these new, better located sites.

1.5.7 Additional Emergency Preparedness Considerations

While the emergency measures organization is in place to react to natural and other disasters, this organization also undertakes a number of activities to ensure that government agencies and citizens are prepared for emergency situations. Given that storm events will become more frequent and more severe, it is recommended that the Town work with its Emergency Measures Organization to educate the public about having adequate food, water, and fuel on hand to tide them over for a few days. They should also develop and test systems that will warn residents about major storm events and provide information about moving to safer locations as required.

The Town should continue to work with the fire departments and EMO to ensure that the fire station and the Community Centre remain prepared to act as emergency shelters in the event that they are needed. The Town should also work with its protective services agencies to ensure emergency vehicles can get access or travel through flooded areas.

The Town should also examine its fuel quantity storage policies to ensure that there will be adequate fuel on hand at all times to be able to operate equipment such as snowplows, fire trucks, electrical utility repair vehicles, other emergency vehicles, and back-up generators for a week without re-supply.

1.5.8 Establishment of Coastal and Floodplain Setbacks

Coastal and floodplain setbacks will help to reduce risks associated with increased flooding and erosion, and long term inundation associated with climate change.

The Town's Municipal Planning Strategy recognizes that its shorelines reinforce the scenic qualities of Lunenburg. Council wishes to maintain the open character of the shorelines, while allowing for recreation uses on the Front Harbour area and commercial and recreation uses on the Back Harbour.

In addition to guiding shoreline use, it is recommended that The Town institute a coastal setback policy which should be related to elevation of coastal land above sea level and the protection of sensitive areas. This approach will protect new development, homes and other buildings from erosion, inundation, and flooding.

The Town should limit new development in low-lying and other flood-prone areas to reduce risks associated with increased flooding and erosion associated with climate change. New development in undeveloped coastal areas should be above 4.41 m geodetic.

While this policy is more easily implemented in new development, it will be a challenge to implement in existing developed urban areas with smaller lots, where choices of where to locate a building on a site are limited. In these locations, the Municipality should provide 1 in 100 year floodlines and the projected seal level in 2100 on all zoning maps and should indicate these lines when receiving inquires about land purchases or building permit applications. This will make purchasers aware of the potential flooding issues.

Based on a continued dialogue, The Town could take a leadership role with the Province to encourage the development of a Province-wide coastal setback and management policy. This advocacy role will allow the Town to influence the process that the Province is developing and the decisions that are being made on coastal zoning.

1.5.9 Organizing a Process to Collect Municipal Staff Knowledge about Locations of Climate Change Impacts

Collecting and maintaining information in an accessible format on the types and locations of climate change-related hazards and impacts in one of the key issues facing the Town. This information is important as it allows the Town to determine where changes are occurring that are affecting its infrastructure or residents and if these impacts are occurring more often.

Based on the interviews undertaken as part of the research for this project, it is clear that municipal staff have an extensive knowledge and personally held data about climate change impacts in the Town. Unfortunately, this information is not currently collected in a systematic manner by the Town and when staff move to other positions in other communities or retire, this information ceases to be available to the Town. The Town should consider the development of a GIS-based system that could include anecdotal, photographic and report based information that staff holds related to climate change issues. Ideally, users should be able to click on a map and be linked to information related to that location.

The information collected can be a combination of quantitative science and engineering –based information supported by anecdotal information. The purpose of the database is to act as a trigger to indicate where further studies are required or to have information on hand regarding the extents and incidence of issues such as flooding, erosion and other storm / climate changes –related incidents, when the existing infrastructure is being maintained or the development of new infrastructure is being considered. Having good anecdotal information, i.e., measurements, photos, etc., that can show the impacts, will improve designs and support requests to other levels of government for further study or assistance in addressing a problem. As an example, the system would allow bureaucrats and designers considering the redevelopment of Victoria Road to see if flooding in the area seems is happening more often in the past and what are the extents for the area affected. This information can then inform the re-design of the road. A similar approach has be suggested for the Victoria Rd. and Hall Street area (see Section 1.5.1).

This approach has been suggested to a number of other municipalities in the province. The Town could consider partnering with other communities or working through the Union of Nova Scotia Municipalities or the Province to develop such a system.

1.5.10 Implement Monitoring at Dares Lake

While Dares Lake is not currently experiencing any issues, the dramatic increase in hot days and variations in precipitation could cause lower water levels in the future. It is recommended that the Town begin monitoring lake water levels and outflows, combined with the collection of weather data. This information should be analyzed to determine if there are trends developing that might affect future water supply from the Lake.

1.5.11 Review of Municipal Structures for Snow and Ice Loading

While the frequency of snowstorms and overall snow amounts in a season may decrease, the intensity and amount of snow dropped in an individual storm may increase. This is potentially compounded by the increase in winter rain events, whereby any snow that remains on a roof may act as a “sponge” holding water and creating additional weight on the roof. The increase in freeze thaw cycles may also create ice build-ups that could cause problems associated with weight and ice jams. These impacts could cause increased snow and ice loading on buildings. The Town should review all structures it owns and ones that might be used as emergency shelters to ensure that they have sufficient structural integrity to support anticipated snow loads.

1.5.12 Annual Regional Meeting

It is recommended that The Town meet annually with:

- other South Shore municipal governments;
- South Shore First Nations communities;
- relevant provincial government departments such as Transportation and Infrastructure Renewal, Natural Resources, and Environment, and the Municipal Services Division of Service Nova Scotia and Municipal Relations;
- Nova Scotia Power Inc.; and
- Bell Aliant.

The utilities and Provincial government agencies control infrastructure that may not be located within the Town that is nonetheless critical to the functioning of the Town of Lunenburg.

The Town should work with other local municipalities to coordinate / ensure communications between groups responsible for different developments in and around the Town making sure that climate change is on the radar of appropriate government department, for example the Department of Education as they decide on school locations.

Meeting as a group will allow common issues to be determined and enable the groups to share knowledge of potential hazards and how the different organizations are responding to issues. It is recommended that the following subjects be addressed in the meeting:

- location and type of potential hazards;
- potential solutions; and
- the party responsible for taking action.

1.5.13 General Climate Change Reviews and Stormwater Management Plans

It is recommended that the subdivision by-law should be altered so that all subdivision and building permit applications require the provision of storm water management plans to ensure that new developments do not allow any net increase in storm water run-off, increase flooding in adjacent

areas nor exceed the capacity of downstream systems. For single lot developments, these plans could be fairly simple sketches show how storm water will be collected and allowed to infiltrate on site through the use of rain gardens and infiltration trenches. For multi-lot subdivisions, more elaborate plans looking at the overall site and mitigative measures should be required. See Appendix D for suggestions of best management practices for stormwater management.
Building permit applications should also include a requirement for a review and statement about how the proposed building and location addresses climate change.

1.5.14 Education

The Town can play a role in educating / informing the public, including businesses, about how climate change directly impacts their lives and operations by:

- telling people about what The Town is doing about climate change;
- identifying the risks and encouraging people to think about them; and
- telling people how climate risks or opportunities could affect the development of their properties.

The Town should develop a brochure that talks about climate change risks and the appropriate placement of buildings to lessen risks and place this information in with its building permit application forms, so people know the issues and can make better informed decisions about where and how they build. The Town could also circulate the brochure with its tax bills.

SECTION 2 ACTION PLAN - MITIGATION

Section 2 of the MCCAP outlines Lunenburg's plan for climate change ***mitigation***. Climate change mitigation refers to "a human intervention to reduce the sources or enhance the sinks of greenhouse gases." (SNSMR, 2011a). Preparing a corporate mitigation plan is a three-step process:

1. Collect energy and emissions information;
2. Complete energy and emissions inventory table; and
3. Set goals and identifying actions for mitigation.

2.1 Energy and Emissions Information

Municipal energy consumers and greenhouse gas emissions sources include municipal buildings, recreational facilities, parks, streetlights, water/wastewater treatment and pumping facilities, solid waste management facilities, and municipal vehicles. Information regarding energy consumption from the municipally owned buildings, facilities and equipment were input into the Corporate and Emissions Spreadsheet developed by the Union of Nova Scotia Municipalities (2013). This information has been provided to the Town in a digital format.

2.2 Energy and Emissions Inventory Table

Table 2.1 summarizes the information developed through the completion of the Corporate and Emissions Spreadsheet in section 2.1.

Table 2.1: Corporate and Emissions Inventory Summary Table

Emission Category	***Energy Type***	***Energy Consumption***	***Cost ($)***	***Units***	***Emission Factor (tCO2/units)***	***Emissions (tCO2e)***
Buildings	Electricity	614,351	90,380	kWh	0.82839	508.92
	Nat. Gas	-	-	M3	-	-
	Fuel Oil	122,702	110,051	L	2.68	328.84
Water & Wastewater	Electricity	2,030,927	252,677	kWh	0.82839	1,682
Streetlights	Electricity	115,648	92,835	kWh	0.82839	95.80
Vehicles	Reg. Gasoline	19,155	25,246	L	2.34	44.82
	Diesel	29,813	39,918	L	2.63	78.41
Solid Waste	n/a	13.523	1,902	tonnes	0.5	6.7615
Others	-	-	-	-	-	-

Figure 2.1 indicates the major producers of greenhouse gases from municipally owned buildings, facilities and equipment.

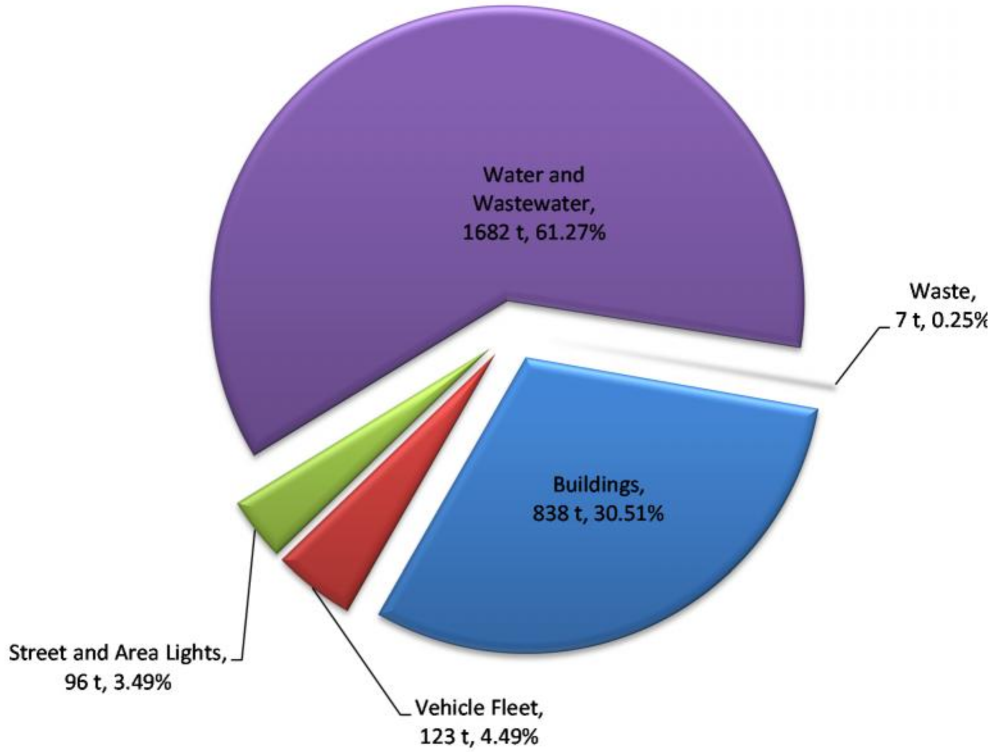

Figure 2.1: Greenhouse Gas Emissions by Sector in tonnes equivalent (2102)

2.3 Setting Goals and Actions for Mitigation

In 2004, the Town commissioned Enerplan to develop a Feasibility Study for Energy Management Services. The plan was updated in 2008 and 2009. The following table summarizes the list of actions to improve energy conservation in Town facilities that were recommended in the Feasibility Study.

Table 2.2: Recommended Measures from 2009 Enerplan Report

Building	Recommended Measures from 2009 Enerplan Report											
	Lighting				HVAC	Bldg Envelope			EMCS			
	Replace incandescent lamps with CFLs	Replace T12 fluorescents with T8s w/magnetic ballasts	Replace exit lamps with LED exit lamps	Install occupancy detectors	Thermally insulate domestic hot water piping	Install new weather-stripping and door-sweeps	Seal wall penetrations	Install wooden boxes around window A/C units in htg season	Install new DDC system	Demand control & load shedding	Install programmable t-stats	Power factor correction implemented for pumps
Town Hall	✓	✓	C	N/A	N/A	✓	✓	N/A	✓	N/A	N/A	N/A
Old Fire Hall	✓	✓	✓	N/A	N/A	✓	N/A	✓	✓	N/A	N/A	N/A
Community Centre Arena	C	C	✓	✓	✓	N/A	N/A	N/A	✓	✓	N/A	N/A
Community Centre Auditorium	✓	C	✓	✓	N/A	✓	N/A	✓	✓	N/A	N/A	N/A
Library	N/A	C	✓	N/A	✓	N/A	N/A	N/A	✓	N/A	N/A	N/A
New Fire Hall	✓	✓	C	✓	N/A	N/A	N/A	N/A	✓	N/A	N/A	N/A
Electric Light Department	N/A	C	N/A	✓	N/A	✓	N/A	✓	✓	N/A	N/A	N/A
Pump House	✓	✓	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	✓	✓
Sewage Treatment Plant	C	C	C	N/A	N/A	N/A	N/A	N/A	✓	N/A	N/A	N/A
Armouries	N/A	✓	N/A	N/A	N/A	✓	N/A	✓	✓	N/A	N/A	N/A

Legend	
Symbol	Description
✓	Recommended in 2009
C	Completed prior to 2009
N/A	Not applicable (not mentioned in the 2009 report)
	Completed between 2009 and 2013

The Town has already made major efforts to address energy conservation and greenhouse gas emissions. The cells marked with a "C" indicate the actions that the Town completed before the 2009 report. The shaded areas indicate the recommended actions from the 2009 report that have subsequently been completed.

The following measures are additional actions that are recommended as cost effective ways to reduce energy use and resultant costs and greenhouse gas emissions.

2.3.1 Install Direct Digital Controls or SCADA System

This recommendation from the Enerplan report has not yet been implemented. This system would allow building systems like HVAC, lighting and other environmental controls to be controlled and monitored from a centralized computer. Direct digital control allows for equipment scheduling based on hours of operation and automatic setback of thermostats so excess energy is not used in unoccupied areas. Direct digital controls (DDC) will also enable equipment and lights to be turned on or off from the central computer. This could also lead to improved efficiencies.

In addition to the installation of direct digital controls for its buildings, the Town should consider the installation of a SCADA system on it water and wastewater systems. SCADA (supervisory control and data acquisition) systems collect runtime data, flow history and power quality information. SCADA systems can also be used to identify groundwater infiltration in wastewater infrastructure or leaks in water infrastructure. For example, data collected with a SCADA system with provide a baseline for pumping flow and power when the weather is dry. When it rains, groundwater infiltration can be detected through significant increases in flow and power. While the initial costs can be high for such a system, continual use of a SCADA system throughout the pump inventory will lead to long-term energy and cost savings. Better monitoring of major sources of energy consumption will enable a better understanding of events or actions that trigger spikes in energy consumption as well as monitoring of the general decline / loss of efficiency related to equipment. This information will enable better maintenance and management of facilities and equipment, hopefully leading to better efficiencies and a longer lifespan. For example, inefficient pumps can operate for long periods of time undetected. A worn centrifugal pump will typically exhibit a rise in pumping energy to compensate for a loss of pumping performance. These issues can be resolved with monitoring and diagnosis of water and waste water pumps.

2.3.2 Improve Insulation in Older Buildings

Adding insulation to an existing building envelope is one of the most effective ways to reduce energy use and save money. Simple paybacks are typically less than five years. Examples of upgrading building envelope include blown-in insulation in exterior walls and attics and insulating basement headers. Work should continue to make improvements to the insulation in the Electrical Utility building. The Public Woks building and the Angus Walters House is also older and may present opportunities for energy savings and reductions in greenhouse gas emissions through improved insulation. Incentives may be available to help offset installation costs.

2.3.3 Alternative Heating Fuels

Generally, electricity and oil are the most common heating energy sources throughout most municipal buildings and facilities. Switching to alternate fuels such as natural gas, propane, and wood can reduce greenhouse gas emissions and heating costs.

2.3.4 Vehicle Fleet

Regular maintenance is a cost effective method to insure vehicles perform efficiently. A well maintained vehicle will use 5% to 10% less fuel than a poorly maintained vehicle. Ensuring proper tire inflation can also result in improved fuel efficiency. It is recommended to regularly review if each vehicle in the municipal fleet is best suited for its intended purpose as well. Vehicles oversized for their intended purpose should be replaced with smaller, more fuel efficient models. When the Town purchases a new vehicle, consider fuel efficiency in the selection criteria.

2.3.5 Additional Resources

Additional mitigation resources are available on the Union of Nova Scotia Municipalities website:
http://www.sustainability-unsm.ca/climate-changeenergy-efficiency.html

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APPENDIX A

Climate Change Hazard Impact Matrix

Appendix A: ***Climate Change Hazard Impact Matrix***

The following matrix outlines the Committee's subjective best estimate of impacts associated with different climate change hazards that have affected the Town in the past or very recently. The discussion row (containing the bulleted points) illustrates key considerations, how much risk could be tolerated, and which hazards should receive priority attention. **Severity** is roughly determined by how important and costly the impacted infrastructure or facilities are and whether or not essential services would be disrupted, as well as how many people (especially vulnerable groups) would be impacted (e.g. fatalities, injury, illness, property damage, displacement). **Frequency** denoted as "often" would be highly likely within 5 years or less, "sometimes" would be an event likely to occur within 5-20 years, and "rarely" would indicate an unlikely event or one that has not occurred in recent memory. **Area** determined as "large" would be all or a majority of the Town, "medium" would be a substantial area that impacts several properties, roads and critical infrastructure or facilities, whereas "small" would include a contained area, only one or two properties, and would be unlikely to impede an entire road. Detailed discussion of hazards and impacts can be found in the body of the report.

Hazards and Potential Impacts	Potential Locations	Severity			Frequency			Area			Overall Risk
Sea Level Rise and Storm Surge		Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small	high, moderate, low
• damage to property and critical infrastructure (e.g. water, power) • disruption of roads • isolation and limits to access • evacuation • water contamination • increased runoff/ strain on storm water system • coastal erosion • warmer winters, freezing rain/ icy road conditions • habitat disruption • fatalities and injury	• Old Town Waterfront • Starr St. around sewage treatment plant and Public Works yard • Area around Lunenburg Foundry (Falkland St.) back up over Victoria Rd. to Hirtle St. • Coastal erosion could occur on any oceanfront lands throughout the Town	✔				✔			✔		High
		Notes: • Severity is severe, because of the impacts on the waterfront which provide much of the character and tourism attraction of the Town, the community centre / emergency shelter, the school and other businesses in the Victoria Rd area as well as potential impacts on the sewer system lifts stations, sewage treatment plant outlet and the electrical substation supplying the Town.									

Appendix A: ***Climate Change Hazard Impact Matrix***

<table>
<tr><th colspan="2">INCREASED PRECIPITATION AMOUNT, INTENSITY AND FLOODING</th><th>Severe</th><th>Moderate</th><th>Minor</th><th>Often</th><th>Sometimes</th><th>Rarely</th><th>Large</th><th>Medium</th><th>Small</th><th>high, moderate, low</th></tr>
<tr><td rowspan="2">• disruption of roads
• isolation of emergency services
• isolation and limits to access
• damage to property and critical infrastructure (e.g. water, power)
• increased runoff/ strain on storm water system
• warmer winters, freezing rain/ icy road conditions
• habitat disruption
• fatalities and injury</td><td rowspan="2">• Area around Victoria Rd. and Hall St.</td><td></td><td>✔</td><td></td><td>✔</td><td></td><td></td><td>✔</td><td></td><td></td><td>High</td></tr>
<tr><td colspan="10">Notes:
• Severity is moderate, because of the disruptions to access to and from the Town as well as impacts on access to and from areas for ambulance and fire services.
• The area impacted is considered large as disruptions to ambulance services could affect the whole Town.
• Overall risk is considered high due to the severity of the impact, the fact that flooding closes Victoria Rd. quite often and that the situation is likely to get worse over time.</td></tr>
<tr><th colspan="2">HURRICANES, LIGHTNING AND WIND</th><th>Severe</th><th>Moderate</th><th>Minor</th><th>Often</th><th>Sometimes</th><th>Rarely</th><th>Large</th><th>Medium</th><th>Small</th><th>high, moderate, low</th></tr>
<tr><td rowspan="2">• direct hits and fallen tree limbs and branches
• damage to power and communication lines and other critical infrastructure
• disruption of roads
• limits to access
• damage to private property
• injury or fatalities
• loss of crops / damage to forest resources
• lightning –fire</td><td rowspan="2">• Can occur throughout the Town.
• Power lines are especially vulnerable.</td><td></td><td>✔</td><td>✔</td><td></td><td>✔</td><td></td><td></td><td>✔</td><td></td><td>Moderate</td></tr>
<tr><td colspan="10">Notes:
• Severity is moderate-to-minor, because fallen limbs and branches that do not impact power lines or other infrastructure are minor, but if power lines are damaged, there could be a more serious impact. Power lines can be repaired relatively quickly, thus the potential impact is moderate and not severe.
• Impacted area could be quite small (e.g. a single downed tree limb, obstructing one road), or there could be multiple areas of damage, thus the overall potential impacted area is ranked as “medium”.</td></tr>
</table>

Appendix A: ***Climate Change Hazard Impact Matrix***

LANDSLIDES		Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small	high, moderate, low
• damage to property and infrastructure • water contamination/ siltation • habitat disruption • road and access disruptions • slumping in banks along the river	• no particular areas of risk were noted within the Town			✔			✔			✔	Low

Notes:

- Risk is considered low in the Town as no particular areas where this is likely to occur were identified. Coastal erosion and associated landslides are considered in the sea level rise and storm surge section.

DROUGHT		Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small	high, moderate, low
• Surface water flows / recharge reduction • habitat disruption • forest and agricultural pests • loss of agricultural productivity	• Dares Lake and the water supply system • Habitat throughout town		✔				✔	✔			Moderate

Notes:

- Currently drought is not a concern, but with an increasingly warmer climate, the risk will increase.
- If overland flows and evaporation rates at Dares Lake are impacted enough to result in lower water levels, all of the Town of Lunenburg's water supply will be diminished and thus the area impacted is large.
- Given, current conditions, the overall risk is considered low.

EARTHQUAKES		Severe	Moderate	Minor	Often	Sometimes	Rarely	Large	Medium	Small	high, moderate, low
• damage to property and infrastructure	• Unknown			✔			✔			✔	Extremely unlikely

Notes:

- Earthquakes in Nova Scotia are of such a low magnitude that they are rarely felt.
- No evidence of an earthquake within Lunenburg Town Boundaries (for data from 1985-2013, NRCAN, 2013b).

APPENDIX B

Climate Change Scenario Data

Climate Change Scenario Data for Lunenburg

Table A 18: Lunenburg, Climate Station Bridgewater (id: 8200600) @ 44.40N 64.55W, CHS site Lunenburg

Parameter	1980s	2020s		2050s		2080s	
	Value	Value	SD	Value	SD	Value	SD
Temperature - Annual	6.8	8.0	0.4	9.2	0.6	10.5	1.0
Winter	-4.0	-2.7	0.6	-1.3	0.8	0.2	1.1
Spring	4.9	6.0	0.4	7.1	0.7	8.2	1.1
Summer	17.6	18.7	0.4	19.9	0.7	21.1	1.0
Autumn	8.7	9.9	0.4	11.0	0.6	12.3	0.9
Precipitation - Annual	1522.5	1564.2	37.4	1577.2	43.3	1624.0	56.6
Winter	436.2	457.5	17.3	468.4	22.3	493.9	28.6
Spring	392.4	405.4	16.5	411.2	22.3	427.3	29.3
Summer	294.4	299.3	17.4	298.4	23.2	298.8	38.3
Autumn	399.5	404.3	18.2	403.8	19.1	412.8	29.6

	1980s	2020s	2050s	2080s
Heating Degree Days	4190.5	3847.0	3480.8	3127.0
Cooling Degree Days	136.9	197.9	283.6	387.6
Hot Days (Tmax > 30)	5.8	12.6	21.6	31.4
Very Hot Days (Tmax > 35)	0.0	0.5	1.2	2.6
Cold Days (Tmax < -10)	3.1	2.3	1.0	0.5
Very Cold Days (Tmax < -20)	0.0	0.0	0.0	0.0
Growing Degree Days > 5	1828.8	2055.8	2327.1	2628.8
Growing Degree Days > 10	940.7	1102.9	1299.5	1515.9
Growing Season Length (days)	160.3	174.5	191.9	213.5
Corn Heat Units (CHU)	2518.5	2809.7	3144.2	3495.3
Corn Season Length (days)	133.8	142.5	153.4	164.9
Freeze Free Season (days)	195.6	222.5	243.8	263.1
Days With Rain	138.1	147.1	150.9	154.0
Days With Snow	36.1	51.7	43.9	37.1
Freeze-Thaw Cycles - Annual	117.6	108.7	95.6	82.7
Winter	45.5	45.9	46.2	44.9
Spring	42.2	37.8	30.6	24.3
Summer	0.6	0.4	0.0	0.0
Autumn	29.3	24.6	18.8	13.7
Water Surplus (mm)	1157.1	1004.5	978.1	982.7
Water Deficit (mm)	31.5	35.8	44.0	53.1
Δ Intensity Short Period Rainfall (%)	0	5	9	16

	2000	2025	2055	2085	2100
Total Sea Level Rise (m)		0.15 ± 0.03	0.43 ± 0.15	0.83 ± 0.36	1.06 ± 0.48
Extreme TSL - 10 Yr Ret Period	3.14 ± 0.20	3.29 ± 0.23	3.57 ± 0.35	3.97 ± 0.56	4.20 ± 0.68
Extreme TSL - 25 Yr Ret Period	3.24 ± 0.20	3.39 ± 0.23	3.67 ± 0.35	4.07 ± 0.56	4.30 ± 0.68
Extreme TSL - 50 Yr Ret Period	3.31 ± 0.20	3.46 ± 0.23	3.73 ± 0.35	4.14 ± 0.56	4.37 ± 0.68
Extreme TSL - 100 Yr Ret Period	3.38 ± 0.20	3.53 ± 0.23	3.80 ± 0.35	4.21 ± 0.56	4.44 ± 0.68

From Richards and Daigle (2011: 58) Table A 18

APPENDIX C

Infrastructure Risk Assessment Spreadsheets

Climate Change Adaptation Plan

Municipal Asset	Sea Level Rise		Precipitation (extreme event)				Extreme Wind		Flooding		Temperature				Erosion		Earthquake		Total	Risk
			Snow		Rain						High		Low							
Water System																				
Water Source (Wells, Surface Water, Other)	H	3	N	0	L	1	N	0	L	1	L	1	N	0	N	0	N	0	**6**	**L**
Water Treatment Plant	H	3	N	0	N	0	N	0	M	2	L	1	N	0	N	0	N	0	**6**	**L**
Water Storage Facilities	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Water Pumping Facilities	N	0	N	0	N	0	N	0	N	0	H	3	N	0	N	0	N	0	**3**	**L**
Water Distribution System	L	1	N	0	N	0	N	0	N	0	N	0	M	2	N	0	N	0	**3**	**L**
Individual Water Service Lines	L	1	N	0	L	1	L	1	N	0	N	0	N	0	N	0	N	0	**3**	**L**
Total	**8**		**0**		**2**		**1**		**3**		**5**		**2**		**0**		**0**		**21**	
Sanitary Sewer System																				
Wastewater Treatment Plant	H	3	L	1	H	3	N	0	H	3	N	0	N	0	N	0	N	0	**10**	**M**
Buildings	H	3	L	1	M	2	N	0	M	2	N	0	N	0	N	0	N	0	**8**	**L**
Wastewater Gravity Sewer	L	1	L	1	L	1	N	0	L	1	N	0	N	0	N	0	N	0	**4**	**L**
Wastewater Pressure Sewer (Forcemain)	L	1	N	0	N	0	N	0	L	1	N	0	N	0	N	0	N	0	**2**	**L**
Pumping Stations	H	3	L	1	M	2	N	0	L	1	N	0	N	0	N	0	N	0	**7**	**L**
Total	**11**		**4**		**8**		**0**		**8**		**0**		**0**		**0**		**0**		**31**	

Adaptation measure classification:
High - 3
Medium - 2
Low - 1
None - 0

Municipal Asset	Sea Level Rise		Precipitation (extreme event)				Extreme Wind		Flooding		Temperature				Erosion		Earthquake		Total	Risk
			Snow		Rain						High		Low							
Storm Sewer System																				
Catchbasins	M	2	L	1	L	1	N	0	M	2	N	0	N	0	L	1	N	0	**7**	**L**
Manholes	M	2	L	1	L	1	N	0	M	2	N	0	N	0	L	1	N	0	**7**	**L**
Pipes	M	2	L	1	M	2	N	0	M	2	N	0	N	0	L	1	N	0	**8**	**L**
Total	**6**		**3**		**4**		**0**		**6**		**0**		**0**		**3**		**0**		**22**	
Municipal Buildings																				
Buildings	M	2	L	1	M	2	L	1	H	3	N	0	N	0	N	0	N	0	**9**	**L**
Total	**2**		**1**		**2**		**1**		**3**		**0**		**0**		**0**		**0**		**9**	
Landfills/Solid Waste Facilities																				
Flooding	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Access Road	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Leachate Collection	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Leachate Treatment	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Buildings	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Total	**0**		**0**		**0**		**0**		**0**		**0**		**0**		**0**		**0**		**0**	
Dams																				
Flooding	N	0	N	0	N	0	N	0	M	2	N	0	N	0	N	0	N	0	**2**	**L**
Control Gates	N	0	N	0	N	0	N	0	M	2	N	0	N	0	N	0	N	0	**2**	**L**
Access Road	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Fish Passage	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Total	**0**		**0**		**0**		**0**		**4**		**0**		**0**		**0**		**0**		**4**	

Municipal Asset	Sea Level Rise		Precipitation (extreme event)				Extreme Wind		Flooding		Temperature				Erosion		Earthquake		Total	Risk
			Snow		Rain						High		Low							
Roads																				
Bridges	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Traffic Signals	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	N	0	**0**	**L**
Street Lighting	M	2	N	0	N	0	N	0	M	2	N	0	N	0	N	0	N	0	**4**	**L**
Signs	M	2	N	0	N	0	N	0	L	1	N	0	N	0	N	0	N	0	**3**	**L**
Culverts	M	2	N	0	N	0	N	0	H	3	N	0	N	0	N	0	N	0	**5**	**L**
Sidewalks	M	2	N	0	N	0	N	0	H	3	N	0	L	1	N	0	N	0	**6**	**L**
Local Roads	M	2	N	0	N	0	N	0	H	3	N	0	L	1	L	1	N	0	**7**	**L**
Collectors	M	2	N	0	N	0	N	0	H	3	N	0	L	1	L	1	N	0	**7**	**L**
Total	**12**		**0**		**0**		**0**		**15**		**0**		**3**		**2**		**0**		**32**	

Risk Assessment Adaptation Measures - Water System

Water System	Water Source (Wells, Surface Water, Other)	Water Treatment Plant	Water Storage Facilities	Water Pumping Facilities	Water Distribution System	Individual Water Service Lines
Sea Level Rise	X	X				
Extreme Snow						
Extreme Rain						
Extreme Wind						
Flooding						
High Temp				X		
Low Temp						
Erosion						
Earthquake						
Impacts						
Possible Adaptation Measures						

Risk Assessment Adaptation Measures - Sanitary Sewer System

<table>
<tr><th>Sanitary Sewer System</th><th>Wastewater Treatment Plant</th><th>Buildings</th><th>Wastewater Gravity Sewer</th><th>Wastewater Pressure Sewer (Forcemain)</th><th>Pumping Stations</th></tr>
<tr><td>Sea Level Rise</td><td>X</td><td>X</td><td></td><td></td><td>X</td></tr>
<tr><td>Extreme Snow</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Extreme Rain</td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Extreme Wind</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Flooding</td><td>X</td><td></td><td></td><td></td><td></td></tr>
<tr><td>High Temp</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Low Temp</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Erosion</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Earthquake</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Impacts</td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td rowspan="4">Possible Adaptation Measures</td><td></td><td></td><td></td><td></td><td></td></tr>
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</table>

Risk Assessment Adaptation Measures - Storm Sewer System

Storm Sewer System	Catchbasins	Manholes	Pipes
Sea Level Rise			
Extreme Snow			
Extreme Rain			
Extreme Wind			
Flooding			
High Temp			
Low Temp			
Erosion			
Earthquake			
Impacts			
Possible Adaptation Measures			

Risk Assessment Adaptation Measures - Municipal Buildings

Municipal Buildings	Buildings
Sea Level Rise	
Extreme Snow	
Extreme Rain	
Extreme Wind	
Flooding	X
High Temp	
Low Temp	
Erosion	
Earthquake	
Impacts	
Possible Adaptation Measures	

Risk Assessment Adaptation Measures - Landfills

Landfills/Solid Waste Facilities	Flooding	Access Road	Leachate Collection	Leachate Treatment	Buildings
Sea Level Rise					
Extreme Snow					
Extreme Rain					
Extreme Wind					
Flooding					
High Temp					
Low Temp					
Erosion					
Earthquake					
Impacts					
Possible Adaptation Measures					

Risk Assessment Adaptation Measures - Dams

Dams	Flooding	Control Gates	Access Road	Fish Passage
Sea Level Rise				
Extreme Snow				
Extreme Rain				
Extreme Wind				
Flooding				
High Temp				
Low Temp				
Erosion				
Earthquake				
Impacts				
Possible Adaptation Measures				

Risk Assessment Adaptation Measures - Roads

Roads	Bridges	Traffic Signals	Street Lighting	Signs	Culverts	Sidewalks	Local Roads	Collectors
Sea Level Rise								
Extreme Snow								
Extreme Rain								
Extreme Wind								
Flooding					X	X	X	X
High Temp								
Low Temp								
Erosion								
Earthquake								
Impacts								
Possible Adaptation Measures								

APPENDIX D

Best Practices for Low Impact Development

Best Practices for Low Impact Development

One the most efficient ways to deal with flooding risks is to manage the issue of high runoff at its source. Flooding is only amplified when runoff is allowed to increase, and infiltration of water into the ground is decreased. Most often, development allows this to happen and therefore increases flooding risks. The more water is encouraged to infiltrate in the ground, the more the high water levels are controlled, and the more the overall river health is protected. Stormwater Management has the following benefits for the river, the riverine residents, the overall watershed community and the Municipality:

- Decreases flooding risks and entailed risks to infrastructure, land value, liability and public safety;
- Decreases peak flows, resulting in smaller infrastructure costs;
- Aquifer recharge, reducing the strain on water supply sources;
- Reduces pollution to drinking water supplies, recreational waters and wetlands, saving future expenditures for restoration of valuable water resources;
- Protects water quality and increases low flows in the river, enhancing fish habitat in this uniquely valuable river system;
- Reduces energy costs by constructing new green roofs or retrofitting existing roofs, and
- Through the above results, improves the quality of life and increases property value.

A more concentrated (cluster) subdivision design, with less impervious area and smaller infrastructure (stormwater drainage and other utilities), also means significant cost savings to developers (who will therefore show less resistance in implementing this type of design) and reduces maintenance costs for municipalities.

These aspects show that even if the original target for stormwater management is the reduction of flooding risks, there are a host of other associated benefits to the overall community, which all contribute to more sustainable development. This makes stormwater management through Low Impact Development (LID) and Best Management Practices (BMPs) an important recommendation for implementation at the planning and by-law levels in the Municipality.

Stormwater management is no longer an innovative or rare approach. It is now very well understood and implemented in a majority of communities across North America. There is a multitude of very-well researched documents describing comprehensively how-to approaches to Low Impact Development (LID) from the planning level to the lot development stage, including retrofitting existing developments. This section of the report gives a summary of typical approaches in various settings from areas with proven records of successfully implementing LID and BMPs. General recommendations on typical targets for results are also included at the end of the chapter.

1.1 Planning for Low Impact Development

The LID approach provides opportunities to build homes and businesses, while conserving natural areas and drainage patterns. LID is accomplished as a two-step process;

- Thoughtful site planning; and
- Incorporation of "natural" stormwater best management practices (BMPs).

Thoughtful site planning begins with the identification of critical site features such as wetlands, habitat areas, and /or drinking water protection areas that should be set aside as protected open space. Natural features, such as vegetated buffers and view sheds, will also play an integral role in any LID planning exercise. After the critical open space areas are identified and set aside, sustainable development areas are then identified as "building envelopes". General goals include the following:

- Concentrate Development and Mix Uses: The LID site planning process sets aside key natural features and focuses development into clustered patterns on the remaining land. The LID planning process results in housing that makes more efficient use of land and conserves critical natural features such as wetlands, vegetated buffers, and drinking water protection areas; and
- Protect Land and Ecosystems: The reduction of impervious surfaces reduces the amount of surface runoff and through the infiltration of stormwater recharges the groundwater system, thereby restoring the natural hydrologic cycle. This preserves groundwater supplies and base flow to streams and wetlands.

The Credit Valley Conservation a community conservation area in Ontario, has published a comprehensive guide to implementing sustainable development through Low Impact Development and Stormwater Best Management Practices (“Low Impact Development Stormwater Management Planning and Design Guide”, Version 1.0 – 2011). An extract is presented below, which tabulates the summary of stormwater management and land use planning steps in order to achieve Low Impact Development. This guide presents a very well organised approach, without being overly prescriptive on individual approaches to achieving Low Impact Development. This document could serve as an example for creating a similar document in the Town of Lunenburg.

Scale	Planning Stage	Description
Watershed plans	Master Plans Growth Plan Official Plan	Major themes and objectives for the municipality’s future growth are established, and challenges and opportunities for growth are identified, such as municipal policy direction for innovative SWM approaches and other climate change initiatives.
Community/ Subwatershed	Secondary Plan	Major elements of the natural heritage system are identified including terrestrial, aquatic and water resources (hydrology, hydrogeology, fluvial geomorphology, etc.). Stormwater management objectives for surface and groundwater resources. Future drainage boundaries, locations of stormwater management facilities and watercourse realignments are established.
	Block Plan	The location of lots, roads, parks and open space blocks, natural heritage features and buffers, and stormwater management facilities are defined. A full range of opportunities to achieve stormwater management objectives are identified, establishing a template for the more detailed resolution of the design of stormwater management facilities at subsequent stages in the planning and design process.
Neighbourhood	Draft Plan of Subdivision/ Functional Servicing Plan	Conceptual design is carried out for stormwater management facilities. Consideration must be given to how stormwater management objectives can be achieved and how these objectives influence the location and configuration of each of the components listed above
	Registered Plan	Detailed design is carried out for stormwater management facilities.
Site	Site Plan	Site-specific opportunities are identified to integrate stormwater management facilities into all of the components of a development including landscaped areas, parking lots, roof tops and subsurface infrastructure. Solutions must be considered in the context of the overall stormwater management strategy for the block or secondary plan area to ensure that functional requirements are achieved
Site	CA Permits and other approvals	Detailed design of SWM for the site

It is recommended that at the planning level, the system described above be adopted, which includes the development of:

- Watershed Master Plans, a Growth Plan and an Official Plan;
- Community / Subwatershed Secondary and Block Plans;
- Neighbourhood Draft Plan of Subdivision / Functional Servicing Plan, followed by the Registered Plan;
- Site Plan with site specific opportunities, while staying consistent with the direction of the higher level plans; and
- Site Permits and approvals.

Stormwater management planning is closely linked with resource, land use and community planning. This is essential since it establishes the linkage and inter-dependence of community planning with stormwater management planning at all levels. At the higher watershed level, it typically requires the cooperation of several municipalities to incorporate into their official planning documents the approaches recommended in the watershed plan. Full descriptions of each type of plan are given in the “Infraguide: Stormwater Management Planning”, NRC, 2005 document.

1.2 Recommendations for Stormwater Management in Urban Areas

This section will focus on the stormwater management practices that are most suited to urban areas, which cover a large part of the study area. The following descriptions reference the USEPA “National Menu of Stormwater Best Management Practices”, which is very comprehensive and constantly updated (it contains close to 150 fact sheets on individual approaches, from education to implementation).

Typical BMPS at the site level are shown below, distinguished by whether they apply best to new developments or as retrofits to existing developments.

1.2.1 Recommendations based on density of development and new Vs retrofit application

Table D-1 below shows the various approaches that are recommended depending on whether a site is located within a high density or low density development, as well as whether the project involves a new development or a retrofit application.

Table D-1: Recommendations Based on Density of Development and New Vs Retrofit Application

Recommendations for Stormwater Management in Low-Density Urban Areas	
New Development	**Retrofit Applications**
• Grassed swales; • Infiltration trenches; • Permeable pavement; • Riparian buffers; • Sand and organic filters; • Soil amendments; and • Vegetated filter strips.	• Curb and gutter elimination; • Permeable pavement; • Sand and organic filters; • Soil amendments; • Vegetated filter strips; and • Rain barrels and cisterns.
Recommendations for Stormwater Management in High-Density Urban Areas	
New Developments	**Retrofit Applications**
• Bioretention cells; • Green parking design; • Infiltration trenches; • Inlet protection devices; • Permeable pavement; • Permeable pavers; • Rain barrels and cisterns; • Sand and organic filters; • Soil amendments; • Stormwater planters; • Tree box filters; • Vegetated filter strips; and • Vegetated roofs.	• Inlet protection devices; • Permeable pavement; • Permeable pavers; • Rain barrels and cisterns; • Sand and organic filters; • Soil amendments; • Stormwater planters; and • Tree box filter.

Each of these measures is described in detail below.

1.2.2 Description of Each Recommended Site Stormwater BMP Measure

Grassed Swales

Grassed swales are shallow grass-covered hydraulic conveyance channels that help to slow runoff and facilitate infiltration. The suitability of grassed swales depends on land use, soil type, imperviousness of the contributing watershed, and dimensions and slope of the grassed swale system. In general, grassed swales can be used to manage runoff from drainage areas that are less than 4 hectares (10 acres) in size, with slopes no greater than 5 percent. Use of natural, low-lying areas is encouraged and natural drainage courses should be preserved and utilized.

Infiltration Trenches

Infiltration trenches are rock-filled ditches with no outlets. These trenches collect runoff during a storm event and release it into the soil by infiltration (the process through which stormwater runoff penetrates into soil from the ground surface). Infiltration trenches may be used in conjunction with another stormwater management device, such as a grassed swale, to provide both water quality control and peak flow attenuation. Runoff that contains high levels of sediments or hydrocarbons (for example, oil and grease) that may clog the trench are often pretreated with other techniques such as water quality inlets (a series of chambers that promote sedimentation of coarse materials and separation of free oil from storm water), inlet protection devices, grassed swales, and vegetated filter strips.

Permeable Pavement

As an alternative to asphalt or concrete surfaces, permeable pavement allows stormwater to drain through the porous surface to a stone reservoir underneath. The reservoir temporarily stores surface runoff and allows it to infiltrate into the subsoil. The appearance of the alternative surface is often similar to asphalt or concrete, but it is manufactured without fine materials and instead incorporates void spaces that allow for storage and infiltration. Underdrains may also be used below the stone reservoir if soil conditions are not conducive to complete infiltration of runoff.

Riparian Buffers

A riparian, or forested, buffer is an area along a shoreline, wetland, or stream where development is restricted or prohibited. The primary function of aquatic buffers is to physically protect and separate a stream, lake, or wetland from future disturbance or encroachment. If properly designed, a buffer can provide stormwater management and can act as a right-of-way or floodplain during floods, sustaining the integrity of stream ecosystems and habitats.

Sand and Organic Filters

Sand and organic filters direct stormwater runoff through a sand bed to remove floatables, particulate metals, and pollutants. Sand and organic filters provide water quality treatment, reducing sediment, biochemical oxygen demand (BOD), and fecal coliform bacteria, although dissolved metal and nutrient removal through sand filters is often low. Sand and organic filters are typically used as a component of a treatment train to remove pollution from stormwater before discharge to receiving waters, to groundwater, or for collection and reuse. Variations on the traditional surface sand filter (such as the underground sand filter, perimeter sand filter, organic media filter, and multi-chamber treatment train) can be made to fit sand filters into more challenging design sites or to improve pollutant removal.

Soil Amendments

Soil amendments increase the soil's infiltration capacity and help reduce runoff from the site. They have the added benefit of changing physical, chemical, and biological characteristics so that the soils become more effective at maintaining water quality. Soil amendments, which include both soil conditioners and fertilizers, make the soil more suitable for the growth of plants and increase water retention capabilities. The use of soil amendments is conditional on their compatibility with existing vegetation, particularly native plants.

Vegetated Filter Strips
Filter strips are bands of dense vegetation planted downstream of a runoff source. The use of natural or engineered filter strips is limited to gently sloping areas where vegetative cover can be established and channelized flow is not likely to develop. Filter strips are well suited for treating runoff from roads and highways, roof downspouts, very small parking lots, and other small or linear impervious surfaces. They are also ideal components for the fringe of a stream buffer, or as pretreatment for a structural practice.

Curb and Gutter Elimination
Curbs and gutters transport flow as quickly as possible to a stormwater drain without allowing for infiltration or pollutant removal. Eliminating curbs and gutters can increase sheet flow and reduce runoff volumes. Sheet flow, the form runoff takes when it is uniformly dispersed across a surface, can be established and maintained in an area that does not naturally concentrate flow, such as parking lots. Maintaining sheet flow by eliminating curbs and gutters and directing runoff into vegetated swales or bioretention basins helps to prevent erosion and more closely replicate predevelopment hydraulic conditions. A level spreader, which is an outlet designed to convert concentrated runoff to sheet flow and disperse it uniformly across a slope, may also be incorporated to prevent erosion.

Bioretention Cells
A bioretention cell or rain garden is a depressed area with porous backfill (material used to refill an excavation) under a vegetated surface. These areas often have an underdrain to encourage filtration and infiltration, especially in clayey soils. Bioretention cells provide groundwater recharge, pollutant removal, and runoff detention. Bioretention cells are an effective solution in parking lots or urban areas where green space is limited.

Green Parking Design
Green parking refers to several techniques that, applied together, reduce the contribution of parking lots to total impervious cover. Green parking lot techniques include: setting maximums for the number of parking lots created; minimizing the dimensions of parking lot spaces; utilizing alternative / porous pavers in overflow parking areas; using bioretention areas to treat stormwater; encouraging shared parking; and providing economic incentives for structured parking.

Rain Barrels and Cisterns

Rain barrels and cisterns harvest rainwater for reuse. Rain barrels are placed outside a building at roof downspouts to store rooftop runoff for later reuse in lawn and garden watering. Cisterns store rainwater in significantly larger volumes in manufactured tanks or underground storage areas. Rainwater collected in cisterns may also be used in non-potable water applications such as toilet flushing. Both cisterns and rain barrels can be implemented without the use of pumping devices by relying on gravity flow instead. Rain barrels and cisterns are low-cost water conservation devices that reduce runoff volume and, for very small storm events, delay and reduce the peak runoff flow rates. Both rain barrels and cisterns can provide a source of chemically untreated “soft water” for gardens and compost, free of most sediment and dissolved salts.

Stormwater Planters
Stormwater planters are small landscaped stormwater treatment devices that can be placed above or below ground and can be designed as infiltration or filtering practices. Stormwater planters use soil infiltration and biogeochemical processes to decrease stormwater quantity and improve water quality, similar to rain gardens and green roofs but smaller in size—stormwater planters are typically a few square feet of surface area compared to hundreds or thousands of square feet for rain gardens and green roofs. Types of stormwater planters include contained planters, infiltration planters, and flow-through planters.

Tree Box Filters
Tree box filters are in-ground containers used to control runoff water quality and provide some detention capacity. Often premanufactured, tree box filters contain street trees, vegetation, and soil that help filter runoff before it enters a catch basin or is released from the site. Tree box filters can help meet a variety of stormwater management goals, satisfy regulatory requirements for new development, protect and restore streams, control combined sewer overflows (CSOs), retrofit existing urban areas, and protect reservoir watersheds. The compact size of tree box filters allows volume and water quality control to be tailored to specific site characteristics. Tree box filters provide the added value of aesthetics while making efficient use of available land for stormwater management. Typical landscape plants (for example, shrubs, ornamental grasses, trees and flowers) are an integral part of the bioretention system. Ideally, plants should be selected that can withstand alternating inundation and drought conditions and that do not have invasive root systems, which may reduce the soil’s filtering capacity.

Vegetated Roofs
Green roofs consist of an impermeable roof membrane overlaid with a lightweight planting mix with a high infiltration rate and vegetated with plants tolerant of heat, drought, and periodic inundations. In addition to reducing runoff volume and frequency and improving runoff water quality, a green roof can reduce the effects of atmospheric pollution, reduce energy costs, and create an attractive environment. They have reduced replacement and maintenance costs and longer life cycles compared to traditional roofs.

1.3 Best Management Practices in Forested Areas
Sources of pollution associated with forestry activities include removal of streamside vegetation, road construction and use, timber harvesting, and mechanical preparation for the planting of trees. Of these, road construction and road use are the primary sources of pollution on forested lands, contributing up to 90 percent of the total sediment from forestry operations.

Harvesting trees in the area beside a stream can affect water quality by reducing the stream bank shading that regulates water temperature and by removing vegetation that stabilizes the stream banks. These changes can harm aquatic life by limiting sources of food, shade and shelter.

1.3.1 Recommendation to Use Nova Scotia's Code of Forest Practice

Nova Scotia has recently published a very good document in this specific area, which describes an approach to implementing sustainable forest management techniques. The document was produced for Crown Land, but it is applicable to any forested area in the province. The document indeed recommends that it be used for forest management in the province wherever possible.

The reference for this document is the following:
Nova Scotia's Code of Forest Practice
A Framework for the Implementation of Sustainable Forest Management
Guidelines for Crown Land
Nova Scotia Natural Resources
August 2012

General recommendations for forestry Best Management Practices to include in a preharvest plan are listed in the following section, extracted from the USEPA.

1.3.2 Typical Forestry Best Management Practices

Preharvest Planning: Opportunities to Prevent Pollution

To limit water quality impacts caused by forestry, public and private forest managers have developed and followed site-specific forest management plans.

Following properly designed preharvest plans can result in logging activities that are both profitable and highly protective of water quality. Such plans address the full range of forestry activities that can cause pollution. They clearly identify the area to be harvested; locate special areas of protection, such as wetlands and streamside vegetation; plan for the proper timing of forestry activities; describe management measures for road layout, design, construction, and maintenance, as well as for harvesting methods and forest regeneration.

Public meetings should be held to provide residents with an opportunity to review and comment on the development of forest management plans.

Factors Considered in the Preharvest Plan

Surveying the Site

Preactivity surveys can help identify areas that might need special protection or management during forestry operations. Sensitive landscapes usually have steep slopes, a greater potential for landslides, sensitive rock formations, high precipitation levels, snowpack, or special ecological functions such as those provided by streamside vegetation. Forestry activities occurring in these areas have a high potential of affecting water quality.

Timing

Because most forestry activities disturb soil and contribute to erosion and runoff, timing operations carefully can significantly reduce their impact on water quality and aquatic life. Rainy seasons and fish migration and spawning seasons, for example, should be avoided when conducting forestry activities.

Establishing Streamside Management Areas (SMAs)

Plans often restrict forestry activities in vegetated areas near streams (also known as buffer strips or riparian zones), thereby establishing special SMAs. The vegetation in an SMA is highly beneficial to water quality and aquatic habitat. Vegetation in the SMA stabilizes streambanks, reduces runoff and nutrient levels in runoff, and traps sediment generated from upslope activities before it reaches surface waters. SMA vegetation moderates water temperature by shading surface water and provides habitat for aquatic life. For example, large trees provide shade while alive and provide aquatic habitat after they die and fall into the stream as large woody debris.

Managing Road Construction, Layout, Use, and Maintenance

Good road location and design can greatly reduce the transport of sediment to water bodies. Whenever possible, road systems should be designed to minimize road length, road width, and the number of places where water bodies are crossed. Roads should also follow the natural contours of the land and be located away from steep gradients, landslide-prone areas, and areas with poor drainage. Proper road maintenance and closure of unneeded roads can help reduce pollution impacts from erosion over the long term.

Managing Timber Harvesting

Most detrimental effects of harvesting are related to the access and movement of vehicles and machinery, and the dragging and loading of trees or logs. These effects include soil disturbance, soil compaction, and direct disturbance of stream channels. Poor harvesting and transport techniques can increase sediment production by 10 to 20 times and disturb as much as 40 percent of the soil surface. In contrast, careful logging disturbs as little as 8 percent of the soil surface.

Careful selection of equipment and methods for transporting logs from the harvest area to areas where logs are gathered can significantly reduce the amount of soil disturbed and delivered to water bodies. Stream channels should be protected from logging debris at all times during harvesting operations.

Managing Replanting

Forests can be regenerated from either seed or seedlings. Seeding usually requires that the soil surface be prepared before planting. Seedlings can be directly planted with machines after minimal soil preparation. In either case, the use of heavy machinery, if not performed carefully, can result in significant soil disturbance.

1.4 Summary of Recommendations and Proposed Targets

One the most efficient ways to deal with flooding risks is to manage the issue of high runoff at its source. Municipal Plan policies could include statements such as "expansion of the built environment or forestry operations shall be managed according to Best Management Practices and the BMP documents referenced". At the implementation (regulatory) level, specific BMPs could be incorporated into language in the municipal regulations – such as requirements for a certain width of stream buffer or how the buffer would be calculated for example. Several examples are presented here as a general guide. In order not to be too prescriptive, the documents referenced focus more on the objectives rather than on the detailed approach to reaching them. Attaining the objectives will be made through a combination of various measures, both at the planning and site level. Since every site and every development is different, it is recommended that the policies and By-laws produced be generic enough to allow flexibility of method employed, while focusing on the ultimate objective of controlling runoff volumes and runoff water quality.

In this spirit, some good reference documents are presented, and a range of best management practices are described. Some standard objectives are proposed, which are not expected to be excessively stringent or expensive to implement. Costs can be best controlled with a clear watershed master plan and efficient site plans that blends stormwater management practices smoothly into the local site characteristics.

1.4.1 Planning Level

The Credit Valley Conservation, a community conservation area in Ontario, has published a comprehensive guide to implementing sustainable development through Low Impact Development and Stormwater Best Management Practices ("Low Impact Development Stormwater Management Planning and Design Guide", Version 1.0 – 2011). It is recommended that at the planning level, the main steps in the document mentioned above be followed, which refers to the development of:

- Watershed Master Plans, a Growth Plan and an Official Plan;
- Community / Subwatershed Secondary and Block Plans;
- Neighbourhood Draft Plan of Subdivision / Functional Servicing Plan, followed by the Registered Plan;
- Site Plan with site specific opportunities, while staying consistent with the direction of the higher level plans; and
- Site Permits and approvals.

1.4.2 Forested Areas

Nova Scotia has recently published a very good document in this specific area, which describes an approach to implementing sustainable forest management techniques. The document was produced for Crown Land, but it is applicable to any forested area in the province. The document indeed recommends that it be used for forest management in the province wherever possible.
The reference for this document is the following:

- Nova Scotia's Code of Forest Practice "A Framework for the Implementation of Sustainable Forest Management Guidelines For Crown Land" Nova Scotia Natural Resources, August 2012

1.4.3 Low Density and High Density Urban Areas – New Developments

It is recommended that by-laws be implemented which require no increase through lot development of:

- Total Suspended Solids in surface runoff;
- Phosphorous in surface runoff;
- Nitrates and ammonia in surface runoff;
- Peak flows; or
- Total Runoff Volume

To help achieve these targets, it is recommended that the practices listed in section 5.3 and any others the Municipality feels are relevant be encouraged through education and incentives.

1.4.4 Low Density and High Density Urban Areas – Retrofit Applications

For development of previously developed sites, it is probably quite challenging to re-establish pre-development level aspects. For these areas, it is therefore recommended that by-laws be implemented which require a 25% reduction through on-lot development of:

- Total Suspended Solids in surface runoff;
- Phosphorous in surface runoff (not applicable if only hard surface);
- Nitrates and ammonia in surface runoff (not applicable if only hard surface);
- Peak flows; and
- Total Runoff Volume.

These would apply to the surface area being re-developed and not the entire site. For areas that already include stormwater management features that work very efficiently, the percentage reduction requirement can be decreased if the developer can show that this would bring runoff volume to a lower level than the runoff volume of the original natural treed site.

To help achieve these targets, it is recommended that the practices listed in section 5.4 and any others the Municipality feels are relevant be encouraged through education and incentives.