International Joint Commission

Health Professionals Task Force

Transboundary Water Quality and Human Health Issues in an International Watershed Context: The St. Croix Watershed

June 2011

Acknowledgements

In preparing this report the author, Jacqueline A. Oblak, worked under the direction and guidance of the International Joint Commission's Health Professionals Task Force. Members of the Task Force reviewed and edited report drafts and developed four recommendations to the International St. Croix River Watershed Board.

The author would like to thank Lee Sochasky of the St. Croix International Waterway Commission for her contribution to this report. Ms. Sochasky has been very involved in a number of projects in the St. Croix watershed both in a professional capacity and as a volunteer. Her understanding of the watershed and her willingness to share that knowledge is a valuable asset.

The author is grateful to the following individuals who also contributed their time and knowledge:

Frank Carroll
Mayor, Village of McAdam, New Brunswick

Stephen Drost
New Brunswick Department of Environment
Municipal Wastewater Biologist

Darren McCabe
New Brunswick Emergency Management Organization

Dr. Pierre Mineau
Environment Canada
Head
Ecosystem Health Research

Darryl Pupek
New Brunswick Department of Environment
Director
Environmental Evaluation and Reporting

Vic Serveiss
IJC Environmental Advisor

Douglas Walker
New Brunswick Department of Health
Regional Director - Health Protection Branch
South Region

Transboundary Water Quality and Human Health Issues in an International Watershed Context: The St. Croix Watershed

Table of Contents

List of Figures

List of Tables

1 Background

1.1 Report Scope and Objective

This report provides a broad look at the boundary waters of St. Croix River Basin, identifying potential water quality issues and demonstrating how watershed management and health management issues are interrelated. It provides background information on existing and emerging water issues which have an associated human health component and provides information on agencies in both the United States and Canada which are involved in or are responsible for legislation, collection and analysis of information related to health and water issues, and implementation of water quality and quantity protection measures in the region.

The objective of this report is to assist the International St. Croix Watershed Board by supporting the development of a common understanding of the linkages between ecosystem and human health in their watershed. Additionally, the information collected should spurn on new relationships among local health professionals (health, scientist, policy-makers) to share information and thereby provide for a more informed decision making process to resolving water quality issues in a shared international watershed.

The report takes a watershed approach to identifying water and health related issues in boundary waters, identifying both direct and indirect effects on human health. It first provides some basic geographical information on the St. Croix River and the surrounding area which makes up the watershed. The second section outlines some general water quality and quantity issues, provides a brief overview of each, identifies how each relates to health and then provides available local examples and other information. In the third section some observed information gaps are listed with suggestions for next steps in addressing these gaps as well as suggesting other initiatives. The fourth section presents background information on key government agencies which deal with water and health issues in some fashion. The final appendix provides specific contact information on the multitude of players in the field on both sides of the border.

1.2 Geographical Description

Watershed characteristics play a large role in water availability and water quality. Climate, soil and rock types, whether the terrain is flat or hilly, and organisms on land and in the water all have a role. Whether considering physical geographic characteristics or human uses and impacts on the landscape and water an understanding of the part these factors play and how the watershed as a whole functions is important in identifying potential issues and risks to human health in the watershed.

1.2.1 Physical Characteristics

The St. Croix River is a natural international boundary for 185 km (115 miles) between the U. S. State of Maine (ME) on the western shore and the Canadian Province of New Brunswick (NB) to the east.

The St. Croix River watershed covers an area of approximately 1,630 square miles (4,230 km^2). It is the seventh largest river basin in Maine and the fourth largest in New Brunswick (IJC 2011). It borders on the St. John River watershed to the north and east, and the Penobscott River watershed to the west.

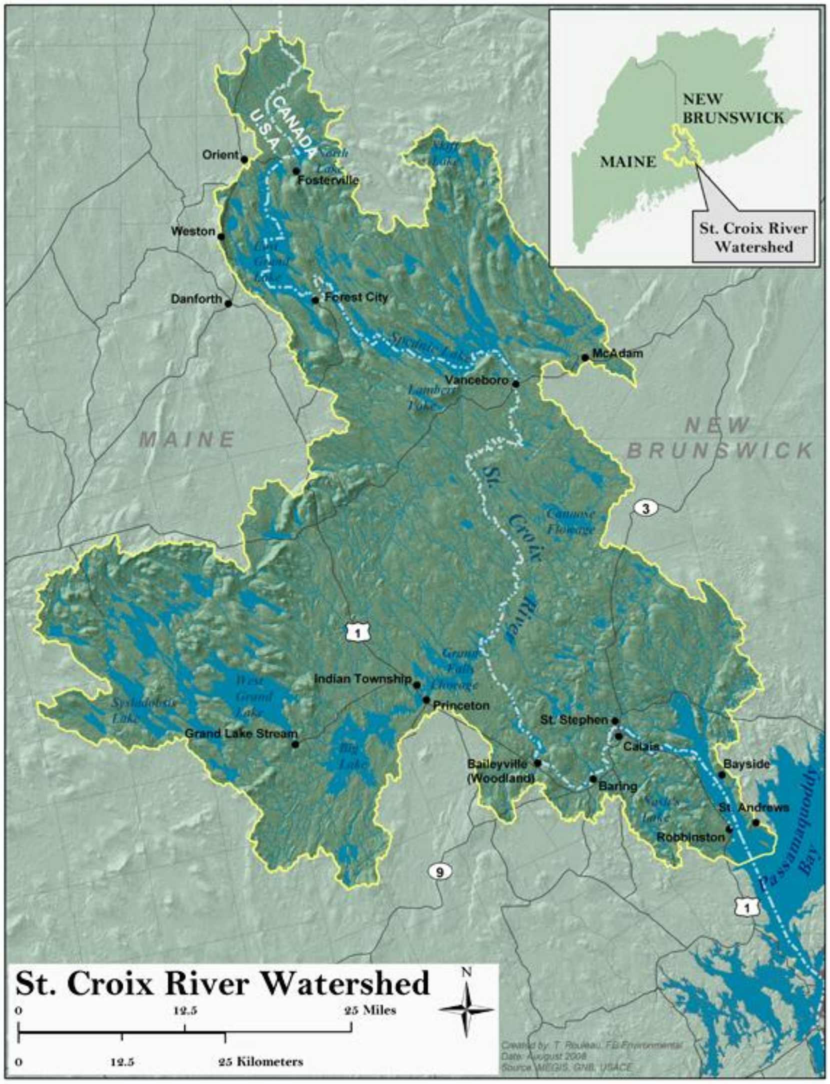

Figure 1. The St. Croix Watershed.
Source: International St. Croix River Watershed Board State of the Watershed Report. 2008.

The headwaters of the river are a series of lakes, with the upper waters having two branches. The west branch includes West Grand and Big Lakes and is located in Maine until it reaches Grand Falls. The east branch originates in Chiputneticook Lakes and includes East Grand and Spednic Lake and forms part of the international border.

Further downstream, the river channel is characterized by marshes and open water. Much of the basin, especially in the northern and central parts of the region is forested rolling hills, sometimes rocky terrain, interspersed with a variety of water features including a number of tributaries as well as lakes, streams and bogs.

The river discharges into Passamaquoddy Bay, part of the Bay of Fundy, at St. Stephen NB and Calais ME (IJC 2011). The river mouth is an estuary which extends for approximately 15 miles (24 km) and is known for its tidal bore where the water level may fluctuate 25 feet (7.6 m) between high and low tides. At low tide large mud flats are revealed in the estuary.

Land Cover and Land Use

The St. Croix watershed is largely forested land, covering approximately 81% of the basin. Water features are prevalent, with open water and wetlands covering approximately 14%. Settled lands may be in the form of agriculture, towns, villages, and generally under other, make up approximately 5% of the watershed.

Land Use/Land Cover	Percentage of watershed
Forest	81
Water	8
Wetlands	6
Agricultural lands	3
Towns, villages, etc.	1
Other	1
Total	**100**

Table 1. Land use/topography in the St. Croix River Watershed.
Source: St. Croix International Waterway Commission's Water Classification Report (2000).

The watershed topography is generally rolling hills, with underlying sedimentary and some igneous rock. New Brunswick soils are generally classified as Shaly Loam, with good drainage in higher areas and poor drainage in lowlands (Ag. Can. 1953). In the New Brunswick portion of the watershed, the geomorphologic regions which fall in the watershed have been identified as the St. Croix highlands (southern part of watershed) and the Chaleur Uplands (northern part of watershed) (Ag. Canada 1995). A Maine Geological Survey map of the southern watershed shows several bedrock outcroppings and soils which vary between gravelly sand and clay (MGS Surficial Materials 2000), while mid-watershed is sand and gravel close to the river, with undifferentiated sandy till further west (MGS Surficial Materials 2001). Sand with some bedrock outcropping is prevalent in the upper watershed (MGS Surficial Materials 2001b).

Land conservation of various types protects approximately 67% of the watershed (700,000 acres), with approximately 42% under permanent protection, primarily in Maine (ISCRWB SoW 2008). Having such a large portion of the watershed protected contributes greatly to ecosystem health through retaining natural functions and supporting diversity. This in turn helps protect the quality and quantity of water resources in the watershed. A list of the types of conservation lands, and the percentage of conservation lands each includes, follows.

Land Conservation Type/owner	Approximate % of all Conservation Lands	Location or example of protected lands
U.S. Federal	1%	Moosehorn National Refuge
State	2%	State conservation areas
Land Trusts (private)	76%	N/A
Provincial	17%	Spednic Lake Protected Natural Area
Provincial Parks	2%	N/A
Non-government conservation lands	<1%	N/A

Table 2. Breakdown of Conservation Lands in the St. Croix Watershed.
Source: ISCRWB State of the Watershed Report. 2008.

Natural features of the watershed influence water characteristics, which in turn are important to human health. For example, groundwater which flows slowly through soils and rock over time is more likely to pick up minerals from its surroundings than faster flowing groundwater. Fast flowing surface waters carry sediment and solids that still waters drop. Water pH is also influenced by soils, rock and vegetation that come into contact with the water. Shallow warm lakes and streams provide a more favourable environment for organic growth than deep cold waters.

Naturally occurring pathogens may be present in water in areas where wildlife is present, especially when found in concentrated numbers such as wildfowl staging areas. Since we depend on these waters for our drinking water as well as using them for recreation understanding the watershed, how natural features function, and how these features respond to anthropogenic influences is in our best interests.

Groundwater quality in New Brunswick (NB DE) is generally considered to be good with localized elevated levels of naturally occurring substances (NB DE Groundwater Atlas 2008). A number of naturally occurring conditions are also noted in areas of Maine (MGS 2009).

Surface water quality in the St. Croix River ranges from excellent to marginal. This is according to a Water Quality Survey which was carried out in the watershed over a ten year period, 1996-2006, and was based on Canadian Council of Ministers of the Environment (CCME) Guidelines for Freshwater Aquatic Life. Lower ratings occur primarily in the southern portion of the waterway.

Climate

Climate plays a large role in shaping the watershed, and therefore directly and indirectly impacts both ecosystem and human health. When precipitation and temperature extremes occur they may increase human health risks, such as through flooding or drought and extreme high or low temperatures. Average conditions influence seasonal water availability, river flows, and the types of aquatic and terrestrial ecosystems which will be present. The direction of prevailing winds determines where pollutants from other parts of the continent are carried and where they are deposited.

The St. Croix watershed is part of the Atlantic Ecozone, which is characterized by a temperate, climate with fairly high amounts of annual precipitation. The watershed as a whole averages approximately 1300 mm (51.2 inches) in annual precipitation (NB DE Environmental Reporting Series 2007).

Historical weather data provides us with a picture of the climate over a period of time, but it is not available for many areas of the watershed. Temperature and precipitation data for Grand Falls Drummond, New Brunswick, located in the central part of the watershed, is available for the period of 1971-2000, and it provides a general picture of climate in the interior of the watershed. Environment Canada's records show 1134.4 mm (44.7 inches) of annual precipitation and annual daily average temperatures of 3.5°C (38°F) for the area during that period (Env. Canada Weather Office). Precipitation for the period averages approximately 300 cm (118 inches) of snow annually between October and May, and rainfall of approximately 834 mm (32.8 inches) annually, with rain falling throughout the year.

The highest amount of average precipitation at the station for the period was in August, with 126.8 mm (5.0 inches), the lowest average precipitation is 65.8 mm (2.6 inches) in February. A fair degree of variability in rainfall and temperatures is normal for the area.

Grand Falls Drummond, New Brunswick Climate Normals 1971-2000												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Daily Average (°C)	-13	-10.8	-4.6	2.7	10.6	15.4	18.1	17	11.7	5.8	-1.1	-9.5
Rainfall (mm)	22.8	10.7	34.4	52.6	85.4	101.2	117.5	126.8	99.6	89.5	61	32.8
Snowfall (cm)	71.6	55.1	47	24.8	0.7	0	0	0	0	1.8	31.1	67.9
Total Precip. (mm)	94.4	65.8	81.5	77.5	86.2	101.2	117.5	126.8	99.6	91.3	92.1	100.8

Table 3. Grand Falls Drummond, New Brunswick, Canada. Climate Normals for 1971-2000.
Source: Environment Canada. Weather Office. Undated.

Grand Falls, at an elevation of 228.6 metres (1,472 feet) above sea level and further north and inland than many of the communities in the watershed, likely has a lower average temperature than areas of the watershed which are located further south and closer to moderating influences of Passamaquoddy Bay. To illustrate, Portland, ME is a coastal community located (outside of the watershed) approximately 290 km (180 miles) southwest of Calais. Portland's average total annual precipitation for the same period is 45 inches (1143 mm), similar to Grand Falls but it has a warmer average annual temperature of 45.8°F (7.2°C) (NOAA 2011).

Since the 1900s, annual average precipitation has gradually increased in Northeastern U.S., which includes the St. Croix watershed, by five to ten percent with the increases occurring in every season except winter. More recently, this has changed as winter precipitation has increased (NCIAST 2007).

1.2.2 Political Features

Watershed History

Settlement patterns and associated natural resource harvesting, transporting and processing facilities play a large role in the health of the watershed. Conversely human health can be affected in some parts of the watershed where environmental degradation has resulted from anthropogenic activities.

The St. Croix River watershed has a long history of occupation, first inhabited by First Nations. The Passamaquoddy Indians have inhabited the area on both sides of the river for approximately 12,000 years, followed by the French who first settled the area in the early 1600s.

The English settled in the area not long after the French arrived. The river was used as a transportation route inland from the Atlantic Ocean and Passamaquoddy Bay. The early economy was based on lumber, shipbuilding, milling and water power. Later, manufacturing moved into the area in the form of a textile mill and tanneries. Fish hatcheries have more recently been introduced into the region (ISCRWB SoW 2008).

The St. Croix River Watershed Today

Many reminders of historical activities are still apparent today, perhaps the most obvious being the remaining water retention and hydro dams, but also in the traditional settlement patterns in the watershed which have been largely carried forward. Today the economy is still based largely on natural resources and tourism, with timber harvesting and processing being the largest contributor to local economies followed by recreation in the forms of sport fishing, hunting, camping and similar activities. The river is widely known as a recreational destination as well as being a source of hydro power (ISCRWB 2009).

Most of the population, over 75%, is found in the southern portion of basin. The total watershed population in 2006 was 24,300 after population decreased in the watershed by six percent in the period 1996-2006 (ISCRWB SoW 2008). Since tourism is a large component of the economy, it would be assumed that seasonal populations would fluctuate with summer populations in cottage communities temporarily increasing.

There are a number of towns and villages on or close to the main stem of the river in both Maine and New Brunswick, all small communities numbering in the hundreds to a few thousand residents, and traditionally this is where the majority of the population has been located. More recently, rural areas have increased in population as residents have moved to rural and notably riverfront properties, leaving the small municipalities with declining populations (ISCRWB SoW 2008).

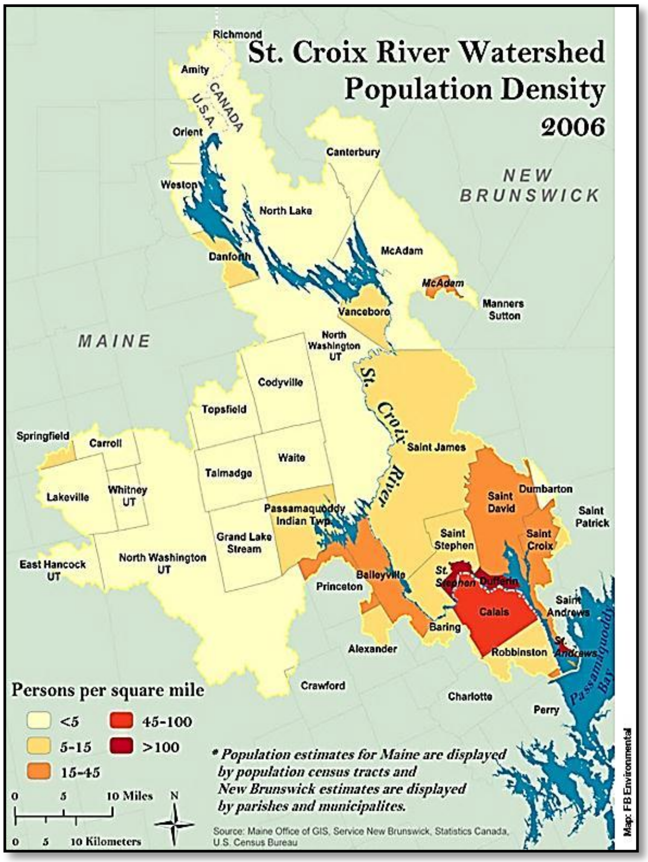

Figure 2. Population Density in the St. Croix River Watershed.
Source: International St. Croix River Watershed Board State of the Watershed Report. 2008.

The largest municipalities in the St. Croix River watershed are Calais, ME with a population of approximately 3,500 residents and St. Stephen, NB with a population of approximately 4,800 residents. Other settlements in Maine include Baileyville, Robbinston, and Vanceboro. New Brunswick settlements include McAdam, Milltown, St. Andrews, and St. Croix.

The Passamaquoddy Indians have inhabited the area on both sides of the river for approximately 12,000 years. In Maine the Passamaquoddy have two separate councils, located in Indian Township on the west branch of the St. Croix River and at Pleasant Point Reservation on Passamaquoddy Bay. In Canada the St. Croix Schoodic Band is located in St. Stephen, NB.

The St. Croix River was designated as the first Canadian Heritage River in Atlantic Canada in 1993. The river has been recognized for its importance in the Atlantic regions of both the U.S. and Canada. There are a number of important archeological sites throughout the watershed, including the St. Croix Island International Historic Site, which has been recognized by the U.S. and Canada as having great historical significance.

2 Water Management and Human Health

2.1 Introduction

Water management within a watershed can influence human health directly or indirectly. For example, industrial or municipal effluent may have a direct effect on human health if not treated sufficiently and then ingested or it may have an indirect effect through causing accelerated algal growth which can be harmful to human health. With the integration of a number of aspects of environmental health management which were previously addressed separately an understanding is emerging of the sometimes complex interrelationships between human health and key natural functions and features.

Water management considerations are typically divided into two categories, water quality and water quantity. Though each category requires specialized knowledge to understand and address specific issues the two are interrelated as quality is affected by quantity. Both must be taken into account when solutions to water quality issues are being developed. This becomes apparent when considering effluent discharge into changing quantities of receiving waters, and how these changes affect concentrations. When a small waterway is at low levels, contaminant concentrations at and downstream of the effluent release sites may be significantly higher than during high water periods when volumes of receiving waters are greater. Concentrations are further affected by how quickly the water is flowing, dispersing the contaminants as they are carried downstream.

Drinking water may be drawn from groundwater or surface water. Groundwater water quality issues may be related to naturally occurring contaminants or may be related to human activity. Human health is affected by groundwater primarily through its use as drinking water source water though in some instances contaminated groundwater may seep into surface waters which are used for drinking water or recreation. Municipal drinking water in the St. Croix River watershed is drawn from aquifers with the exception of the Town of St. Andrews, NB where drinking water is supplied from a reservoir.

Surface water quality issues related to human health considerations include identifying potential health issues which may occur in drinking water source water such as rivers, lakes or reservoirs, issues associated with fish consumption, and issues where contact or incidental water consumption may occur, such as during recreational activities.

Contaminants which may be present in water can be naturally occurring, anthropogenic, or a combination of both. Microorganisms and parasitic worms (e.g. schistosomiasis) though naturally occurring may have increased concentrations or increased distribution as a result of human activity.

Waterborne organisms may affect people through external exposure as in the case of swimmer's itch (cercarial dermatitis) or microorganisms that can be accidently ingested while swimming in contaminated water. Contaminants may also be present in the form of heavy metals, and endocrine-disrupting substances which may be released through overland runoff or effluent releases.

Both the U.S. and Canadian federal governments are involved in various levels of water protection through issue identification and monitoring programs as well as through setting guidelines and regulations. The state of Maine has a water classification system which has been applied to the St. Croix River which identifies outstanding natural waters and encourages remediation and subsequent protection of degraded areas. The province of New Brunswick has set the groundwork for a similar classification system and this system is partially in place (Lee Sochasky, St. Croix International Waterway Commission, pers. comm. February 2011)

Environment Canada's National Water Research Institute has identified 15 threats related to source water and aquatic ecosystem health. Thirteen of these threats were initially identified in 2001, with two added after initial meetings (points 8 and 9 following).

- Waterborne pathogens
- Industrial wastewater discharges
- Municipal wastewater effluents
- Algal toxins and taste and odour
- Pesticides
- Persistent Organic Pollutants and Mercury
- Urban runoff
- Agricultural and Forestry Land Use Impacts
- Natural sources of trace element contaminants
- Impacts of dams/diversions and climate change
- Nutrients
- Acidification
- Endocrine disrupting substances
- Genetically modified organisms
- Solid waste management practices (Environment Canada NWRI 2001)

As noted, water-related human health threats are closely related to source water health and this list serves as a basis for the discussion that follows. Additionally, we have chosen to supplement the list with issues which have environmental health relevance, and modify or exclude others due to their apparent lack of relevance in the basin. Hence, in this report, we will focus on the following issues:

- Industrial wastewater discharges
- Municipal wastewater effluents
- Bacterial Contaminants
- Algal toxins
- Pesticides
- Urban runoff and stormwater
- Water quantity due to climate change
- Water quantity changes due to diversion (water management)
- Water quantity and extreme events
- Nutrients
- EDS, pharmaceuticals, and personal care products
- Acidification
- Endocrine disrupting substances
- Drinking water treatment and distribution systems
- Airborne originating contaminants

Issue	Fish Consumption	Drinking Water	Incidental Contact or Consumption
Industrial wastewater discharges			
• pulp and paper effluent	√		√
• mining/quarry effluent	√		√
Municipal and small community wastewater effluents	√		√
Bacterial Contaminants	√	√	√
Algal Toxins	√	√	√
Pesticides	√	√	√
Urban runoff and stormwater	√		√
Climate change and water		√	√
Water quantity and water management			√
Water quantity and extreme events			√
Nutrients		√	√
Pharmaceuticals, personal care products and EDS	√		√
Acidification		√	
Drinking water treatment and distribution systems		√	
Airborne originating contaminants	√		

Table 4. Human Health Linkages to Water Issues.

The preceding table is a summary of the modified list of threats and identifies connections to three categories of human health concerns related to water; local fish consumption, drinking water and incidental contact or consumption (recreational water use). It can be argued that all threats are related to all categories, however the table illustrates what may be considered to be primary concerns for each issue.

In each of the sub-sections that follows a general description of the issue is provided, followed by potentially adverse health impacts and local examples of occurrences in the St. Croix watershed. It should be noted that some of the categories may be of marginal importance directly, as drinking water supplies are largely from aquifers and there are no public beaches in the watershed (L. Sochasky, pers. comm. 2011) but they have been included as there may be incidental contact (or consumption) by individuals with surface waters where these issues occur.

Further details on monitoring activities related to the following issues may be found in Section 3.

2.2 Wastewater Effluent - Sources and Type

Wastewater originates from a number of sources and can contain hundreds of chemical and biological substances. Treatment is specific to the type of wastewater. It is recognized that even in compliant discharges only a fraction of the compounds may be removed prior to release into receiving waters. As such, wastewater can have both direct and indirect effects on human health, many which are still being identified.

As well as contributing contaminants, wastewater may change the temperature and the amount of dissolved oxygen in receiving waters with the potential to degrade downstream aquatic ecosystems.

2.2.1 Industrial Wastewater Discharge

There are traditional resource based industries currently operating within the watershed. Lumber and pulp mills, continuing on as main economic drivers from the past, are operated much differently than 50 or 100 years ago with an eye on reducing environmental impacts related to water and air and increasing sustainability. In the past there were also tanneries and a textile mill. Legacy issues emerged in the river from past industrial activity. In the 1950's there were reports of thick accumulations of sawdust and coal ash slag in areas of the riverbed of the St. Croix (ISCRWB SoW 2008). Over time it became apparent in rivers such as the St. Croix that treating effluent prior to release is important. As more has been learned about the effects of certain contaminants on human and ecosystem health, regulations have been introduced and modified to prevent harmful levels of contaminants from entering rivers and lakes.

The New Brunswick Department of Environment (NB DE) oversees municipal and private wastewater effluent through issuing Approvals to Operate, which require monitoring for set parameters at set frequencies. An annual audit, which includes effluent sampling, is done by the Water and Wastewater Management Section of the NBDE.

Maine also requires permitting for wastewater release under the Department of Environmental Protection, Bureau of Land and Water Quality. Maine has a water classification system in place where waters are assigned a class rating which determines discharge license limits. There is also an anti-degradation policy which restricts authorization of additional discharges in water bodies which don't meet the classification requirements (Maine Rivers 2011).

Pulp and Paper

Timber harvesting and processing has historically been a key industry and continues to be an important part of the economy in the St. Croix River basin. The Woodland Mill has been operating since it was first opened in 1905 as St. Croix Pulp and Paper. It was purchased by Georgia Pacific in 1964, and then by Domtar in 2001. It changed ownership again in the fall of 2010 and is currently owned by International Grand Investment Corporation (IGIC). The mill is now known as Woodland Pulp LLC, has an annual production capacity of 400,000 tons of hardwood pulp and currently employees approximately 300 people (The Quoddy Tides October 8, 2010).

Pulp and paper effluents have traditionally included a number of substances including dioxins, furans, and other organochlorines. The specific chemical byproducts are dependent on the processes used in the pulping and bleaching. Some of the chlorinated compounds which are typically used have been found to be persistent and toxic when they are released into receiving waters (EC Pulp and Paper 2010). Volatile organic compounds (VOCs) and nitrogen oxides may also be released into the air (EPA 1997).

Historically, effluents were released with little or no treatment but that has changed as regulations and effluent monitoring programs have been developed. Effluent treatment now includes primary and secondary treatment which removes solids and allows microorganisms to remove oxygen-consuming materials. Tertiary treatments may also be in place to remove colour (EC NWRI 2008).

Environmental impacts of effluent from the pulp and paper industry are again dependent on processes used but are usually focused on BOD, TSS, and acute toxicity related to suspended solids and increased nutrients, organics, and turbidity.

Potential health effects from the by-products of dioxins include skin disorders, liver and immune systems problems, endocrine system and reproductive issues, as well as increasing risks of developing certain types of cancer. Bioaccumulation of these contaminants over time in humans occurs primarily through the consumption of contaminated fish (HC 2006).

In Canada, regulatory limits applicable to pulp and paper effluents were initially set in the 1990's, updated in 2004 and amended in 2008 (EC Pulp and Paper 2010) with regards to dioxins, furans, Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) (Government of Canada 2008). Mills are required to carry out testing and submit results to Environment Canada under the Environmental Effects Monitoring program (EEM), a long term site specific monitoring program designed to measure the long term effectiveness of regulatory limits. EEM is in place for both the mining and the pulp and paper industries and also includes studies of lethal and sub-lethal effluent effects on fish and benthic communities.

The U.S. Environmental Protection Agency (EPA) sets regulatory guidelines for pulp and paper effluent and emissions discharges in the U.S. Regulations are specific to the type of operation.

A study of water quality in the St. Croix Estuary, completed in 2003, reports regular spills of black liquor and other substances from Woodland Mill, then owned by Georgia-Pacific Corp. (MacKay et. al 2003). The industry as a whole has changed in the past decade and so has ownership of the mill. Current information on spills and specifics on effluent from the mill was not located.

Flakeboard Production and Chemical Facility

Flakeboard Company Limited in St. Stephen is a composite wood company which was opened in 1960 and produces particleboard and thin MDF panels at the local plant using what previously was considered wood waste materials (Flakeboard 2010). According to the NB Department of Environment, the plant has approvals to release industrial effluent (Stephen Drost, Municipal Wastewater Biologist, NB Department of Environment pers. comm. March 16, 2011). The 2003 St. Croix

Estuary study shows that this company has reported a 1999 release of formaldehyde (MacKay et. al 2003), but further information on effluent or emissions composition and monitoring were not available.

Woodchem Canada Limited, also in St. Stephen, has reported past releases of Ammonia, Formaldehyde, and Methanol (MacKay et. al 2003) but further information was not available.

Champlain Industrial Park

This area has an extended aeration facility which treats industrial and domestic wastewater. In the 2009 ISCRWB Annual Report it was reported to meet provincial requirements.

2.2.2 Municipal Wastewater Treatment

Municipal wastewater is a mixture of everything from chemicals and pharmaceutical products to human waste and therefore potentially has a wide range of chemical, viral and bacterial contaminants before treatment. Contaminants may include cyanide, sulfides, phenols, and heavy metals. Effluent toxicity may be caused by un-ionized ammonia or total residual chlorine (EC NWRI 2010).

Initially Municipal Water Treatment Plants (MWTPs) were designed to kill waterborne disease organisms, remove solids and oxygen-demanding material and in some cases nitrogen or phosphorus (Servos et. al 2008). These plants may also be referred to as Waste Water Treatment Plants (WWTPs) Further treatment to remove other bacterial contaminants before release is now done but some chemical contaminants will remain. In some instances the treated sludge from MWTPs may be used on farm fields and substances from this sludge may enter the water system as non-point source pollution through this route. Point source discharges such as wastewater outlets provide an opportunity to closely monitor effluent and downstream receiving waters to determine site specific dilution rates and dispersion characteristics.

In the U.S., Maine sets rules on wastewater effluent levels to meet EPA regulations. Under the Clean Water Act, EPA regulations require a minimum of secondary treatment to be carried out at municipal wastewater treatment facilities and require monitoring and reporting (EPA NPDES 2007). The Maine Department of Environmental Protection provides technical support to municipalities to address operations issues.

In Canada, effluent regulation has been under the provincial governments, in New Brunswick under the Clean Environment Act (New Brunswick Regulation 82-126). In 2010, new proposed regulations were released for national effluent standards, which will apply to any wastewater system that "has a capacity to deposit a daily effluent volume of 10 m^3 or more from its final discharge point" (EC Pulp and Paper 2010). A Canada-wide strategy, the Management of Municipal Wastewater Effluent was approved by the Canadian Council of Ministers of the Environment (CCME). This legislation has been developed under the federal Fisheries Act and there are plans to introduce the new legislation through a phased approach, depending on assigned risk rankings (CCME 2009).

In the province of New Brunswick as a whole, 57 facilities were analyzed and of these 13 facilities are ranked as low risk, requiring upgrading by 2040, 44 are ranked as medium risk, requiring upgrading by 2030, and none are considered high risk (CCME 2009).

Municipal Wastewater Treatment and CSOs in the St. Croix Watershed

Untreated wastewater usually contains bacteria and chemicals which poses risks to human and ecosystem health. Some wastewater treatment systems may accidently release untreated wastewater during high flow periods such as rainstorm or snowmelt events due to treatment plant overflow or combined sewer overflow (CSO). CSOs are a combination of wastewater and stormwater and are found in some municipalities in the watershed.

Certain strains of *E. coli* from wastewater can be of particular concern if they are released without treatment as they can affect recreational water use downstream of discharge sites and can be detrimental for aquatic ecosystems both at release sites and downstream.

Municipal wastewater has been identified as a key source of water contamination in recent years and governments in both the U.S. and Canada have been working to address this issue and reduce harmful contaminants. Locally there have been a number of issues throughout the watershed with wastewater, both with treatment plants and CSOs overflowing. Activity within the watershed to improve wastewater treatment processes and reduce the number of CSOs is underway in an effort to stop accidental effluent releases and provide more thorough processing of wastewater. The following provides some background information on treatment processes, issues, and efforts to address them.

Calais, Maine

In 2008 Calais had 10 sewage pumping stations. The WWTP was originally built in 1969 and had historically had problems with high flows which are over the capacity of the system, resulting in overflows. Remedial work was done to the WWTP in 1990 and completed on sewers in 1999. There continued to be a number of overflow issues and in 2001 the Maine Department of Environmental Protection initiated enforcement action. In 2002 operations management was privatized. Operational improvements were implemented between 2002-2005, including repairs to, or replacement of, pumping stations and implementing full reporting of CSO and plant compliance issues. A Master Plan, identifying CSO and sewer improvement needs was also implemented (ISCRWB CSO Appx. 2 2008).

Calais had five CSOs in 2008, including one at the sewage treatment plant. The city had developed plans to eliminate CSOs and in May 2008 it was reported that CSO events from pump stations had been reduced by 89% since 2003 with the number projected to improve in 2008 to 96%. The City reported continuing implementation of the approved CSO removal plan in 2009. The 2007 CSO overflow at Calais was approximately 22 million gallons (ISCRWB CSO 2008).

St. Stephen, NB

In 2008 St. Stephen had 28 CSOs, 11 on the riverfront. CSO overflow occurs during intense or prolonged precipitation or infrequent mechanical issues such as extended power outages or pump failures. There are plans to remove CSOs from sewer system which will be implemented once funding is available. The 2008 estimate to carry out this work was $7.5M (ISCRWB CSO 2008).

Overflows during extreme weather events may occur when flow in the system is two to three times higher than normal. Events which create flows four to five times higher have been observed (ISCRWB CSO 2008).

St. Stephen has two sewage treatment plants. One was recently built where wastewater is chlorinated and declorinated before discharge into the river (ISCRWB CSO 2008).

St. Andrews, NB

St. Andrews wastewater is sent first to a sewage lagoon and from there into the primary pond. It is aerated then sent to a finishing pond and finally discharged into Passamaquoddy Bay. The effluent quality is monitored twice a week by staff and monthly by an independent lab (Town of St. Andrews 2010).

Baileyville, Maine

Baileyville, ME improved its sludge drying bed in 2009 and reported work on an infiltration/inflow project (ISCRWB 2009).

McAdam, NB

McAdam is a village located on Wauklahegan Lake in New Brunswick, in the central-northeastern part of the watershed. McAdam reported an infiltration problem in 2009 that may have required bypassing the system, threatening water quality in Wauklahegan Lake (ISCRWB 2009).

Unlike other wastewater treatment facilities in the watershed which release effluent into the St. Croix River, the McAdam WWTP releases effluent into Station Brook, which feeds into Wauklahegan Lake. The lake drains into Diggitty Stream, through First Lake and then into Spendic Lake. Wauklahegan is a shallow lake with deeper basins throughout, and a surface area of 3.6 km^2 (1.7 square miles). The area is a popular recreational area, with a private campsite and some cottages on the lake.

A report on a supplementary investigation of wastewater overflows was completed in 2006 and it details how the sewage collection pipe for the town discharges into a concrete box with a wooden weir. Overflows of untreated sewage enter Station Brook at this point when inflow exceeds the lift station pumping rates (NATECH 2006).

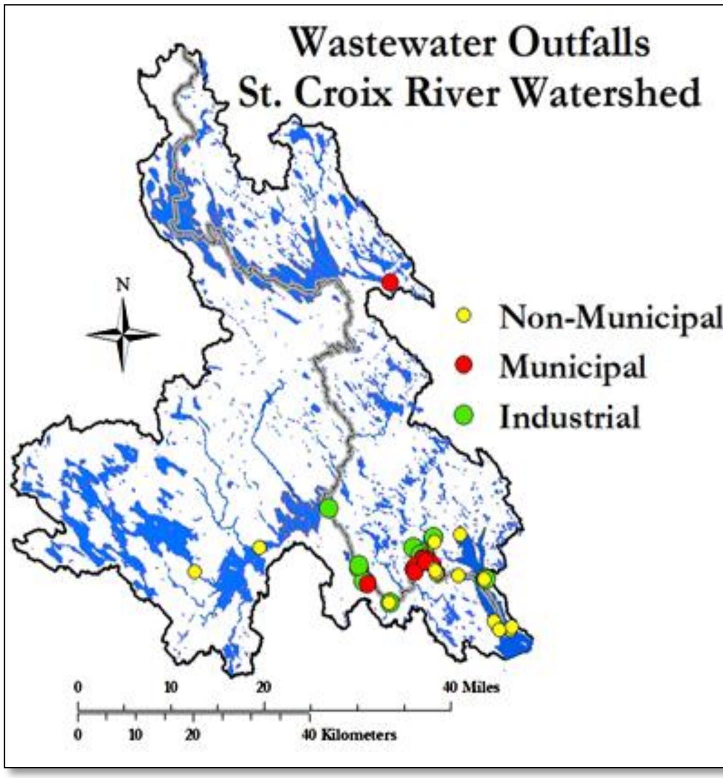

Figure 3. Wastewater Discharge sites in the St. Croix River System.
Source: ISCRWB St. Croix State of the Watershed Report 2008.

It was estimated that during a study period of 19 days in November and December 2005, 14 days showed overflows of untreated sewage, with an estimated total of 40,000 m^3 (52,318 cubic yards). It should be noted that the study period coincided with two rainfall events, a one day event of 65 mm (2.6 inches) rain and a three day event where over 48 mm (1.9 inches) fell (NATECH 2006). The study found that the sewage collection system has a significant amount of exterior water entering it from surface or groundwater and this is contributing to overloading the system (NATECH 2006). Station Brook phosphorus concentrations are reported to have doubled due to the overflows.

2.2.3 Small Community Wastewater Treatment and Private Septic Systems

There are a number of septic systems in rural and cottage communities which may contribute wastewater products and nutrients to surface waters. As populations migrate to waterfront properties in rural areas which are situated close to the southern urban areas, impacts from developed properties may become more prevalent (ISCRWB SoW 2008).

In Canada, protocols have been developed which address wastewater and drinking water standards for First Nations by the federal Department of Indian and Northern Affairs. (INAC 2009).

In recent years work has been done in New Brunswick to ensure septic systems are in place and upgraded where necessary (L. Sochasky, pers. comm. 2011). In

2007 septic system regulations in New Brunswick were updated and in March 2011 New Brunswick released updated technical guidelines which were to take effect April 1st 2011. These updates require primary and secondary chambers in the septic tank, an effluent filter, and a minimum capacity of 3410 litres (900.8 gal.). Work done within 30 m (98.4 ft.) of a watercourse must be approved by the Department of Environment prior to commencing work. Systems are inspected by the Health Department.

In Maine, regulations require septic systems to be designed by a licensed site evaluator. The septic system program is overseen by the Department of Health and Human Services under Center for Disease Control and Prevention, Division of Environmental Health. Subsurface wastewater disposal rules were updated in 2009 and took effect January 18, 2011. The minimum setback for ground or vegetation disturbance related to septic system installation adjacent to major water bodies is 75 feet (22.9 m) from the normal high water mark to reduce the likelihood of sedimentation or contaminants entering the waterway (HHS Wastewater Disposal 2009).

East Coast Village Mobile Home Park

This residential community of 58 mobile homes discharges treated effluent into Meadow Brook. According to the ISCRWB 2009 St. Croix Annual Report the situation will be resolved by extending services from the Town of St. Stephen, NB though no reference to a plan or timeline was provided.

Oak Bay Campground

According to the International St. Croix Watershed Board's 2009 Annual Report, this New Brunswick campground uses a trickling filter system to treat domestic wastewater from 110 sites. The treated effluent is disinfected and discharged into Oak Bay. It is recognized that this system requires upgrading (ISCRWB 2009).

Other types of small wastewater systems which may be in the watershed include educational and health institutions. Information on other small systems which may be operating in boundary waters was not readily available.

Conclusions

Wastewater effluent, from industrial and municipal and to a lesser extend private sources continues to be a contributing factor to water quality degradation in the watershed. CSOs have been recognized as an issue in the southern portion of the watershed and plans have been made on both sides of the border to address overflow issues.

McAdam, in the central/northern portion of the watershed also has overflow issues at its wastewater treatment plant which is a contributing factor to water quality degradation of Wauklahegan Lake.

Past data from 2000 on effluent and spills from the Woodland Mill indicates that it was also a contributing factor to lower water quality. Similarly, Woodchem and Flakeboard have reported past releases which may be contributing factors but more current data is not available.

2.3 Bacterial Contaminants

There are a number of naturally occurring bacteria and other microorganisms in surface rivers and lakes, and in certain situations in groundwater, which may adversely affect human health. These include some Escherichia coli (*E. coli*), cryptosporidium, and Giardia. *E. coli* is possibly the best known and is monitored at beaches and in drinking water due to its potentially adverse health effects when ingested. The presence of *E. coli* is used as an indicator of fecal pollution in fresh waters.

Sources of *E. coli* include feces from warm-blooded organisms such as humans, pets, livestock, and wildlife. *E. coli* may enter surface waters due to runoff and can be found in improperly treated wastewater effluent.

Maine has, and New Brunswick plans to have, a water classification system for rating surface water quality which uses *E. coli* and dissolved oxygen as quality indicators. The Maine system has been in place for over fifty years and sets water quality standards for a number of different types of waterbodies. The New Brunswick system is compatible to the Maine system and was expected to be completed in 2008 (ISCRWB SoW 2008), and is partially in place (L. Sochasky pers. comm. 2011). The New Brunswick system is in place for drinking water surface source water.

Municipal and private drinking water in the watershed is primarily drawn from aquifers. Aquifers can be contaminated by *E. coli* through being supplied directly by contaminated surface water, such as in wells which are identified as "Groundwater Under the Direct Influence of Surface Water" (referred to as GUDI) wells. GUDI wells may be located in karst formations, limestone which dissolves in water, often leaving cave type formations which may be open to surface water infiltration. Surface water may also enter groundwater through fractured rock such as granite, which often has stress fracturing which provides pathways for surface water. It is often difficult to determine whether a groundwater drinking water source is GUDI and where the source of surface water may be, and extensive study and modeling can be required.

Surface water may also enter wells through improperly sealed well casings which allow surface water to follow the casing down to the groundwater. In some circumstances shallow groundwater, which may have originated on the surface and therefore may be contaminated, can follow well casings in a similar fashion. Leaching of septic systems into groundwater which supplies an aquifer also occurs. *E. coli* can enter aquifers, especially shallower aquifers, through any of these routes.

In Canada, Drinking Water Quality Guidelines are established by the federal government through Health Canada and are used to establish provincial regulations. The Guidelines include consideration of a number of microbial, chemical, radiological and physical parameters. In New Brunswick, drinking water quality guidelines stipulate that there should be no detectable *E. coli* per 100 ml. Similarly, there should be no detective total coliforms per 100 ml.

In the U.S., the federal Environmental Protection Agency (EPA) sets drinking water standards through the Safe Drinking Water Act. Maine carries out activities to ensure compliance with federal regulations. The EPA protocol requires regular testing of municipal drinking water supplies and repeat sampling within 24 hours in the event of a positive coliform sample result (EPA Total Coliform Rule 2010).

St. Andrews, NB is the one exception to groundwater being the source of municipal drinking water in the watershed. St. Andrews has a surface water drinking water source, Chamcook Lake and water is pumped from the lake to a reservoir in town. As surface water, the reservoir may be more susceptible to bacterial contaminants than groundwater and may also be susceptible to atmospheric contaminant deposition.

Municipal drinking water is routinely treated for bacterial contaminants prior to distribution, and the 'raw' source water is tested regularly for bacteria levels. Of greater concern may be some chemical contaminants which may not be included within the monitoring or treatment parameters.

Incidental Contact and Ingestion

Incidental contact refers to activities such as swimming, wading, or fishing where there is contact with the water. Incidental ingestion is when some water is swallowed during an activity, as often occurs while swimming.

Maximum levels of *E. coli* at public beaches are regulated in both Canada and the U.S., with beaches being closed if levels are exceeded.

The U.S. EPA criterion for freshwater full body contact is 126 *E. coli* per 100 ml for a minimum of five samples spaced equally over a one month period. Enterococci are limited to 33 per 100 ml for freshwater and 35 per 100 ml for marine water over the same period (EPA Bacterial Quality Standards 2003).

Health Canada's freshwater Guidelines of Canadian Recreational Water Quality require a minimum of five samples taken within 30 days. The mean of the samples should not exceed 2000 *E. coli* per litre (*E. coli*/l) (200 *E. coli* per 100 ml). Resampling should be performed when any sample exceeds 4000 *E. coli*/l. (HC Microbiological Characteristics 2010).

Under Canadian Council of Ministers of the Environment (CCME) water quality index guidelines, 8% of tests in the watershed during the Water Quality Survey carried out between 1996 and 2005 did not meet *E. coli* recreational use guidelines (ISCRWB SoW 2008).

Three saltwater New Brunswick public beaches were identified in the lower watershed. Water samples were collected by the New Brunswick Department of Health for the period 2003-2008. In a few instances single sample counts exceeded maximums, but where geometric means are available for enterococci they all fell below limits (Douglas Walker, CPHI(C), Regional Director - Health Protection Branch, South Region pers. comm. May 9, 2011).

Shellfish Consumption

Shellfish in the estuary and lower St. Croix River have had high bacterial contamination for over 40 years. (ISCRWB SoW 2008, L. Sochasky pers. comm. 2011). *E. coli* has been an ongoing problem in the estuary, resulting in the area being closed in the 1970s to clam harvesting. Current *E. coli* levels are still high in parts of the estuary and for the majority of the area harvesting remains closed as *E. coli* levels fluctuate.

In the past twenty years a concerted effort to address anthropogenic sources of *E. coli* in the area has been undertaken on New Brunswick lands adjacent to Oak Bay. Results have been mixed, as levels have receded and increased throughout the flats. It is thought that natural sources and conditions contribute to the issue as the contamination continues even after reduction of anthropogenic sources. Concerted monitoring of many points within the affected areas would be required to determine, at any given time, the presence of *E. coli* (L. Sochasky, pers. comm. 2011).

Depuration harvesting in the western portion of Oak Bay began in 2005. Environment Canada surveyed the area in 2007 for bacterial contamination and more surveys may be required. A depuration area was mapped out and some areas outside that area were identified as permanently closed (ISCRWB 2008).

Conclusion

E. coli is present in surface waters and elevated levels are an issue in relation to shellfish consumption and recreational water contact at times in parts of the watershed. *E. coli* is found in higher abundance, though not exclusively, in the southern portion of the river, the estuary, and in Passamaquoddy Bay.

2.4 Nutrients

Phosphorus and nitrogen are common elements which are necessary for plant life. Having an overabundance of these nutrients in an aquatic ecosystem can lead to eutrophication, a process of accelerated aging of the water body that includes excessive algal growth and some species of algae are harmful to human health (see Algal Toxins). Eutrophication also leads to reduced amounts of dissolved oxygen (DO) being available in the water for living organisms due to consumption of DO by large masses of decaying plants, resulting in deteriorating water quality.

Nutrients originate from a variety of sources, some natural and some associated with anthropogenic activity. Wastewater treatment plant effluents have been identified as nutrient sources (see Wastewater Effluents) however treatment now typically includes some level of removal of phosphorus before release. Fertilizers from farm fields and residential lawns can also contribute significant amounts of nutrients to water either through being flushed into adjacent waterways or sewer systems which are not treated prior to release, or through entering the groundwater. The practice of spreading treated solid waste from waste water treatment plants on agricultural fields means that nutrients (and other substances) which were originally diverted from release in waterways via effluent eventually enter waterways through runoff from agricultural fields. Private septic systems which are working improperly or are flooded during high water periods may also be a nutrient source.

Environment Canada (EC) and the New Brunswick Department of Environment have two water quality monitoring stations, one at the outlet of East Grand Lake Dam (Maine) and the other at the Milltown Dam in St. Stephen. USGS has a station upstream of the Milltown Dam.

IJC objectives for dissolved oxygen are minimum 5.0 mg/L, and at all monitoring stations readings were above the minimum, an indication that eutrophication is not occurring even in areas where elevated nutrient concentrations may be occurring. This may be due, in part, to the characteristics of the river and its flows.

The Water Quality Survey which was done in the St. Croix watershed between 1996 and 2005 indicates that reduced dissolved oxygen occurred in 2% of samples, elevated nitrates occurred in 1% of samples, and pH did not meet guidelines in 2% of samples. These numbers indicate that there may some local areas of concern but that nutrient levels in the waterway do not appear to be a widespread issue.

An example of overabundance of nutrients in an aquatic system can be found in Wauklahegan Lake. This New Brunswick lake has elevated levels of phosphorus, which is traditionally considered to be a limiting factor in plant growth as it is not typically abundant. The lake experiences algae growth in the summer, reducing its suitability for recreational activities.

The village of McAdam is located on the lake. A wastewater treatment plant (WWTP) was installed in 1976 which discharges effluent into Station Brook, which empties into Wauklahegan Lake. Over the years the village has reduced the amount of phosphorus in the effluent in an attempt to reduce the amount of phosphorus in the lake, but phosphorus in the lake continues to be elevated and algae blooms have continued (NATECH 2005). The WWTP experiences a number of overflows a year, contributing to the phosphorus loading (see Municipal Wastewater Treatment and CSOs in the St. Croix Watershed).

Studies were completed by NATECH Environmental Services for the Village of McAdam to determine the origin of the excess phosphorus. It was determined that there are a number of contributing factors, some natural and some anthropogenic, which combined result in excess total phosphorus in the lake, enhancing algae blooms, and causing the degradation of the lake water quality. The physical characteristics of the lake, which is shallow and has only three inlets and one outlet which does not have significant low water flows, contribute considerably to the problem. The shallow waters warm quickly during warm months. Oxygen is depleted in the still waters and eutrophication occurs, which are prime conditions for the release of phosphorus from lake bottom sediment. It was estimated that the bottom sediment contribution to phosphorus in the lake increases from 16% to 42% in summer low flow conditions. It should be noted that blue-green algae has not been observed.

Summer low flows for 2005 were calculated and the major input was from an adjacent lake, Modsley Lake which flows into Wauklahegan by Colter Brook. Water from this lake contributed 32% of the total phosphorus input (NATECH 2005). Its sources are not included in the report. Urban runoff (11%) and the WWTP (18%) combined contributed almost 30% of the total phosphorus input. WWTP overflows were not included in the 2005 report. WWTP overflows were later estimated to contribute as much as an additional five percent to total phosphorus loading (NATECH 2006).

This example illustrates the complexity of addressing water quality issues. Recommendations have been put forward to help reduce phosphorus loading in the lake and it is clear that solutions will need to address a number of issues to be effective.

Conclusion

Excessive nutrients, specifically phosphorus, are a contributing factor to degraded water quality in Wauklahegan Lake in the central/north part of the watershed. Studies show that sources are both natural and anthropogenic.

Nutrient loading is also a localized issue in other parts of the watershed, especially in the southern portion of the watershed.

2.5 Algal Toxins

Algae are naturally occurring organisms found in lakes and rivers and prefer warm, slow moving shallow areas, areas which may also be considered as ideal for recreational use.

Blue-green algae is a cyanobacteria which may experience large population increases, often referred to as an algae bloom, during warm summer months when nutrients such as phosphorus and nitrogen are more readily available. Total phosphorus is often a limiting factor for growth as it is not as readily available as other nutrients. When it becomes available, often due to human factors such as allowing urban runoff or sewage effluent to enter waterways, growth occurs quickly.

Some blue-green algae may release toxins, commonly microcystins. These may enter the water when the algae are exposed to chlorine or as the algae dies. Microcystins are difficult to remove from water, putting the emphasis on prevention of growth conditions for the algae especially in the vicinity of drinking water intake systems or recreational water use areas such as beaches. Pre-filtering at intakes of drinking water treatment plants can provide effective removal.

Flu like symptoms (nausea, headaches, fever, etc.) may occur if microcystins are ingested with more severe health outcomes possible if large amounts are ingested.

The Trophic State Index (TSI) is an indicator used to measure lake health. It measures a number of factors which contribute to various types of aquatic plant growth. The ranking is from 0-100 with 100 indicating high levels of chemicals and nutrients such as phosphorus and nitrogen. A low ranking suggests, in combination with other indicators, that there is likely to be little algae growth and a reduced likelihood of blue-green algae. Sixteen monitoring locations in lakes within the watershed all have TSI rankings under 60 (ISCRWB SoW 2008), rankings which are indicative of good water quality.

Algae blooms have been identified as being a local issue in Wauklahegan Lake, where elevated phosphorus levels have been identified through monitoring. The sources of the phosphorus are both natural and anthropogenic. No blue-green algae have been identified in the lake (NATECH 2005).

Blue-green algae has recently been identified in the St. Croix watershed in Chamcook Lake reservoir (L. Sochasky, D. Pupek, pers. comm. 2011), and it has been found in Lake Utopia, about 24 km (14.9 miles) NE of St. Andrews and in

Baker Lake, north of the watershed near the Quebec/New Brunswick border (NB Health News Release 2008).

Conclusion

Blue-green algae is a localized issue in the watershed, having been observed recently in the southern watershed at the Chamcook Lake reservoir which is the source of drinking water for the Town of St. Andrews, NB.

2.6 Pesticides

The term pesticide includes insecticides, fungicides, herbicides, nematocides, and rodenticides (FAO 1996). Human health may be affected by pesticides through ingestion of pesticide-contaminated water as well as through direct contact or through inhalation.

Pesticides are used for a variety of purposes. They are used to protect forests from pest outbreaks such as Spruce Budworm (*Choristoneura fumiferana* (Clem.)), in agriculture for weed control in lowbush wild blueberries (CCME 2009), and for weed control on urban gardens and lawns.

Approximately 81% of the Basin is forested and some is actively harvested for timber. Three percent of land in the St. Croix River Basin is identified as agricultural and approximately one percent is settled. Therefore pesticides may enter the waterway throughout the system as non-point source pollution after application in forests, farms, or lawns.

Pesticides such as organochlorine pesticides, polycyclic aromatic hydrocarbons (PAHs) and PCBs, have been reported to be transported long distances by air currents and deposited hundreds or thousands of miles downwind. A study done at Casco Bay, Maine, approximately 275 km (171 miles) southwest of the mouth of the St. Croix River shows estimates of dry and wet atmospheric deposition and identifies atmospheric deposition to be a significant contributor of PAHs (EPA Casco Bay 2003). Similarly, the St. Croix watershed is downwind of major population areas in both the U.S. and Canada and it is likely that there is some pesticide deposition from air currents occurs in the region as occurs with a number of other contaminants (see Acidification).

Some pesticides such as atrazine have more recently been identified as endocrine disrupting substances (EC 2002) and may have sub-lethal effects on fish and wildlife (see Endocrine Disrupting Substances). As the extent of the risk of these types of compounds is recognized, use is being restricted or substances replaced with more suitable substitutes. There are approximately 21,000 acres of wild blueberries in New Brunswick, with about half in production each year. "Wild" blueberries are farmed through clearing a forested site of its timber (NB Blueberries DAAF undated). In the past, atrazine was commonly used as a general and broadleaf weed killer in blueberry farming and on lawns but since 2005, atrazine is no longer registered in New Brunswick for use in wild blueberries (NB DAAF 2005). Water monitoring information on the presence or absence of atrazine in the watershed could not be found but it is likely that the presence of atrazine in the watershed is diminishing or non-existent. Use of biopesticides and other biocontrol tools is being encouraged as a more sustainable approach to pest control (Agriculture Canada 2011).

Canadian responsibilities for pesticide regulation and management are shared by federal, provincial and municipal agencies. Federal responsibilities include assessment of the risks posed by a pesticide to human health and safety under the Pest Management Regulatory Agency (PMRA) under Health Canada. The New Brunswick Department of Agriculture, Aquaculture, and Fisheries (DAAF) is responsible for pesticide control and licensing in the province. In the fall of 2009, New Brunswick banned the use of over 200 lawn care pesticide products, including the use of 2,4−D by homeowners (NB DE News Release 2009). Integrated Pest Management (IPM) accreditations are required for commercial-grade users and new regulatory restricts apply.

In the U.S. a federal regulatory system is in place under the U.S. Environmental Protection Agency with enforcement carried out by state authorities. The Maine Board of Pesticides Control falls under the Maine Department of Agriculture, Food, and Rural Resources and is responsible for licensing of restricted use and limited use pesticides (BPC 2011). A number of towns in Maine have restricted lawn chemicals (NRCM News Release 2010).

Pesticides may be persistent or may break down readily over a short period of time when exposed to water or air, so data on specific local practices must be collected to determine the specific types of chemicals present and adverse effects on human health. As the possible adverse effects of many types of pesticides is better understood it is likely that use patterns will shift further towards reducing cosmetic use and using as well as using less persistent and harmful compounds.

Conclusion

Pesticides are likely applied throughout the watershed in varying amounts, in forests, agricultural areas, and urban areas. Information was not found on pesticide monitoring programs or the presence of pesticides. As regulations on pesticide use become more stringent, even if pesticides are present it is anticipated that this will become less of an issue over time, with the exception of persistent compounds where in localized cases they are trapped and not flushed from the system.

Water Quality Facts

- *One drop of oil can render up to 25 litres of water unfit for drinking.*
- *One gram of 2,4-D (a common household herbicide) can contaminate ten million litres of drinking water.*
- *One gram of PCBs can make up to one billion litres of water unsuitable for freshwater aquatic life.*
- *One gram of lead in 20,000 litres of water makes it unfit for drinking. Older homes often contain plumbing made of lead or soldered in lead, which can then leach into water.*
- *Copper is another essential element – for optimal absorption and metabolism of iron and bone formation - and is fairly common in natural water. More than one milligram per litre may make water unpalatable.*

(From Environment Canada Water Introduction 2010)

2.7 Urban Runoff and Stormwater

In general, urban runoff is from a wide number of sources which are often but not always adjacent to rivers, lakes, and streams. Typically during rainfall and snowmelt, water flows across the land, picking up contaminants and then carrying these contaminants into waterways. This is referred to as non-point source pollution and may be bacterial or chemical. Runoff may also be collected in catch basins and piped directly to waterways or be sent to storm water ponds to settle out solids. Contaminants in runoff may have adverse human and ecosystem health effects.

As well as chemical contaminants being flushed into natural water systems from residential and institutional lawns and golf courses, *E. coli* and other bacterial contaminants may enter waterways this way. Pet and wildlife (e.g. aquatic birds) feces are a major source of *E. coli* contamination. Fecal contamination is often present at parks adjacent to waterways as well as waterfront private residences. Residential septic systems may also contribute to nutrient and bacterial loading in waterways, primarily if placed close to surface water. Septic systems are especially at risk of failure in flood prone areas where surface water or shallow groundwater may overwhelm the system.

Impervious surfaces such as asphalt parking lots and roads collect a number of contaminants from the vehicles using them. Road salt, gasoline, and other contaminants may quickly enter waterways during rain or snowmelt where stormwater ponds are not in place, without the benefit of being at least partially removed from the water through soil infiltration or settling.

Concerns from runoff are not due only to chemical or bacterial contaminants. The International St. Croix River Watershed Board's (ISCRWB) 2008 Annual Report discusses quarrying activities in the Industrial Park by Jamer Materials Ltd. The Board had expressed concerns since 2001 over siltation issues and associated effects on fish habitat resulting in the loss of local scallop grounds (ISCRWB 2008). In this situation the concern is due to dust and silt from quarrying activities which finds its way into the waterway during periods of rainfall and snowmelt and degrades aquatic ecosystems.

The challenge in addressing contamination from urban runoff is that it is widespread and from non-point sources, so entry into waterways is pervasive though individual volumes may be small. This type of water contamination cannot readily be monitored except by general monitoring downstream of an urban area or other area suspected of contamination such as an agricultural area or rural residential area. Since much of it originates on privately owned lands, public outreach and cooperation is vital to adequately address the sources. Stormwater ponds can be used to allow partial settling of sediments and contaminants and while these catchment areas may have issues of their own they can provide a limited answer to reducing some effects of urban runoff.

In Maine a Non-point Source Water Pollution Management Program statute was enacted in 1991 to address runoff containing contaminants and sediment. Maine regulates land use within 250 ft. (76.2 m) of the St. Croix to reduce runoff and contamination, and its water classification system in in place to protect surface waters from further degradation and encourage remediation in identified areas (L. Sochasky pers. comm. 2011).

In Canada and the U.S., fish habitat which may be degraded through sedimentation and water contamination is protected under the respective federal Fisheries Acts.

The New Brunswick Clean Water Act, 1990, requires permitting for site alteration or timber harvesting within 30 m (98.4 ft.) of freshwater shorelines. This provides a riparian buffer zone aimed at reducing non-point source pollution and erosion. A water classification system is partly in place, restricting land use upstream of municipal surface water drinking water intakes.

Though this watershed does not have any large cities located on boundary waterways, locally urban runoff is generated the towns and villages which are adjacent to the lakes, the main river, and its tributaries. Newer residential and especially commercial development often includes a large percentage of the site being paved to provide for roads and adequate parking, so may result in larger volumes of runoff (L. Sochasky pers. comm. 2011). The Water Quality Survey (1996-2006) for the St. Croix River included a number of categories based on CCME Guidelines for Freshwater Aquatic Life.

From thirty-two sample sites throughout the watershed, considering four key indicators;

- Dissolved oxygen minimum levels was not met for 2% of samples;
- *E. coli* was above guideline levels for 8% of samples;
- Nitrate was above guideline levels for 1% of samples; and
- pH did not meet the guideline for 2% of samples.

Conclusion

Reductions in water quality in the southern portion of the river are likely due in part to a number of contaminants entering the waterway through urban non-point source pollution.

2.8 Water Quantity and Water Management

Water volumes in a naturally flowing river system vary seasonally due to changes in precipitation, temperature, and the associated amount of evapotranspiration (evaporation and transpiration by plants). Flow rates and water levels change with the seasons and usually have historic seasonal characteristics of highs and lows. Modifying these natural levels and flow rates can have a positive or negative effect on water quality and aquatic ecosystems but often the results are mixed. Changes in water levels and flows which affect water quality and change the balance of an ecosystem can inadvertently have adverse impacts on human health.

In managed systems flows and water levels are modified, holding back water at times and increasing water flows and levels beyond natural amounts at other times. Dams may have been built for a number of reasons, most often to control water levels and for power generation. Control dams are used to influence water levels, usually to reduce seasonal high and low periods and distribute water more evenly in an effort to balance water needs throughout the system. Hydro dams may hold back water in reservoirs, to be used in lower flow times for power generation, or they may be run-of-river, which generates power from existing flows. Some dams have historical significance related to historical timber movement which date back to the 1700s (ISCRWB SoW 2008).

Water management may result in direct or indirect effects on human health and safety, changing flood risk in parts of the watershed or modifying water quality for better or worse. Usually reduction of flood risk is a high priority for water management plans (see Water Quantity and Extreme Events) and the plans also have minimum water flow and level requirements.

The level of impact dams have on water quality and aquatic ecosystems is partly dependent on the specific components of each natural system and the level of adaptability the species in that system may have to changes which occur. In some instances water quality can be improved through introducing higher flows during what would naturally be low flow periods when dissolved oxygen would be depleted. Dams have been in the waterway for a century or more so aquatic and near shore communities will have long adjusted from what were once natural flows and levels.

In some local instances water management may result in flows or water levels being reduced in an effort to ensure water is available for other parts of the system. Areas of low summer flows and water levels and high water temperatures provide favourable conditions for algal and bacterial growth. When this happens, changes in the water quality puts stresses on the aquatic ecosystem and the system will change over time, striving to find a new equilibrium. Minimum flow and water level requirements are designed to address this problem.

The dams may be barriers to movement and migration of many diadromous fish species and this has been mitigated in the watershed through development of fish passage structures. These structures are usually designed for passage by specific fish species. Fish passages may provide opportunities for small aquatic organisms to move through the river system during periods when water is not flowing through the dams.

Dams in the St. Croix River

There are currently an estimated 38 control dams of various types in the St. Croix basin, including six major dams used for water level control and hydroelectric facilities. Many of these dams have been in place since the mid to late 1800s, and the rest since the early 1900s. Water levels and flows in the watershed are overseen by the ISCRWB. Minimum and maximum water levels, along with set minimum flow rates provide an operating range for dam operators (ISCRWB SoW 2008).

Dam operators are required to manage the water levels and flows in the river system within prescribed parameters. The 2009 ISCRWB Annual Report shows that water levels and flows throughout the river system were within prescribed limits (ISCRWB 2009) and this appears to be the norm.

Dam Name	Owner/operator	Dam Type
Woodland dam	IGIC	hydroelectric
Milltown dam	NB Power	hydroelectric
West Grand dam	IGIC	control
Grand falls dam	IGIC	hydroelectric
Vanceboro dam	IGIC	control
Forest City	IGIC	control

Table 5. Major Dams in the St. Croix River.
Source: ISCRWB State of the Watershed Report. 2008.

Dam failure can also be a concern for flooding of downstream communities as it may pose a flood risk. Many of the dams in the river have been in place at least a century and require regular monitoring and maintenance. A 1998 IJC study of dams in international waterways notes that there may not be regular domestic government inspections and inspection reports for some dams in the St. Croix River (IJC 1998). It was also noted that inspections may take place but that the information was not available. Dam owners usually have a program for inspecting their facilities, often by consulting engineers but the availability of the results to the public varies (IJC 1998).

There are different approaches on either side of the border to ensuring dam safety. In the U.S. there is federal dam safety legislation in place under the U.S National Dam Safety Program for Regulated Facilities. The Regulated Facilities include the U.S. portions of the Forest City, Vanceboro, Grand Falls, and Milltown dams. States are responsible for dam safety at other sites. The U.S. Federal Energy Regulatory Commission (FERC) also inspects the Canadian portions of the Forest City and Vanceboro dams (IJC 2006).

In Canada there was not a Regulated Facility safety program in place by either the federal or provincial government in an IJC report on dams in 1998 (IJC 1998). Current information was not found so it is not known if this issue has been addressed.

Profession associations on either side of the border include the Canadian Dam Association, which issued Dam Safety Guidelines in 2007 and provides a number of Technical Bulletins (CDA 2011), and the U.S. Association of State Dam Safety Officials which works in conjunction with the National Dam Safety Program, the Federal Emergency Management Agency, and the Interagency Committee on Dam Safety. The Interagency Committee promotes communications and represents state interests when dealing with federal agencies and Congress (IJC 1998).

Conclusion

Water levels and flows are regulated in the St. Croix system and are typically operated within prescribed limits. Information on aging dam structures in the watershed is not universally available, though it is likely that regular dam maintenance is occurring and there is likely little threat of dam failure.

2.9 Water Quantity and Extreme Events

Extreme events may be prolonged periods of no rainfall, quick snowmelt, and too much precipitation. Precipitation events may occur as intense rainfall over a short period of time or less intense rainfall which continues over a long period. Rainfall combined with a quick melt of the snowpack can also create extreme conditions. High water can create a direct risk to human health through flooding and contamination. Drought can reduce water quality and availability, potentially affecting both human and ecosystem health.

Water management strategies strive to keep water levels and flows in the river system within certain minimum and maximum limits and is planned and scheduled based on historical water level and flow patterns of the river.

Lower water levels resulting from summer drought may affect water quality as bacterial and algal growth is more likely to occur in warmer water temperatures and where there are low flows. In particular reservoirs may be susceptible to increased rates of bacterial and algal growth where there may be drawdown as a result of increased demand coupled with higher temperatures during hot dry periods. As with rain events, water level decrease associated with drought are somewhat offset in the main stem of the river and its upper lakes through water level management but these management strategies have limited influences on some of the outer waterways and none on lakes which are not part of the system.

High water levels and increased water flows in spring are a normal occurrence in many watersheds including the St. Croix, especially in areas where heavy snowpacks may melt quickly and are augmented by spring rains. When this occurs water levels can increase quickly over a short period of time. In areas such as the St. Croix watershed where water control structures are in place, high water and flooding can often be alleviated through careful management, holding water back and releasing it at each of the dams in such a way as to avoid or reduce flooding.

Extreme events may occur which exceed the capacity of water management to alleviate. Heavy rains and prolonged storms at 'non-traditional' times such as in mid-winter can increase water volumes when storage areas are already full and flows are high. During these times dam operators are challenged to find a balance between holding back and releasing water.

Localized flooding in built up areas can also occur not only from river water but from rainfall collecting more quickly than it can run off into the waterway. In areas with a high percentage of impermeable surfaces, runoff gets trapped by undersized culverts and storm water drainage systems which were not designed for the load (see Urban Runoff and Stormwater).

Infrequent flood events have been reported in the watershed but generally appear to be localized. A report of floods of record indicates that on May 1, 1923 the St. Croix River stream gauge at Baring, Maine measured a discharge of 24,100 cubic feet (682.4 m^3) per second, considered to be the worse flood in the watershed (ENSR 2007).

An example of localized flooding occurred during a rain event in mid-December, 2010. During this event St. Stephen received 174 mm (6.9 in.) of rain, the third highest amount recorded (the first and second highest events both were spring rains). Local roads and homes were flooded, and large amounts of waters quickly filled local tributaries and ditches. A gas station was also flooded (L. Sochasky pers. comm. 2011). During and immediately after the event, dams in the St. Croix were successfully operated as to release the water accumulating in the river so that no widespread flooding occurred (L. Sochasky pers. comm. 2011).

Understanding how local land surfaces will react to heavy rainfall events is important in preventing both flooding and contaminant movement into local waterways. Impervious surface mapping is a useful tool in determining where water will run off in built up areas and where opportunities exist to promote natural infiltration or storm water ponds. This type of mapping is currently in the process of being developed in the region (L. Sochasky pers. comm. 2011).

Conclusion

Widespread flooding has not been an issue in the watershed with a few exceptions and in most instances is prevented through water management responses. Localized flooding was recorded in the southern portion of watershed during rainfall events including a recent event in 2010, likely due in part to restrictions in infrastructure (e.g. culverts) slowing runoff in urban areas.

2.10 Climate Change and Water

Human health may be affected by climate change either directly or indirectly. Direct effects may include injury or death from violent storms and resulting flooding. The increased frequency of precipitation events has already been observed in New Brunswick (NB 2007).

Climate change has the potential to impact built landscapes and infrastructure of human communities (HC CC 2008). When there are changes in climate the balances in water volumes of both surface water and groundwater may change over time. This can influence the health of aquatic communities which in turn may have indirect effects on human health through reductions in water quality or fish health.

Effects of a changing climate are becoming evident in both gradual trends and in increased variability of weather patterns. Gradual changes in annual average temperature, precipitation patterns and wind are being noted, and are projected to continue. An increase in weather variability and the number of extreme weather events is also forecast for the region.

Annual average temperatures in the region are forecast to increase, with temperatures in Northeastern U.S., including the St. Croix River watershed, predicted to rise 2.5°F to 4°F (1.4^{o}C to 2.2^{o}C) in winter and 1.5°F to 3.5°F (0.8^{o}C to 1.9^{o}C) in summer by the year 2100 (NCIAST 2007). Water temperatures change at a slower rate than air temperatures, warming and cooling more slowly. Water bodies, therefore, have a lag in temperature increase in the short term, but will also retain their temperature in the short term when air temperatures drop.

As average winter temperatures rise, there is an increased likelihood of more winter thaws and a higher percentage of winter precipitation falling as rain. This translates into increased likelihoods of higher winter flow rates in rivers and streams, earlier and reduced spring freshet, and increased risks of early ice-jam flooding in susceptible areas. Winter minimum temperatures (usually occurring at night) are predicted to rise at a faster rate than average temperatures.

Earlier spring temperatures and higher summer temperatures mean that surface water temperatures will likely also be higher. Higher water temperatures affect aquatic ecosystems and may encourage increased aquatic plant and bacterial growth, degrading water quality and under some circumstances making it unfit for human consumption or recreational use.

Average annual precipitation is forecast to steadily increase, with winter precipitation being the key season where the increases will occur. By the year 2100, winter precipitation may increase by 20-30% (NCIAST 2007). So as well a higher percentage of winter precipitation occurring as rain, projections are for more winter precipitation overall.

Rain events have both direct and indirect implications to human health and safety component where coastal and riverfront communities are at increased risk from flooding.

As well as the dangers from flooding to affected individuals and communities, indirect effects include drinking water infrastructure damage and sewage treatment systems which may be overwhelmed, both which may affect accessibility to safe drinking water and may make recreational activities unsafe.

Heavy summer storm events flush a number of bacterial and chemical contaminants from adjacent land into surface waters, referred to as non-point source contamination (see Urban Runoff). Sudden heavy flows can also disturb contaminants which may have collected in sediment on river, stream and lake bottoms in situations where flows suddenly increase. Both result in increased water contamination and decreased water quality. The number of heavy summer storms, interspersed with dry periods, is forecast to increase.

Increases in temperature and changes in precipitation patterns may, in turn, influence other components of the watershed's water budget such as evapotranspiration (the estimate of a loss of water to the atmosphere through a combination of evaporation and transpiration, referred to as ET). ET tends to increase as air temperature and winds increase. As ET increases it may contribute to lower lake and river levels and drier soils.

Summer drought events are predicted to become more prevalent over time as the climate changes. As water quantity in surface waters is reduced in summer, coupled with higher temperatures, bacterial and organic problems may increase in some parts of the river. This may become evident through the predominance of swimmer's itch in shallow areas which are favoured for swimming and can be the time when other waterborne diseases flourish. Recreational contact and involuntary ingestion of untreated water is likely to be where human health affects become evident.

During summer, increased temperatures and drought can reduce the volume of water in soils for prolonged periods which can stress agricultural crops. In the case of annual crops which grow quickly and often require constant moisture, this may increase water demand, often from surface water sources, for crop irrigation. When drawn from smaller water bodies such as creeks and small lakes, reduced volumes of these surface waters may result in reduced water quality. Smaller volumes of water will increase temperature more quickly, providing favourable conditions for bacterial growth. As water from these surface water sources is used for irrigation it then increases the risk of exposing crops to contamination.

Climate change often serves to augment existing water quality and quantity issues. For example, shorter ice cover periods on lakes and rivers with later ice-on and earlier ice-off dates can contribute to increases in the risk of algal blooms in susceptible areas as water temperatures increase earlier in spring. Algal blooms can affect human health through ingestion (see Algal Toxins) and are often indicative of aquatic ecosystem stress.

New Brunswick has developed a Climate Change Action Plan 2007-2012 which addresses both mitigation and adaptation. This plan indicates that "climate models predict average global temperature increases toward the higher end of the 1.4 to 5.8 degrees Celsius range relative to 1990 by the year 2100." The plan recognizes the need, among other potential water issues, to protect drinking water from salt water intrusion through the development of a provincial water management strategy.

Maine's adaptation report People and Nature, Adapting to a Changing Climate: Charting Maine's Course, was presented by the Maine Department of Environmental Protection to the Joint Standing Committee on Natural Resources in February, 2010. This report takes an integrated approach to adapting to climate change and encourages a "focus on taking action on a "no regrets" basis – for example, improving stormwater and wastewater infrastructure to protect water quality in any eventuality."

The Northeast Climate Impacts Assessment Synthesis Team (NCIAST) developed the 2007 report Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. This report notes that the northeastern states, including Maine, are already experiencing changes consistent with climate change. Regional temperatures have increased by an average of 0.5oF per decade, with winter temperatures increasing at a faster rate.

With the challenges of seasonal changes and shifts in available surface water, water quantity and quality management strategies may require review and modifications over time to continue to protect communities from flooding and safeguard aquatic ecosystem health.

It should be noted that as air temperatures increase and the risk of hot spells increases there are a number of implications for human health which fall outside the scope of this report, including increased heat related illnesses, decreased air quality associated with ozone and other contaminants (HC CC 2008), and the northward spread of diseases such as Lyme's Disease.

Conclusion

Climate change is projected to modify temperature and precipitation patterns in the watershed. It will likely have more impact on water quality and quantity over time and may amplify other stressors already occurring in the watershed in addition to creating new issues. The result may be an increase in bacterial and algal concentrations in some locations where conditions are favourable.

2.11 Endocrine Disrupting Substances, Pharmaceuticals and Personal Care Products

Endocrine disrupting substances (EDS) are both naturally occurring and are man-made. The key concerns with EDS are;

- they may interfere with hormonal function in humans and animals even when exposure is in low doses;
- they can affect most organs;
- they are persistent; and
- they are widespread in the environment (US HHS 2010).

A number of EDS may be found in municipal or industrial effluents, including nonylphenol and estrone. Dioxins and furans, found in pulp processing effluent, have also been identified as potentially affecting the endocrine system (HC Dioxins and Furans 2006).

At least 80 pharmaceuticals and personal care products (PPCPs) have been found worldwide originating in wastewater as well as from non-point source practices. PPCPs have also been found in groundwater. This is a relatively new field of study and recent studies indication that some PPCPs may cause environmental harm.

Studies on juvenile Atlantic salmon indicate that exposure to nonylphenol, estradiol, or methyl testosterone for a week in fresh water results in a higher percentage of small fish in the fall. A study of Coho and Chinook salmon exposed the fish to concentrations similar to those found in some municipal wastewater, resulting in changes in immune-related and metabolism-based genes. A study of blue mussels exposed to wastewater in Pictou Harbour, NB and Burrard Inlet, BC also suggests that treated and untreated wastewater "can modulate the immune system" (EC 2009), in part due to exposure to EDS.

Substances such as atrazine, which was used for general weed control as well as a weed control in low brush blueberries, corn, and rapeseed has been found in Canada in drinking water originating from both surface and groundwater (CCME 2009). Atrazine may enter waterways through runoff from treated agricultural areas (EC EDS 2008), through spillage, or from accidental release during the production or shipping process. Generally, fish and wildlife reproduction and development may be affected by exposure to EDS.

In the case of atrazine in Canada, studies of a number of substances previously included studying the subtle, sub-lethal effects of EDS on organisms under Environment Canada's Toxic Substances Research Initiative (EC 2002). Environment Canada continues to conduct research into sub-lethal effects of EDS on organisms, fish, and wildlife (Melanie Nelson, Environment Canada, Manager, Water Quality Monitoring & Surveillance – Ontario, pers. comm. June 5, 2009).

The Canadian Federal-Provincial-Territorial Committee on Drinking Water has set an interim acceptable maximum atrazine concentration of 5 micrograms per litre water and the Canadian Water Drinking Guideline for Protection of Aquatic Life limits atrazine at 1.8 micrograms per litre water (CCME 2009). Higher than recommended levels of atrazine in drinking water can affect human health and short term exposure can cause dizziness and nausea. There are some concerns of an association between longer termer exposure to atrazine and some cancers (CCME 2009).

Environment Canada recognizes that a coordinated monitoring program is needed to further identify issues and determine specific compounds for study (Environment Canada 2008). Options for managing environmental exposure to PPCPs include treating wastewater effluent, drinking water treatment where the source is surface water, prevention through source control and source separation, and biosolids management and agricultural BMPs. All of these approaches would be complex and costly and discussions are in early stages (EC 2009).

In the U.S., the EPA has developed a strategy to increase the understanding of PPCPs, develop monitoring programs and education programs, and determine whether and when related legislation may be required (EPA 2009).

Conclusion

As very low levels of EDS and PPCPs are widespread in both municipal and industrial effluents they are likely to be present in the watershed, especially in the southern portion of the river where wastewater treatment plants are located, but specific information on their presence, or significance, was not found.

2.12 Acidification

Water acidification may be due to natural processes or anthropogenic activities. Acidification of surface water can occur naturally from contact with peat-based soils. Water pH levels may also be reduced by runoff of fertilizers, from livestock manure entering waterways, or from acid precipitation.

Acid precipitation (rain and snow) is caused by air contaminants which change in the atmosphere and become acidic. Sulphur dioxide, nitrous oxides, and ammonia once modified may fall as acid rain or dry, deposited by air currents onto waterways and land.

The degree of impact of acidification on waterways is influenced by the geology of the watershed. Critical loads for acidification are identified as the annual amount of sulfate that falls per hectare and the most sensitive areas have the lowest critical loads, with areas of southwestern New Brunswick falling in that category.

Potential health effects may occur from exposure to concentrations of some airborne contaminants which cause acidification (Netherlands EAA 2005). Acidification may also result in increased human and fish exposure to heavy metals such as mercury and aluminum in toxic amounts. In a study on acid rain effects, these metals were found to be released from sediment in the Experimental Lakes area of northern Ontario when water pH was lowered (DFO 2009).

Acid rain was first identified as an issue in the 1980s, and local monitoring has continued since then as efforts to reduce emissions has continued. The 1991 Canada-United States Air Quality Agreement's Acid Rain Annex committed both countries to reducing sulphur dioxide and nitrogen oxides. In 2008, Canada's total sulphur dioxide emissions had decreased by 47% and U.S. emissions by 51% from 1990 levels (AQA 2010).

Acidification continues to be an issue in northeastern North America on both sides of the border and in New Brunswick critical loads continue to be exceeded (NB Air Quality 2009). The source can be local or contaminants may be carried long distances, such as from highly populated areas west and south of the St. Croix watershed.

Conclusion

Acidification has been an issue in the area for decades and will likely continue to be an issue until sources both inside and outside with watershed are reduced.

2.13 Drinking Water Treatment and Distribution Systems

Drinking water for municipal and private drinking water systems may be from groundwater or surface water sources. Most drinking water in the St. Croix watershed originates as groundwater.

Municipal drinking water systems must meet a number of requirements and standards for all parts of the system to ensure the safety of water users. Any possible presence of bacteria is addressed through routine treatments of municipal source water and water is tested frequently. Domestic wells are not regulated to the same extent but private well owners are strongly encouraged to have their water tested regularly for the possibility of bacterial contaminants.

2.13.1 Source Water Protection

Source water is the "raw" water that is treated at municipal or private drinking water treatment plants prior to distribution for consumption. Source water refers to both surface water and groundwater drinking water sources. Protection of source water through ensuring contaminants are not entering it is important in protecting human health, and also has the benefit of protecting the aquatic ecosystems present in the source water. The goal of source water protection is not to ensure sources of drinking water are pure but rather to ensure that substances related to anthropogenic activities do not enter the water and that natural levels of organic and inorganic compounds are all that is present. Source water protection also protects water quantity to ensure that enough water continues to be available for drinking water needs.

2.13.2 Drinking Water Treatment

Drinking water treatment addresses key bacterial and known chemical contaminants in water prior to distribution. Treated water may contain trace amounts of a number of other substances depending on the water source, and these substances may fall outside monitoring parameters as their presence in the water is either not known or they have been determined to not pose a health risk.

Municipal drinking water sources in the St. Croix watershed are generally from groundwater which often reduces the likelihood of airborne and some waterborne contaminants being present. The one exception is St. Andrews' drinking water source, which is a reservoir fed from Chamcook Lake. As a surface water municipal drinking water source, the reservoir may be more susceptible to bacterial contaminants than groundwater and may also be susceptible to atmospheric contaminant deposition.

2.13.3 Drinking Water Distribution Systems

Water treatment is an important component of providing safe water but it is not the complete picture. Drinking water distribution systems require protection and monitoring to ensure that contamination does not enter the system between the treatment system and access points. This can occur due to water main breaks or improper systems maintenance procedures as well as through failures in the treatment system if safeguards are not in place.

Protocols which address drinking water treatment for systems supplying five or more private households as well as larger public systems have been developed for First Nations communities in Canada under the federal Department of Indian and Northern Affairs Canada (INAC). These protocols include the design and implementation of water monitoring programs that incorporate the multi-barrier approach to providing safe drinking water and that recognize the importance of source protection (INAC 2009). Additionally, the INAC protocols for safe drinking water include ensuring protection of drinking water distribution systems from re-infecting drinking water after treatment (INAC 2009).

In Maine, the U.S. the Office of Ground Water and Drinking Water, under the EPA, is in charge of ensuring safe drinking water. It is recognized that the presence of some of the 90 contaminants and indicators it tests for in drinking water may be due to the integrity of the distribution system (EPA 2010).

In New Brunswick, water distribution systems are tested by the province on a rotational annual basis. Local testing is also completed regularly (D. Pupek pers. comm. 2011).

2.13.4 Drinking Water Regulations

In the U.S., the federal Environmental Protection Agency sets public drinking water quality standards based on approximately 90 contaminants and indicators. Private drinking water wells are regulated by states and municipalities. The Maine government and municipalities carry out water quality administration and enforcement.

Maine has a water classification system which has been in place since the 1950s.This system classifies surface water bodies and requires the retention of the water quality at a specific level. The quality of water in Classes AA through C must all be suitable for drinking water purposes after treatment. The St. Croix River has been assigned a number of classifications as follows:

A. St. Croix River, main stem.
(1) Except as otherwise provided, from the outlet of Chiputneticook Lakes to its confluence with the Woodland Lake impoundment, those waters lying within the State - Class A.
(2) Those waters impounded in the Grand Falls Flowage including those waters between Route 1 (Princeton and Indian Township) and Grand Falls Dam - Class GPA.
(3) Woodland Lake impoundment - Class C.
(4) From the Woodland Dam to tidewater, those waters lying within the State, including all impoundments - Class C. [2009, c. 163, §9 (AMD).]

B. St. Croix River, tributaries, those waters lying within the State - Class B unless otherwise specified.
(1) All tributaries entering upstream from the dam at Calais, the drainage areas of which are wholly within the State - Class A unless otherwise classified.
(2) Tomah Stream - Class AA.
(3) Monument Brook - Class A.
(4) Waters connecting the Chiputneticook Lakes, including The Thoroughfare, Forest City Stream and Mud Lake Stream - Class A. [2003, c. 317, §16 (AMD).] (ME Statutes 2011).

Groundwater classification in Maine is broken into two classes. Class GW-A is highest quality and can be used for municipal drinking water and Class GW-B is suitable for all other uses (ME Statutes 2011).

Canada has incorporated a multi-barrier system to ensure the protection of drinking water. The federal Health Canada agency issued Health Canada's Guidelines for Canadian Drinking Water Quality. These are incorporated into provincial (New Brunswick) regulations. Municipalities which operate drinking water treatment facilities are required to meet provincial regulations.

To help protect surface water drinking water sources, the New Brunswick government has a watershed protection program which sets land use regulations in identified watersheds, including Chamcook Lake, which supplies the reservoir for St. Andrews' municipal drinking water. Land and waterway uses are regulated in these areas, with greater restrictions closer to the municipal water intake (NB Watershed Protection undated). The reservoir is continuously monitored under Environment Watershed Protection Program.

Conclusion

Municipal drinking water in the watershed, originating from either surface water or groundwater, is protected from a number of contaminants by multiple levels of government regulations on both sides of the border throughout the treatment and distribution systems. Regular testing occurs throughout the systems to ensure compliance.

2.14 Emerging Issues

2.14.1 Airborne originating contaminants

It is recognized that a number of airborne contaminants are eventually deposited in surface waters. These contaminants may originate locally or may cross state, provincial, or international boundaries from the point of origin. This may occur either during transport by prevailing winds or when traveling by water.

Mercury

Mercury in water may come from natural processes or may have been introduced due to anthropogenic activity. It usually enters the body through ingestion, generally through consumption of fish and wildlife. Mercury accumulates in muscle tissue of fish (USGS 2000). The level of toxicity is partly dependent on its form, with Methylmercury identified as the most toxic form. Embryos are particularly susceptible. Human health effects of methylmercury exposure include damage to the nervous system and altering of genetic and enzyme systems. Methylmercury also affects the immune system. Elemental mercury is less toxic but is more readily available in higher concentrations in areas where gold mining occurs as it is used for gold extraction (USGS 2000).

It is estimated that globally between 25% and 50% of mercury found in the atmospheric is naturally occurring (HC Mercury 2007). In 1998 it was estimated that at least 30% of the mercury which was deposited in northeastern North America came from sources outside the region, usually from emissions from industry and cars (NEGECP 1998). These sources, combined with local sources both from anthropogenic and natural origins, result in mercury being readily available in waterways.

As with many states and provinces across North America, Maine has a fish consumption advisory in place on fish from all inland waters in the state, including those in the St. Croix watershed. This is due in part to mercury bioaccumulation. The state advisory identifies pregnant women and children less than 8 years of age as being at risk and states that these groups should generally not eat inland waters freshwater fish. Others outside the advisory focus should only consume two fish meals a month (Maine 2006).

The New Brunswick "Fish 2010" publication provides guidelines for freshwater fish consumption for a number of species due to elevated mercury levels which are partly attributed to atmospheric deposition. As with Maine, pregnant women and children under eight years of age are advised not to consume wild freshwater fish (except for brook trout less than 29 cm or 11.4 in.) in New Brunswick. Limited fish consumption of one meal every two weeks is generally suggested for individuals outside the general advisory focus (NB Fish 2010).

The National Atmospheric Deposition Program (NADP) has a Mercury Deposition Network (MDN) which has long term records of total Mercury. This program has over 100 sites in the U.S. and Canada. There is also the Atmospheric Mercury Network (AMNet), which has 21 automated sites where continuous monitoring occurs (NADP 2009).

The 1998 Mercury Action Plan was developed by the New England Governors and Eastern Canada Premiers and identifies steps to address mercury in the region through "virtual elimination of anthropogenic mercury releases in the region" (NEGECP 1998). This will be accomplished in part through collecting relevant local information and data on mercury.

Ozone

Nitrogen oxides and sulphur dioxide are industrial and vehicle emissions which may travel long distances in air currents prior to being deposited in the watershed. Discussions on the effect of these contaminants on water and human health can be found in the previous discussion on Acidification.

There are a number of large air quality networks in place across North America. Sites are maintained by various levels of government that contribute or share data with the larger networks.

Maine's Bureau of Air Quality has a Daily Ozone count by Air Quality Index readings posted on its website. Historical data indicates that annual summary data for 1980-2010 the number of "Very Unhealthy" and "Unhealthy" days has decreased in the past decade, an indication that the amount of ozone has been reduced (Maine AQI 2010).

Until recently local emissions contributions in urban areas in the southern portion of the watershed may in part have been attributed to long lineups at the St. Stephen and Calais border crossing, one of the busiest Canada/U.S. ports of entry. In December of 2009 a new crossing was opened and truck traffic rerouted to it, out of the downtown areas (L. Sochasky pers. comm. Feb. 2011).

Air quality in the St. Croix River watershed is considered to be generally good, though there may be localized reductions in quality related to traffic congestion at the border crossings located in towns.

2.14.2 Natural gas shipping

Calais LNG had preliminary plans and had filed an application to the Maine Board of Environmental Protection, to build a Liquid Natural Gas (LNG) import and storage terminal approximately six miles south of Calais on the St. Croix River. A connecting pipeline would be built to join the existing pipeline near Baileyville, ME, approximately 20 miles (32 km) away. After several delays, the application was withdrawn in December 2010.

Access to the site where the facility was proposed is through Passamaquoddy Bay and an area that the Canadian federal government considers to be Canadian internal waters (BDN 2010). A general information point in the International St. Croix River Watershed Board's 2009 Annual Report states, "In a letter dated April 7, 2006, the Canadian Ambassador to the U.S. conveyed Canada's strong concerns with the passage of LNG vessels through Head Harbor Passage to access the Maine LNG sites" (ISCRWB 2009).

A second proposal is for a LNG import and storage terminal in Robbinston, near the confluence of Passamaquoddy Bay and the St. Croix River. From there, a pipeline of approximately 30 miles (48 km) is proposed to be built to Baileyville.

As with any shipping facility there are a number of water quality concerns which could affect human health including chemical and gas spills, and emissions which could degrade local air and water quality (L. Sochasky pers. comm. 2011).

2.14.3 Chemicals of Concern

A number of chemicals may enter waterways through release of effluents either from direct release or spills, from atmospheric deposition, or from overland runoff. Monitoring is carried out for some of these substances and some are removed from drinking water during treatment but there may be others which remain in the water after treatment, often at very low concentrations. Potential adverse effects of many of these substances are not currently known.

In the U.S., the EPA has recently "issued a final rule under the Toxic Substances Control Act (TSCA) requiring manufacturers of 19 high production volume (HPV) chemicals to test the health and environmental effects of the chemicals" (EPA HPV 2011). These chemicals are part of a list of 2,200 HPV chemicals which was voluntarily compiled by industry, and is indicative of the large variety of anthropogenic substances which may find their way into waterways. Under the

TSCA, the EPA has set out six principles to help address the risk that some chemicals may pose to human health (EPA 2010).

In Canada, assessment and management of certain chemicals falls under the federal Toxics Substances Control Act or Canadian Environmental Protection Act regulations (ISCRWB 2009).

2.14.4 Arsenic in Drinking Water

Arsenic is a naturally occurring substance which is found in some bedrock and dissolves into groundwater. It was also used in other forms as a crop pesticide in the early 1900s (Nielsen et. al 2010) and may be found in industrial effluents. Acceptable concentrations for human consumption are 0.010 milligrams per litre (mg/l) in both Maine and New Brunswick (USGS 2010, NBGCA 2008).

Arsenic primarily enters the body through ingestion of food or water and is then distributed by the bloodstream. According to Health Canada and the International Agency for Research on Cancer, consuming levels of arsenic above 0.35 ppm (0.35 mg/l) over a lifetime can increase risk of cancer to internal organs, as well as cause a number of other health issues. There can also be health issues associated with short term ingestion of high levels of arsenic, such as abdominal pain, weakness, or numbness in hands and feet (HC Arsenic 2006).

In New Brunswick, elevated arsenic levels in groundwater have been identified in a number of areas in the watershed. New Brunswick Department of Health advises that well water which has arsenic levels above 0.010 mg/l can safely be used for bathing, washing hands, and dishwashing (NB Health Arsenic in Water undated) but should not be used for drinking water.

The USGS has completed an assessment of arsenic concentrations in Maine domestic wells, using data from 2005-09. Domestic wells provide over 80% of drinking water in Washington County, ME (Nielsen et. al 2010). Elevated levels of arsenic, above 0.010 mg/l appeared at a number of sites in the watershed.

2.14.5 Aquaculture

Aquaculture is a growing industry in the Atlantic Region, primarily salt water species and to a lesser extent freshwater species. Atlantic salmon is the primary species of fish being farmed, but the industry is expanding to include farming of cod, trout, and arctic char. New Brunswick farmed salmon is the province's largest agricultural export and currently has the annual capacity to produce 25-40 metric tonnes (ACFFA 2010).

Aquaculture activities are regulated in New Brunswick by the Department of Agriculture, Aquaculture, and Fisheries. Fish farms are also subject to a federal assessment under the Canadian Environmental Assessment Act. There are currently eight salmon farming companies across New Brunswick, including a hatchery located in Passamaquoddy Bay, owned by Cooke Aquaculture.

In Maine, aquaculture activity is evaluated and monitored by the Maine Department of Environmental Protection, and federally under the U.S. Department of Agriculture.

Sea lice can be a key issue in fish farming, and treatment is problematic due to the inability to isolate chemicals used for pest management. Sea lice do not pose a direct threat to human health. Indirect threats may come from exposure to chemicals used to treat the lice, primarily if handled improperly. Research is being conducted in Atlantic Canada to address the issue is sea lice and the effect on aquaculture operations (ACFFA 2010).

Conclusions

Mercury and ozone are issues in the watershed to differing extents and reductions will come when sources outside the watershed are reduced.

Arsenic in groundwater is at elevated levels in locations within the watershed, including in groundwater used for private wells.

3 Information Collection and Gaps

3.1 Data Collection and Analysis

Numerous agencies and organizations collect and analyze water and health information in the watershed and the region. The following are some examples of data collection and analysis activities in the St. Croix watershed. Where available information has been provided which is specific to the watershed but in some instances it is only available on a larger scale, such as for the state, province or region.

Surface Water Monitoring and Results

There are six water quality stations in the watershed. In the lower river two are in the Milltown area, one run by United States Geological Survey (USGS) and one by Environment Canada (EC). The EC station in the Milltown area is located just above the Milltown Dam in St. Stephen, New Brunswick and the USGS station is about 3000 ft. (914 m) upstream of the dam at the international bridge at Mill City, ME. The two Milltown sites monitor areas below Baileyville and generally above St. Stephen and Calais.

Other monitoring occurs at an EC station at the Forest City, ME outlet of the East Grand Lake dam and an USGS station on the Forest City Stream below the dam. There is also a station at Lewy Lake in Princeton, Maine and one at West Grand Lake at Grand Lake Stream, Maine (USGS Real-Time Data for Maine undated).

Operator/ Monitoring site	Water Quality Monitoring Parameters					
	DO	pH	Specific Conductance	Water Temperature	Turbidity	Real-Time
USGS/Milltown	√	√	√	√	?	seasonal
USGS/Forest City	√	√	√	√	?	√
USGS/W. Grand Lake	√	√	√	√	?	√
USGS/Lewy Lake	√	√	√	√	?	√
EC/Milltown	√	√	√	√	√	√
EC/Forest City	√	√	√	√	√	√

Table 6. Water Quality Monitoring Stations in the St. Croix River.
Source: International St. Croix River Watershed Board 2009 Annual Report and USGS Real-Time Data for Maine: Water Quality.

Real-time monitoring provides immediate access to information on a number of parameters and can be used to identify events and changing river characteristics which might be detrimental to human and ecosystem health. As well as continuous monitoring of a number of parameters, the EC stations are visited every four to five weeks when a grab sample is taken for analysis.

The EC Milltown, NB water quality monitoring station showed exceedences (above Canadian Council of Ministers of the Environment (CCME) aquatic ecosystem guidelines) in a number of samples of extractable aluminum in 2009. One sample had exceedences in extractable iron and extractable lead as well as increased turbidity, attributed to localized precipitation events which may have washed these contaminants into the waterway (ISCRWB 2009).

The ISCRWB 2008 Annual Report shows the following exceedences from the monthly EC grab samples at St. Stephen, NB:

- Dissolved Aluminum;
- Extractable Aluminum;
- Phosphorus;
- Dissolved Zinc; and
- Extractable Zinc (ISCRWB 2008).

In the ISCRWB 2007 Annual Report the results from the monthly EC grab samples show four parameters exceeded their applicable guideline at St. Stephen, NB. They are:

- Dissolved Zinc (January);
- Extractable Zinc (May);
- Phosphorous (October); and
- Extractable Aluminum (7 out of 11) (ISCRWB 2007).

Human health effects of exposure to these contaminants is likely negligible, as most aluminum is ingested through food, not water (HC Aluminum 2008) and the exceedence in 2009 of 138 micrograms per litre (μg/l), while exceeding aquatic life guidelines of 100 μg/l are well below normal daily levels of ingestion. Adverse effects from zinc only occurs at long term exposure to amounts above upper tolerable intake levels for adults of 40 mg (EPA Zinc 2009) while water quality guidelines are 30 μg/l and 2008 exceedence for extractable zinc was 33 μg/l.

The U.S. National Water Information System (NWIS) provides current and historical water quality and quantity data across the U.S. and is under the jurisdiction of the USGS. Its website provides up to date information on a number of surface water quality parameters including pH, conductivity, temperature, and dissolved oxygen (DO). Water quantity measures of discharge are available. There are also a number of other surface water sites monitored in the watershed which are not on-line. At the time of access, data for the St. Croix region was not available, with the exception of water temperature.

New Brunswick Department of Environment partners with EC to monitor water quantity throughout the province, with 60 sites being monitored for water levels and flows, under the National Hydrometric Agreement. The province and EC also have 57 sites in New Brunswick where water quality is tested a minimum of four times per year for over a dozen parameters under the Canadian Environmental Sustainability Indicators (CESI) program (Darryl Pupek, Director of Environmental Evaluation and Reporting, New Brunswick Department of Environment pers. comm. March 8, 2011).

Benthic invertebrate sampling is also done in the watershed as an indication of water quality and aquatic ecosystem health (D. Pupek pers. comm. 2011).

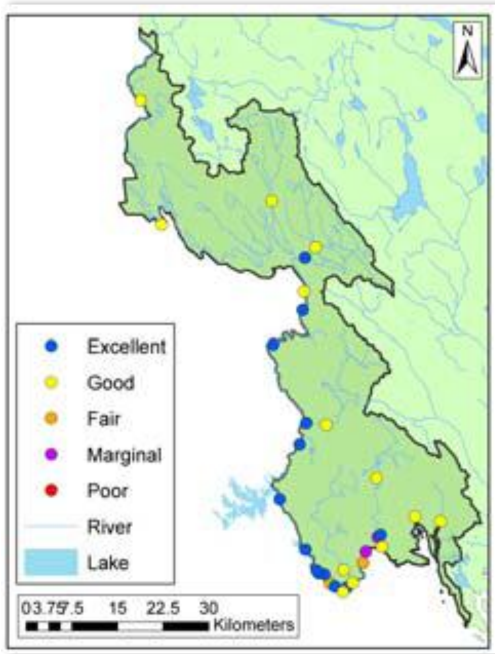

Figure 4. Water Quality Survey Results (1996-2006) in the St. Croix River.
Source: New Brunswick Department of Environment. The St. Croix River: Environmental Reporting Series 2007.

A water quality survey was carried out between 1996-2006 using data from thirty-two monitoring sites throughout the watershed. Results for each site were rated on a scale of 1-100 as follows:

- Excellent: 95-100
- Good:80-94
- Fair:65-79
- Marginal:45-64
- Poor:0-44

Based on assessments using the CCME Water Quality Index, most sites were found to have good to excellent water quality (14 sites each), two were graded fair and two marginal (NB DE St. Croix ERS 2007).

From the thirty-two sample sites throughout the watershed, considering four key indicators;

- Dissolved oxygen minimum levels was not met for 2% of samples,
- *E. coli* was above guideline levels for 8% of samples,
- Nitrate was above guideline levels for 1% of samples, and
- pH did not meet the guideline for 2% of samples.

A study of lake water quality in Maine lakes in the watershed was measured using the Trophic State Index (TSI). TSI considers a combination of information from a number of parameters such as looking at relationships between Total Phosphorus, Chlorophyll-a, and Transparency (Secchi Disk) as is done in Carlson's Trophic State Index (Carlson 1977).

Sixteen monitoring sites were given a TSI value. The following table shows the lakes, the number of sites monitored on each lake, and the TSI or range of TSIs where lakes had multiple monitoring sites (ISCRWB SoW 2008).

Lake	Number of Monitoring Sites	Assigned TSI Value(s)
Big Lake	1	46
E. Grand Lake	6	27-45
Nash's Lake	1	29
Pleasant Lake	1	36
Spednic Lake	7	46-54

Table 7. Assigned TSI Values for Some Maine Lakes in the St. Croix Watershed.
Source: International St. Croix River Watershed Board. State of the Watershed Report. 2008.

The Woodland Mill, then under Georgia-Pacific Corp. ownership and currently owned by IGIC reported water and airborne releases in 2000 as seen in the following table, reproduced from a study of the St. Croix Estuary, completed in 2003. Current data was not found, but this provides a past picture of contaminant release in the lower watershed. The red background represents known carcinogens (MacKay et. al 2003).

	Water				Air			
Chemical	Sawmill Input	Pulp Mill Input	Total Input	Av./day	Sawmill	Pulp Mill	Total	Av/Day
Acetaldehyde*	0	1,300	1300	3.56	3,328	70,000	73,328	200.90
Ammonia*	-	18,000	18,000	49.32	0	160,500	160,500	439.73
Benzo(G,H,I)Perylene*	0	0	0	-	-	7.70	7.70	0.021
Catechol*	-	70	70	0.19	-	0	0	0
Chlorine*	-	0	0	0	-	3,305	3,305	9.05
Chlorine Diozide*	-	0	0	0	-	6,014	6,014	16.48
Dioxin & dioxinl-like*	0	1.80	1.80	0.005	0.12	1.10	1.22	0.003
Formaldehyde*	0	3,000	3,000	8.22	18,885	18,200	37,085	101.60
Formic Acid*	-	535	535	1.47	-	0	0	0
Hydrochloric Acid*	0	0	0	0	4.00	60,000	60,004	164.39
Manganese Compounds*	0	700	700	1.92	900	2,100	3,000	8.22
Methanol*	0	4,805	4,805	13.16	95,543	226,100	321,643	881.21
Nitrate Compounds*	-	210,000	210,000	575.34	-	0	0	0
Nitric Acid*	-	0	0		-	?	?	?
Phenol*	0	0	0		8,527	800	9327	25.55
Polycyclic Aromatic Compounds*	0	0	0		0.93	146.3	147.23	0.40
Sulfuric Acid*	0	0	0		-	43,000	43,000	117.81
Zinc compounds*		17,700	17,700		-	1,400	1,400	3.84

Table 8. Reported air- and water-borne Releases during the year 2000 for Georgia-Pacific Corp. This does not include "release onsite or disposal offsite".
Authors' Sources: EPA TRI data, www.RTK.org, and www.scorecard.org.
Source: The St. Croix Estuary. MacKay et al. 2003.

Surface Water and Recreation

E. coli

E. coli is used as an indicator of fecal contamination. Health Canada's freshwater Guidelines of Canadian Recreational Water Quality require a minimum of five samples taken within 30 days. The mean of the samples should not exceed 2000 *E. coli* per litre (*E. coli*/l) (200 *E. coli* /100 ml). Resampling should be performed when any sample exceeds 4000 *E. coli*/l. (HC Microbiological Characteristics 2010). The enterococci group is often the best fecal contamination indicator in salt water as they survive longer than fecal coliforms but in some instances where proven effective *E. coli* or fecal coliform freshwater limits may be used (HC Microbiological Characteristics 2010). Marine samples should not exceed 350 *enterococci* per litre.

The U.S. EPA criterion for freshwater full body contact is 126 *E. coli* per 100 ml for a minimum of five samples spaced equally over a one month period. Enterococci are limited to 33 per 100 ml for freshwater and 35 per 100 ml for marine water over the same period (EPA Bacterial Quality Standards 2003).

The New Brunswick Health Department monitored three saltwater beaches in the St. Andrews and St. Stephen area in the period 2003-2008;

- Katy's Cove Beach;
- New River Beach; and
- Oak Bay Beach.

Following is a summary of the sampling results for that period.

Year	Beach	Number of Sample Sites	Geometric Mean *E. coli*/100 ml	Geometric Mean Fecal coliform (FC) or Enterococci (E)
2003	Katy's Cove	2	N/A – single sample high 120, low <10	FC - N/A
	New River Beach	3	N/A – single sample high 360, low <10	FC - N/A single sample high 300, low 2
	Oak Bay	2	N/A – single sample high 40, low <10	FC - N/A single sample high 3, low 1
2004	Katy's Cove	2	N/A – all samples <10	FC - N/A all samples < 10
	New River Beach	3	10 – all 3 sites	10,10, 21
	Oak Bay	2	50, 41.2	36.9, 41.7
2005	Katy's Cove	2	N/A	E - N/A single sample results high 55, low 0
	New River Beach	3	N/A	E – N/A Single sample results high 30, low 0
	Oak Bay	2	N/A	E – N/A Single sample results high 29, low 0
2006	Katy's Cove	2	N/A	E – 5.9, 11.9*
	New River Beach	3	N/A	E – 4.0, 6.7, 7.4
	Oak Bay	2	N/A	E – 4.5, 4.7
2007	Katy's Cove	2	N/A	E – 1.3, 2.4
	New River Beach	3	N/A	E – 1.3, 2.2, 1.7
	Oak Bay	2	N/A	E – 3.7 & 1.2, 3.3 & 1.2
2008	Katy's Cove	2	N/A	E – 5.6, 18.2
	New River Beach	3	N/A	N/A
	Oak Bay	2	N/A	N/A

*June 6th 2006, reading of 141 & 123 enterococci. Highest reading of season and only sample period (for all beaches) to indicate rainfall within 48 hrs.

Table 9. Summary of Beach Monitoring Results, Charlotte County, NB for 2003-2008.
Source: D. Walker, NB Department of Health.

These public beaches were not monitored in 2009 and 2010.

Cyanobacterial Toxins

Health Canada's Guidelines of Canadian Recreational Water Quality has a Total Mycrocystins guideline value of less than or equal to 20 µg/l water (HC Guidelines for Recreational Water Quality 2010). Information on local occurrence or monitoring of Mycrocystins was not found, though blue-green algae was recently identified in the drinking water reservoir for the town of St. Andrews.

The St. Croix Estuary

Surface Water Quality in the Estuary

A study completed in the St. Croix Estuary in 2003 shows 2002 sampling resulted in some parameters having a number of exceedences, with the highest number in the areas closest to the mouth of the river at St. Stephen/Calais. Of the 20 parameter tested, a total of 13 parameters were elevated at some of the nine monitoring stations in that test zone area for the study, 11 chemical as well as Total and Fecal Coliform (MacKay, et. al 2003).

The following table is from the St. Croix Estuary study and provides the 2002 water sampling results in detail for nine monitoring sites in the estuary. The table colour coding is related to maximum standards.

- Green indicates a level <50% of the standard;
- Yellow indicates a level from 50 to 100% of standard;
- Red indicates a level 100 to 200% above standard; and
- Purple or pink indicates a level more than 200% above standard.

It should be noted that TNTC represents "too numerous to count".

		Test Site Number								
Parameter	**Standard**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Aluminum (Al)	100 ug/l*	70	110	76	77	90	61	78	155	107
Ammonia (NH3)	2200 ug/l*	4500	2000	250	250	250	2000	2000	1000	2000
Arsenic (As)	50ug/l*	<30	<30	<30	<30	<30	<30	<30	<30	<30
Barium (Ba)	100 ug/l**	<10	13	33	46	16	13	20	15	12
Beryllium (Be)	100 ug/l**	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cadmium (Cd	10 ug/l*	<10	<10	<10	<10	<10	<10	<10	<10	<10
Calcium (Ca)	100mg/l*	15	38	102	95	19	13	77	24	51
Copper (Cu)	50 ug/l*	123	36	15	13	12	123	79	88	<5
Iron (Fe)	300 ug/l**	205	<50	<50	<50	<50	229	<50	850	<50
Lead (Pb)	5.6 ug/l**	<30	<30	<30	34	<30	<30	30	<30	<30
Magnesium (Mg)	100 mg/l*	4	13	115	126	18	6	161	16	12
Manganese (Mn)	20 ug/l**	75	30	<5	<5	<5	167	1090	112	<5
Nickel (Ni)	75 ug/l**	10	11	<10	<10	<10	<10	<10	<10	<10
Nitrite (NO2)	60 ug/l*	150	500	0	0	0	150	150	3000	500
Nitrate (NO3)	500 ug/l*	0	2000	2000	100 0	1000	2000	2000	5000	2000
Phosphorus (P)	25 ug/l*	4420	271	<50	<50	<50	6110	510	2890	<50
Silver (Ag)	2.3 ug/l**	<1	<1	2	<1	<1	<1	<1	<1	3
Zinc (Zn)	86 ug/l**	25	49	19	28	24	24	56	49	14
Total Coliform	100/100ml	TNTC	TNTC	90	300	30	TNTC	TNTC	TNTC	TNTC
Fecal Coliforms	100/100ml	2	TNTC	20	6	6	TNTC	TNTC	2	102

Table 10. Results of analyses for various parameters sampled in the St. Croix Estuary during 2002 including the relationship to maximum standards provided by Environment Canada, Environmental Protection Agency and others.
Source: St. Croix Estuary 1604-2004. MacKay et. al. 2003.

Little other specific information could be located regarding effluent monitoring or other activities of the Woodland Mill. In the ISCRWB 2009 Annual Report the Woodland mill, then owned by Domtar, reported chips being discharged into the St. Croix River, with most being recovered behind the Woodland Dam. The mill also reported remediation work on their landfill and installation of a groundwater recovery well down gradient of the facility (ISCRWB 2009).

Shellfish Contamination

The following map shows areas in Oak Bay where shellfish harvesting has being partially resumed after being closed for approximately 40 years due to continuous bacterial contamination. Harvesting includes areas designated conditional, restricted-depuration area (yellow and labelled), and closed area (pink) (ISCRWB 2009).

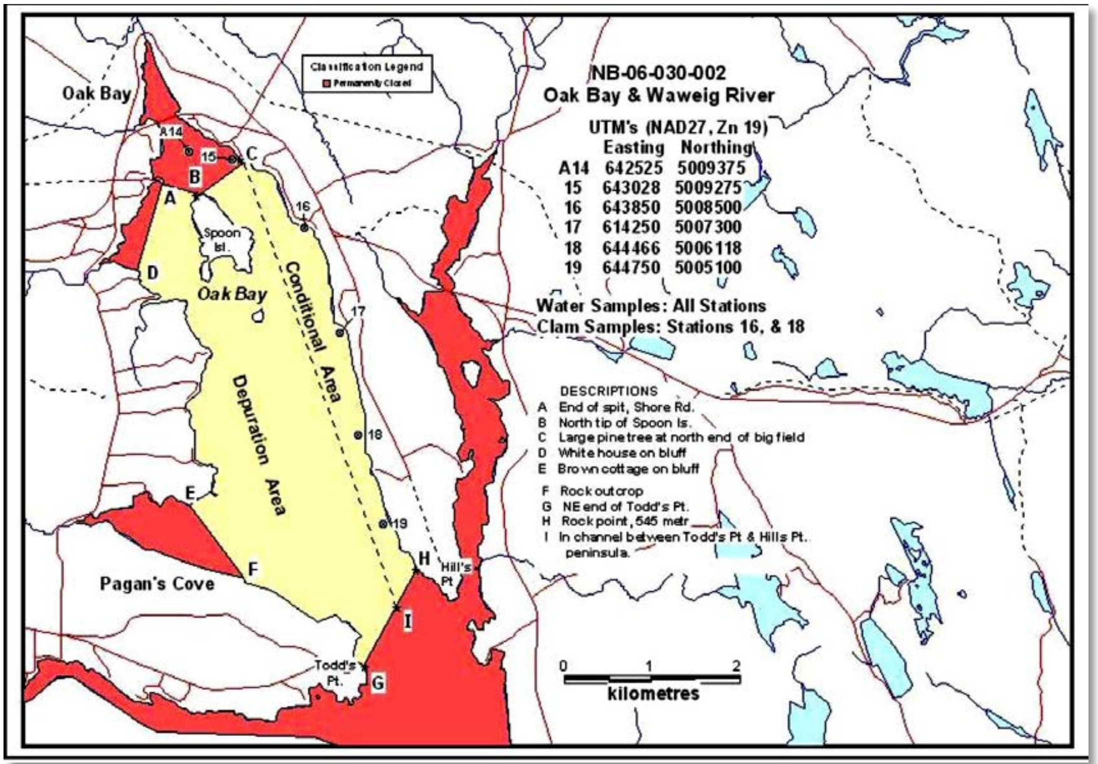

Figure 5. Shell Fish Harvesting in Oak Bay – Area Management by DFO under MOU (2005-2008).
Source: ISCRWB 2008 Annual Report.

The ISCRWB 2009 Annual Report states that Environment Canada planned, beginning in 2010, to survey St. Croix River and Oak Bay five times per year for contamination (ISCRWB 2009).

Groundwater and Drinking Water

Most drinking water in the watershed is drawn from aquifers both for municipal and private use.

In Canada, federal drinking water standards are adopted by New Brunswick and municipalities are responsible for monitoring drinking water at the drinking water intakes, though the province conducts rotating annual testing of municipal water (D. Pupek pers. comm. 2011).

New Brunswick water regulations require each new domestic well to have bacterial and chemical water testing. This information is gathered to provide an overall profile of the aquifers within the province, but information is currently not publicly available on individual wells. This information has been compiled in the New Brunswick Groundwater Chemistry Atlas.

In situations where the bacterial count is high in well water samples, the Health Department provides information on addressing well and waterline contamination (D. Pupek, pers. comm. 2011). In New Brunswick, over 10,000 samples from domestic wells, dated from 1994-2007, were analyzed for 28 parameters. For the

11 health-based parameters, samples had over 94% compliance with the Guidelines for Canadian Drinking Water Quality (NB DE 2008).

Source protection for municipal wells is done through identifying the aquifer flow rate and direction, then setting varying levels of restrictive land use within two, five, and twenty-five year travel zones to prevent contamination of the groundwater. Water within each area has been determined to flow to the well within that period of time. These areas are called wellhead protection areas (WHPAs). Locations of the municipals wells are dots in the centre.

Moving out from the well locations, areas within the first line would be the two year zone, where groundwater inside that line would enter the well within a two year period. This is where land use is most restrictive. The second area, the five year zone, identifies areas where water would enter the well within five years, and land use is usually fairly restrictive to protect this area from contamination. The outer area, the twenty-five year zone, would have least restrictive land use.

The first map shows the WHPAs for McAdam, NB while the second shows the WHPAs for St. Stephen, NB.

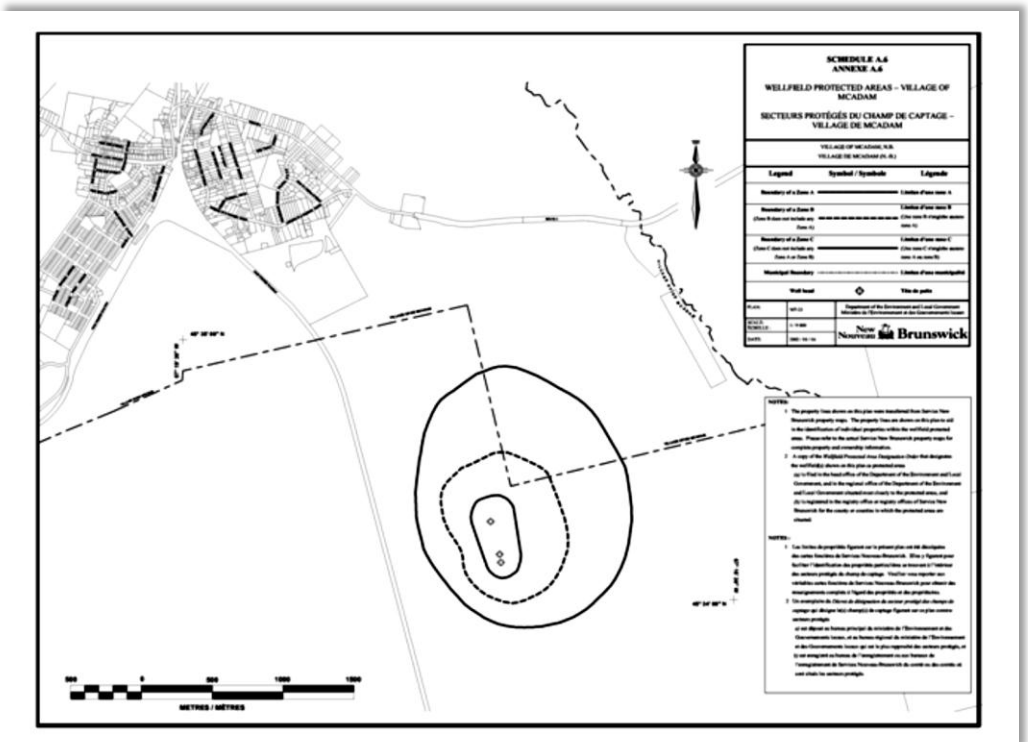

Figure 6. McAdam, NB. Wellhead Protection Areas.
Source: New Brunswick Clean Water Act. 2000.

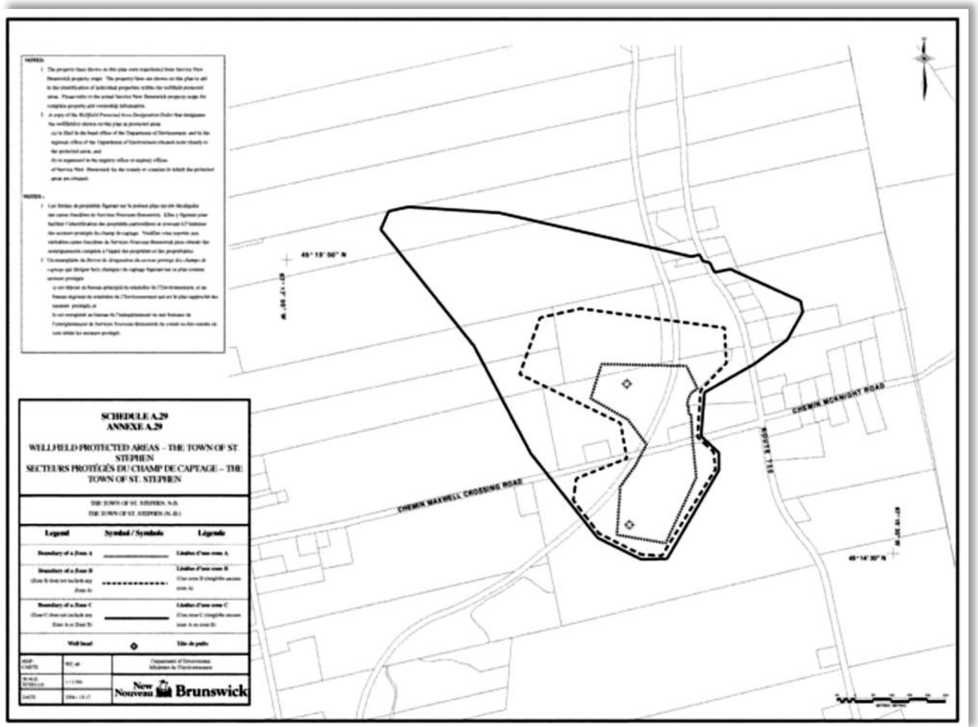

Figure 7. St. Stephen, NB. Wellhead Protection Areas.
Source: New Brunswick Clean Water Act. 2000.

There are nine observation wells across New Brunswick. The New Brunswick wells are used to monitor groundwater levels and are not used for chemistry monitoring (D. Pupek pers. comm. 2011).

The Maine Center for Disease Control and Prevention (MECDC) environmental and Occupational Health Program (EOHP) is in charge of developing guidelines on human consumption of chemical contaminants in drinking water, setting Maximum Exposure Guidelines (MEGs). These differ from Maximum Contaminate Levels (MCLs), which are set under the federal Safe Drinking Water Act and regulate public drinking water supplies (MEG 2010).

Groundwater in Maine occurs primarily in sand and gravel, or in some instances fractured bedrock (USGS 2005). There are three observation wells maintained by the USGS in Maine within the St. Croix watershed (USGS NWIS undated) including a site near Calais where real-time data is available on the USGS website. Some water quality information is available for the early 1980s from this site. There are a number of other groundwater sites in Maine where data has been collected (USGS undated).

Arsenic

Elevated arsenic levels were found to be widespread throughout southern Maine, with occurrences in the St. Croix watershed at Danforth and Perry. Danforth has a cluster of wells with extreme concentrations of arsenic ranging from 1.0 to 3.0 mg/l, while in Perry there were generally low concentrations in most samples, with only a few greater than 0.050 mg/l (Nielsen et. al 2010).

The following map shows the percentage of wells in Maine's towns in which exceeds 0.010 mg/l arsenic concentrations. The relevant legend categories are;

- Pale green, < 3.0%;
- Lime green, 3.1-9.0%;
- Light blue, 17.1-26%;
- Dark blue, 46.1-62%; and
- White indicates fewer than 20 samples available.

The approximate area of the St. Croix watershed is circled in red for ease of reference.

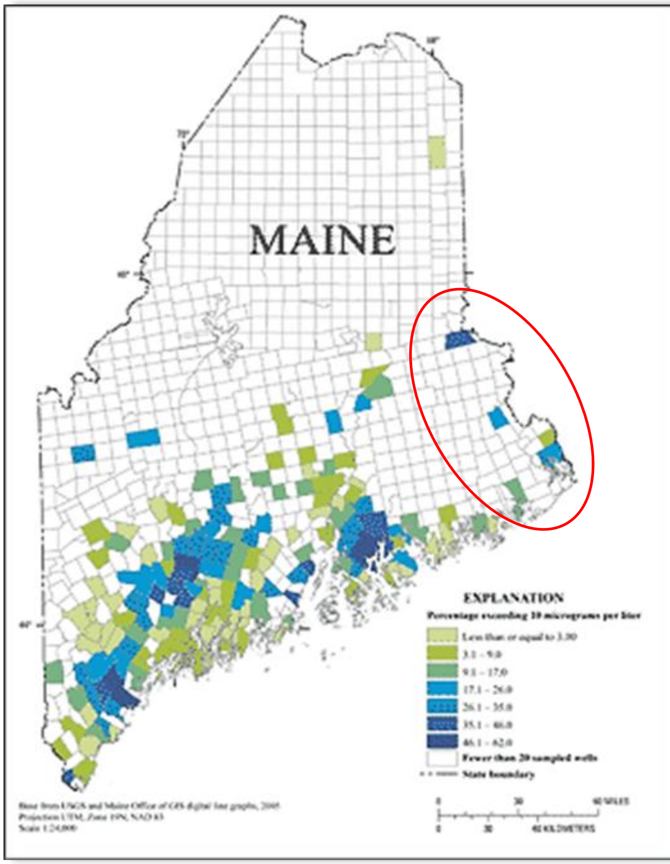

Figure 8. Percentage of Samples from Domestic Wells for Arsenic Exceeding Concentrations of 10 Micrograms/Liter in Maine.
Source: Nielsen et. al. 2010.

The following is a modified map from the New Brunswick Atlas to illustrate arsenic occurrences and concentrations in groundwater in the St. Croix watershed on the New Brunswick side. For easy reference, Fredericton's location is included on the map (top right corner) and the general watershed area (not exact due to the watershed configuration) is circled in red.

As noted, maximum acceptable concentrations (MAC) for arsenic are 0.010 mg/l. The black dots indicate locations of arsenic concentrations of 0.025 mg/l or more, the red dots concentrations of 0.010-0.025 mg/l and the yellow dots indicate concentrations below the MAC of less than 0.010 mg/l.

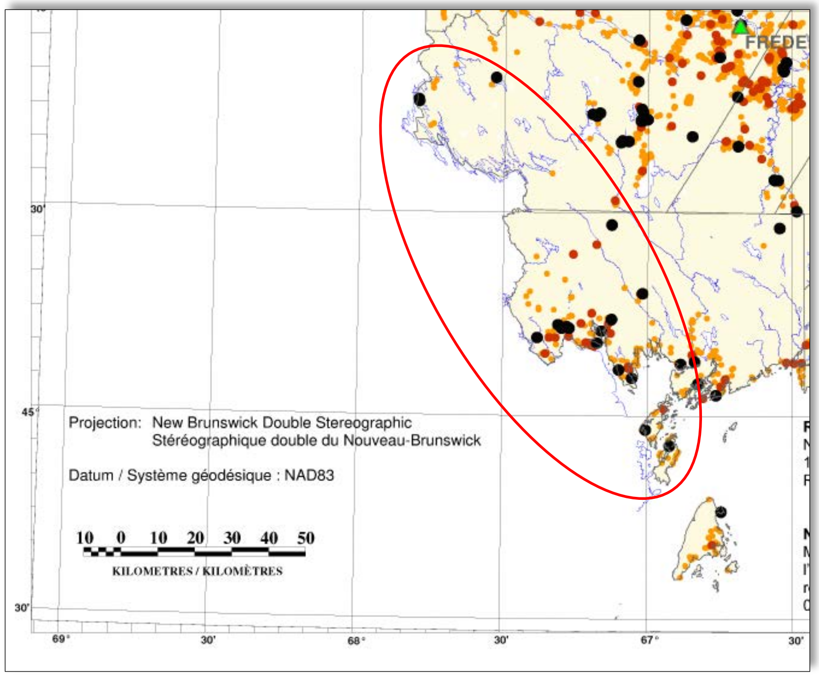

Figure 9. Arsenic Levels Measured in Groundwater in the St. Croix River Watershed – New Brunswick.
Source: Modified from New Brunswick Groundwater Chemistry Atlas: 1994-2007.

Air Quality and Deposition

Air quality is related to water quality through deposition. Air currents may deposit contaminants from local sources or other parts of North America into the St. Croix watershed.

Air quality parameters have been identified on both sides of the border. Following is a partial list of concentration objectives for some contaminants, first for the U.S. followed by Canada (New Brunswick). Some parameters in the table such as lead and particulate matter are included for information purposes but fall outside the focus of this report.

	Primary Standards		Secondary Standards	
Pollutant	**Level**	**Averaging Time**	**Level**	**Averaging Time**
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour (1)	None	
	35 ppm (40 mg/m^3)	1-hour (1)		
Lead	0.15 $\mu g/m^3$ (2)	Rolling 3-Month Average	Same as Primary	
	1.5 $\mu g/m^3$	Quarterly Average	Same as Primary	
Nitrogen Dioxide	53 ppb (3)	Annual (Arithmetic Average)	Same as Primary	
	100 ppb	1-hour (4)	None	
Particulate Matter (PM_{10})	150 $\mu g/m^3$	24-hour (5)	Same as Primary	
Particulate Matter ($PM_{2.5}$)	15.0 $\mu g/m^3$	Annual (6) (Arithmetic Average)	Same as Primary	
	35 $\mu g/m^3$	24-hour (7)	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour (8)	Same as Primary	
	0.08 ppm (1997 std)	8-hour (9)	Same as Primary	
	0.12 ppm	1-hour (10)	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Average)	0.5 ppm	3-hour (1)
	0.14 ppm	24-hour (1)		
	75 ppb (11)	1-hour	None	

(1) Not to be exceeded more than once per year.
(2) Final rule signed October 15, 2008.
(3) The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard
(4) To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010).
(5) Not to be exceeded more than once per year on average over 3 years.
(6) To attain this standard, the 3-year average of the weighted annual mean PM2.5 concentrations from single or multiple community-oriented monitors must not exceed 15.0 μg/m3.
(7) To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 μg/m3 (effective December 17, 2006).
(8) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm. (effective May 27, 2008)
(9) (a) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.
(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.
(c) EPA is in the process of reconsidering these standards (set in March 2008).
(10) (a) EPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding").
(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤ 1.
(11) (a) Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb

Table 11. U.S. Air Quality Standards.
Source: Environmental Protection Agency National Ambient Air Quality Standards. 2010.

New Brunswick Air Quality Objectives				
Pollutant	**Averaging period**			
	1 hour	8 hour	24 hour	1 year
Carbon monoxide	30 ppm	13 ppm		
Hydrogen Sulphide	11 ppb		3.5 ppb	
Nitrogen dioxide	210 ppb		105 ppb	52 ppb
Sulphur dioxide*	339 ppb		113 ppb	23 ppb
Total suspended particulate			120 micrograms/m^3	70 micrograms/m^3

Table 12. New Brunswick Air Quality Objectives for Five Parameters.
Source: New Brunswick Department of Environment. Air Quality Report 2008.

The National Atmospheric Deposition Program/National Trends Network (NADP) is a U.S. cooperative program which has a network of precipitation monitoring sites. The network monitors precipitation chemistry.

Following is a summary of air quality monitoring stations in the watershed.

Site	Monitors/Programs	Indicators Measured
Huntsman Marine Science Centre (HMSC), St. Andrews, NB	HMSC & NB Department of Environment	ozone, particulate matter mercury (previous)
Canterbury, NB	NB Department of Environment	ozone, particulate matter, acid rain
Moosehorn National Wildlife Refuge, Baring, ME	U.S. Fish & Wildlife Service (FWS)	particulate matter
Sipayik, Perry, ME	Passamaquoddy Tribe	ozone

Table 13. Air Quality Monitoring Stations in the St. Croix Watershed.
Source: International St. Croix River Watershed Board's State of the Watershed Report. 2008.

Mercury

The Mercury Deposition Network (MDN) is a program of the National Atmospheric Deposition Program (NADP) and has over 100 monitoring sites throughout the U.S and Canada. A MDN station at Wolapomomqot Ciw Wocuk, ME was active for a short time between 2002-2006. A MDN monitoring station in St. Andrews, NB was active from 1996 through 2003. Readings at the St. Andrews site were generally very low (NB Air Quality 2007). Mercury monitoring in St. Andrews was discontinued as the readings were similar to those taken at Kejimkujik National Park, Nova Scotia (D. Pupek pers. comm. 2011). During its operation, readings at this site were lower than those at New England monitoring stations (NB Air Quality 2006).

Environment Canada has a total of 11 mercury monitoring sites under the Canadian Atmospheric Mercury Measurement Network.

Ambient Air			
St Andrews		**Other sites**	
Year	Annual Average (ng/ cubic metre)	Site	Annual averages (ng/cubic metre)
1995	1.9	Mt Mansfield, VT	2.0 (94-96)[1]
1996	1.5	Kejimkujik, NS	1.5 (2004)[3]
1997	1.4	Westfield, NY	2.6 (94-96)[1]
1998	1.4	Moss Lake	2.4 (94-96)[1]
1999	1.6		
2000	1.4		
2001	1.4		
2002	(1.2)‡		
2003	1.5*		
2004	1.3		
2005	Unavailable		
2006	1.2		
Precipitation (rain and snow*)			
Year	Total mercury concentration (ng/L)	Kejimkujik, N.S.	Total mercury concentration (ng/L) [2]
1998	6.5	1998	5.3
1999	6.7	1999	4.9
2000	6.7	2000	5.4
2001	7.2	2001	6.6
2002	5.0	2002	5.4
2003	5.6	2003	5.0
2004	closed	2004	5.2
		2005	4.4
		2006	5.4

Notes:
ng = nanograms. 1 nanogram is one thousand millionth of a gram. Ambient air mercury data supplied by Environment Canada.
‡ Note: in 2002, sampler operated only January-July.
* In 2003, sampler operated May-December

References:
[1] NESCAUM (1998)
[2] NADP
[3] Environment

Table 14. Air Quality - Mercury Monitoring Results in St. Andrews, NB & The Eastern Seaboard, 1995-2006.
Source: New Brunswick Department of Environment. Air Quality Report 2008.

A MDN monitoring site in Aroostook County (Caribou), Maine has been active since 2007 and is operated by the Maine Department of Environmental Protection (MDN undated).

Acid Rain

The Clean Air Status and Trends Network (Castnet) is an EPA regional long-term environmental monitoring program which was established in 1991 under the U.S. Clean Air Act. It was established to "measure acidic deposition and measures concentrations of air pollutants involved in acidic deposition affecting regional ecosystems and rural ambient ozone levels" (Castnet 2007). The Castnet network has 86 sites located in rural areas, with a monitoring site in Penobscot (Howland), ME. This site appears to be situated approximately 56 km from the inactive MDN Wolapomomqot Ciw Wocuk site.

New Brunswick has carried out acid precipitation monitoring since the early 1980s and since 1987 has done so in partnership with NB Power (NB Air Quality 2009). Ozone monitoring occurs throughout New Brunswick with monitoring at the EC station in St. Andrews as well as a provincial station in Canterbury. In 2006 there were no exceedences of the 1-hour ozone objective of 82 ppb at either station (NB Air Quality 2008).

Ozone

In the St. Croix watershed, ozone monitoring takes place in Maine at Sipayik and in New Brunswick at St. Andrews and Canterbury.

In 2000 the Canada Wide Standards (CWS) for ozone were brought forward to reduce human health and environmental risk associated with elevated levels. The standards for ozone which came into effect in 2010 are 65 ppb over an eight hour averaging period, with an achievement based on the 98th percentile measurement annually, averaged over three consecutive years (EC CWS 2010).

Data at the St. Andrews site indicates that for the years 2000-2007, ozone fell below the 2010 CWS, with 2001 and 2003 closest to the standard at approximately 63-64 ppb. There has been a steady decline in ozone levels at this site since 2003, with 2006 being lowest at approximately 54 ppb and 2007 at approximately 56 ppb (NB Air Quality 2009).

The 2008 U.S. ozone standard is 75 ppb over an eight hour averaging period. The three year average of the fourth-highest daily maximum eight hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (EPA Air Quality 2010).

Adjusted summary data for indication of standards compliance and could not be located for the Sipayik site, but a cursory scan of 2009 data showed most daily levels between January 1st and August 31st well below 75 ppb with the exception of May 21st (75 ppb) and May 22nd (63 ppb). Summary data of ozone maximum level exceedences for the state did not indicate any occurrences at the Sipayik site for the period 1997-2010 (Maine Air Quality 2010).

Water Temperatures

Water temperature affects water quality through providing conditions for increased rates of organic growth and decomposition, and associated reductions in dissolved oxygen levels. It may also affect the rate of uptake of elements that come onto contact with the water.

Many aquatic species, notably fish, prefer certain maximum water temperatures. Warm waters are classified to be greater than 25^{o}C, cool waters are 19-25^{o}C and cold waters are less than 19^{o}C. Among other factors, water temperatures fluctuate in relation to seasonal air and land temperatures, water volume, and the angle and amount of solar radiation on the surface.

In the U.S. the USGS has a website which shows real-time water temperature reading from across the U.S., including in the St. Croix River (see Water Quality).

Water temperatures for the river are also available from the two EC monitoring stations in the river.

The ISCRWB 2008 Annual Report shows mean monthly temperatures at Milltown, NB in the range of 0.0^oC in January to 24.4^oC in July. There was little variation between 2008 to 2009 mean monthly temperatures as can be seen by the 2009 results for the same site which ranges from the January mean of -0.1^oC to 24.0^oC mean in August. Earlier ISCRWB Annual Reports show summer temperature summaries; July 2006 had a mean of 24.7^oC and July 2004 had the highest daily mean of approximately 24^oC at Milltown ME.

Water Quantity

There are two U.S. river flow gauges, one at Vanceboro and the other at Baring Plantation, Maine operated by the USGS. The Grand Falls flowage dam is 8 miles upstream of Baileyville ME, having a storage capacity of 88,000 acre-feet of water. The Grand Falls gauging station for lake levels on the right bank of the dam (ISCRWB 2009).

There are six Canadian river flow gauges in the St. Croix River watershed:

- St. Croix, New Brunswick;
- Baring, New Brunswick;
- Dennis Stream near St. Stephen, New Brunswick ;
- Grand Lake at Forest City, New Brunswick ;
- Spednic Lake at St. Croix, New Brunswick; and
- Forest City Stream, below the Forest City Dam at Forest City, New Brunswick.

Water flows and levels are regulated in the St. Croix, with minimum and maximum water levels and minimum discharge for dams throughout the river system set by ISCRWB. The 2009 ISCRWB Report indicates that mean flows (discharge) were kept above the mandated minimum flows for the year and water levels were retained within prescribed boundaries (ISCRWB 2009). This is the norm for most years in the period 2001-2009.

Interestingly, low flows are reported in the ISCRWB 2007 Annual Report related to shell ice which formed in early December in East Grand Lake. It occurred three times that winter and each time was remediated immediately (ISCRWB 2007).

3.2 Data Sharing and Distribution

3.2.1 Examples of Interaction and Coordination between Agencies

The International St. Croix River Watershed Board (ISCRWB) has a mandate to “proactively assist in preventing and resolving disputes regarding the boundary waters of the St. Croix River by working with stakeholders within the watershed” (IJC 2011). The ISCRWB oversees water management and its Annual Reports provide data on water quantity and quality as well as information on ongoing projects.

The St. Croix International Waterway Commission is an independent international board representing provincial and state interests in the watershed. By its nature this board is an example of cross-boundary interaction, dealing with issues in the waterway corridor, defined by a 250 foot (75 m) shoreline setback in both countries (SCIWC undated). The board has a management plan for the waterway which was agreed upon by New Brunswick and Maine.

Information sharing in the watershed occurs through the informal sharing of benthics monitoring information between Maine and New Brunswick agencies. This type of informal cooperation, while effective in many instances, may fail when interested individuals are no longer in involved programs unless a more formal sharing system is developed.

Maine has had a water classification system in place while New Brunswick currently has a system which classifies areas around municipal water intakes (D. Pupek pers. comm. 2011). New Brunswick plans to have a system in place soon which will be compatible to the Maine system (L. Sochasky pers. comm. 2011).

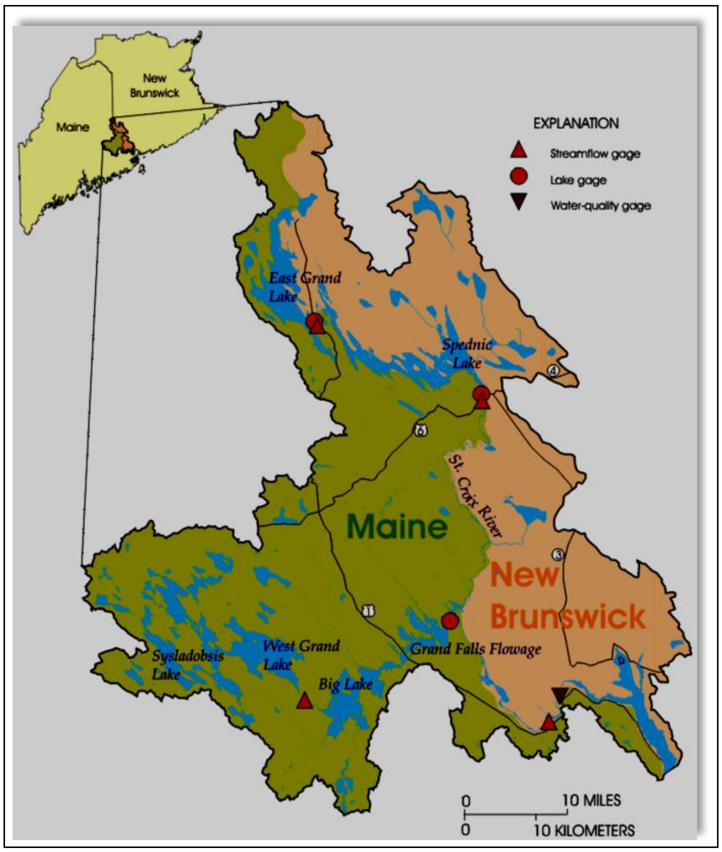

Figure 10. St. Croix River Basin Cooperative Hydrologic Network.
Source: U.S. Department of the Interior, U.S. Geological Survey, reproduced on the International St. Croix River Watershed Board website.

The Cooperative Hydrologic Network has a number of stations, as indicated on the previous map. The network has streamflow, lake, and water quality gauges.

3.2.2 Observed and Identified Information Gaps

There is a large amount of water quality and air quality data which is being collected in the watershed. There is also water discharge and water level data available from long term monitoring programs.

While there is a good range of parameters included in various sampling programs, it does not appear that there is data available on the prevalence of some contaminants in the waterway which have been identified as EDSs and PPCPs. This is an emerging area of study where guidelines or regulations for concentrations are often not in place but may be of interest in relation to bioaccumulation in shellfish.

Information Distribution

There is a wide array of general health information available on state, provincial, and regional websites, providing the public with background and response information to issues. It would be advantageous to have environmental health information more readily available on a local scale, perhaps collected together on a local website.

For example fish consumption information, while it is available, was not easily located. It would be more useful to have this information readily accessible for the general public, perhaps through a website which would act as a local health information portal. Information on drinking water, recreation and water quality, local information on where there may be risks associated with swimming or other activities, and other environmental health and water related issues could be made available on this site. This website could further be designed to have different levels of access and provide professionals with opportunities to share information and collaborate on programs.

3.3 Capacity to Anticipate and Respond to Water-related Health Threats

3.3.1 Identification of Health Risks

Environmental health risks have been identified throughout the watershed but primarily in the lower part of the watershed and the estuary. Following is a summary of the key water related environmental issues in Section 2 where available information indicates there is the potential to affect human health.

Category	Location	Key issue	Status
CSOs	lower watershed/estuary - St. Stephen, NB, St. Andrew, NB, Calais, ME	Effluent overflow during high flow events resulting in untreated effluent releases	Ongoing – issue identified, remediation plans not completed
WWTP	Mid-watershed – McAdam, NB	Effluent overflow of untreated effluent into Station Brook and Wauklahegan Lake	Ongoing – issue identified, potential solutions available, remediation not completed
Pulp & Paper - IGIC	Lower watershed –Milltown and downstream	Past releases of effluent with chemical contaminants identified as known carcinogens	unknown
Industry - Flakeboard Co.	Lower watershed/estuary – St. Stephen	Past release of formaldehyde reported	unknown
Bacterial Contaminants – *E. coli*	Lower watershed/estuary Potentially throughout waterway - localized	Shellfish contamination *E. coli* is not a widespread issue but may exceed guidelines at times in some locations	Ongoing – some areas have been reopened, some permanently closed – ongoing monitoring to identify current risks
Algal Toxins	Lower watershed – St. Andrews reservoir	Localized - Recent identification of Blue green algae in St. Andrews reservoir	unknown
Urban Runoff and Stormwater	All urban areas throughout watershed which are primarily located in lower section of waterway, some in other parts of watershed	Multiple contaminants entering waterways – contributing issue throughout waterway, more localized in mid and upper watershed	Ongoing – identified as contributing issue to water quality reduction, remediation plans not finalized
Climate Change	Throughout watershed	May be added stressor to some water quality and water quantity issues May add new issues	Ongoing – some issues identified, incorporation of impacts into monitoring and regulatory protocols needed
Airborne originating contaminants Mercury Ozone	Throughout watershed, some localized	Originating from outside the watershed mercury -bioaccumulation in fish ozone – water pH	Ongoing – issue identified, binational programs in place to address emissions in upwind areas
Arsenic - groundwater	Throughout watershed - localized	Elevated levels of naturally occurring arsenic in localized areas	Ongoing – many locations identified, continue monitoring new wells

Table 15. Summary of Identified Potential Environmental Health Issues in the St. Croix Watershed.

3.3.2 Capacity to Respond

The capacity to respond to health related environmental issues may be gauged, in part, by the protocols, systems, and resources in place to;

- identify potential health issues (listed in the previous table);

- prevent issues by anticipating them prior to occurrence; and
- respond to rectify issues when they do occur.

Inclusion of a health professional perspective in the management of the watershed increases the capacity to identify and prevent associated health issues from escalating, anticipate new issues, and develop appropriate responses to health related environmental issues where required. Health professionals can help to determine the level of risk specific environmental threats may pose to the health of the community and will also be able to contribute to the identification of future health threats. The inclusion of health professionals in coordination of emergency preparedness can help protect the health and safety of communities in the watershed.

There is an opportunity to include health professionals in the watershed management process at a number of levels:

- through inclusion of a local health professional on the ISCRWB board;
- through development of a health subcommittee which reports to the ISCRWB; and
- by inclusion of health related reviews as part of general annual reporting.

Addressing Water Related Issues

There are a number of systems in place throughout the watershed to identify and address water related health issues. There are also response plans in place for spills and dam failure, and protocols for drinking water Boil Water Advisories. Following is information on some water and health issues threat response protocols and responsibilities.

Drinking Water

In New Brunswick, the Department of Health, Office of the Chief Medical Officer of Health issues advisories such as Boil Water and Do Not Drink advisories for drinking water. This information is updated daily.

In Maine, the Drinking Water Program, under the Office of the Department of Health and Human Services, is responsible for drinking water and issuing Boil Water Orders. Affected public are advised within 24 hours.

Emergency Response

Water Quality - Spill Response in Boundary Waters

There is a joint contingency plan in place for response coordination of emergencies in joint U.S./Canada inland lands and waters. This would include response to an oil spill or a spill of other hazardous materials on international bridges or areas within a 20 km (12.4 mi.) zone of the international boundary.

"The Plan ensures appropriate cooperative preparedness, notification, and response measures between Canada and the United States, coordinates the federal response to a significant polluting incident, and provides a mechanism for cooperative responses among all levels of government" and for the St. Croix watershed is titled CANUSEAST (EPA JCP 2011). It also applies to an incident which may be only in one country but is large enough to require that assistance is required.

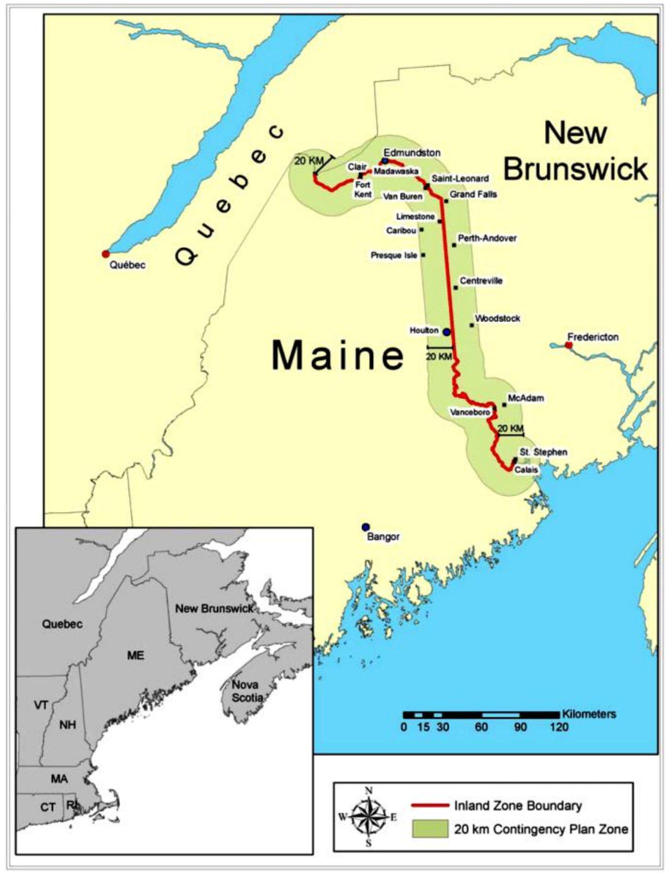

Figure 11. CANUSEAST Geographical Area.
Source: Canada-United States Joint Inland Pollution Contingency Plan. Annex V: CANUSEAST. Undated.

Joint response in the waterway is important to the health and safety of residents on both sides of the river, as the release of a contaminant in one of the countries in the waterway may result in the other being affected.

Joint emergency response also occurs on a local level. A regional news article describes a longstanding cooperative relationship between fire departments in the lower watershed in Calais, ME and St. Stephen, NB. There is an automatic response system in place where firefighters on both sides of the border work cooperatively. In some instances the system includes equipment sharing to avoid duplication and ensure the most equipment possible is available. Responses may also include addressing local hazardous material leaks at border crossings (Bangor Daily News, March 26, 2011).

Water Quantity – Dam Failure

IGIC (formerly Domtar) is responsible for emergency response in case of dam failure. The company has an up-to-date emergency response plan, developed by Klein Schmidt Consulting, which is updated yearly. This plan includes response in both New Brunswick and Maine. There is also an annual table top and field emergency response practice session. Contact information for all agencies and organizations which would be involved in such an emergency are updated regularly

(Darren McCabe, New Brunswick Emergency Management Organization, pers. comm. March 22, 2011).

Widespread flooding in the St. Croix is not of great concern except in the unlikely event of dam failure (D. McCabe, pers. comm. 2011). If dam failure were to occur, municipalities in the lower watershed, in both Maine and New Brunswick, would need to be advised as flooding in some communities could occur. This falls under the IGIC plan.

IGIC coordinates dam operations throughout the watershed. In the event of high water levels from precipitation and snowmelt, dams are operated in such a way as to allow water to pass through the system without upstream or downstream flooding.

Contact Information

Contact information is in place for large emergency response plans such as the dam failure response plan. Maintenance of current contact information is important within the basin to ensure timely contact during emergency situations. Existing response plans include contact information which is updated regularly. Ease of access to contact information is also important for day to day dealings with water and health issues for both the public and agencies. This report includes a number of contacts throughout the basin but due to time constraints not all individuals or organizations could be identified.

3.4 Opportunities for Shared or Coordinated Programs

There are a large number of water-related agencies which are involved in water management, many of which have either an implicit or explicit role in addressing water and human health threats in the St. Croix watershed on both sides of the border. A number of opportunities exist to develop and implement integrated cross-boundary programs.

Standardization of source water protection approaches, fish consumption guidelines and other water-related regulations between countries would make the job of managing the shared watershed easier (L. Sochasky pers. comm. 2011). This would include the process of identifying and prioritizing health issues in shared waters.

Following is a list of suggested areas where joint programs or coordinated guidelines, regulations, and protocols might be considered.

Subject	Shared/Coordinated Program Opportunity
Communications	• Interagency – information sharing between health and environmental agencies cross-boundary, all levels of government • Public outreach – local environmental health information and issues • Dam maintenance reports available between countries for boundary waters
Riparian land use regulations	• Common setbacks – structures and impervious surfaces, shoreline naturalization guidelines to protect water quality
Surface water quality guidelines and regulations	• Coordination of future changes between existing Maine classification system and NB system once NB system completed
Surface water quality monitoring	• New program resource sharing in boundary waters • Coordinate existing programs and protocols in boundary waters
Knowledge gap identification	• In boundary waters – e.g. presence of EDS, PPCPs
Fish consumption guidelines	• Coordinated monitoring programs, advisory information
Climate change impacts	• Joint identification of potential local impacts, coordinated watershed based program for proactively addressing potential health impacts where applicable

Table 16. Examples of Opportunities for Shared Water-Related Environmental Health Programs.

The first steps could be in developing communications links between international agencies and initiating the process of standardization of monitoring efforts (where possible) to meet the needs throughout the watershed, with the focus on joint waters. This should reduce duplication of effort and free resources which then would be available to address other areas of common concern.

Integration of consideration of health risks into ecosystem monitoring programs, through identification of important parameters is currently done when monitoring some parameters such as *E. coli*. Inclusion of other health related parameters, such as pesticides and PPCPs in surface water, would be a next step in health and ecosystem monitoring integration.

There may also be the opportunity to coordinate land use regulation related to rural development along river through completion of the land classification system which is in place in Maine and parts of New Brunswick. This would contribute to uniform water quality protection throughout the watershed.

The international portion of the St. John River watershed has a number of shared programs which may be a useful reference tool in determining what types of shared programs may be possible (D. Pupek pers. comm. 2011).

3.5 Recommendations

1. Include health professionals in water management and emergency preparedness planning.
2. Determine the level of risk that the identified issues, and others as they become apparent, pose to the community.
3. Identify ways to work with and support communities with health related infrastructure issues (e.g. CSOs) to ensure issues are addressed in a timely manner.
4. Develop strategies to increase communications between cross-boundary agencies at all levels and identify ways to coordinate environmental health programs.

4 Organizational Structures, Key Responsibilities, and Related Programs

In both the United States and Canada water protection and management is shared among a number of agencies, all with their own focus and many with what appear to be overlapping or shared responsibilities. Federal responsibilities in both countries include setting direction on protection of water from a human health and an environmental perspective. In the U.S., drinking water legislation is set federally and, in Canada, federal guidelines are in place for drinking water which are followed by provincial legislation and implemented locally.

Both the U.S. and Canada are moving towards source water protection, with municipal wellhead protection programs being implemented at the state and provincial levels. Source water protection also applies to protection of surface water quality and quantity and efforts towards reducing the volume and types of contaminants entering waterways is occurring in both countries.

A summary of Water Governance in the Atlantic Region, located on University of British Columbia's Department of Geography Program on Water Governance website, provides an overview of multilevel governance responsibilities in the Atlantic Region (UBC Water Governance). Understanding governance is the first step to determining which agencies may be involved in monitoring and data analysis.

In some instances there are not clear cut lines as to a department's health and/or water management responsibilities and in these cases the same organization may appear under either health and/or water management agencies, listed under each in relation to a specific responsibility.

For ease of use, web links are provided for a number of the organizations discussed in this section.

4.1 International

4.1.1 International St. Croix River Watershed Board (ISCRWB)

http://www.ijc.org/conseil_board/st_croix_river/en/stcroix_mandate_mandat.htm
The ISCRWB was formed in September 2000 by the International Joint Commission (IJC). Prior to its formation IJC had two boards in the watershed which worked together to address water quality and quantity concerns. The International St. Croix River Watershed Board of Control monitored dams on the river for compliance, while the International Advisory Board on Pollution Control – St. Croix River reported on water quality issues (ISCRWB website undated).

The Board was the first IJC International Watershed Board. It has a wide range of duties which include recommending objectives for aquatic ecosystem health and evaluating whether those objectives are being met. Where objectives are not being met, it is the Board's duty to "obtain assurance that appropriate and timely corrective action will be taken" (ISCRWB website undated). The Board also oversees management of the dams in the St. Croix which influence water levels.

4.1.2 St. Croix International Waterway Commission

http://www.stcroix.org/
The St. Croix International Waterway Commission is an independent organization which was established in 1986 by the provincial (New Brunswick) and state (Maine) legislatures. It deals with joint concerns of water quality, natural resources protection, and heritage in the waterway.

The St. Croix International Waterway Commission is an important partner in working toward a healthy international watershed through assisting in implementing healthy waterway management (ISCRWB SoW 2008).

4.2 United States

4.2.1 U.S. Health Agencies

U.S. Federal Health Agencies

U.S. Department of Health and Human Services

This department is the primary U.S. federal agency for protecting citizens' health and has over 300 programs. The National Toxicology Program and National Institutes of Health fall under this department.

U.S. Environmental Protection Agency (EPA)

Safe Drinking Water Act and Drinking Water Data

http://water.epa.gov/lawsregs/rulesregs/sdwa/index.cfm#sdwafs
The EPA sets nation-wide drinking water standards through the Safe Drinking Water Act (SDWA) which are reviewed at least every six years. These standards apply to wells which serve more than 25 individuals (EPA SDWA Factsheet 2004).

The EPA has a number of water related databases. The agency develops list of contaminants found in water which may require further research which helps set research priorities, the Drinking Water Contaminant Candidate list and maintains a national contaminant occurrence database. It also has databases on watershed health and water related research projects (EPA Safe Water Data 2011).

The EPA has a Safe Drinking Water Information System/Federal Version (SDWIS/FED) national database which contains monitoring information on 175,000 public water systems. There is also a state version which has been developed to assist states to run their systems (EPA 2008).

Office of Ground Water and Drinking Water (OGWDW)

http://water.epa.gov/drink/resources/aboutogwdw.cfm
This federal agency works with states, tribes, and other partners to protect public health through ensuring drinking water is safe. The Standards and Risk Management Division develops regulatory tools related to drinking water treatment and contaminant identification as well as developing regulations for individual

chemical contaminants. The Drinking Water Protection Division has a number of branches which address protection, prevention, and infrastructure and is responsible for source water protection and wellhead protection programs.

Centers for Disease Control and Prevention

http://www.cdc.gov/Environmental/
This government agency provides information on toxic substances, water quality, air quality, and natural disasters. It provides information on public and private drinking water systems.

National Center for Environmental Health

This agency directs a program to ensure human health is protected by promoting a healthy environment. The center provides information on a number of agencies which collect data related to environmental health.

Agency for Toxic Substances and Disease Registry

This federal public health agency provides information on a large number of toxic substances and includes fact sheets on a number of substances which have been identified as harmful to human health.

Toxic Releases Inventory Program

This program compiles data on toxic chemical releases and waste management activities.

Maine State Health Agencies

Maine Department of Health and Human Services

Drinking Water Protection

http://www.maine.gov/dhhs/eng/water/resources/resourceshome.htm
The state carries out activities related to ensuring the quality of community public water supplies comply with the federal Safe Water Drinking Act under the Maine Public Drinking Water Source Water Assessment Program. This program evaluated public water supply sources throughout Maine.

Source Water Protection

The Source Water Protection program considers how susceptible a public water source may be to contamination, whether it is surface water such as a lake or river or whether it is groundwater. A public water system serves 25 or more people for 60 or more days of the year. Under the federal Safe Water Drinking Act states are required to do source water assessments for all public systems.

The results must be available to the public and in Maine drinking water Do Not Drink Orders are available on the Maine Office of the Department of Health and Human Services website, http://www.maine.gov/dhhs/eng/water/BoilWaterOrders.htm.

Fish Consumption Advisories

Maine Center for Disease Control

http://www.maine.gov/dhhs/eohp/fish/2KFCA.htm

The Maine government has a freshwater fish advisory for mercury levels. PCBs, Dioxins or DDT may also be a factor. Safe eating guidelines are provided on the Fish and Game Guidelines.

Maine Regional and Local Health Agencies

The Department of Health and Human Services has a regional office in Calais which serves the region. Information on county health agencies was not readily available.

4.2.2 U.S. Water Management Agencies

U.S. Federal Water Management Agencies

The U.S. Environmental Protection Agency (EPA) is the key federal water management agency. The United States Geological Survey (USGS) is also included in this section due to its involvement in relevant work in the basins.

U.S. Environmental Protection Agency

The U.S. Clean Water Act is the basis for water quality standards across the country and state programs are developed to meet Clean Water Act requirements. The EPA's STORET data system is the main storage system for much of the water quality monitoring which is done by the state.

Pulp and Paper Effluent

The Environmental Protection Agency sets regulatory guidelines for pulp and paper effluent discharges in the U.S. These are designed to meet water quality standards under EPA's Water Quality Act.

Watershed Management

http://water.epa.gov/polwaste/nps/handbook_index.cfm
The EPA encourages the development of watershed management plans to protect local water quality and quantity. It takes in integrated stakeholder approach to the development of local management plans and to encourage the sharing of information and best practices.

U.S. Department of the Interior

United States Geological Survey (USGS)

"The USGS is a science organization that provides impartial information on the health of our ecosystems and environment, the natural hazards that threaten us, the natural resources we rely on, the impacts of climate and land-use change, and the core science systems that help us provide timely, relevant, and useable information" (USGS Website 2011).

The USGS has a vast amount of information available on its website pertaining to groundwater and surface water.

Maine Water Science Center

The USGS has extensive information on groundwater resources in Maine. It has information on well types throughout Maine and has a real time groundwater

watch website which includes a site near Calais, ME where groundwater levels are monitored (USGS Groundwater Watch 2011).
http://groundwaterwatch.usgs.gov/countymaps/ME_029.html

The USGS also has a Climate Response Network which monitors long-term wells without pumping influence, to monitor long-term groundwater level trends. The Network is funded jointly by the USGS and local agencies.
http://www.maine.gov/doc/nrimc/mgs/explore/water/regs/nielsen.pdf

State of Maine Water Management Agencies

Maine Department of Environmental Protection

Bureau of Land and Water Quality

http://www.maine.gov/dep/blwq/

This agency oversees a wide range of programs such as the Combined Sewer Overflow (CSO) Program which provides technical assistance and guidance on CSO abatement in an effort to reduce release of untreated wastewater during storm events.

The agency sets regulations on waste discharge, shoreline zoning, stormwater, and provides information to the public on a number of drinking water and water sustainability related issues.

Beach Management

Maine coastal beaches have a Beach status website which provides daily information on water quality at 37 coastal beaches. Status is determined through bacteria water quality samples and considering the conditions of the sample site.

There are no freshwater public beaches within the watershed (L. Sochasky pers. comm. 2011).

Bureau of Air Quality

http://www.maine.gov/dep/air/

There are seven sites in Maine collecting weekly data on atmospheric deposition where pH and conductivity, as well as a number of other parameters, are measured (BAQ 2005).

Maine Department of Agriculture

Board of Pesticides Control

http://www.maine.gov/agriculture/pesticides/

The Board is the lead state agency for pesticide regulation and is in charge of certification and licensing. The Board also promotes public education programs on natural "yardscaping," and protection and monitoring of surface and groundwater quality from pesticide contamination.

Local Water Management

Waste Water Treatment

Calais' waste water treatment plant is managed privately by Olver Associates.

4.3 Canada

Canada has developed an integrated multi-barrier approach to ensure reliable, safe drinking water is the norm. This is done through the coordinated effort of all levels of government and multiple agencies. Source water protection, drinking water treatment and proper management of the drinking water distribution system are all components of this approach (CCME 2002).

4.3.1 Canadian Health Agencies

Canadian Federal Health Agencies

Health Canada

Federal-Provincial-Territorial Committee on Drinking Water (CDW)

http://www.hc-sc.gc.ca/ewh-semt/water-eau/drink-potab/fpt/index-eng.php
The Guidelines for Canadian Drinking Water Quality are published by Health Canada on behalf of CDW.

Healthy Environments and Consumer Safety Branch, Safe Environments Program: Water Quality and Health Bureau

http://www.hc-sc.gc.ca/ahc-asc/branch-dirgen/hecs-dgsesc/index-eng.php
This agency sets guidelines for drinking water quality through the Federal-provincial-territorial committee on drinking water. It publishes "Guidelines for Canadian Drinking Water Quality". The agency participates in World Health Organization development of drinking water guidelines and works closely with U.S. EPA (Health Canada 2008).

Beach Management

Health Canada sets guidelines for maximum *E. coli* levels in recreational waters and recommends posting warning signs at beaches if the *E. coli* count exceeds 200 per 100 ml of water in 5 samples (i.e. their Geometric mean) within a 30 day period. Actual standards are set provincially.

Wastewater Effluent Monitoring

Health Canada monitors First Nations wastewater effluent on First Nations reserves.

Pest Management Regulatory Agency

The Pest Management Regulatory Agency is responsible for compliance and enforcement of Pesticide Control Products Act and regulations. Federal responsibility in relation to pesticides also includes human health and safety.

First Nations and Inuit Health (FNIH)

http://www.hc-sc.gc.ca/fniah-spnia/index-eng.php
Health Canada, through FNIH, funds 33 First Nations communities for the programs and services related to a number of programs including prevention of disease. It also delivers environmental health programs and services. Each First Nations community has a health centre. (FNIH 2010).

Public Health Agency of Canada (PHAC)

This agency has the goal of "increasing Canada's capacity to protect and improve the health of Canadians" (PHAC 2011). PHAC is responsible for providing information on waterborne diseases and collects information on a number of communicable diseases and provides infection prevention and control guidelines for a number of infectious diseases. The agency also produces a weekly report titled "Canada Communicable Disease Report".

New Brunswick Provincial Health Agencies

In Canada, provinces have primary responsibility over drinking water, while municipalities must meet provincial requirements. Provinces set regulations in line with federal guidelines. The New Brunswick Clean Water Act 2000 regulates drinking water in the province.

New Brunswick has two Regional Health Authorities responsible for health services, Vitalite Health Network and Horizon Health Network, each with a Board of Directors. There are a number of regional sub-offices, one located in St. Stephen.

Office of the Chief Medical Officer of Health (OCMOH)

http://www.gnb.ca/0053/public_health/about-e.asp

This division has three units including one which is in charge of health protection, which includes water quality and testing (NB OCMOH undated). The OCMOH website provides information on water quality and testing, including links for understanding water quality results and a Q&A on blue-green algae.

Regional and Local Health Agencies

Board of Health

There do not appear to be local Health Boards in New Brunswick. There are a number of provincial regional and sub-regional offices throughout the watershed.

4.3.2 Canadian Water Management Agencies

Canadian Federal Water Management Agencies

Environment Canada

Water Science & Technology Directorate (WSTD)

Fresh water monitoring, including identifying quality trends is a focus of this agency. The Canadian Environmental Sustainability Indicators (CESI) program monitors air and water quality, as well as measuring natural areas protection.

National Water Research Institute (NWRI)

The NWRI, under Environment Canada, is the largest freshwater research entity in Canada with a goal to generate the scientific knowledge necessary to sustain aquatic ecosystems and resources.

Water Use Data

Environment Canada has municipal and industrial water use databases from 1999 for which include wastewater treatment levels. Under Canadian Council for Ministries of the Environment (CCME) there is an effort to develop a data referencing system to bring together all levels of water monitoring information (EC 2008).

Environmental Effects Monitoring (EEM)

The Environmental Effects Monitoring Program (EEM) in Canada was introduced after federal regulations were set in place. EEM monitors environmental factors downstream of effluent discharge. An objective of this program is to ensure regulations are adequate to address environmental considerations in a number of situations (EC Pulp and Paper 2010).

Department of Fisheries and Oceans (DFO)

http://www.dfo-mpo.gc.ca/index-eng.htm

DFO regulates Canadian inland and coastal waters, protecting fish habitat from degradation or destruction. It is also involved with a number of partners in research work on a number of fish species. The St. Andrews Biological Research Station is DFO's oldest Atlantic Canada research station.

A proposed federal regulation on wastewater systems effluent was brought forward in March 2010 under the *Fisheries Act*. The intent of the regulation is to reduce risks to human and ecosystem health through reducing the level of harmful substances which enter waterways in effluent (Canada Gazette 2010).

The Canadian Heritage River System (CHRS)

http://www.chrs.ca/Main_e.htm

This national conservation program, established in 1984, ensures the sustainable use and management of Canada's most important rivers. It is a public trust which promotes local involvement while being supported and guided by federal, provincial, and territorial governments. It is administered by the Canadian Heritage Rivers Board, with members being appointed by governments. It has no legislative authority.

Canadian Environmental Assessment Agency

http://www.ceaa.gc.ca/default.asp?lang=En&n=D75FB358-1

Pulp and Paper and Mining Effluent

The Environmental Protection Operations Division of Environment Canada is regulator of a number of substances found in effluents as well as the testing programs on aquatic communities. If monitoring indicates levels are exceeding limits the director is notified (EC Pulp and Paper 2010).

Natural Resources Canada (NRCan)

NRCan is involved with internal (government) federal water conservation programs and wastewater programs.

New Brunswick Provincial Water Management Agencies

New Brunswick Department of Environment

http://www.gnb.ca/0009/0004-e.asp
The Department of Environment is, among other things, responsible for environmental monitoring activities, effluent regulations and permitting, and drinking water regulations in New Brunswick.

Environmental Evaluation and Reporting Branch

This branch works with many other branches and sections to monitor environmental conditions within the province and provide evaluation and analysis of information.

Water and Wastewater Section

This section sets standards and assesses compliance for wastewater, both wastewater treatment systems and domestic systems.

Department of Agriculture, Fisheries, and Aquaculture

http://www.gnb.ca/0027/index-e.asp
The department oversees fish farming, is in charge of livestock licensing, and oversees crown land leasing for agriculture.

Regional and Local Water Management Agencies

Municipalities are required to meet provincial drinking standards in Canada. Smaller drinking water facilities are also regulated in Ontario when they serve year-round populations or facilities that provide water for 'vulnerable populations' such as elderly residences and seasonal children's camps (MOE 2006).

St. Andrews, St. Stephen, Baileyville, and McAdam have municipal wastewater treatment plants.

Appendix

Contact Information

Where information is available, the following contact list provides name and position of individuals within the agencies mentioned in the report.

International Agencies

International St. Croix River Watershed Board

http://www.ijc.org/conseil_board/st_croix_river/stcroix_memb.php?language=english

Canadian Membership

Bill Appleby
(Canadian Co-Chair)
Director, MSC Operations - Atlantic
Environment Canada
MSC Operations - ATL
45 Alderney Drive
Dartmouth, NS B2Y 2N6
Tel. (902) 426-7231
bill.appleby@ec.gc.ca

Jessie Davies
4 O'Neill Farm Road
St. Andrews NB E3B 3A2
Tel. (506) 529-8378
jdavies@unb.ca

Robert Stephenson, Ph.D.
Director, St. Andrews Biological Station
531 Brandy Cove Road
St. Andrews, NB E5B 2L9
Tel. (506) 529-5882
stephensonr@mar.dfo-mpo.gc.ca

Jean-François Bibeault
Acting Manager - Atlantic Fresh Water Quality Monitoring
Manager of the National Water Quality Indicators Program
Environment Canada

U.S. Membership

Col. Philip T. "Tom" Feir
(U.S. Co-Chair)
U.S. Army Corps of Engineers
New England District
696 Virginia Road
Concord, MA, USA 01742-2751
Tel. (978) 318-8220
philip.t.feir.col@usace.army.mil

Matthew Schweisberg
Wetlands Protection Unit
Environmental Protection Agency
1 Congress Street
Suite 1100
Boston, MA 02114-2023
Tel. (617) 918-1628
schweisberg.matt@epa.gov

Edward Logue
Regional Director, Eastern Maine
Maine Dept. of Environmental Protection
106 Hogan Rd, Bangor, ME, 04401
Tel. (207) 941-4570
Edward.Logue@maine.gov

Joan Garner Trial, Ph.D.
Senior Atlantic Salmon Biologist
Department of Marine Resources
Bureau of Sea Run Fisheries and Habitat

105 McGill, 7th Floor
Montréal (QC) H2Y 2E7
Tel. (514) 496-2898
Fax (514) 496-2676
Jean-Francois.Bibeault@ec.gc.ca

Darryl Pupek
Director
Environmental Evaluation and Reporting
News Brunswick Environment (Department)
Tel. (506) 457-4844
Fax (506) 453-2265
Darryl.PUPEL@gnb.ca

650 State Street
Bangor, ME 04401
Tel. (207) 941-4452
joan.trial@maine.gov

Robert Lent, Ph.D.
Maine District Chief
United States Geology Survey
196 Whitten Road
Augusta, Maine 04330
Tel. (207) 622-8201
rmlent@usgs.gov

Secretariat

Nadine MacKay (acting)
Strategic Analysis and Policy Division
Strategic Integration and Partnerships Branch
Environment Canada
16th floor Queen Square, 45 Alderney Drive
Dartmouth, NS B2Y 2N6
Tel. (902) 426-2234
Fax (902) 426-6348
nadine.naas@ec.gc.ca

Barbara Blumeris
US Secretary
U.S. Army Corps of Engineers
New England District
696 Virginia Road
Concord, MA 01742-2751
Tel. (978) 318-8737
barbara.r.blumeris@usace.army.mil

St. Croix International Waterway Commission

www.stcroix.org

Canadian address

190 Milltown Blvd.
P. O. Box 2
St. Stephen, NB
E3L 2W9

Tel. (506) 466-7550
Fax (506) 466-7551
staff@stcroix.org

American address

Box 610
Calais, ME 04619

Commissioners

Ken Gordon* (Baileyville, ME)
Don Doherty* (McAdam, NB)
* Serving as co-chairs

David Irving (Baileyville, ME)

Dale Wheaton (Forest City, ME)
Judy East (Calais, ME)
Stanley Choptiany (St. Andrews, NB)
David Welch (St. Andrews, NB)

Lorne Drake (Green Mountain, NB)

Government Liaisons

Danielle Shineton (New Brunswick - Department of Natural Resources)
Will Harris (Maine - Department of Conservation)

Federal Observers

Jean-Guy Deveau (Canada - Environment Canada), Matt Schweisberg (United States - Environmental Protection Agency)

Staff

Lee Sochasky (Executive Director)
Marilyn Moore (Administrative Assistant)

U.S. Health Agencies

Federal Health Agencies

U.S. Department of Health and Human Services

Agency for Toxic Substances and Disease Directory

4770 Buford Hwy NE, Atlanta, GA 30341
Tel. (800) 232-4636
http://www.atsdr.cdc.gov/

U.S. Environmental Protection Agency (EPA)

Public Drinking Water Systems Programs
Office of Groundwater and Drinking Water
Ariel Rios Building
1200 Pennsylvania Avenue, NW
Washington, DC 20460-0003

Tel. (202) 564-3750
Safe Drinking Water Hotline
Tel. (800) 426-4791

Maine State Health Agencies

Maine Department of Health and Human Services

Calais

State House Station 11
392 South Street
Calais, ME 04619

General Information

Tel. (207)454-9000
(800) 622-1400
Fax (207) 454-9012

Maine Health and Human Services

Drinking Water Program

http://www.maine.gov/dhhs/eng/water/contact.htm

286 Water Street
Key Plaza, 3rd Floor
Augusta, Maine 04333

Tel. (207) 287-2070
Fax (207) 287-4172
TTY (800) 606-0215

U.S. Water Management Agencies

Federal Water Management Agencies

Environmental Protection Agency (EPA)

Region 1 – New England

EPA New England
Customer Call Center
New England States:
Tel. (888) 372-7341
Fax (617) 918-0101

Environmental Emergencies
Tel. (800) 424-8802

Pulp and Paper

U.S. EPA, Office of Compliance
Pulp and paper industry sector lead
Scott Throwe
Tel. (202) 564-7013
throwe.scott@epa.gov

U.S. EPA, Office of Water
Effluent guidelines and standards
Don Anderson
Tel. (202) 260-7189
anderson.donald@epa.gov

United States Geological Survey (USGS)

USGS Headquarters (Virginia)

USGS National Center
12201 Sunrise Valley Drive
Reston, VA 20192, USA
Tel. 703-648-5953
USGS Employee Information Line: 703-648-7075 or 1-800-228-0975

Maine Water Science Center

dc_me@usgs.gov
USGS Building
196 Whitten Rd.
Augusta, ME 04330
Tel. (207) 622-8201
Fax (207) 622-8204

USGS Maine Cooperative Fish and Wildlife Research Unit

5755 Nutting Hall, Room 258
University of Maine
Orono, ME 04469-5755
Tel. 207-581-2870
Fax 207-581-2858
usgs@umenfa.maine.edu

Maine State Water Management Agencies

Maine Emergency Measures Agency

Mike Hinnerman
Tel. (207) 255-3931
wnema@roadrunner.com

St. Croix River Emergency Response Coordinator – IGIC Dams

(non-government)
Klein Schmidt Consulting – for IGIC
Pittsfield, ME
Jennifer Williams
Tel. (207) 487-3328

Maine Department of Environmental Protection

Bureau of Land and Water Quality

Combined Sewer Discharge Coordinator

David Breau
Tel. (207) 287-7766
David.P.Breau@maine.gov

Watershed Planning and Management

Jeff Dennis
Tel. (207) 287-7847
jeff.dennis@maine.gov

Bureau of Remediation and Waste Management

Eastern Maine Regional Office - Bangor
Tel. 207-941-4570; 888-769-1137

Well Testing for Oil or Gas Contamination

Response Office
Tel. 800-452-1942

To Report Oil Spills (24 hours)
Tel. (800) 482-0777

To Report Hazardous Material Spills call (24 hours)
Tel. (800) 452-4664

Local Water Management Agencies

Baileyville

baileyville@verizon.net

Director of Public Works
Wesley Richards
Tel. (207) 427-6208

Jimmy Moffitt
Wastewater Treatment Plant
Tel. (207) 427-6207

Utilities (water co.)
Tel. (207) 427-3328

Calais

Director of Public Works
Robert Seelye
Tel. (207) 454-2763
pwdirector@calaismaine.org

Wastewater Treatment Plant
Annaleis Hafford (Facility Contact)
Tel. (207) 223-2232
Elm St.
Calais, ME

Canadian Agencies

Health Agencies

Canadian Federal Health Agencies

Health Canada

http://www.hc-sc.gc.ca/contact/ahc-asc/index-eng.php

Federal-Provincial-Territorial Committee on Drinking Water

Department of Health and Wellness
Karen White

Health Canada Atlantic Regional Office

Suite 1525, 1505 Barrington Street
Halifax, NS
B3J 3Y6

Tel. 902-426-2038
Fax 902-426-3768
TTP 1-800-267-1245 (Health Canada)

Public Health Agency of Canada
130 Colonnade Road
A.L. 6501H
Ottawa, Ontario K1A 0K9

Tel. (613) 957-2991
Fax (613) 941-5366
TTY 1-800-267-1245*

New Brunswick Provincial Health Agencies

Health.Sante@gnb.ca

Office of the Chief Medical Officer of Health (OCMOH)

Tel. (506) 444-2112
Fax (506) 453-5243
http://www.gnb.ca/0051/index-e.asp

Mailing Address
HSBC Place
Floor: 5
P. O. Box 5100
Fredericton, NB
E3B 5G8
Canada

Information on Freshwater Fish Species

Public Health Services
Tel. (506) 453-2323

New Brunswick Local Health Agencies

St. Stephen Health Protection Regional Sub-Office

General Information

Tel. (506) 457-4800
Fax (506) 466-7908
Email Health.Sante@gnb.ca
http://www.gnb.ca/0051/index-e.asp

Mailing Address

St. Stephen Regional Centre
41 King Street

St Stephen, New Brunswick
E3L 2C1
Canada

Public Health Advisories
http://www.gnb.ca/0051/index-e.asp

Grand Falls Health Protection Regional Sub-office

131 Pleasant St.
Grand Falls

General Information

(506) 457-4800
Tel. (506) 737-4400
Fax (506) 475-2443
Health.Sante@gnb.ca

Mailing Address
Municipal Building
P. O. Box 5001
Grand Falls, New Brunswick
E3Z 1G1
Canada

Inspector

St-Laurent, Alain
(506) 737-4400
alain.stlaurent@gnb.ca

Canadian Water Management Agencies

Canadian Federal Water Management Agencies

Environment Canada

Wastewater Section

Environmental Protection Branch - Atlantic
Environment Canada
Queen Square, 16th Floor
45 Alderney Drive
Dartmouth, Nova Scotia, B2Y 2N6
Tel. (902) 426-9558
Fax (902) 426-3897

Canadian Heritage River System

Harry Collins
P.O Box 85, 21 Cove Road
Miramichi NB E1V OA6
Tel. (506) 778-8591
Fax (506) 773-9755
mreac@nbnet.nb.ca

New Brunswick Provincial Water Management Agencies

New Brunswick Emergency Management Organization

Darren McCabe
Tel. (506) 466-7370
Darren.McCabe@gnb.ca

New Brunswick Department of Agriculture, Fisheries, and Aquaculture

Sustainable Aquaculture and Fish Health

850 Lincoln Road, Fredericton, NB
E3B 9H8
DAAF-MAAP@gnb.ca

New Brunswick Department of Environment

General Information
Tel. (506) 453-2690
Reception. (506) 453-2690
Fax (506) 457-4991
To report oil, pesticide, chemical spills and other environmental emergencies.
1-800-565-1633.
env-info@gnb.ca

Mailing Address
Marysville Place
P. O. Box 6000
Fredericton, NB
E3B 5H1
Canada

Environmental Evaluation and Reporting

Director
Darryl Pupek
Darryl.Pupek@gnb.ca

20 McGloin St.
Fredericton, NB
(506) 457-4844

Local Water Management Agencies

Grand Falls

Director of Public Works
Mike Rioux
mikerioux@nb.aibn.com

131 Industrial Park
Tel. (506) 475-7763
Fax (506) 475-7737

Town Hall

131 Pleasant Street, suite 200
Grand Falls, New Brunswick
Canada E3Z 1G6
Tel. (506) 475-7777
Fax (506) 475-7779

Chief Adm. Officer / Clerk
Peter Michaud
tgf@nbnet.nb.ca

St. Andrews

Water and Wastewater Management
Dan Barlett
(506) 529-5255
212 Water Street
Saint Andrews, NB
E5B 1B4
(506) 529-5120

St. Stephen

Public Works
Lee Johnson
Tel. (506) 466-7700
ljohnson@town.ststephen.nb.ca

Barry Godsoe
Tel. (506) 466-7787
bgodsoe@town.ststephen.nb.ca

Village of McAdam

Mayor
Frank Carroll
Tel. (506) 784-2293
villageofmcadam@nb.aibn.com

References

Abelsohn, Dr. Alan, Dr. Val Rachlis, Dr. David Rosen, M. Janet Kasperski. 2008. Ontario College of Family Physicians. Addressing the Health Effects of Climate Change: Family Physicians are Key.

Agriculture and Agri-Food Canada. 2011. Biopesticides.
http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1288727518132&lang=eng
Accessed April 1, 2011.

Agriculture Canada. 1953. Soil Survey of Southwestern New Brunswick, St. Stephen sheet.
http://sis.agr.gc.ca/cansis/publications/nb/nb4/intro.html#sheet2
Accessed February 1, 2011.

Atlantic Canada Fish Farmers Association (ACFFA). 2010. Fish farming: Atlantic Canada's vibrant and thriving industry.
http://atlanticfishfarmers.com/farming-fish-in-atlantic-canada.html
Accessed March 16, 2011.

Bangor Daily News. 2011. Two cities in two countries with one emergency-response mission. Sharon Kiley Mack. March 26, 2011, Down East News.
http://new.bangordailynews.com/2011/03/26/news/downeast/two-cities-in-two-countries-with-one-emergency-response-mission/
Accessed March 27, 2011.

Bangor Daily News. 2010. Calais LNG withdraws application to build $1 billion natural gas terminal. December 14th 2010, Maine Business.
http://new.bangordailynews.com/2010/12/14/business/calais-lng-withdraws-application-to-build-1-billion-natural-gas-terminal/
Accessed February 6, 2011.

Canada Gazette. 2010. Wastewater Systems Effluent Regulations. Government of Canada.
http://www.gazette.gc.ca/rp-pr/p1/2010/2010-03-20/html/reg1-eng.html
Accessed January 27, 2011.

Canadian Broadcasting Corporation (CBC). December 15th 2010.
http://www.cbc.ca/canada/new-brunswick/story/2010/12/15/nb-fredericton-flooding-536.html
Accessed January 12, 2011.

Canadian Council of Ministers of the Environment (CCME). 2009. Source to Tap: What Governments are Doing.
http://www.ccme.ca/sourcetotap/atrazine.html
Accessed February 1, 2011.

Canadian Council of Ministers of the Environment. 2004. Recreational Water Quality Guidelines and Aesthetics 1998 (Revised 2004).
http://ceqg-rcqe.ccme.ca/

Accessed March 29, 2011.

Canadian Dam Association (CDA). 2011.
http://www.cda.ca/cda_new_en/publications/publications.html
Accessed March 18, 2011.

Canadian Geographic. The Canadian Atlas online.
http://www.canadiangeographic.ca/atlas/themes.aspx?id=atlantic&sub=atlantic_basics_ecozones&lang=En
Accessed January 25, 2011.

Canadian Heritage River System (CHRS). St. Croix River Fact Sheet.
http://www.chrs.ca/Rivers/StCroix/StCroix-F_e.htm
Accessed Jan. 20, 2011.

Carlson, Robert E. 1977. A Trophic State Index for Lakes.
http://www.aslo.org/lo/toc/vol_22/issue_2/0361.pdf
Accessed March 31, 2011.

Colpitts, Mark C., Sherif H. Fahmy, John E. MacDougall, Tom T. M. Ng, Bryce G. McInnis, and Vincent F. Zelazny. Agriculture Canada. 1995. Forest Soils of New Brunswick.
http://sis.agr.gc.ca/cansis/publications/nb/nb9538/nb9538_report.pdf
Accessed February 1, 2011.

ENSR Corporation. 2007. Historic Flooding in Major Drainage Basins, Maine. Document No.:12092-003-B.
http://www.maine.gov/spo/flood/docs/maineriverbasinreport.pdf
Accessed March 18, 2011.

Environment Canada (EC). 2010. Environmental Indicators. Regional Freshwater Quality.
http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=en&n=1C71AB61-1
Accessed March 10, 2011.

Environment Canada. 2010. Introduction to Water Quality.
http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=2C3144F5-1#sec2
Accessed February 7, 2011.

Environment Canada. 2010. National Water Research Institute.
http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=7CE9E3AC-1
Accessed February 14, 2011.

Environment Canada. 2010. Pulp and Paper Technical Guidance.
http://www.ec.gc.ca/esee-eem/default.asp?lang=En&n=3D1EC15C-1
Accessed February 3, 2011.

Environment Canada. 2009. Pharmaceuticals and Personal Care Products in the Canadian Environment: Research and Policy Directions.
http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=C00A589F-1&offset=10&toc=show
Accessed February 1, 2011.

Environment Canada. 2009. Wastewater Management.
http://www.ijc.org/rel/boards/saint/stcroixmtg080520_Appendix_2_e.pdf
Accessed January 27, 2011.

Environment Canada. 2008. Endocrine Disrupting Substances.
http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=0841672A&xsl=articlesservices,viewfull&po=5A17879E
Accessed March 17, 2011.

Environment Canada. 2008. National Assessment of Pulp and Paper Environmental Effects Monitoring Data. 3.0 Historical Overview of the Pulp and Paper Mill Effluents.
http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=C5BD35C5-1&xml=C5BD35C5-923F-4E1A-B5DA-3B1F527456E8&offset=3&toc=show
Accessed February 13, 2011.

Environment Canada. 2004. Factsheet 5: Environmental Effects Monitoring (EEM): Metal Mining and Pulp and Paper Mill Effluent Regulations.
http://www.ec.gc.ca/ceqg-reqe/English/Html/SAS/factsheet_5.cfm.
Accessed March 21, 2011.

Environment Canada Weather Office. Climate Normals. Undated.
http://climate.weatheroffice.gc.ca/climate_normals/stnselect_e.html
Accessed January 13th, 2011.

Environment Canada. Undated. Water.
http://www.ec.gc.ca/eau-water/default.asp?lang=En&n=AAD01CB4-1
Accessed January 24, 2011.

Environmental Protection Agency. 2011. About the Office of Groundwater and Drinking Water.
http://water.epa.gov/drink/resources/aboutogwdw.cfm#Drinking%20Water%20Protection%20%20%20Division
Accessed February 1, 2011.

Environmental Protection Agency (EPA). 2011. EPA Requires Testing of 19 Widely Used Chemicals.
http://yosemite.epa.gov/opa/admpress.nsf/a543211f64e4d1998525735900404442/b4a91485f80b15c48525780e0056ed2b!OpenDocument&Highlight=2,list
Accessed February 5, 2011.

Environmental Protection Agency. 2011. Office of Dietary Supplements. Zinc.
http://ods.od.nih.gov/factsheets/Zinc-HealthProfessional/#h8
Accessed April 2, 2011.

Environmental Protection Agency. 2011. Safe Water Data and Data Bases.
http://water.epa.gov/scitech/datait/databases/drink/index.cfm
Accessed March 11, 2011.

Environmental Protection Agency. 2010. Basic Information about Regulated Drinking Water Contaminants and Indicators.
http://water.epa.gov/drink/contaminants/basicinformation/index.cfm

Accessed February 1, 2011.

Environmental Protection Agency. 2010. Existing Chemicals. Essential Principles for Reform of Chemicals Management Legislation.
http://www.epa.gov/oppt/existingchemicals/pubs/principles.html
Accessed February 5, 2011.

Environmental Protection Agency. 2010. National Ambient Air Quality Standards (NAAQS).
http://www.epa.gov/air/criteria.html
Accessed March 27, 2011.

Environmental Protection Agency. 2010. Total Coliform Rule: A Quick Reference Guide.
http://www.epa.gov/ogwdw000/disinfection/tcr/pdfs/qrg_tcr_v10.pdf
Accessed March 20, 2011.

Environmental Protection Agency. 2009. Pharmaceuticals and Personal Care Products in Water.
http://www.epa.gov/waterscience/ppcp/basic.html
Accessed January 31, 2011.

Environmental Protection Agency. 2007. Clean Air and Trends Network (Castnet).
http://java.epa.gov/castnet/
Accessed April 29, 2011.

Environmental Protection Agency. 2007. National Pollutant Discharge Elimination System (NPDES). Secondary Treatment Standards.
http://cfpub.epa.gov/npdes/techbasedpermitting/sectreat.cfm
Accessed March 16, 2011.

Environmental Protection Agency. 2004. Water Quality Standards for Coastal and Great Lakes Recreational Waters; Final Rule. Part II. Federal Register/Volume 69, No. 220. 40 CFR Part 131. Table 1 pp. 67221.

Environmental Protection Agency. 2003. Bacterial Water Quality Standards for Recreational Waters (Freshwater and Marine Waters) Status Report. June 2003.
http://water.epa.gov/type/oceb/beaches/upload/2003_06_19_beaches_local_statrept.pdf
Accessed March 29, 2011.

Environmental Protection Agency. 2003. Estimating Estuarine Pollutant Loading from Atmospheric Deposition Using Casco Bay, Maine as a Case Study.
http://www.epa.gov/owow/airdeposition/cascobay.pdf
Accessed. February 13, 2011.

Environmental Protection Agency. 2002. EPA Office of Compliance Sector Notebook Project. Profile of the Pulp and Paper Industry: 2nd Edition. EPA/310-R-02-002.
http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/pulppasnp1.pdf
Accessed March 29, 2011.

Environmental Protection Agency. 1997. The Pulp and Paper Industry, the Pulping Process, and Pollutant Releases to the Environment. Fact Sheet.
http://water.epa.gov/scitech/wastetech/guide/pulppaper/upload/1997_11_14_guide_pulppaper_jd_fs2.pdf
Accessed February 7, 2011.

Environmental Protection Agency, Environment Canada. Undated. Canada - United States Joint Inland Pollution Contingency Plan. Annex V: CANUSEAST. A Plan for Response to Spills and Releases of Pollutants Along the Inland Border Between New Brunswick, Canada and the State of Maine, United States of America.
http://www.epa.gov/oem/docs/chem/canuseast.pdf
Accessed March 24, 2011.

Fisheries and Oceans Canada, Department of (DFO). 2009. Protecting the Health of Canada's Lakes. Experimental Lakes Area.
http://www.dfo-mpo.gc.ca/regions/central/pub/ela-rle/index-eng.htm
Accessed March 15, 2011.

Flakeboard. 2010. Sustainability Report.
http://www.flakeboard.com/environsust.asp
Accessed February 14, 2011.

Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser, and D.J. Wuebbles. 2007. Confronting Climate Change in the U.S. Northeast: Science, Impacts, and Solutions. Synthesis report of the Northeast Climate Impacts Assessment (NECIA). Cambridge, MA: Union of Concerned Scientists (UCS).
http://www.northeastclimateimpacts.org/pdf/confronting-climate-change-in-the-u-s-northeast.pdf
Accessed January 28, 2011.

Health Canada. 2011. Contact information.
http://www.hc-sc.gc.ca/contact/ahc-asc/index-eng.php
Accessed January 24, 2011.

Health Canada. 2010. First Nations and Inuit Health.
http://www.hc-sc.gc.ca/ahc-asc/branch-dirgen/rapb-dgrp/reg/atlant-eng.php#fnih
Accessed January 24, 2011.

Health Canada. 2010. Guidelines for Canadian Recreational Water Quality. Microbiological Characteristics.
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/guide_water-1992-guide_eau/section3-eng.php#sec3_1_1
Accessed March 29, 2011.

Health Canada (HC). 2010. Guidelines for Canadian Recreational Water Quality – Summary Table.
http://www.hc-sc.gc.ca/ewh-semt/consult/_2009/water_rec-eau/draft-ebauche-eng.php#tab1
Accessed March 24, 2011.

Health Canada. 2009. Regulation of Pesticides in Canada.
http://www.hc-sc.gc.ca/cps-spc/pubs/pest/_fact-fiche/reg-pesticide/index-eng.php
Accessed January 24, 2011.

Health Canada. 2008. Environmental and Workplace Health. Aluminum.
http://www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/aluminum/aluminum-aluminium-eng.php
Accessed April 4, 2011.

Health Canada. 2008. Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity. Synthesis Report. HC Pub.: 4111. Cat.: H128-1/08-529E.ISBN: 978-0-662-48366-3.

Health Canada. 2007. Mercury: Your Health and the Environment.
http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/mercur/q47-q56-eng.php
Accessed April 4, 2011.

Health Canada. 2006. Arsenic in Drinking Water. The Health Effects of Arsenic.
http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/arsenic-eng.php
Accessed March 14, 2011.

Health Canada. 2006. Dioxins and Furans.
http://www.hc-sc.gc.ca/hl-vs/iyh-vsv/environ/dioxin-eng.php
Accessed January 29, 2011.

International Joint Commission (IJC). 2011. International St. Croix River Watershed Board.
http://www.ijc.org/conseil_board/st_croix_river/en/stcroix_mandate_mandat.htm#basin
Accessed January 22, 2011.

International Joint Commission. 2009. Great Lakes Water Quality Agreement. Working Group Report on Chemicals of Emerging Concern.
http://www.ijc.org/en/priorities/2009/reports/2009-chemicals.pdf
Accessed February 5, 2011.

International Joint Commission. 2009. International St. Croix River Watershed Board Annual Report 2009.
http://www.ijc.org/rel/boards/saint/saint2009ar.pdf
Accessed January 04, 2011.

International Joint Commission. 2008. Combined Sewer Outflows (CSO). International St. Croix River Watershed Board (ISCRWB).
http://www.ijc.org/rel/boards/saint/stcroixmtg080520_summary_e.pdf and
http://www.ijc.org/rel/boards/saint/stcroixmtg080520_Appendix_2_e.pdf
Accessed January 27, 2011.

International Joint Commission. 2008. International St. Croix River Watershed Board (ISCRWB) 2008 Annual Report.
http://www.ijc.org/rel/boards/saint/saint2008ar.pdf
Accessed March 31, 2011.

International Joint Commission. 2008. St. Croix River: State of the Watershed. International St. Croix River Watershed Board.
http://www.ijc.org/rel/boards/saint/watershed_report.pdf
Accessed January 27, 2011.

International Joint Commission. 2007. International St. Croix River Watershed Board (ISCRWB) 2007 Annual Report.
http://www.ijc.org/rel/boards/saint/saint2007ar.pdf
Accessed March 31, 2011.

International Joint Commission. 2006. International St. Croix River Watershed Board (ISCRWB) 2006 Annual Report.
http://www.ijc.org/rel/boards/saint/saint2006ar.pdf
Accessed March 31, 2011.

International Joint Commission. 2005. International St. Croix River Watershed Board (ISCRWB) 2005 Annual Report.
http://www.ijc.org/rel/boards/saint/saint2005ar.pdf
Accessed March 31, 2011.

International Joint Commission. 2004. International St. Croix River Watershed Board (ISCRWB) 2004 Annual Report.
http://www.ijc.org/rel/boards/saint/saint2004ar.pdf
Accessed March 31, 2011.

International Joint Commission. 1998. Unsafe Dams? ISBN 1-895085-95-0.
http://www.ijc.org/php/publications/html/safedam/unsafe.html
Accessed March 18, 2011.

International Joint Commission. International St. Croix River Watershed Board.
http://www.ijc.org/conseil_board/st_croix_river/en/directive.htm
Accessed December 1, 2010.

MacKay, Arthur, Jennifer Cameron, Mark Bader. 2003. The St. Croix Estuary:1604-2004. Volume 2 of 2: Field Studies. St. Croix Estuary Project, Inc. Occasional Report No. 03/2. Tables 8.2, 8.3.
http://issuu.com/artmackay/docs/stcroixhealthoptimized/128
Accessed April 14, 2011.

Maine Center for Disease Control and Prevention. 2010. Environmental and Occupational Health Program. Maximum Exposure Guidelines for Drinking Water.
http://www.maine.gov/dhhs/eohp/wells/documents/MEGProcedures2010.pdf
Accessed February 7, 2011.

Maine Center for Disease Control and Prevention. 2005. Maine Department of Health and Human Services. Maine Family Fish Guide: Advice from the Maine Center for Disease Control and Prevention.
http://www.maine.gov/dhhs/eohp/fish/documents/MeFFGuide.pdf
http://www.maine.gov/dhhs/eohp/fish/2KFCA.htm
Accessed March 11, 2011.

Maine Department of Agriculture. 2011. Maine Board of Pesticides Control.
http://www.maine.gov/agriculture/pesticides/about/index.shtml
Accessed January 20th, 2011

Maine Department of Environmental Protection. Bureau of Air Quality. 2010. Ozone Exceedence Summaries.

http://www.maine.gov/dep/air/ozone/view_exceedance_data.html
Accessed March 28, 2011.

Maine Department of Environmental Protection. 2005. Bureau of Air Quality. Atmospheric Deposition.
http://www.maine.gov/dep/air/monitoring/Atmosdepos.htm
Accessed March 21, 2011.

Maine Department of Environmental Protection. 2005. Bureau of Land & Water Quality.
http://www.maine.gov/dep/blwq/doceng/csotech.htm
Accessed January 20, 2011.

Maine Department of Environmental Protection. 2010. People and Nature, Adapting to a Changing Climate: Charting Maine's Course.
http://www.maine.gov/dep/oc/adapt/summary_report.pdf
Accessed January 28, 2011.

Maine Department of Health and Human Services (HHS). 2009. Maine Center for Disease Control and Prevention. Division of Environmental Health. Maine Subsurface Waste Water Disposal Rules 10-144 Cmr 241. Summary.
http://www.maine.gov/dhhs/eng/plumb/Adobe/10-144_CMR_241_Final.pdf
Accessed March 30, 2011.

Maine Geological Survey (MGS). 2009. An Introduction to Ground Water Hydrology. Section 4 – Maine's Water Situation.
http://www.maine.gov/doc/nrimc/mgs/explore/water/handbook/section4.htm
Accessed March 16, 2011.

Maine Geological Survey. 2001a. Vanceboro Quadrangle, Maine. Surficial Materials Mapping by Michael E. Foley, Robert G. Marvinney, and Robert D. Tucker. Open-File No. 01-301 2001.
http://www.maine.gov/doc/nrimc/mgs/pubs/online/materials/sm-vanceboro.pdf
Accessed April 14, 2011.

Maine Geological Survey. 2001b. North Amity Quadrangle, Maine. Surficial Materials Mapping by Daniel B. Locke, Michael E. Foley, Robert G. Marvinney, and Robert D. Tucker. Open-File No. 01-180 2001.
http://www.maine.gov/doc/nrimc/mgs/pubs/online/materials/sm-north-amity.pdf
Accessed April 14, 2011.

Maine Geological Survey. 2000. Calais Quadrangle, Maine. Surficial Materials Mapping by Daniel B. Locke, Robert G. Marvinney, Michael E. Foley, Susan S. Tolman, and Robert D. Tucker. Open-File No. 00-105 2000.
http://www.maine.gov/doc/nrimc/mgs/pubs/online/materials/sm-calais.pdf
Accessed April 14, 2011.

Maine Healthy Beach Program.
http://www.mainecoastdata.org/public/CurrentBeachStatus.aspx#MaineHealthyCoastalBeachesProgram
Accessed January 24, 2011.

Maine Rivers. 2011. Water Classification Program.

http://mainerivers.org/river-legislation/water-classification-issues/
Accessed March 17, 2011.

Maine Rivers. 2005. St. Croix Watershed.
http://www.mainerivers.org/st_croix.html

Maine Revised Statutes. 2011. Title 38: Waters and Navigation Chapter 3: Protection And Improvement Of Waters. Subchapter 1: Environmental Protection Board. Article 4-A: Water Classification Program. §465-C. Standards of Classification of Ground Water.
http://www.mainelegislature.org/legis/statutes/38/title38sec465-C.html
Accessed March 31, 2011.

Maine Revised Statutes. 2011. Title 38: Waters and Navigation Chapter 3: Protection And Improvement Of Waters. Subchapter 1: Environmental Protection Board. Article 4-A: Water Classification Program. §465. Standards for Classification of Fresh Surface Waters.
http://www.mainelegislature.org/legis/statutes/38/title38sec465.html
Accessed March 31, 2011.

Maine Revised Statutes. 2011. Title 38: Waters and Navigation Chapter 3: Protection And Improvement Of Waters. Subchapter 1: Environmental Protection Board. Article 4-A: Water Classification Program. §467. Classification of Major River Basins.
http://www.mainelegislature.org/legis/statutes/38/title38sec467.html
Accessed March 31, 2011.

NATECH Environmental Services Inc. 2009. McAdam Infrastructure Study, Environmental Components. Draft, August 27, 2009.

NATECH Environmental Services Inc. 2008. Environmental Surveillance Report for Wauklahegan Lake, McAdam, NB. Draft, February 9, 2008.

NATECH Environmental Services Inc. 2006. Letter, February 13, 2006. Re:Supplementary Investigation of Wastewater Overflows into Wauklahegan Lake.

NATECH Environmental Services Inc. 2005. Assessment of Measures to Reduce Algae Blooms in Wauklahegan Lake.

National Atmospheric Deposition Program. Mercury Deposition Network.
http://nadp.sws.uiuc.edu/data/mdndata.aspx
Accessed January 26, 2011.

National Oceanic and Atmospheric Administration (NOAA). 2011. National Weather Service Forecast Office: Gray/Portland. Climate Data – Past Weather and Norms.
http://www.erh.noaa.gov/er/gyx/climate_f6.shtml
Accessed April 5, 2011.

Natural Resources Council of Maine (NRCM). 2010. News Detail. Maine Towns Restrict Lawn Chemicals. Friday, July 30, 2010.
http://www.nrcm.org/news_detail.asp?news=3761
Accessed March 17, 2011.

Netherlands Environmental Assessment Agency. 2005. Acidification and Transboundary Air Pollution: causes and impacts.
http://www.mnp.nl/mnc/i-en-0178.html
Accessed March 20, 2011.

New Brunswick. 2000. New Brunswick Regulation 2000-47 under the Clean Water Act (O.C. 2000-451).
http://www.gnb.ca/0062/PDF-regs/2000-47.pdf
Accessed March 21, 2011.

New Brunswick. 1982. New Brunswick Regulation 82-126 under the Clean Water Act (O.C. 82-588).
http://www.gnb.ca/0062/PDF-regs/82-126.pdf
Accessed January 27, 2011.

New Brunswick. 2009. Regulation 2009-137 under the Public Health Act (O.C. 2009-456).
http://www.gnb.ca/0062/acts/Bbr-2009/2009-137.pdf
Accessed March 30, 2011.

New Brunswick Department of Agriculture, Aquaculture, and Fisheries. Undated. Blueberries: Industry Overview.
http://www.gnb.ca/0171/10/A10e2010.pdf
Accessed March 17, 2011.

New Brunswick Department of Agriculture, Aquaculture, and Fisheries. 2009. News Release. Province introduces lawn care pesticide ban (09/06/18).
http://www.gnb.ca/0171/10/0171100002-e.asp
Accessed March 17, 2011.

New Brunswick Department of Agriculture, Aquaculture, and Fisheries. 2005. Wild Lowbush Blueberry IPM. Weed Management Guide.
http://www.gnb.ca/0171/10/017110020-e.pdf
Accessed March 11, 2011.

New Brunswick Department of Environment. 2009. New Brunswick Air Quality Monitoring Results for the Year 2007.
http://www.gnb.ca/0009/0355/0021/0001-e.pdf
Accessed February 7, 2011.

New Brunswick Department of Environment. 2008. Atlantic Climate Change Adaptation.
http://www.gnb.ca/0009/0373/0007/index-e.asp
Accessed January 28, 2011.

New Brunswick Department of Environment. 2008. New Brunswick Air Quality Monitoring Results for the Year 2006. Technical Report T-2008-01.
http://www.gnb.ca/0009/0355/0019/index-e.pdf
Accessed March 25, 2011.

New Brunswick Department of Environment. 2008. New Brunswick Groundwater Chemistry Atlas: 1994-2007. Sciences and Reporting Branch, Sciences and Planning Division, Environmental Reporting Series T2008-01, 31p.

http://www.gnb.ca/0009/0371/0014/0001.pdf
http://www.gnb.ca/0009/0371/0014/maps/arsenic.pdf
Accessed March 14, 2011.

New Brunswick Department of Environment. 2007. New Brunswick Climate Change Action Plan.
http://www.gnb.ca/0009/0369/0015/0001-e.pdf
Accessed January 28, 2011.

New Brunswick Department of Environment. 2007. St. Croix River Factsheet.
http://www.gnb.ca/0009/0371/0013/English/St.Croix.pdf

New Brunswick Department of Environment. Watershed Protection. Undated.
http://www.gnb.ca/0009/0373/0001/0002-e.asp
Accessed February 14, 2011.

New Brunswick Department of Natural Resources. 2010. Fish 2010.
http://www.gnb.ca/0078/publications/Fish-e.pdf
Accessed February 7, 2011.

New Brunswick Health Department. 2008. News release NB 1115. August 1, 2008.
http://www.gnb.ca/cnb/news/he/2008e1115he.htm
Accessed March 15, 2011.

New Brunswick Health Department. Drinking Water Quality Guidelines in New Brunswick. Undated.
http://www.gnb.ca/0053/public_health/water-quality_guidelines-e.asp
Accessed January 13th, 2011.

New Brunswick Lung Association (NBLA). Undated.
http://english.nbhub.org/
Accessed January 11, 2011.

New England Governors/Eastern Canadian Premiers. 1998. Mercury Action Plan.
http://www.epa.gov/ne/eco/mercury/pdfs/Mercury_Action_Plan.pdf
Accessed February 8, 2011.

Nielsen, Martha G., Pamela J. Lombard, and Luther F. Schalk. 2010. Assessment of Arsenic Concentrations in Domestic Well Water, by Town, in Maine, 2005–09. Figure 15, pp.29. U.S. Geological Survey Scientific Investigations Report 2010–5199, 68 p.
http://pubs.usgs.gov/sir/2010/5199/pdf/sir2010-5199_nielsen_arsenic_report_508.pdf

Parks Canada. 2009. St. Croix Island International Historic Site.
http://www.pc.gc.ca/lhn-nhs/nb/stcroix/natcul/natcul9.aspx
Accessed March 11, 2011.

Passamaquoddy Tribe. Undated.
http://www.passamaquoddy.com/
Accessed January 13th, 2011.

Public Health Agency of Canada. 2011. About the Agency.

http://www.gnb.ca/0062/PDF-regs/2000-47.pdf
Accessed March 21, 2011.

Quoddy Tides, The. October 8, 2010. Volume 42, Number 21. Domtar mill sold: 300 jobs retained.
http://quoddytides.com/domtar10-8-10.html
Accessed March 15, 2011.

RMB Environmental Laboratories Inc. 2007. Lakes Monitoring Program.
http://www.rmbel.info/reports/Static/TSI.aspx
Accessed March 31, 2011.

Servos, Mark, Patricia Chambers, Ron Macdonald and Glen Van Der Kraak. 2008. Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada. Section 9. Municipal Wastewater Effluents. Environment Canada.
http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=235D11EB-1&offset=10&toc=show
Accessed March 14, 2011.

Servos, Mark, Peter Delorme, Glen Fox, Roger Sutcliffe, and Michael Wade. 2008. Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada. Section 5. Endocrine Disrupting Substances. Environment Canada.
http://www.ec.gc.ca/inre-nwri/default.asp?lang=En&n=235D11EB-1&offset=6&toc=show
Accessed March 17, 2011.

Small Woodlot Owners of Maine.
http://www.swoam.org/

St. Andrews, Town of.
http://www.townofstandrews.ca/subcontents2.php?id=8&sid=25
Accessed January 21, 2011.

St. Croix International Waterway Commission.
http://www.stcroix.org/
Accessed January 21, 2011.

St. Stephen, Town of. Public Works.
http://www.town.ststephen.nb.ca/townhallsub.php?id=8&sid=39
Accessed January 21, 2011.

University of British Columbia. Undated. Canada-United States Transboundary Water Governance: Atlantic Region.
http://www.watergovernance.ca/wp-content/uploads/2010/02/AtlanticRegion9.pdf
Accessed March 11, 2011.

U.S. Department of Health and Human Services. 2010. Endocrine Disrupting Chemicals in Drinking Water: Risks to Human Health and the Environment. Statement by Linda S. Birnbaum, Ph.D., DABT, ATS before Committee on Energy and Commerce, Subcommittee on Energy and Environment, United States House of Representatives. Thursday, February 25, 2010.
http://www.hhs.gov/asl/testify/2010/02/t20100225a.html
Accessed February 15, 2011.

U.S. Department of Health and Human Services. 2009. Agency for Toxic Substances and Disease Registry (ATSDR).
http://www.atsdr.cdc.gov/
Accessed January 24, 2011.

U.S. Geological Survey. 2011. Real-Time Data for Maine: Water Quality.
http://waterdata.usgs.gov/me/nwis/current/?type=quality
Accessed April 5, 2011.

U.S. Geological Survey. 2011. Water Quality Watch.
http://waterwatch.usgs.gov/wqwatch/
Accessed February 10, 2011.

U.S. Geological Survey. 2005. Water Resources in Maine.
http://www.maine.gov/doc/nrimc/mgs/explore/water/facts/water.htm
Accessed February 7, 2011.

U.S. Geological Survey. 2000. Mercury in the Environment. Fact Sheet 146-00.
http://www.usgs.gov/themes/factsheet/146-00/
Accessed February 7, 2011.

Wabanaki Nation. Passamaquoddy Tribe. Schoodic Band.
http://www.wabanaki.com/index.html
Accessed January 13th, 2011

Wake, Cameron, Liz Burakawski, Gary Lines, Kyle McKenzie, Thomas Huntington. Editor Bill Burtis. 2006. Cross Border Indicators of Climate Change over the Past Century: Northeastern United States and Canadian Maritime Region. The Climate Change Task Force of the Gulf of Maine Council on the Marine Environment in cooperation with Environment Canada and Clean Air-Cool Planet.
http://www.gulfofmaine.org/council/publications/cross-border-indicators-of-climate-change.pdf
Accessed March 9, 2011.