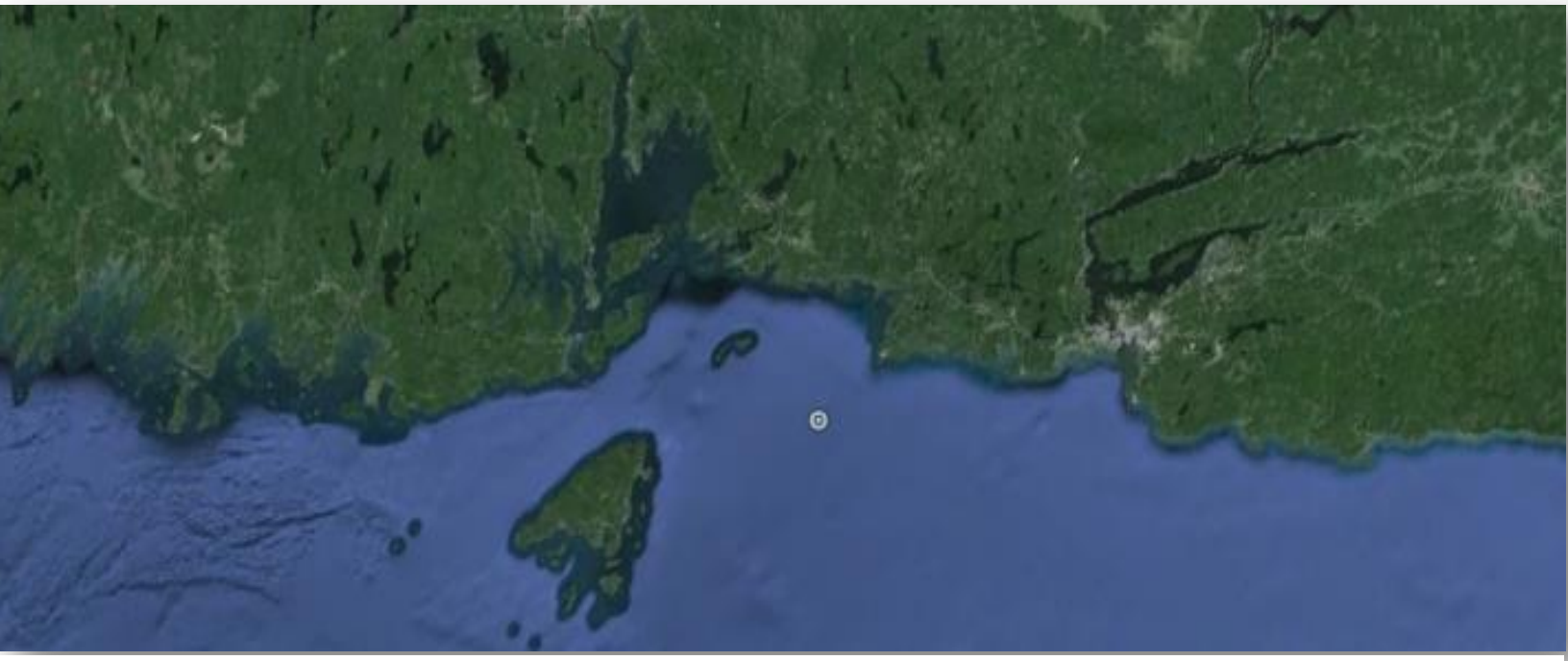
CHARLOTTE COUNTY COMMUNITY VULNERABILITY ASSESSMENT

SUMMARY DOCUMENT



ST. STEPHEN, ST. ANDREWS, ST. GEORGE, BLACKS HARBOUR & GRAND MANAN

NEW BRUNSWICK

2013 - 2014

ST. CROIX ESTUARY PROJECT INC ~ EASTERN CHARLOTTE WATERWAYS INC

St. Croix Estuary Project Inc.

SCEP is dedicated to the continual improvement of environmental quality of the St Croix estuary ecosystem, in full collaboration with and in support of, healthy and prosperous coastal communities. SCEP's goal is to engage local and regional decision-makers and citizens in working together to better understand, sustain and improve the environment at local and regional scales through research & monitoring, application of scientific data, education and action.

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Eastern Charlotte Waterways Inc. (ECW) is a not-for-profit, environmental resource and research centre, collaborating with like-minded organizations to promote community well-being through sound environmental health. This is accomplished by facilitating projects that integrate common social, economic and environmental concerns.

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Completion of the Community Vulnerability Assessment of Climate Change Impacts in Charlotte County, New Brunswick was accomplished by Kim Reeder, Executive Director for The St. Croix Estuary Project Inc., Donald Killorn, Executive Director for Eastern Charlotte Waterways Inc. and Kristie Signer, Project Coordinator for Eastern Charlotte Waterways Inc. March 2014.

CONTRIBUTORS

Working collaboratively with five municipalities throughout Charlotte County, New Brunswick, this Project could not have been completed without the participation of dedicated the residents from each community who formed the working groups. The working groups were made up of residents from each of the represented municipalities of Charlotte County who volunteered their time to participate in the community engagement process by attending a collective, County-wide meeting in addition to four to five meetings held in their respective communities.

This work was also completed with contributions from:

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EXECUTIVE SUMMARY

In recent years, the southwestern region of New Brunswick has experienced multiple and significant hydro-meteorological hazards including floods, blizzards, and ice storms. These events have caused health impacts, physical and infrastructure damage, loss of household savings, temporary loss of services resulting in economic disruption, and environmental damage. As these hazards have impacted the communities of Charlotte County to varying degrees and proactive initiatives to adapt to future impacts have been lacking, two local environmental organizations, the St Croix Estuary Project Inc (SCEP) and Eastern Charlotte Waterways Inc (ECW) organized the Charlotte County Community Vulnerability Assessment (CCCVA) during 2013. The purpose of this initiative was to enable the community to share knowledge and concerns relative to climate change, as well as to develop and share down-scaled information on such topics as socioeconomic systems, sea-level rise, and inland flooding. With this information, the CCCVA process was able to help shape recommendations for reducing the vulnerability of the participating Charlotte County communities to future climate related hazards.

The process worked to determine which community elements are most sensitive to changes in the environmental and climate, and to start the development of plans that focus on building resilience. This was accomplished by utilizing a community level advisory and engagement process to allow local stakeholders to identify locations, groups, and processes that are most susceptible to climate change hazards and impacts, based on past experience and new local projections for climate change. The long term objective of the CCCVA and resultant climate change adaptation planning is to increase the resilience of five Charlotte County communities to the impacts of climate change and variability. This report reflects the discussions, perceptions and potential actions of five Charlotte County communities regarding their concerns for climate impacts, community vulnerabilities and resilience development, under a changing climactic regime.

The development of a regional all-hazards plan was the strongest recommendation shared by all working groups, which could contribute to improving community resilience. However, the severe hazards and associated emergencies that have already occurred in Charlotte County must be addressed in the planning process, with consideration being given to any possible adaptations that could contribute to less severe impacts. Attention must be paid to those hazards with a high likelihood of reoccurrence to make certain they thoroughly planned for.

Suggestions for hydraulic studies were put forward in St Stephen and St George, the communities which experienced significant inland flooding from rivers and brooks. It was suggested that a more detailed understanding of these areas would allow building and infrastructure issues to be addressed through mitigation.

In Blacks Harbour and Grand Manan, where climate related hazards had not posed a significant threat in the past, but were of concern into the future. Working groups indicated that their foremost concern focussed on impacts which posed a risk to crucial industry, thus, economic diversification studies were recommended.

St Andrews was most concerned with communicating to, and gaining feedback from, their citizenry in order to formulate a place-based response to future challenges, including developing recommendations for actions to decrease vulnerability.

The recommendations from the community working groups that participated in the CCCVA are expected to support long term strategic resource management and policy development, build community resilience, and strengthen adaptive capacity as part of climate change adaptation planning process.

The CCCVA process has illustrated that one of the main factors which influences a community's ability to respond to new and potential circumstances is access to information. In the coming months and years, increasing the adaptive capacity of Charlotte County municipalities will also depend on the ability to clearly communicate information, the development of methods to effectively implement policy, and the resources to support these proactive efforts.

1. BACKGROUND

Climate change adaptation has become widely accepted as an issue of importance for municipal planning within local governments. Climate change adaptation literature insists that *adaptation is local,* as the impacts of climate change are geographic in their variability and must be addressed by 'place-based' approaches (Measham *et al.* 2011). As such, "adaptation science and practice have promoted the concept of community-based adaptation, which is locally focused, participatory, and draws on the normative preferences and knowledge of local people" (Measham *et al.* 2011).

In many fields, including sociology, anthropology, rural development, and food security, local vulnerability is determined using variations of participatory assessments of community conditions. These methods allow for the recognition of numerous motivations including political, cultural, economic, institutional, and technological sensitivities. These experience-based approaches recognize the interaction of the community's various exposures and its level of adaptive capacity over time. The concepts of vulnerability and adaptive capacity are central to climate change adaptation planning (Smit & Wandel 2006). Therefore, this project was designed to identify vulnerable areas and build adaptive capacity in participating municipalities.

Anticipating the effects of climate change and taking adaptive action is a fiscally responsible and effective strategy to manage climate change risk and reduce vulnerability at the local level. Adaptation planning at the municipal level must include the identification of the physical, social, economic, and environmental risks that result from climate hazards; and the development and implementation of strategies to reduce the impact of those hazards. Increasing the adaptive capacity of communities to respond to these vulnerabilities will lead to effective adaptation planning for the long term.

In November 2013, the International Institute for Sustainable Development (IISD) released a report entitled *Climate Change Adaptation and Canadian Infrastructure* which comments:

> In recent years, many government, private sector, and civil society actors in Canada have taken actions to address the cause of climate change (mitigation); but in comparison, limited efforts have been made to address the present and future negative impacts of climate change and to maximize potential benefits (adaptation). There is a pressing need to shift towards forward-looking, long-term planning and investment decision-making that strengthens adaptive capacity and builds resiliency across a number of sectors.
>
> New Brunswick's *Climate Change Action Plan* (2007 – 2012), [which is being renewed for the 2013–2020 period,] similarly included plans to enhance provincial adaptation planning with special emphasis on coastal regions. Key actions include incorporation of vulnerability considerations into cross-governmental decision making, and the implementation of a regulatory framework to help protect the coastal environment, infrastructure, and public and private property… [Established in 1990, the province's] *Environmental Trust Fund*… has funded some 50 projects related to mapping vulnerabilities and engaging stakeholders in adaptation planning (Government of NB 2012).

Many of these Environmental Trust Fund projects were undertaken as part of the Regional Adaptation Collaborative (RAC) Program. The RAC Program includes projects in New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador that prepare and adapt communities to the impacts of climate change and variability. RAC projects were administered through the Atlantic Canada Adaptation Solutions Association (ACASA) and served as guidance for the Charlotte county project. The Charlotte county project is the beginning of a long-term strategic community planning effort in the area and was developed by two local environmental non-governmental organizations (ENGOs), the St. Croix Estuary Project (SCEP) and Eastern Charlotte Waterways Inc. (ECW) for five municipalities, St. Stephen, St. Andrews, St. George, Blacks Harbour, and Grand Manan. These participating municipalities took part in a community-level advisory process that identified their vulnerabilities to climate related hazards and fostered building adaptive capacity.

1.1 Climate change adaptation projects in New Brunswick

The Charlotte County Community Vulnerability Assessment (CCCVA) was designed in consultation with various stakeholders as well as ACASA representatives. The collaboration of ACASA with local ENGOs, academia, climate change consultants, and various levels of government has enabled multiple climate change adaptation projects throughout New Brunswick. These projects, including the CCCVA, worked to develop and test tools and methodologies regarding adaptation measures. The resultant outcomes guide land use practices throughout New Brunswick, help to protect the province's valuable infrastructure, and identify pertinent social, economic, and governance issues (ACASA 2013). Figure 1 highlights six of these projects undertaken from 2009–2012 throughout New Brunswick. Each project is further detailed in the sections that follow.

The Provincial government has also started new work, shared at a stakeholders meeting January 2014 based on direction from the 2012 Speech from the Throne, "Recognizing the continuing risks associated with extreme weather events and climate conditions, your government will begin a collaborative effort to develop a province-wide Flood Risk Reduction Strategy. This strategy will build on past experiences including the flood event in the Perth- Andover-Tobique area earlier this year. It will benefit all areas of the province in reducing risk to life and property in the future." This initiative is now in its second phase, progressing on draft objectives and actions.

1.2 The climate of Charlotte County

The climate of Charlotte County is dominated by the tempering airflow of the Atlantic Ocean's Bay of Fundy and can be described as a *moderate maritime climate.* It features cool summers and mild winters, extensive periods of fog, and strong autumn and winter winds. The water in the Bay of Fundy has a much higher heat capacity than soil and rock maintaining a smaller temperature range than continental climates. The proximity to the ocean causes increased humidity, resulting in greater amounts of precipitation in the coastal climate.

2. METHODOLOGY

The CCCVA project incorporated proven vulnerability assessment methods with community concerns to identify local vulnerabilities and define options for local adaptation. The methodology of this project was based on the CVAT developed by the National Oceanic and Atmospheric Administration (NOAA). During the RAC program, it was modified for use in rural communities by the Department of Geography at Memorial University in Newfoundland and Labrador (Leone Pippard & Associates 2012). The CVAT process has also been recognized by the United Nations Framework Convention on Climate Change (UNFCCC). A description of the UNFCC's modified CVAT method is available on their website under the title *Compendium on methods and tools to evaluate impacts of, and vulnerability and adaptation to, climate change*. The methodology used in this project was also guided by the book *From Vulnerability to Resilience, A framework for analysis and action to build community resilience* by Katherine Pasteur, 2011. Pasteur outlines the Vulnerability to Resilience (V2R) method, which provided valuable input on disaster risk reduction methods that were successfully integrated into the CCCVA for use in Charlotte County.

This project's primary action was a series of facilitated consultations with community members, designed to identify local climate hazards and the associated impacts. The community members were formed into working groups in each participating municipality and each working group was guided through a five step process, outlined below in Table 1. Initially, the working group members, in addition to the local public and media, were addressed by New Brunswick leaders in climate change and social science during a general meeting on September 24, 2013. Through autumn of 2013, four to five working group meetings were held in each of the five participating municipalities.

Meeting on a bi-weekly basis, the working group members took part in an interactive community mapping exercise to identify physical, social, economic, and environmental climate hazard impacts. This process captured the complex network of factors that exist and operate on varying spatial and temporal scales, giving rise to vulnerability. It is these complex interactions between physical, social, economic, and environmental factors that affect the ability of individuals and communities to prepare for, cope with, and recover from climate related hazards (Thomalla *et al.* 2006). Throughout the process, background information and scientific research was provided to the working groups to prompt discussions, assist with mapping activities, and develop recommendations for future climate change adaptation planning.

2.1 SELECTION OF THE WORKING GROUP MEMBERS

The working groups for each of the participating Charlotte County municipalities were made up of community members that aimed to represent a diverse range of stakeholders. Local knowledge is considered a key source of information on changing climate conditions. Residents have knowledge of changing weather and climate patterns that can be integrated with observations made by climatologists to better understand the changing climate of a community (Vodden 2012).

2.2 LiDAR

LiDAR (Light Detection and Ranging) was first used in New Brunswick in 2004. It generates terrain elevation models of a selected area. The technology requires scanning a laser combined with both GPS and inertial technology to create a three dimensional set of points, referred to as a point cloud. It can detect changes in elevation to within 15 centimetres (cm). For the CCCVA LiDAR imaging was sourced from Leading Edge Geomatics in Fredericton and analyzed by Mr. Réal Daigle of R.J. Daigle Enviro and Dr. Paul Arp from the University of New Brunswick. Mr. Daigle used the LiDAR information to create Digital Elevation Models (DEMs), which were analyzed to create sea-level rise projections (see section 2.2.1). Dr. Arp created DEMs and depth to water maps, also referred to as wet-areas mapping (WAM) (see section 2.2.2 of full report). This information was provided to working group members, helping them to assess the threat of sea-level rise and depth to water for each municipality.

2.2.1 Sea-Level Rise

The Director of R.J. Daigle Enviro, Mr. Réal Daigle, utilized LiDAR data and Intergovernmental Panel on Climate Change (IPCC) scenarios to create projections of future sea-level rise for coastal Charlotte County. Mr. Daigle has over 30 years of experience as a meteorologist and project manager for Environment Canada, and has consulted on several sea-level rise and storm surge climate change projects throughout Atlantic Canada. Mr. Daigle made his projections using the most recent information provided by the IPCC Fifth Assessment Report (AR5) which includes information on sea-level rise estimates. The estimates of sea-level rise are higher than those published in the 2007 IPCC Fourth Assessment Report (AR4). The sea-level rise estimates in the AR5 also now include dynamical modelling of accelerated ice sheet (Greenland and West Antarctic) melting.

The sea-level rise estimates provided in this report are based on the AR5 information using the highest emission scenario known as Representative Concentration Pathway (RCP) 8.5. RCP 8.5 is based on the absence of any significant global policy for the reduction of greenhouse gas emissions. Mr. Daigle's projections also include regional subsidence, the downward motion of the Earth's surface relative to sea-level. Recent research by Natural Resources Canada (report in progress) which is based on precise Global Positioning System (GPS) calculated vertical movements of the Earth's crust state that determined the subsidence of St. Stephen and St. Andrews is near the zero-line, and that Blacks Harbour and Grand Manan are subsiding by four and six centimeters (cm) per century respectively (Daigle 2014).

In order to calculate sea-level rise, a reference, or baseline, must be established from which to determine heights or depths. This baseline is known as tidal datum or chart datum (CD). A CD is a ship navigation reference level that is representative of the lowest tide level for a given area and phase of the tide, as such, the CD varies for each community. It is used as a baseline from which local water levels can be measured (NOAA 2013). The regional tidal datum, inclusive of Charlotte County, is referred to as "CGVD28" and does not vary for each community. CGVD28 is a geodetic reference level that closely represents elevations above Mean Sea Level (MSL). In order to

represent coastal water levels using the Geographic Information System (GIS) software, CD elevations must be calculated in terms of CGVD28 elevations. Mr. Daigle used the CGVD28 baseline in order to calculate the average of the maximum annual predicted tide over the 19 year tidal cycle for each community. This is referred to as the Higher High Water Large Tide (HHWLT). The 19 year tidal cycle for each community was provided to the working groups.

TABLE 1: CALCULATIONS OF SEA-LEVEL CHANGE FOR SELECT CHARLOTTE COUNTY COMMUNITIES.

Anticipated change in relative sea-level (m)						
Location	**Global sea-level rise (2100)**	**Vertical motion (2100)**	**Total change (2025)**	**Total change (2055)**	**Total change (2085)**	**Total change (2100)**
St. Stephen	0.88 ± 0.24	0.00 ± 0.05	0.13 ± 0.03	0.35 ± 0.11	0.68 ± 0.21	0.88 ± 0.29
St. Andrews	0.88 ± 0.24	0.00 ± 0.05	0.13 ± 0.03	0.35 ± 0.11	0.68 ± 0.21	0.88 ± 0.29
Blacks Harbour	0.88 ± 0.24	0.04 ± 0.05	0.14 ± 0.03	0.37 ± 0.11	0.71 ± 0.21	0.92 ± 0.29
Grand Manan (North Head)	0.88 ± 0.24	0.06 ± 0.05	0.15 ± 0.03	0.38 ± 0.11	0.73 ± 0.21	0.94 ± 0.29

Mr. Daigle's sea-level rise projections are referred to as *extreme total sea-level flooding scenarios*. They incorporate the mean value of the HHWLT for each community, local crustal subsidence, anticipated global sea-level rise, and a storm surge return period component. A storm surge is the difference between the observed water level and the predicted astronomical tide. The magnitude of a storm surge depends on the nature of the meteorological event responsible for reduced atmospheric pressure and the strength of the winds associated with a particular event. This equation is represented in Figure 1. The extreme total sea-level flooding scenarios have been calculated to represent the worst-case flooding scenario in which a storm surge event would occur during a high portion of the tide cycle. In the opposite case where a storm surge event coincides with the low portion of the tide cycle, the chance of flooding is eliminated. The return period statistics have been calculated to represent the relative probability that a given storm surge value, also defined as *surge residual*, would coincide with the higher portion of the tide cycle. Because of the nature of the Bay of Fundy's "semi-diurnal" tide cycles, the duration of the high tide peak is short lived (changes of over 1m per hour) and hence the risk of flooding is reduced. As a result, the 1 in 100 year storm surge component for the Charlotte County coastal areas is 0.94m. Therefore there is a 1% relative probability of a storm surge event will reach 0.94m in any given year. This value is the same for each of the Charlotte County communities participating in this project as the storm surge value has been derived from the Saint John tide gauge statistics.

The flooding scenarios have been reproduced in the form of elevation contours (rounded to the nearest tenth of a metre) on LiDAR derived DEMs for the communities of St. Stephen, St. Andrews, Blacks Harbour, and Grand Manan. The resulting flooding scenario maps are included in Meeting #3 for each of the communities. The included extreme total sea-level flooding scenario maps prepared for each affected community are based on a 1 in 100 year flood event and are marked with colour-coded lines representing the extent of flooding for the years 2010, 2025, 2055, 2085, and 2100. For the additional extreme total sea-level flooding scenario maps (1 in 1 year, 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 25 year, and 1 in 50 year) produced by Mr. Daigle.

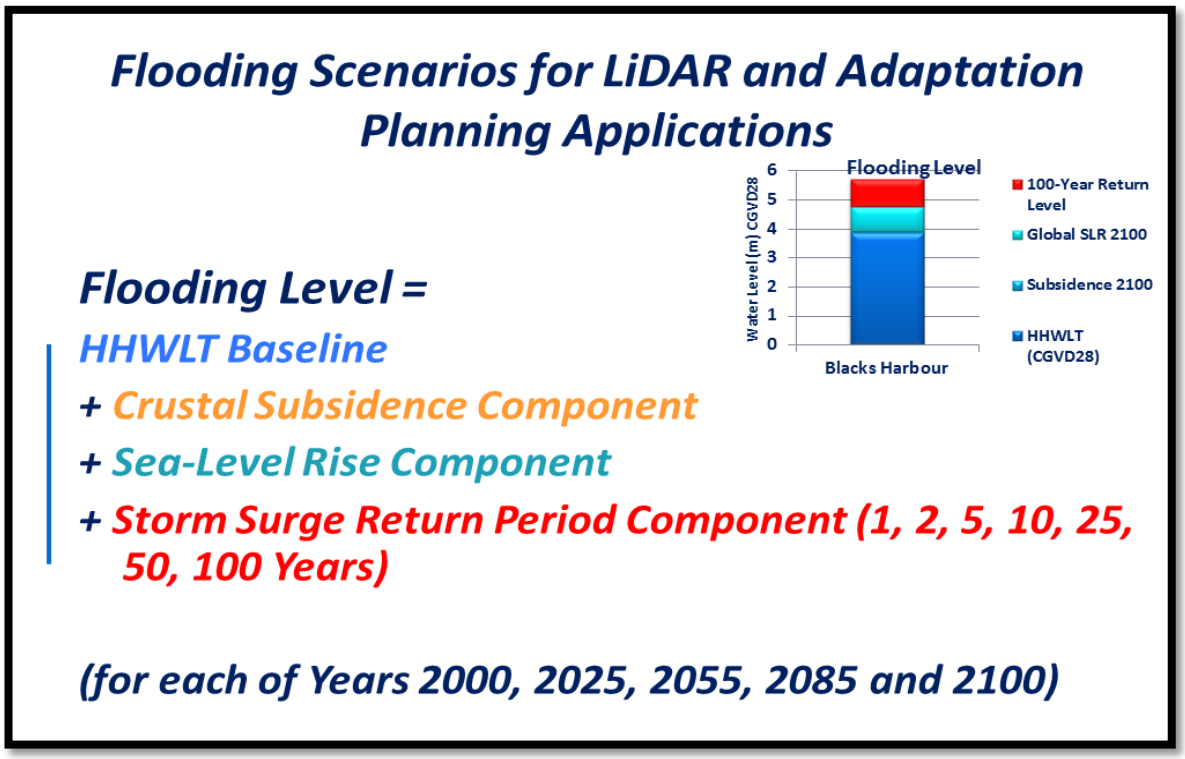


FIGURE 1: MR. DAIGLE'S METHOD OF CALCULATING THE EXTREME TOTAL SEA-LEVEL FLOODING SCENARIOS.

2.2.2 INLAND FLOODING

Wet-areas mapping (WAM) was produced for the participating Charlotte County communities to better understand inland flooding issues. They were prepared by Dr. Paul Arp, a forestry professor at the University of New Brunswick who coordinates research at the Forest Soil Laboratory and at the Forest Watershed Research Centre. The development of the WAM involved a systematic calculation of local flow channels and associated wet areas using DEMs. Two DEMs were used to create the WAM figures: a Provincial DEM for New Brunswick, at a 10m resolution, and LiDAR generated bare earth DEM, at a 1m resolution. The bare earth DEM was used to ensure trees and structures do not disturb the calculations. The DEMs were used to determine the topographic depth-to-water index (DTW), which projects how far the water table is located below the ground

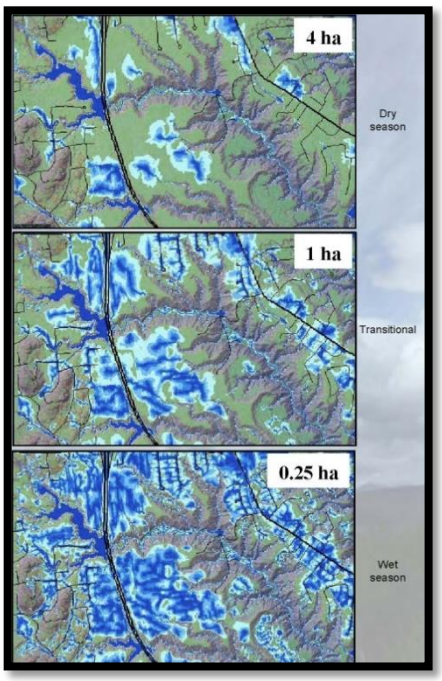


FIGURE 2: VARYING FLOW RATE INITIATIONS USED TO DESCRIBE GROUND SATURATION (SOURCE: ARP 2013).

surface using open water surfaces such as lakes, rivers, streams and shores as DTW = 0 for reference. These waterways are referred to as *flow channels* see Figure 12 below. The elevation rise from the nearest open flow channel is calculated from the DEMs and used to estimate the local soil drainage conditions.

To map the expansion and contraction of flow channels and the resulting wet-areas, the appropriate season and weather variables must be selected. Seasons produce variety in flow channels and ground saturation. The seasonal conditions are assigned a flow rate initiation value. Flow rate initiation is the amount of land that must be drained to create a flow channel. In the late summer season, when the ground is dry, the flow rate initiation selected is 4ha, but during the spring freshet, when the ground is saturated, the flow rate initiation selected is 0.25 ha, see Figure 12 above. The difference in flow rate initiation means that in the spring there are many more flow channels therefore less land is required to initiate flow. For the CCCVA, a 4ha flow rate initiation was used, simulating conditions at end of summer, when the ground is dry. The WAM figures that were presented to the working groups can be found in their respective results sections.

2.3 CHARLOTTE COUNTY GENERAL MEETING

FIGURE 3: GENERAL MEETING IN ST. GEORGE SEPTEMBER 24, 2013.

During the assemblage of the working groups for each municipality, a general meeting was held for the greater Charlotte County region. The meeting was attended by committed working group members, potential working group members, government officials, the media, and the public. This meeting introduced the CCCVA and provided scientific background information regarding climate change and the impacts that have been experienced throughout Charlotte County. The facilitators of the project, SCEP and ECW, were introduced and provided an overview of how they would perform their role, including the provision of knowledge and expertise from outside sources, and by leading the working groups in discussions and mapping exercises.

Additionally, SCEP and ECW explained how their role as facilitators would include working alongside the members of the community working groups to ensure that their input would be used effectively to communicate existing concerns, how communities felt their energies could be best directed, and how recommendations could be appropriately incorporated into long-term planning strategies.

The objectives of the CCCVA for each participating community were identified:

- assess physical, social, economic, and environmental climate hazard impacts
- discuss governance and policy issues relating to climate change and disaster management
- increase resilience to progressively withstand and recover from climate hazard impacts
- make recommendations for future adaptation to climate change and variability
- discuss resource and land use over the long term, under new environmental conditions
- increase awareness of the expected impacts of climate change and variability and how these impacts can be reduced or avoided

Based on these objectives, the working groups were asked to:

- increase their knowledge of climate change and variability and the associated impacts
- identify and prioritize climate related hazards
- identify and prioritize recommendations for future climate change adaptation
- communicate working group discussions to their respective communities

It was explained that the desired outcome of the CCCVA is increased resilience to the impacts of climate change in the participating communities, and that a resilient community is one that takes intentional action to enhance its capacity to respond to change.

To offer expert knowledge and to provide background information on climate change and the associated impacts in Charlotte County, presentations were delivered by Ms. Colette Lemieux, the climate change engagement and mainstreaming coordinator of the Climate Change Secretariat, New Brunswick Department of Environment and Local Government. Her presentation focused on climate change and climate change adaptation in New Brunswick and the concept of increasing resiliency. A presentation was also delivered by Mr. Réal Daigle, a meteorologist and climate change consultant with R. J. Daigle Enviro regarding climate change scenarios and climate change impacts, including coastal flooding in New Brunswick. From Environment Canada, Mr. Rick Fleetwood, a regional climatologist, discussed heavy precipitation events and flooding in New Brunswick and, specifically, Charlotte County. A survey was distributed at this meeting to collect information on the personal impacts of climate hazards, future concerns regarding climate hazard impacts in Charlotte County and any organizational action or attention to climate change/climate change adaptation.

3. MUNICIPALITIES

Charlotte County is located in southwestern New Brunswick (see Figure 4) . It covers an area of 3,424 square kilometers (km^2). The population of the county, based on the 2011 Statistics Canada National Household Survey, was approximately 26,000. Charlotte County is inclusive of six

municipalities including two island communities, Grand Manan and Campobello, as well as Blacks Harbour, St. Andrews, St. George, and St. Stephen.

Located on the International Boundary between New Brunswick, Canada and Maine, United States of America, Charlotte County extends north toward Fredericton and east toward Saint John. The St. Croix River serves as the lower part of the International Boundary and is designated as a Canadian Heritage River. Beyond the St Croix watershed, Charlotte County is also defined by the Magaguadavic and Digdeguash watersheds. St. Croix Island, in the St. Croix River, was the sight of settlements established by French explorers Samuel de Champlain and Sieur De Monts in 1604. With the help of the Passamaquoddy people, they were able to survive the winter. In 1784, the United Empire Loyalists arrived following the American War of Independence, joining the original settlers of the area (Town of St. Stephen 2010). Settlement throughout Charlotte County was encouraged by the government following the war to deter possible American expansion into the area (SGAHAM 2009).

Division of Counties in New Brunswick (Source: LCNB website).

Previously in New Brunswick, governed areas were distinguished using parishes and counties however; local governance in New Brunswick is undergoing a substantial change. The province is redefining the local governance system, implementing the use of Regional Service Commissions (RSCs). Currently, residents receive services either from a local government (city, town, village, or rural community) or the provincial government (Local Service Districts (LSDs)). Some services are delivered by municipalities or rural communities themselves, while others are acquired or arranged for from service providers, including commissions, local volunteers, other municipalities, the private sector, and in the case of RCMP services, from the federal government. The provincial government has recognized that this approach to service delivery is inefficient and does not capitalize on the collective strength of neighbouring communities.

RSCs have been established throughout New Brunswick to enable communities to communicate with one another, to plan and prioritize from a regional perspective, collaborate on projects, cost-share on service delivery, make mutually-beneficial decisions on investments, and share expertise. Twelve RSCs have been established throughout the province. Charlotte County, as well as a small part of York County, has been included in RSC 10.

3.1 St. Stephen

St. Stephen is located at the estuary of the St. Croix River and the coast of Passamaquoddy Bay, see Figure 19 below. It covers an area of approximately 13.45km^2. The Town of St. Stephen was officially incorporated in 1871. In 1973 the municipalities of Milltown and St. Stephen were amalgamated and designated as the Town of St. Stephen (Government of NB 2014). The St. Croix

River acts as the International Boundary, separating the towns of St. Stephen, New Brunswick and Calais, Maine. The two communities are connected at three international border crossings, Ferry Point International Bridge, the Milltown International Bridge, and the International Avenue Bridge (Town of St. Stephen 2010). St. Stephen is also home to Canada's oldest candy company, Ganong Bros. and has been deemed "Canada's Chocolate Town" (Town of St. Stephen 2010). The population of St. Stephen was approximately 4800 in 2011.

In St. Stephen, the working group members were made up of residents from St. Stephen and the surrounding area that had been significantly impacted by the heavy precipitation events of July 2013 and December 2010. The discussions focused more on disaster risk reduction than climate change adaptation planning. However, their contribution to the discussions throughout the meeting process were very helpful in identifying vulnerable areas and what next steps should be taken to increase the resilience of their community to the impacts of climate related hazards. The areas they identified as being most vulnerable to the climate hazards of flooding and sea-level rise are:

- The Bell subdivision, the Tan House Brook, and the Doodle Brook
- The areas adjacent to the St. Croix River, extending from the Milltown Dam to the Axe Factory, and inland three blocks
- The Billy Weston Brook through the residential and commercial areas to the Dennis Stream

The working group members were concerned with the scope of the Dillon Consulting Ltd. report. The report will address flood related issues in the Bell subdivision, and determine if there was a connection between residential flooding issues during the 2010 and 2013 flood events based on the 42 calls to the local EMO. However, during the working group meetings, it became evident that many impacted residences were not reported to the local EMO as residents felt that it was their personal responsibility to deal with flood impacts and that the local EMO did not have the capacity to respond. Also, the Dillon Consulting Ltd. report does not seek to address issues related to the Billy Weston Brook however, based on flood related impacts, the working group felt that priority should be given to a study of that waterway.

The working group indicated that the replacement of infrastructure is a long term priority for community members because many residences were impacted by storm water runoff and surcharging of the system including the impact associated with high tides and CSOs. Such localized infrastructure issues as well as vulnerability to flooding as a result of dam management up river involves multiple actors which requires the municipal council to consult with local residents and examine the multi-level and trans boundary governance aspects of their vulnerability. However, updating or replacement of infrastructure comes with large costs, and resources have not yet been identified. The working group felt as though there was a need for better access to information both before, during, and after flood events and that communication, in general, was lacking with respect to flood events.

3.2. St. Andrews

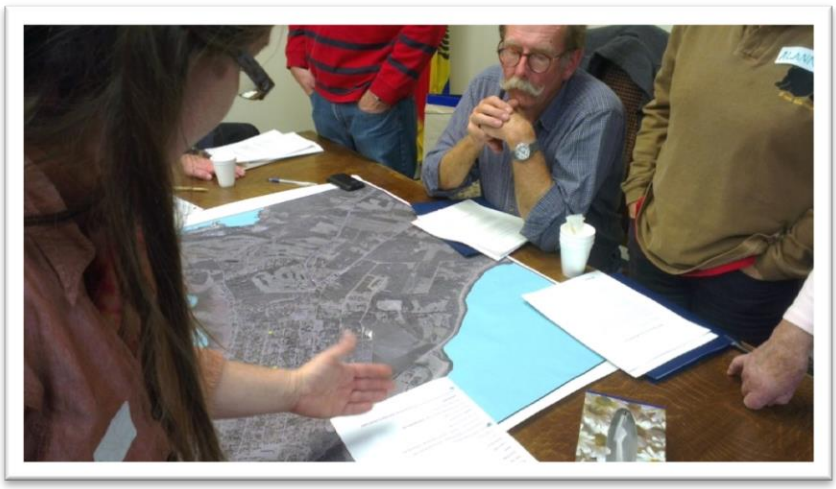
St. Andrews is located adjacent to the estuary, at the mouth of the St. Croix River on the tip of a peninsula that projects into Passamaquoddy Bay and includes Navy Island (Government of NB 2014). St. Andrews was founded by United Empire loyalists in 1783 and is well-preserved with many of the original buildings still standing. In 1998 St. Andrews was designated as a National Historic Site (Town of St. Andrews 2010, St. Andrews by-the-Sea 2014). The town was incorporated in 1903 and served as a seaport, port of entry, and the terminus of the Canadian Pacific Railway (Government of NB 2014). St. Andrews hosts three long-term operations that influence the local socioeconomic system. The St. Andrews Biological Station was permanently established in 1908. The biological station scientists have gained national and international recognition for their pioneering research and industry participation. The Huntsman Marine Science Centre (HMSC) was established by a consortium of 20 universities and several government departments in 1969. The HMSC was developed to become a 'cooperative venture in learning' and still thrives within the community. The Algonquin Hotel, currently with 233 guest rooms, was built in 1889, and has a long-standing history as a top coastal resort. Newer institutions such as a whale watching industry, Ministers Island as a tourist destination, and the Kingsbrae Garden, one of the top 10 horticultural attractions in Canada, are also important to the community. Statistics Canada reported a population of approximately 1,800 residents in 2011.

Municipal boundary of the Town of St. Andrews (Source left: Google Earth, right: GeoNB).

ST. ANDREWS STORM SURGE, FEBRUARY 2008 (SOURCE: FUNDY TIDE RUNNERS).

3.2.1 Meeting # 1 At Meeting # 1 in St. Andrews, the working group was first presented with a breakdown of the meetings, an explanation of the major terms, a brief description of climate change, the IPCC, and climate change scenarios. Following this, the working group members were asked to identify the climate hazards that they would like to discuss throughout the course of the meetings. In St. Andrews, the municipality was concurrently undertaking a storm water management strategy. With this in mind, the working group was asked to consider how storm water management and climate hazard resilience could be mutually addressed in their community. The Town of St. Andrews was also impacted by heavy precipitation events in November 2010, December 2010, and July 2013. Additionally, a storm surge event in February of 2008 was accompanied by approximately 150mm of rain in a four hour time period and caused localized flooding and coastal inundation, see Figure 34. The November 2010 event was accompanied by a large storm surge and had a severe impact on the community. The December 2010 and July 2013 events flooded basements, but roads were not impacted heavily. The working group members decided that the climate hazards they would like to address throughout the course of the community meetings would be *flooding*, *coastal erosion,* and *sea- level rise*. One of the main concerns from the survey was *damage to public infrastructure*.

The working group members were briefed on the storm water management plan by Mr. Tim Henderson, the Chief Administrative Officer (CAO) with the Town of St. Andrews. The company undertaking the storm water management plan, CBCL, will assess the condition of the existing infrastructure. The plan will assess the effect of extreme rainfall events including the 1 in 5 year, 1 in 20 year, and the 1 in 100 year rainfall events on sanitary and combined sewer overflows (CSOs), considering existing and future development within the town. The results will be used to establish



MEETING # 1 IN ST. ANDREWS (SOURCE: KRISTIE SIGNER).

extreme values for overflow volume and peak flows. The flows will be generated based on historical rainfall records and will be modified to reflect increasing rainfall intensities.

The working group was asked to identify areas that were physically impacted by recent storm events or those of concern into the future. They marked areas of physical and infrastructure impact with red sticker dots on the community map including information on the type and degree of impact. The table outlining the red dot number and description of the impact is located in Table A2.1 of the Appendix under St. Andrews in the red table. The areas marked on the community map were primarily impacts that occurred in the past. The mapping exercise revealed that impacts were mainly to the basement level of homes. Travel was dangerous but, within town events did not heavily impact road infrastructure. Major coastal erosion in 2010 was confined to the area of Indian Point in front of the Irish Cross memorial. Lesser erosion impacts were seen around the entire peninsula. Armour stone already in place was reinforced after the November 2010 event, and the market square seawall was impacted. The working group noted that many roads were undermined or topped with high ridges of sediment in the adjacent LSDs.

Meeting # 1 in St. Andrews (Source: Kristie Signer).

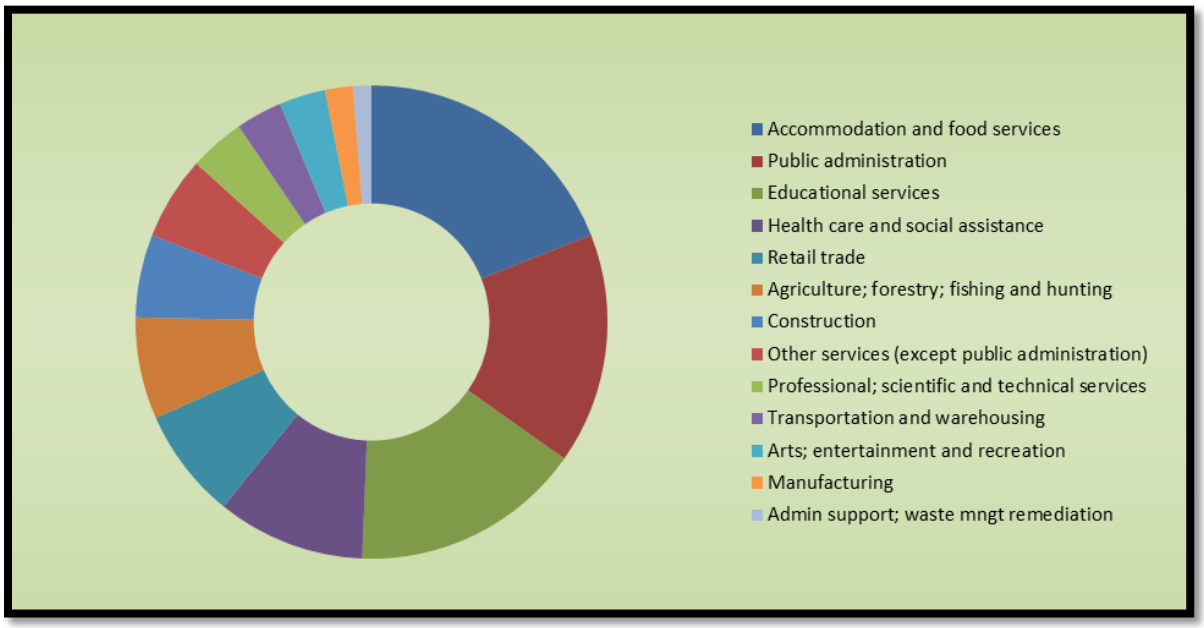
Other points that were raised by the working group in Meeting # 1:

- The February 2008 heavy precipitation event, 150mm in 4 hours, flooded basements and was a combination of sewage and storm water in some homes
- A rare and extreme flooding event of the Market Square was noted. This event took place on a completely calm day. The extreme levels were attributed to a nearby storm. Two working group members had witnessed the event but the date remains unconfirmed. It is thought that the event happened in the spring of 1998, but newspapers reported no such event at this time, or in the spring of 1999. It is possible this event was not reported.

St. Andrews resident, Frank Haughn, shows Councilor Lee Sochasky and Mayor Stan Choptiany historical photographs of St. Andrews (Source: Kristie Signer).

3.2.2 Meeting # 2

In Meeting # 2, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercise from Meeting # 1. Dr. MacLellan, a Senior Research Scientist and Project Leader for the New Brunswick Climate Change Research Collaborative, presented how climate change adaptation is defined in simple systems. Using examples from a climate change adaptation project he was involved with in Lake Simcoe, Ontario, Dr. MacLellan provided information on climate hazard impacts to infrastructure and socioeconomic considerations. He also provided statistical data from the 2011 Statistics Canada National Household Survey for New Brunswick and St. Andrews to guide discussion. Dr. MacLellan explained that community profiles, based on the census data, provided a snapshot of who lives in the community, their age, income, profession, and sector they work in and can help in deriving a broad idea of what climate hazard impacts may be important to the community. Based on the statistics and his analysis, Dr. MacLellan suggested that St. Andrews is a long established community with a high percentage of residents established for three generations or more. St. Andrews is a relatively stable community in terms of mobility. Based on the information presented, Dr. MacLellan commented that there is a mixed industry focus within the community, but that it is service dominated.



OCCUPATIONS BY SECTOR FOR ST. ANDREWS (SOURCE: DR. JAMES MACLELLAN).

There is an older population within the community with the highest home value in Charlotte County. St. Andrews had the oldest population for primary household maintainers with over 24% being 75 years of age or older, followed by 19.5% being 55 to 64 years of age, as seen in Figure 42 below. Additional information provided by Dr. MacLellan can be found in Figures A2.1 to A2.4 of the Appendix under St. Andrews.

Home Maint (age Group)	CANADA	ATLANTIC CAN	NEW BRUNSWICK	CHARLOTTE County	St Andrews T	St Stephen T
Under 25 years	3.4	3.5	3.6	2.9	9.4	4.4
25 to 34 years	14.4	12.4	12.7	9.9	4.7	10.9
35 to 44 years	17.9	16.6	16.7	16.8	11.8	17.4
45 to 54 years	22.7	22.0	21.8	21.4	18.8	20.5
55 to 64 years	19.2	21.0	20.9	21.5	19.4	20.0
65 to 74 years	12.2	13.7	13.4	13.6	12.4	9.1
75 years and over	10.2	10.9	11.0	13.8	24.1	17.9
Median value of dwellings ($)	280552	159687.5	139537	120010	190226	125051
Average value of dwellings ($)	345182	179376.5	153484	142713	209749	126580

COMPARATIVE TOTAL NUMBER OF PRIVATE HOUSEHOLDS BY AGE GROUP OF PRIMARY HOUSEHOLD MAINTAINERS AND DWELLING VALUE, BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).

Dr. MacLellan suggested the working group should try to think broadly about interconnections between values when examining social and economic impacts. He made the following points to help guide the mapping of socioeconomic impacts:

- Think about who is vulnerable and how might they be vulnerable
- Think about the history of socioeconomic impacts and the potential impacts into the future
- Local knowledge is a valid source of knowledge
- Analysis that describes economic damages are critical, but also include non-market factors

The community was then presented with two examples of community members, an elderly woman who lives on her own in a historical home and a young, single mother who lives in an apartment. These fictional community members were used as examples of residents that should be considered when discussing social and economic impacts during climate hazard events. The working group members were then asked to use blue sticker dots to identify areas on the community map where social and economic impacts have been felt or were of concern for the future. The table outlining the number and description of the impact is located in the Appendix under St. Andrews Meeting # 2 in the blue table.

Working group discussions indicated that many residences had basement flooding impacts and also that flood insurance is not available in New Brunswick. Sewer back-up insurance is sometimes an option on homeowner and business policies. However, within the population that does carry this coverage, it has been interpreted by them (and confirmed by a local insurance company) that claiming damage may lead to restrictions or recommendations by insurance policy-holders (need to install back-flow preventer, etc.), increases in premiums or cancellation of that coverage. It was pointed out that residents of the Quinn House, a nine unit low cost housing for senior citizens and residents of the Wabanaki apartments, which house students, are vulnerable populations. It was also observed that the only access roads for the Town are both impacted by gathering water and large areas of ice in winter, making travel dangerous. If these areas experience undermining, this will become a more critical issue, impacting movement of not only citizens in and out of the area, but emergency resources as well.

WORKING GROUP MEETING IN ST. ANDREWS (SOURCE: KIM REEDER).

The area's large elderly population was acknowledged and it was indicated that there is a large amount of community support for them in both normal and extreme circumstances. Despite the impact events in St. Andrews, it appeared, based on working group discussions, that the community was able to function as normal during the heavy precipitation and storm surge events and that the social and economic impacts were not as severe as elsewhere in Charlotte County. There was concern for the reputation of the town as a resort destination, if it were to be largely impacted by climate hazard events. Any irregularities in water quality would have a large impact on residents as well as impacting tourism as the town supplies water for many tourist accommodations including the Algonquin, a specific destination for many visitors. The town currently has a plan for importing water if circumstances require. Cyanobacteria in the water supply of Chamcook Lake first appeared in 2010. If changes in cyanobacteria ecology are linked to climate change, it may cause future issues in the town's water supply.

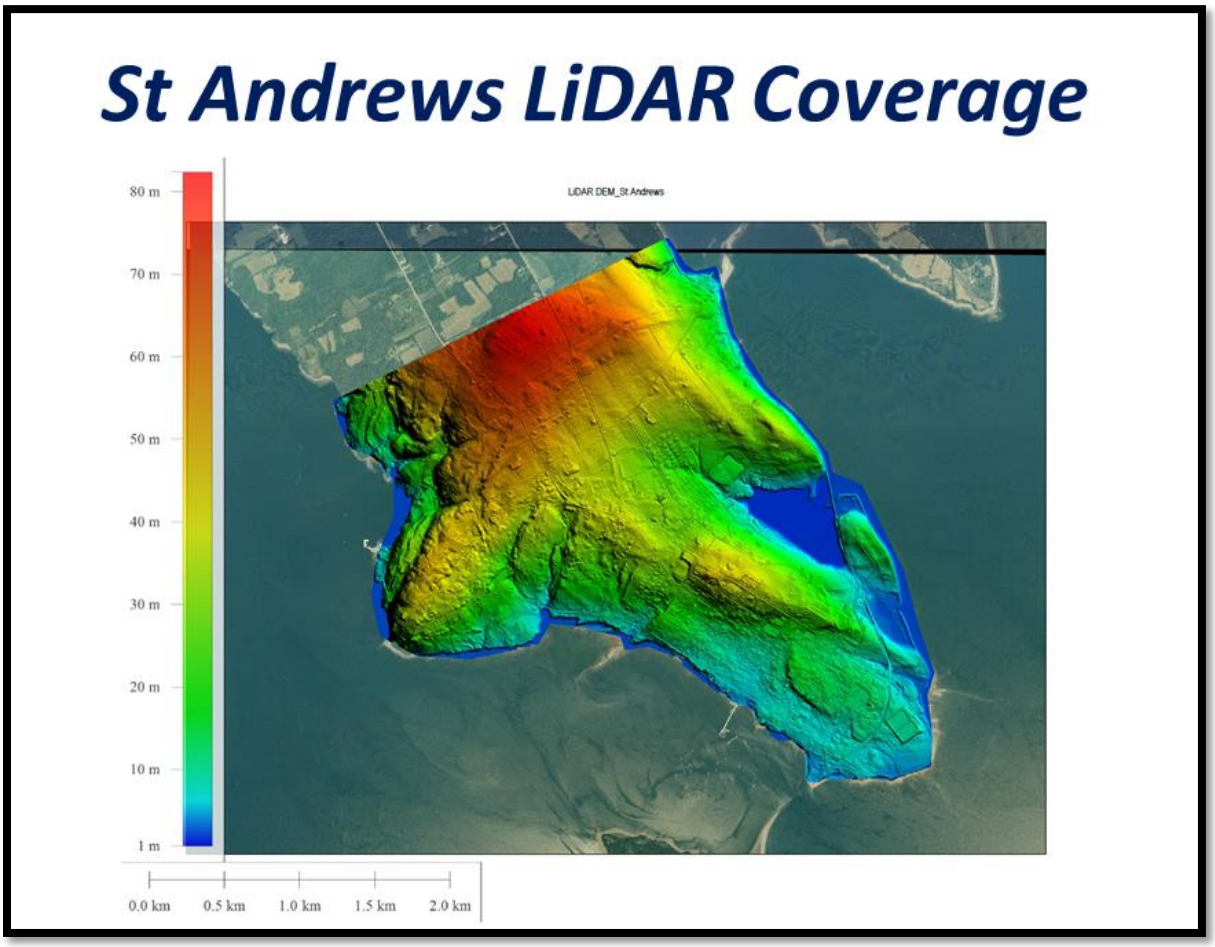
Other points that were raised by the working group in Meeting # 2:

- The time of the hazard events have not coincided with the tourist season and, as such, the impacts to the economic sector have been limited as many businesses close for the winter months. However, increased precipitation has impacted the use of the golf course, especially the driving range, and recreational field use has been impacted for the same reason

- The community has an elderly population and some live on a fixed income, however, the working group specified that a fixed income is not necessarily indicative of poverty
- Various areas that are being considered for development include Indian Point, the area of the Bar Road above Rose Lane, the recently approved seniors facility, and future options for Marine Science Drive and the golf course fairways

3.2.3 Meeting # 3

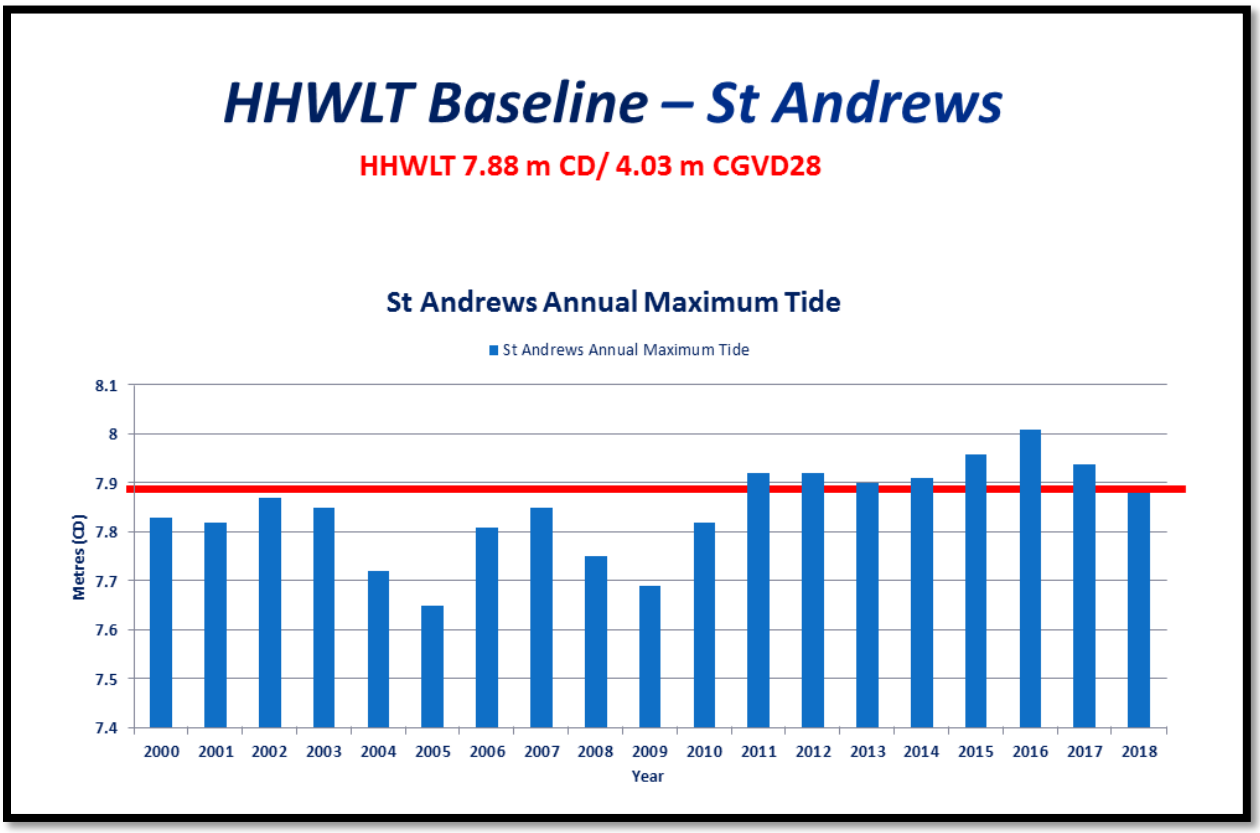
In Meeting # 3, the working group was asked to recall the climate hazards chosen and revisit the mapping exercises from the previous meetings. They were then presented with sea-level rise information by Réal Daigle, a New Brunswick based meteorologist and climate change consultant with R. J. Daigle Enviro. Mr. Daigle began by informing the working group about the most recent IPCC AR5 and the development and use of RCPs. He presented the LiDAR-based DEM for the St. Andrews area, as shown in Figure 40.



DEM for St. Andrews (Source: Daigle 2014).

Mr. Daigle used the DEM to make projections of sea-level rise into the future incorporating information from the IPCC, the extreme high tide value (HHWLT), crustal subsidence, and varying storm surge return periods. The HHWLT is determined using the average of each of the annual

maximum predicted tide values over a



19 YEAR TIDE CYCLE FOR ST. ANDREWS, THE RED LINE ILLUSTRATES THE AVERAGE VALUE OF THE HHWLT: 7.88M CD/ 4.03M CGVD28 (SOURCE: DAIGLE 2014).

19 year tidal cycle as shown in Figure above. A further explanation of how Mr. Daigle made his calculations can be found in the Methodology section.

Mr. Daigle developed extreme total sea-level flooding scenarios for St. Andrews. The value is given for the vertical height in meters from the CGVD28 baseline along with a margin of error for the estimates as shown in Table 4 below. Estimates of the anticipated changes in total sea-levels for the time frames of 2010, 2025, 2055, 2085, and 2100 are represented in Table 4 and are meant to represent the worst case flooding scenario resulting from the simultaneous occurrence of a significant storm surge event for the respective RPs and a high astronomical tide (HHWLT) at a given location. It should be noted from the next Table that with an estimated increase in sea-level of 0.88m by 2100, the present day 1 in 100 year flooding scenario (4.94m) becomes an annual event between 2055 and 2085.

Extreme total sea-level flooding scenarios for St. Andrews (Source: Daigle 2014).

St Andrews HHWLT 4.0 m (CGVD28)						
Return Period	**Surge Residual**	**Level 2010**	**Level 2025**	**Level 2055**	**Level 2085**	**Level 2100**
1-Year	0.47 ± 0.20	4.47 ± 0.20	4.60 ± 0.23	4.82 ± 0.31	5.15 ± 0.41	5.35 ± 0.49
2-Year	0.54 ± 0.20	4.54 ± 0.20	4.67 ± 0.23	4.89 ± 0.31	5.22 ± 0.41	5.42 ± 0.49
5-Year	0.64 ± 0.20	4.64 ± 0.20	4.77 ± 0.23	4.99 ± 0.31	5.32 ± 0.41	5.52 ± 0.49
10-Year	0.71 ± 0.20	4.71 ± 0.20	4.84 ± 0.23	5.08 ± 0.31	5.41 ± 0.41	5.61 ± 0.49
25-Year	0.80 ± 0.20	4.80 ± 0.20	4.93 ± 0.23	5.15 ± 0.31	5.48 ± 0.41	5.68 ± 0.49
50-Year	0.87 ± 0.20	4.87 ± 0.20	5.00 ± 0.23	5.22 ± 0.31	5.55 ± 0.41	5.75 ± 0.49
100-Year	0.94 ± 0.20	4.94 ± 0.20	5.07 ± 0.23	5.29 ± 0.31	5.62 ± 0.41	5.82 ± 0.49

The colour-coded lines on the map represented in the next are indicative of the extreme total sea-level flooding scenarios for a 1 in 100 year storm surge RP for the years 2010, 2025, 2055, 2085 and 2100 along the St. Andrews waterfront. There is an additional line representing the year 2100 flooding scenario with the uncertainty factor.

For the additional extreme total sea-level flooding scenario maps for St. Andrews (1 in 1 year, 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 25 year, and 1 in 50 year) produced by Mr. Daigle, please refer to the report memory stick.

St. Andrews extreme total sea-level flooding scenarios for a 1 in 100 year storm surge return period (Source: Daigle 2014).

After the presentation, the working group discussed the information as well as various governance and policy issues related to climate change adaptation. The discussion included how the LiDAR and resultant sea-level rise contours can help the CBCL consultants decide where to make changes to storm water infrastructure. The working group also indicated that the information presented could help the municipal council strengthen and change bylaws, or create new bylaws. The CBCL consultants and the town's new development officer will also be examining various bylaws. It was also mentioned that with respect to provincial governance, there are no bylaws in LSDs which have impacts on nearby municipalities. Although not specified, it was also discussed that there are gaps in provincial legislation which have allowed for development that was unsupported by the town. The community was aware of upcoming reforms to the Municipalities Act and Community Planning Act.

Discussion also focused on the 19 year tide cycle prediction and the new awareness that from the period of 2014-2017 annual maximum tide values will exceed the average value of the HHWLT over the 19 year cycle (which it has since 2011). By 2016 the annual maximum tide is predicted to reach an approximate 10 cm additional to the 2013 annual maximum tide value. This will be a concern for certain physical structures and infrastructure and may be of significant concern if the maximum annual tide coincides with a heavy precipitation or storm event. Due to this new understanding, suggestions were made regarding tracking weather specifically at the times of predicted maximum tides for the years 2014 – 2017. As well, it was pointed out that weather systems should be tracked when they coincide with high tide cycles in any year, because we must consider that in comparison with a 1+ metre surge, the additional 10 cm may not be the most critical factor.

This was the first meeting where recommendations for future action started to take form. Discussion focused on municipal strategies to reduce their vulnerability to climate hazard impacts, such as whether to focus on bylaws (regulation) or communication (awareness). It was identified that there may be areas within the municipality that have no short term adaptation solutions, such as low-lying areas that are prone to flooding which are already developed. The working group also discussed the issue of land considered "buildable" in a legal sense, but not "protectable" in an economic sense, and areas where temporary uses may be the only option, such as the Kiwanis Oceanfront Campground. A discussion of a time frame for planning climate change adaptation was mentioned, but no decisive recommendations were made.

Other points that were raised by the working group in Meeting # 3:

- In a 15 minute period one metre of land was lost near the Irish Cross during the storm surge event of November 5, 2010
- Communities that have a plan, and who have experienced climate-related impacts may be at the top of the list to receive funding support when it becomes available
- There is a heritage image to be maintained within the town and adaptation planning must consider this
- It may be worthwhile to review building codes for piers as there are currently no bylaws

3.2.4 Meeting # 4

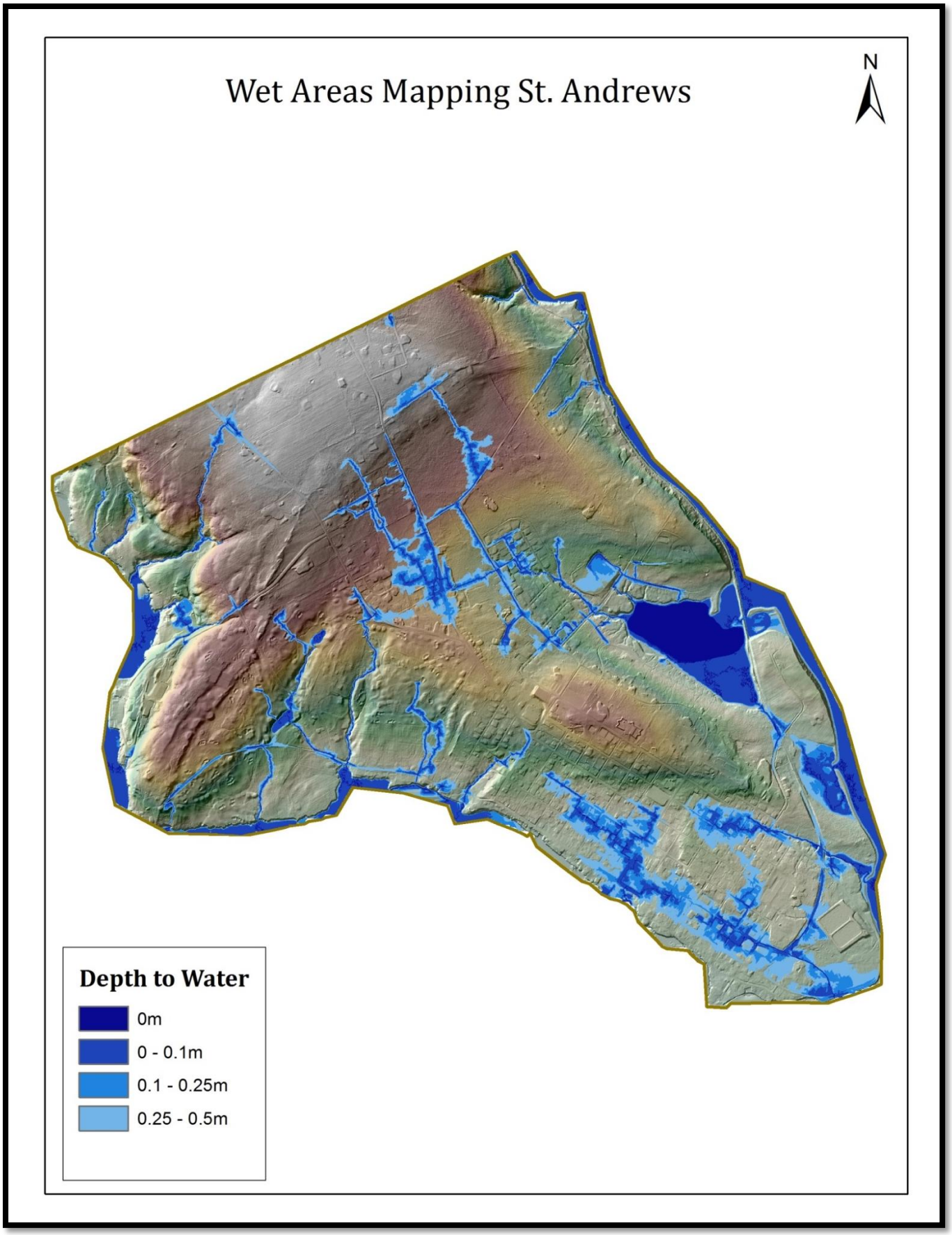
In Meeting # 4, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercises and discussions from previous meetings. This was done to verify the important points made in the discussions and for facilitators to gain context on some of the points previously raised. Recommendations for future climate change adaptation planning were further discussed and expanded to include a communications strategy; personal responsibilities and adaptations, such as the use of eavestrough, water barrels, rain gardens and tree planting; how to budget for long term adaptation to sea-level rise; and if, or to what level, municipalities will be held accountable (liable) for releasing information on the scenarios of climate change impacts in relation to land values or the designation/zoning of vulnerable areas.

Other points that were raised by the working group in Meeting # 4:

- Many bylaws are written without a penalty for non-compliance
- Community television channel is a means for disseminating information
- Future development should be limited in vulnerable areas

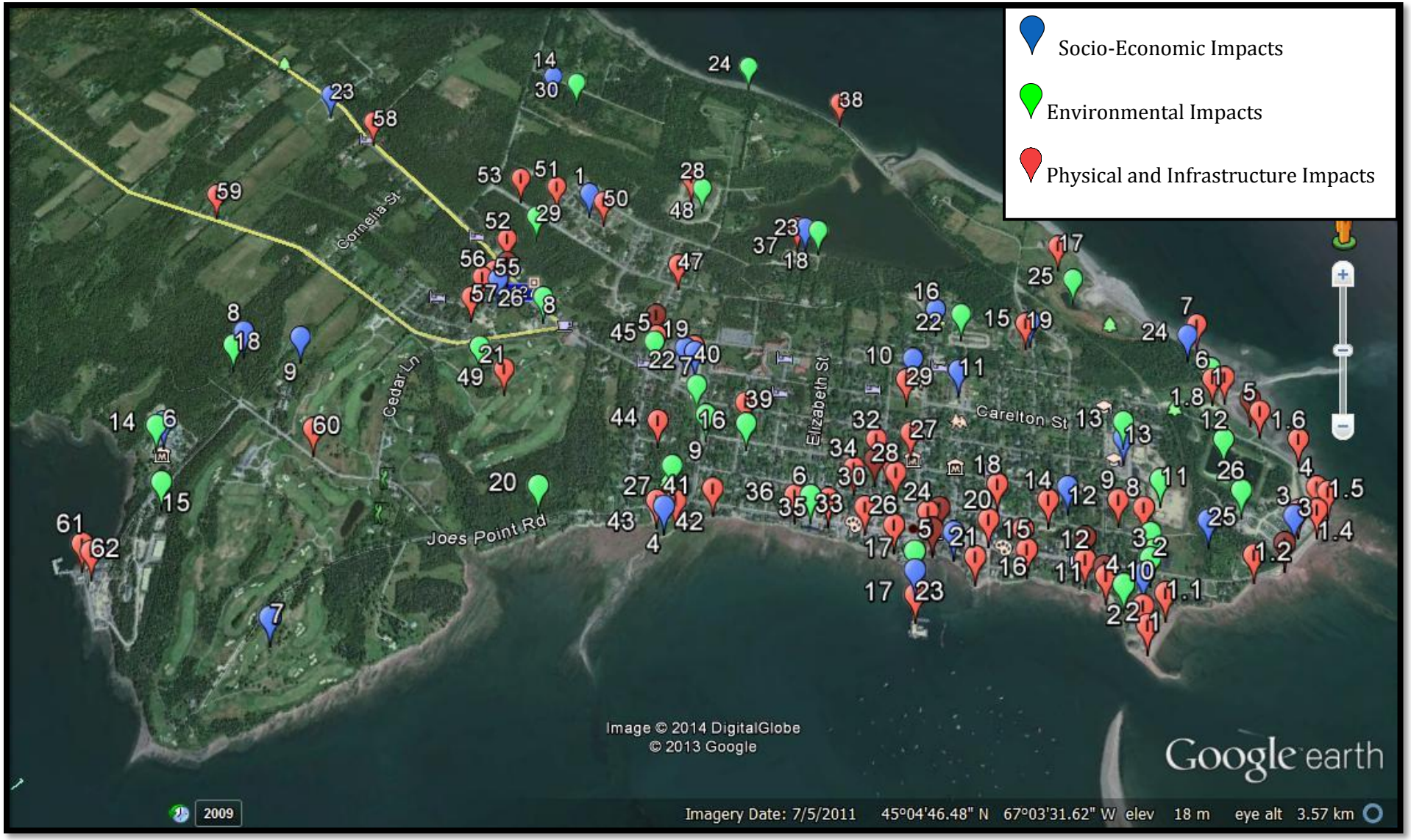
3.2.5 Meeting # 5

In Meeting # 5, the working group members were asked to recall the climate hazards chosen and revisit the mapping exercises and discussions from previous meetings. In Meeting # 5 the working group members were presented information on inland flooding. The inland flooding maps were prepared using the LiDAR data and were analyzed to exhibit the DTW using a specified flow rate initiation of 4ha, which represents the end of summer ground saturation. The WAM was prepared to help the working group understand unseen vulnerabilities related to water depth. The WAM is illustrated in Figure below. Using a projector and screen, the WAM was overlaid on the community map previously used to identify climate hazard impacts. This allowed the working group members to identify where the DTW could be responsible for more significant flooding in some areas. In consideration of the DTW map, the working group commented that the two roads in and out of the peninsula were very close to the water table. The WAM also brought to light possible options for new drainage flows.



WAM for the Town of St. Andrews (Source: ARP 2013).

The environmental impacts of the climate hazards were then discussed. Green sticker dots were placed on the community map representing past environmental impacts and those of concern in the future. A list of the numbered dots placed on the community map representing environmental impacts and their description can be found in Table A2.3 of the Appendix under St. Andrews in the green table. While mapping environmental impacts, the working group commented specifically on shoreline protection and public versus personal responsibility regarding seawall upkeep. Indian Point was a topic of major concern for the working group, as it acts as a natural buffer during storm events and is closely tied to the recreational identity of the community. The working group identified areas of possible ground contamination, such as old dump sites and gas stations. There were no specific impacts to wildlife defined however the working group was aware of two ongoing wildlife monitoring projects, the Greenlaw Mountain Hawk Watch and the Huntsman Marine Science Centre's Bird Banding Station. A digitized version of the community map has been created using Google Earth to indicate where all of the coloured dots were placed on the community map in St. Andrews as illustrated in Figure below.



DIGITIZED MAP OF THE COMMUNITY MAPPING EXERCISE FOR ST. ANDREWS (CREDIT: TANYA ANDERSON).

3.3 ST. GEORGE

The Town of St. George is located in the centre of Charlotte County, as shown in Figure 50 below. The Magaguadavic River and Valley runs north to south through the core of the parish and, following a series of rapids and waterfalls, reaches sea level at the Town of St. George (SGAHAM 2009). The town was established in 1784, incorporated in 1904, and served as a port of entry for the Shore Line Railway (Government of NB 2014). The town was also made famous by the red-granite quarries which operated from 1872 to 1953 (Town of St. George 2012). Today, the Town of St. George is the commercial, business and service centre of the eastern Charlotte Coastal Region, and processing of a large portion of the aquaculture salmon grown in the Bay of Fundy occurs in St. George (Charlotte Coastal Region 2008). Statistics Canada reported a population of approximately 1,500 residents in 2011.

The working group members in St. George had an excellent knowledge and understanding of their community and the impacts of the December 2010 flood event. They were focused on addressing issues related to their chosen climate hazards: flooding and the increase of storm events. As an increase in storm events was likely to increase the chances of reoccurring flooding within the community, the working group members focused their discussions on the December 2010 flood event. Their identification of the vulnerable areas of their community was inclusive of:

- The Canal
- Manor Road
- Riverview Avenue
- Woodbury's Cove
- Second Falls (wanted to include, but it was off of the map area)

The working group mentioned that there was a general lack of communication preceding and during hazard events and that there is a need for the development of a sound regional emergency plan which should be created in consultation with the participating communities. The working group also felt that communication of emergency information should be broadcast on St. Stephen and Saint John radio stations and that there is a need for better communication of road closures during hazard events and that the enforcement of these closures must be effective, such as the use of barriers. The working group was very concerned about the St. George Power hydroelectric dam in St. George. They felt that flooding issues could be directly attributed to dam procedures and a lack of communication. The working group indicated that the St. George hydroelectric dam could become more proactive in advance of storm events if the northeastern American weather models were incorporated into local models. The National Oceanic and Atmospheric Administration (NOAA) is the first to identify weather warnings in the region with Environment Canada following their lead. The working group believed that, by depending only on Environment Canada for weather information, the dam operators were not utilizing all the tools at their disposal to mitigate flooding. The working group also indicated that in July of 2011, St. George Power LP, owned by J. D. Irving, released the results of a study undertaken by Kleinschmidt Associates regarding the flood event of December, 2010. Kleinschmidt Associates had been hired directly following the flood event to "review the role of the dam at St. George in the flood event. The study focused on pre-storm

conditions, the magnitude of the storm, and five key scenarios to address questions in the community about the impact that operations at St. George Power LP would have had during the course of the event" (J. D. Irving no date). The working group expressed concern over the validity of the conclusions made by the study and felt it was not conducted by an independent party.

3.4 Blacks Harbour

Blacks Harbour is located on the shores of the Bay of Fundy, as shown in Figure 65 below, and boasts a strong fishing industry based, almost exclusively, on herring in addition to multiple aquaculture sites for the production of Atlantic salmon (Village of Blacks Harbour ND). Two companies play a major role in the community, Connors Bros. and Cooke Aquaculture. Each has a longstanding relationship in the village. Blacks Harbour is a small, rural community of about 982 residents based on the Statistics Canada 2011 report, and serves as the only ferry point to the island of Grand Manan. Blacks Harbour was incorporated in 1972 (Government of NB 2014).

The working group members were well dispersed throughout the Blacks Harbour area and had a wide-ranging knowledge and understanding of their community. The impacts of ocean acidification and warming, and access to safe drinking water had not been an issue of major concern for the community to date, discussions were focused on future impacts and what policy and governance issues exist. The mapping exercises provided the opportunity to highlight areas where important infrastructure is located, and where social and economic systems function. It was noted by the working group that there is a need to gain a better understanding of the aquifer which provides drinking water to the communities of Pennfield, Beaver Harbour and Blacks Harbour and that further information is needed to determine if the aquifer is at risk due to climate change and the associated impacts. Control of the aquifer, the water lines, and water treatment by Connors Bros. and matters related to that relationship were also discussed. It was established within the meetings that there is deferential communication between the village and Connors Bros. with respect to drinking water related issues.

The economic base of the community is founded, almost entirely, on the fishing industry, and, as such, ocean acidification and warming was of great concern to the working group members into the future. Issues related to shell formation and migration of harvested species due to warming ocean temperatures were discussed and how the greater fisheries might be impacted if any one species is threatened. As the harvesting and manufacturing/processing of marine species has been long established as the main source of economic income for the community, economic diversification for the community was discussed because of the potential impact of a changing ocean environment. Additionally, the vulnerability of the agriculture industry in the local area, namely blueberries and cranberries, was discussed and how it might be affected by climate change into the future.

Although impacts from the recent storm events had greatly affected other communities throughout Charlotte County, impacts in Blacks Harbour had been relatively minor in comparison. Even so, emergency measures were discussed by the working group members and there was a level of uncertainty regarding specific measures and shelter locations. In the December 2013, an ice storm had a significant impact on the community and comments have since been made publicly by residents and local government about the lack of preparedness and emergency response.

3.5 Grand Manan

The island of Grand Manan is the largest of the islands in the Bay of Fundy, located 32 kilometers south of Blacks Harbour, see Figure 76 (Government of NB 2014). The main industry of the village has always been fisheries, and more recently, the lobster industry has flourished. The tourism industry also continues to grow on Grand Manan as whale watching, sea kayaking, and bird watching have made this area favourable to domestic and international tourists alike. Additionally, Seal Cove has been designated as a National Historic Site of Canada, as it remains comparatively unchanged since the 19th century. In 1995, the village was incorporated when five small settlements on the island were amalgamated into what is now known as the Village of Grand Manan, a single municipality (Village of Grand Manan 2004). Statistics Canada reported that the population of Grand Manan was just over 2,300 in 2011 based on the National Household Survey.

Even though the working group on Grand Manan was smaller than the other working groups in the county, it was made up of very knowledgeable community residents including the Program Coordinator for the Grand Manan Fisherman's Association who is also a counselor for the Village of Grand Manan, the executive director of the Grand Manan Whale & Seabird Research Station, as well as another municipal councilor who is also a tourism accommodation owner. The working group was very focused on the social and economic systems of the island and how they have the potential to be impacted by the climate hazards chosen: warming ocean temperatures, the loss of species and the arrival of invasive species. Based on the information presented, in addition to their personal knowledge of the island, the working group members identified that the most vulnerable areas of island include:

- Woodwards Cove
- Whale Cove
- All of the wharves, particularly at North Head East

Comments were made on the decline of the right whale population, which can be attributed, in part, to a decrease in plankton, that the herring population has significantly decreased and that ground fish species are also in decline, with almost no halibut catch over the last few years. An increase in the grey seal population from the north, which eat a lot of cod, other ground fish species, and lobster was seen as a potential threat. Spruce and larch beetles have increased in numbers throughout the island and the spread of Lyme disease has become a major issue of concern.

The working group commented that there is a delicate balance of species which allows for their fishing industry to thrive. As conditions change, they are concerned for the wellbeing of the primary industry as it has been a way of life on the island for centuries. Discussions on economic diversification were directly related to species harvesting diversification which must be passed through the DFO Species Advisory Board, located in Dartmouth, Nova Scotia.

4. CONCLUSIONS FOR CHARLOTTE COUNTY

Charlotte County, New Brunswick has experienced significant climate hazard impacts in recent years, from inland flooding to coastal erosion, shoreline inundation, and changing ocean dynamics. As climate change and variability impacts continue, adaptation is required to increase the ability of the local communities to cope with and reduce the impact of future events. The working groups in each of the participating Charlotte County communities acknowledged that climate hazard impacts have become more frequent and severe, and that appropriate long term planning is necessary for increasing resiliency in the region. The working groups indicated that localized climate hazard and disaster risk reduction information was not adequately accessible, but that the CCCVA process is the first step in advocating for this information to be developed and shared.

In communities that have experienced severe climate related impacts, recommendations for future action prioritized short term disaster risk reduction strategies, while those currently spared devastating impacts, focused on long term adaptation. It is evident that while collaboration between communities will be necessary, the municipalities will require regional, provincial and federal support to move forward with enacting planning measures, as vulnerability and adaptive capacity are unevenly distributed both geographically and socially throughout the region. The participating communities of this project have both similarities and differences regarding infrastructure conditions, socio-economic systems, and environmental surroundings, which result in varying climate hazard impacts. Each community has made recommendations unique to their area; however some recommendations can be applied regionally.

In rural New Brunswick, access to resources is needed both for planning as well as for productive response to imminent situations. With reference to planning, rural communities are not alone, for instance; as reported in the Gulf Of Maine Climate Network's recent report, *Municipal Climate Change Adaptation around the Bay of Fundy: Status and Needs March 2014,* in over 30 Canadian municipalities around the Gulf of Maine, it is a

> "…combination of factors—limited staff time and expertise, stretched budgets, and lack of jurisdictional authority—make it difficult for municipalities to address even well-documented vulnerabilities to climate change. There is strong interest in more ecosystem-based approaches to adaptation, particularly green/living shorelines and sustainable stormwater management techniques, and some municipalities are actively pursuing the latter. In terms of the coastal zone, which falls outside their jurisdiction, municipalities seek both education and active management support from provincial government."
>
> "Among the 33 Bay of Fundy communities that participated in the GOMC Climate Network survey, 79 percent of respondents cited inadequate funds and 73 percent cited lack of staff time as constraints limiting progress in climate change adaptation. That finding echoed the results of a 2010 study of New Brunswick municipalities conducted by Mount Allison University's Small and Rural Town Programme, entitled *Capacity for Climate Change Adaptation in New Brunswick Municipalities.* According to report authors Stephanie Merrill and Gwen Zwicker:

> *Almost half of municipalities felt that their municipalities could commit staff time to work on adaptation planning and staff time to implement adaptation plans, strategies and activities. Fewer were willing to commit funds for planning or implementation and some were unwilling to commit any resources at all. It is unclear, however, if municipalities are actually "unwilling" to commit, or perhaps more likely, "unable" to commit resources (p. 21)."*

More locally, adaptation planning barriers also include issues such as; the RSC 10 responsible for regional land use planning does not currently have GIS or staff trained to use it, let alone the necessary layers which could contribute to efficient and responsible regional land use policy planning. As well, most government stakeholder meetings and climate-related conferences are held in the province's major centres as are informative presentations such as academic lectures. This issue of insufficient resources often coincides with the choice of rural life. However, our communities need to overcome the lack of exposure to these opportunities in order to increase knowledge and start to take on the challenges that lay ahead with respect to climate impacts and adaptation.

Regarding access to resources for productive response to imminent situations, all working group participants agreed that the development of a regional emergency measures plan would increase resiliency. Climate hazard impacts are becoming more frequent and this plan is needed to address how these events are managed, ensuring that all existing capacity is utilized. Capitalizing on existing capacity is the most cost-efficient measure to effectively reduce vulnerability. Currently, municipal EMO planning and jurisdiction extends only as far as municipal boundaries. The most severe climate hazards in Charlotte County are watershed based, and disaster events have affected equally the municipalities and the adjacent communities. It was clear during vulnerability assessments that residents consider their communities to extend beyond the established municipal boundaries to encompass surrounding areas, and that EMO operations must transcended the established municipal jurisdictions.

Access to resources such as informative radio broadcasts including up-to-date road closure reports, stockpiles of generators and kerosene are limited in the rural communities of Charlotte County. As well, as discovered during the extreme winter precipitation events of December 2013, rural communities may be prioritized lower than urban centres in reference to telecommunications and power failure recovery during widespread events. However, a streamlined regional all hazards emergency plan would allow the communities to effectively utilize all of the available resources during an emergency event and enact standard operating procedure to facilitate communication. The regional Emergency Measures Organization (EMO) coordinator for Charlotte County commented following the December 2013 ice storm that direct communication, such as by email, phone and radio was the biggest challenge for getting information out to the public and first responders during the event. It was suggested that regional resources be created online and with physical media that address mitigation efforts, how to prepare for forecasted hazard events, and how to respond to a climate hazard crisis. This resource would also become a crucial link in EMO preparation ensuring up to date information is accessible to all involved in planning as well as relief efforts.

The development of a regional all-hazards plan was the strongest recommendation shared by all working groups, however, the severe hazards and associated emergencies that have already occurred in Charlotte County must be addressed in the planning process, ensuring that those impacts with a high likelihood to reoccur are thoroughly planned for.

St Stephen and St George, communities that experienced these recurring and severe climate related impacts, were eager to address locations where impacts have occurred in the past. Suggestions for hydrologic studies were put forward where communities experienced significant inland flooding from rivers and streams. It was suggested that a better hydrological understanding of these areas would allow building and infrastructure issues to be addressed in planning for those areas. The province is currently working on building a Flood Risk Reduction Strategy, understanding that that proactive management of flood risk yields long-term benefits that far exceed their costs. The Department of Environment and Local Government, in consultation with an inter-departmental working group, has been leading the development of the flood risk reduction strategy that aims to address both inland and coastal flooding in New Brunswick. The working group met several times during 2013 and has conducted extensive background research, resulting in the development of a set of goals, objectives, potential actions and desired outcomes that collectively represent a draft outline of a comprehensive flood risk reduction strategy.

In communities such as St Andrews, Blacks Harbour and Grand Manan, where climate related hazards had not posed a significant threat in the past, but were of concern into the future; working groups indicated that safeguarding their social and economic assets was of most importance.

In the Blacks Harbour and Grand Manan communities, where impacts could pose a risk to crucial industry, economic diversification studies were recommended.

A bylaw review for climate change adaptation in all jurisdictions is recommended. During the CCCVA, valuable downscaled climate change impact scenarios were produced. The information presented should be considered by municipalities to ensure their bylaws reflect proactive planning addressing the current projections for changes within their communities.

Finally, there were recommendations made that could be instituted at low cost, almost immediately including; tracking weather forecasts leading up to high tide cycles in any year, because consideration must be given to the fact that with the potential of a 1+ metre surge, this tracking would enable maintenance of catch basins and pumps as well as allow for issuing community warnings if necessary. Another suggestion was for communities to share knowledge by preparing and producing a visual communication tool at the local wharf to indicate various tide and surge levels - past, current and expected. As well, it was proposed that communities should instigate and participate in discussion forums within the RSC as well as the NB Union of Municipalities focusing on municipal adaptation.

5. Moving Forward with Climate Change Adaptation in Charlotte County

Each of the participating communities in this project made recommendations to reduce the impact of climate related hazards in their respective municipalities. Developing a climate change adaptation strategy is a multi-step process, and participants understood that this community level advisory project was only the beginning of an ongoing effort to reduce the vulnerability of their communities to projected climate impacts. Further analysis of the recommendations suggested by the working groups is necessary in consultation with the identified groups responsible for implementation to ensure that they can be adequately incorporated into long term strategic community planning. Project facilitators aim to share the results of the vulnerability assessments and work with all parties to identify which vulnerabilities pose the greatest risk, which adaptation goals are priorities, the adaptive actions that best meet those goals, and the financial capacity to complete those actions.

Simultaneously, a regional engagement and communications strategy must be developed to ensure that an appropriate mechanism is in place through which all findings can be shared with the residents of coastal southwestern New Brunswick. As importantly, continued interaction with community members, as well as the development of a regional climate impact database would be valuable as "residents have knowledge of changing weather and climate patterns that can be integrated with observations made by climatologists to better understand the changing climate of a community (Vodden 2012)".

To assist with the facilitation of next steps, it is recommended that a GIS resource be created featuring the results of the CCCVA. In addition, the resource should also contain economic analysis of the vulnerable physical sites, including ecosystem function and socio-economic systems, as well as a downscaling of oceanic impacts relative to the Outer Bay of Fundy. This tool will facilitate further communication with communities, industry, academia, and government, which must take place to define the feasibility and timeline for adaptation options. The creation of the GIS resource will also ensure the long term usability of the data collected during the CCCVA, and assist with the monitoring of implemented adaptive actions. Monitoring and evaluation of climate change adaptation initiatives is essential in order to ensure that they are effective and are, in fact, increasing the resiliency of the communities to the impacts of climate related hazards and long term climate impacts.

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APPENDIX - ST. ANDREWS

LIST OF PHYSICAL AND INFRASTRUCTURE IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR ST. ANDREWS.

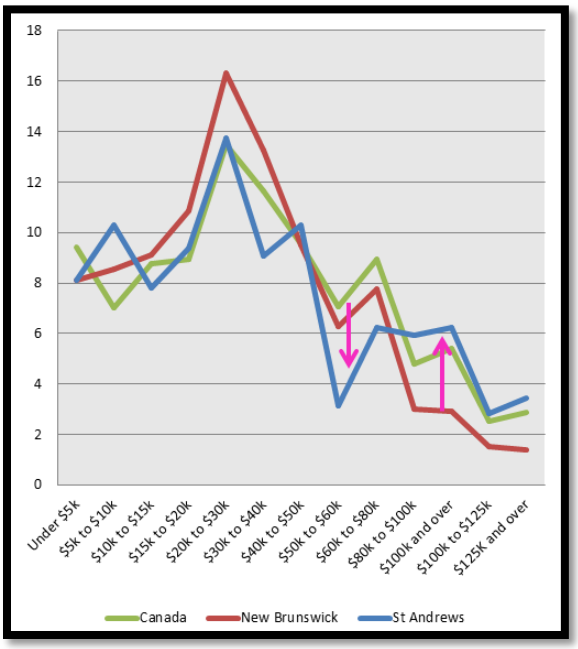
Dot Number	Explanation of Physical and Infrastructure Impact
1 (1-1.8)	Armour stone that has been replaced along the coastline
2	Patrick Street – significant flooding; concern for sea-level rise
3	Ocean View Campground; flooding in 2010 and 2013, low area, seaweed in Kiwanis Campground
4	Passamaquoddy Park flooding
5	Pagan Point flooding and erosion
6	Pagan Point flooding and erosion
7	Current erosion
8	End of Queen Street; significant flooding
9	Lower area; evacuation from homes
10	At the foot of Augustus – manhole discharge; concern for sea-level rise
11	Beach erosion
12	Concern for sea-level rise
13	Water Street; flooding in the past
14	Queen Street; flooding and sewer back up
15	Coastal erosion
16	Water Street; flooding in the past
17	Flooding concern into the future
18	Queen Street; flooding and sewer back up
19	Passamaquoddy Lodge, seniors residence; has generator
20	Water Street; flooding in the past
21	Concern for sea-level rise
22	Storm surge
23	Wharf and breakwater
24	Water Street; flooding in the past
25	Water Street; flooding in the past
26	Concern for sea-level rise

27	Ross Museum; flooding in basement
28	Queen Street; flooding and sewer back up
29	High School field
30	United Church; flooding in 2010 and 2013, low area, storm water issues
31	Sewage in basement
32	Flooded basement
33	Water Street; flooding in the past
34	Queen Street; flooding and sewer back up
35	Water Street; flooding in the past
36	Water Street; flooding in the past
37	Sand continually needs replacing at Katy's Cove; possible water contamination
38	Coastal erosion
39	Ditch erosion
40	Arena; emergency centre
41	Green space, Block house; coastal erosion, armour stone has been replaced
42	Green space, Block house; coastal erosion, armour stone has been replaced
43	Green space, Block house; coastal erosion, armour stone has been replaced
44	Basement flooding, fixed by going on septic field – disconnected from town
45	Fire Hall
46	Ambulance
47	Basement and yard flood
48	Recreation area closed for use
49	Golf course closed often
50	Flooding in cluster of homes and streets
51	Subdivision floods out, but ditching in place now (basements, roads) along Diana Drive
52	Blue Moon Hotel; big puddle
53	Champlain Avenue
54	Thomas Avenue; one incident of flooding, storm water mitigation has been done, flooding on street of more concern than basements after mitigation
55	Thomas Avenue; one incident of flooding, storm water mitigation has been done, flooding on street of more concern than basements after mitigation
56	Thomas Avenue; road flooding, storm water mitigation has been done, flooding on street of more concern than basements after mitigation
57	Thomas Avenue; storm water mitigation has been done, flooding on street of more concern than basements after mitigation
58	Bar Road/Highway; washout – Tara Manor
59	Water over main road in front of 686 Bayview Drive
60	If road were opened, possibility of getting to emergency centre at Biological Station
61	New building/Wet lab – DFO building sea-level rise and run off concern
62	Biological Station – emergency centre

LIST OF SOCIAL AND ECONOMIC IMPACTS AND THEIR EXPLANATION FROM THE COMMUNITY MAPPING EXERCISE FOR ST. ANDREWS.

Dot Number	Explanation of Social and Economic Impact
1	Younger families with children
2	Patrick Street; damage from November 5, 2010 storm surge
3	Kiwanis Campground
4	Block House; armour stone rocks washed out, took two years to get the funding for replacement, issues with Red Tide
5	New armour stone only cost approximately $45-50,000, about one tenth of normal cost, had government funding
6	Huntsman Marine Science Centre is a huge economic driver
7	Golf course; large economic driver, potential for development, driving range has been closed this summer (2013) as it has been very wet
8	Development potential, however, no storm water management
9	Development potential, however, no storm water management
10	Thomas Avenue, (basement flooding), legal suits, incurred personal costs,
11	Elementary school, on high ground, system in place to alert parents of kids being sent home
12	Queen Street, Quinn House and Quoddy Breeze – all seniors housing - food is often delivered, even outside of storm events
13	Community College; on storm days, students may not be able to get to class, school may be closed, students come from all over Charlotte County
14	Rose Lane area, Hansen Development; there was a stormwater management plan, CBCL reviewed it, outcome – new stormwater plan approved and in place
15	Passamaquoddy Lodge, Meals on Wheels
16	Kingsbrae Garden; large amount of visitors seasonally
17	The Wharf; may need to replace wharf with sea level rise
18	Katy's Cove; important tourist and recreational area, impacts to water quality
19	Call centre; many employees may have difficulty getting to work due to access during flooding
20	Chamcook Lake – town water supply
21	ASF – Atlantic Salmon Federation
22	W. C O'Neill Arena, hockey, curling recreation, theatre
23	Water tower; water restrictions in 2010 when Chamcook Lake dropped by four feet, cyanobacteria appeared

AGE CLASS DISTRIBUTION OF ST. ANDREWS BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY (SOURCE: DR. JAMES MACLELLAN).



INCOME DISTRIBUTION EXPRESSED AS A PERCENTAGE FOR ST. ANDREWS BASED ON THE STATISTICS CANADA 2011 NATIONAL HOUSEHOLD SURVEY OF THE 2010 TAXATION YEAR (SOURCE: DR. JAMES MACLELLAN).

	National	Atlantic	New Brunswick	Charlotte C	St Andrews T
Population	32852325	2286655	735835	26080	1800
Household Generations: 1st Gen.	22.0%	4.9%	4.5%	8.6%	14.4%
Household Generations: 2nd Gen.	17.4%	5.6%	5.9%	7.5%	6.4%
Household Generations: 3rd Gen >=	60.7%	89.5%	89.6%	83.9%	79.2%
Household Mobility (1 Yr): Non-movers	91.8%	92.9%	92.9%	94.9%	84.2%
Household Mobility (1 Yr): Movers	13.0%	11.3%	11.3%	9.5%	19.4%
Household Mobility (5 Yr): Non-movers	61.4%	67.9%	67.2%	72.4%	60.4%
Household Mobility (5 Yr): Movers	38.6%	32.1%	32.8%	27.5%	39.9%

Household mobility and generations for St. Andrews based on the Statistics Canada 2011 National Household Survey (Source: Dr. James MacLellan).

OCCUPATIONS	NATIONAL	ATLANTIC	New Brunswick	Charlotte County	St Andrews T
Sales and service occupations	23.1	23.9	24.3	18.6	23.8
Business; finance and administration	16.5	14.3	14.3	10.5	10.6
Trades; transport & equipment operators; related	14.4	16.1	16.6	19.2	14.4
Education; law & social; community & gov't services	11.7	12.8	12.5	10.0	14.4
Management	11.2	9.4	9.2	9.9	17.5
Natural and applied sciences and related	7.0	5.9	5.5	4.2	7.5
Health occupations	6.3	7.2	7.4	6.6	6.9
Occupations in manufacturing and utilities	4.6	4.3	4.8	11.8	0.0
Art; culture; recreation and sport	2.9	2.0	1.9	1.1	1.9
Natural resources; agriculture & related prod.	2.3	4.2	3.5	8.1	1.9

Occupation percentage by type for St. Andrews based on the Statistics Canada 2011 National Household Survey (Source: Dr. James MacLellan).

Prepared by R.J. Daigle Enviro using Leading Edge Geomatics LiDAR (Dec 2011) and NB Orthophoto (1996). LiDAR Vertical Accuracy tested at 11 cm

St. Andrews West extreme total sea-level flooding scenarios for a 1 in 100 year storm surge return period (Source: Daigle 2014).

Prepared by R.J. Daigle Enviro using Leading Edge Geomatics LiDAR (Dec 2011) and NB Orthophoto (1996). LiDAR Vertical Accuracy tested at 11 cm

St. Andrews East extreme total sea-level flooding scenarios for a 1 in 100 year storm surge return period Extreme (Source: Daigle 2014).

Dot Number	Explanation of Environmental Impact
1	Old dump leaches at the Point
2	Across the street from Armstrong's garage, oil storage, homes built there, at Patrick and Water Street
3	Patrick street to the lighthouse, used to be the Haughn garage, homes built there
4	Lobster plant burnt/in-filled industrial site
5	Fire Station
6	There used to be a gas station where the parking lot of the Motor Inn is now
7	Gas station, now cleaned up
8	Old gas station at the Tim Horton's site, has been cleaned up
9	Current gas station on Harriet Street
10	Armstrong's service station
11	Town garage
12	Old and current lagoon
13	NBCC; college uses diesel, has a mechanic shop
14	Huntsman Marine Centre; chemical dumping (appropriate protocols)
15	Biological Station, chemical dumping (appropriate protocols)
16	Past location of dry cleaners
17	Wharf/vessels
18	Song bird monitoring
19	Greenlaw Mountain Hawk Migration Watch (monitoring)
20	Sunbury Shores Two Meadows Nature Trail; could be considered a buffer
21	Golf course
22	Kingsbrae Gardens
23	Katy's Cove
24	End of cemetery road; armoured stone is holding back erosion
25	Salt marsh
26	Campground, town owned land
27	Centennial Park
28	Wetland area by Mallory Field
29	New area of development; has a developed stormwater plan
30	Between the new subdivision and Rose Lane; approved area of development, six lots and has a developed storm water plan