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DEVELOPING A COMMUNITY-BASED MONITORING PROGRAM FOR DRINKING WATER SUPPLIES IN THE INDIAN BAY WATERSHED:

A baseline study of surface water quality, contamination sources and resident practices and perceptions

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Developing a community-based monitoring program for drinking water supplies in the Indian Bay Watershed: A baseline study of surface water quality, contamination sources and resident practices and perceptions

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Executive Summary

Drinking water issues in rural Newfoundland and Labrador are closely tied to the health of watersheds and thus are relevant to residents, users, and neighboring communities of those watersheds. Because boil water advisories (BWA) and persistent challenges to supplying safe drinking water in rural municipalities in Newfoundland are commonplace, this project seeks to explore root causes as well as future directions related to these issues. More precisely, this project seeks to design community-based approaches to water stewardship to supplement the supply and monitoring of drinking water as currently carried out by municipalities and the provincial government.

This project focused on the Towns of Indian Bay and Centreville-Wareham-Trinity (CWT). The Town of Indian Bay has been on BWA since September 2008, largely due to inadequate treatment and distribution infrastructure, while the Town of CWT has experienced periodic BWAs in recent years for a variety of reasons. Evidence suggests that a significant proportion of the residents in these communities draw their primary drinking water sources from outside the public supply: specifically, from natural roadside springs as well as store-bought bottled water. Evidence further suggests that there is a level of distrust as well as distaste for publicly supplied drinking water among residents. For these reasons, it may be inadequate to merely "fix" infrastructural and management related issues within these water systems to ensure drinking water safety and security. Public education, outreach, participation, and awareness are all critical factors.

Several key methods were used to carry out the research. Source water sampling was carried out at sites throughout the Indian Bay Watershed (the Town of Indian Bay's water supply) as well as two popular roadside springs. In addition to results that indicate the presence of E. coli and therefore threats to public health, this sampling provides a baseline for future water quality research and the potential to monitor changes water quality in the Indian Bay Watershed over time. It also provides a starting point for future efforts to monitor the quality of water drawn from popular natural roadside springs, a role that a community-based environmental stewardship organization such as the Indian Bay Ecosystem Corporation (IBEC) may potentially fulfill.

A household survey seeking resident practices and perceptions towards their drinking water supplies was also conducted. All households in the communities were contacted for the survey and asked to provide information on household practices as well as practices while in the IBW. Findings from the survey confirm that a majority of community members (55 percent) draw their water from natural roadside springs despite the presence of municipal water systems, and suggest that the reasons for this relate to taste, smell, and perceived safety. Concerns over drinking water safety were found to be both real and perceived. Survey results demonstrate that perceptions and preferences matter a great deal: distrust of public drinking water supplies has clearly led residents to seek alternate sources, sources that are unmonitored and may have significant added risk

and costs. As users of the IBW, residents appeared both generally informed of, as well as receptive to, regulations in the watershed as a *protected water supply area.* This represents a strong point from which to guide future environmental education and watershed stewardship initiatives, although most residents indicated that they did not believe there were any current threats to their drinking water and therefore may be uninformed about potential risks. Only 20% feel that recreational uses are cause for concern. There were no reported instances of drinking water-related illnesses in the community over the past year. The majority of participants are, however, concerned about such illnesses.

As part of a commitment to a collaborative, iterative approach to community-based research and in recognition that the issues around provisioning of safe and secure drinking water are complex and myriad, feedback and input was sought from a diversity of stakeholders, government officials, and holders of special knowledge with regards to drinking water supplies within the region, the province, and elsewhere in the country. Through such an approach, researchers sought to identify future drinking water quality initiatives in which community participation may play a vital role. Water security, quality, and safety are, after all, rooted in the environments in which these communities are based.

1. Introduction and Project Background

In rural Newfoundland, our watersheds provide critical drinking water supplies as well as other forms of sustenance and activities that are central to our identity and well-being. Drinking water issues in rural areas are inextricably tied to the health of watersheds. Land-use practices occurring in watersheds have an impact on water quality and health of the overall ecosystem, including the individuals that rely on these resources for subsistence, culture, and recreation.

The occurrence of boil water advisories (BWAs) issued by the Dept. of Health and Community Services or municipalities is widespread throughout the province. Baseline studies examining water quality, the presence of toxins, and contamination source points act as tools in identifying potential health concerns in regards to drinking water issues, and in informing future land-use management practices and policies. As part of a community-based approach to grappling with these issues, the Indian Bay Ecosystem Corporation (IBEC) is engaging in a collaborative effort to find solutions to persistent challenges relating to rural drinking water supplies.

The Indian Bay Watershed (IBW) is an extensive freshwater system that includes 16 major lakes (ponds) along with smaller feeder ponds, 15 main tributaries and a large number of sub-tributaries draining an area of approximately 700 km^2 and covering approximately 1000 km^2 including water bodies (Fig. 1).

Water in this system flows through the watershed into the Town of Indian Bay's water supply (Indian Bay Brook) and drains into the ocean at the mouth of the river at the Town of Indian Bay. The water quality of this system is important for potable water supply to the community of Indian Bay, but also as a drinking water source for more than 350 cabin owners and their families in the IBW. Many of these families are from the neighbouring community of Centreville-Wareham-Trinity (CWT, an amalgamated municipality of three former towns), which also sits on the saltwater body - Indian Bay.

This study examined potential threats as well as population perspectives and practices related to drinking water in the Indian Bay watershed and communities of Indian Bay and Centreville-Wareham-Trinity as well as future measures that might be taken to enhance drinking water security.

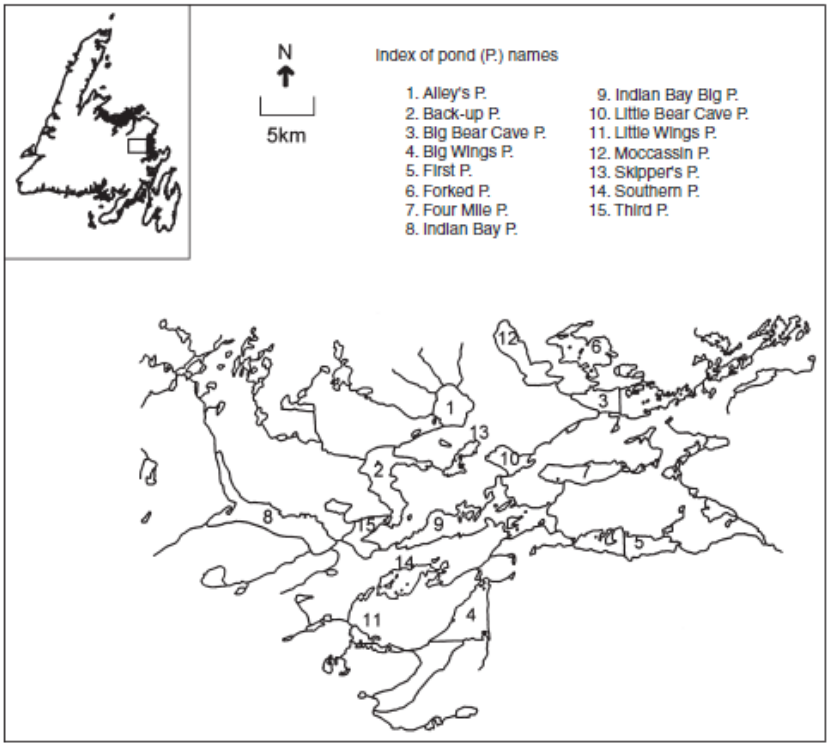


Figure 1. Map of Indian Bay Watershed
Source: M. Van Zyll de Jong, IBEC

1.1 Rationale

The Indian Bay Watershed (IBW) is known as one of the best fishing spots for Brook Trout in Eastern Newfoundland. In the 1970's and 80's easier access, increased fishing pressure and lack of management led to declines in trout populations and general deterioration of the watershed. This resulted in the formation of IBEC in the late 1980s.

Current water quality monitoring in the IBW consists of sampling within the town of Indian Bay under the provincial drinking water monitoring program. The Department of Health and Community Services' environmental health program is generally carried out by Environmental Health Officers with Service NL (Department of Government Services). Department of Health and Community Services provides guidance and protocols and Service NL is responsible for bacteriological water quality monitoring activities, although Environmental Health Officers or Service NL technicians may collect samples. Service NL is responsible for establishing collection regimes and ensuring samples get to the lab for testing. Environmental Health Officers collect water samples from public water

supplies *monthly* and test for chlorine residual and presence of E. coli and total coliforms.

In addition to this monthly sampling municipal staff members check for chlorine residual *daily* to ensure a minimum chlorine level is maintained. According to a provincial representative, bacteriological testing is done by the Public Health Laboratory, either in St. John's or at one of regional water testing sites. These sites are located in hospitals, including Grand Falls and Clarenville. Chlorine residual (free and total) levels are tested at each sampling location and recorded. Based on results, measures like boil water advisories could be implemented. The interpretation of test results is done by Environmental Health Officers and then all test results go back to the community and should also include remedial actions where required (e.g., increase chlorine residual, consider flushing, etc.).

The Department of Environment and Conservation (DOEC) Water Resources Management Division, under the 2009 policy on Drinking Water Quality Monitoring and Reporting for Public Water Supplies and Sect. 39 of the *Water Resources Act*, conducts drinking water quality sampling and tests for a suite of physical, aesthetic, organic and inorganic chemical parameters, including disinfection by-products (e.g. Trihalomethanes or THMs and Haloacetic Acids or HAAs) to determine if public water supplies are meeting the Guidelines for Canadian Drinking Water Quality. The Department samples both water supply and water at the tap. While testing of tap water is generally conducted on a *quarterly* basis for these parameters, for communities of 5,000 or less sampling is conducted on a semi-annual basis at a minimum. Disinfection by-products are sampled four times per year for all communities using chlorine as a disinfectant. Source water must be sampled every two to three years and semi-annually during each sampling year (NL DOEC 2013). Based on this testing municipalities receive immediate notification if issues arise in testing results. In addition, two types of water quality reports for communities are available and provided by the Province of NL: seasonal and annual drinking water quality reports (Ramalho et al. 2013).

The Indian Bay River is also part of an active hydrometric station network maintained under the Canada-Newfoundland Hydrometric Network Agreement and cost shared by federal (through Environment Canada) and provincial governments. Data is collected remotely via satellite. DOEC's Water Resources Management Division collects, processes and distributes this information, which includes includes water temperature and streamflow (see www.env.gov.nl.ca/env/waterres/cycle/hydrologic/info.html and www.env.gov.nl.ca/wrmd/ADRS/v6/Template_Station.asp?station=02YR003).

While testing within the municipal system is relatively extensive, source sampling is generally conducted in only one location close to the municipality's water intake and therefore does not provide insights into differences in water quality throughout the watershed. Further, once a community is declared to be under a BWA (as is the case in Indian Bay) the Province no longer conducts regular testing until changes have been made to the municipalities' treatment system and the BWA is lifted.

Although there is little specific baseline data about water quality in the IBW, previous studies have suggested that the quality of the water bodies in the watershed may be deteriorating. The most common activities that have potential negative affects on the water quality include fishing and other recreational uses, forestry and mining exploration. Municipal representatives have also noted improper waste disposal, including inadequate sewage systems in cabins, as a concern (Vodden 2009).

Observations of community partners and local citizens further suggest that there is a lack of awareness among some residents about safe sources of drinking water. Both towns have instituted multiple BWAs in recent years. Some residents from Indian Bay and CWT perceive their town water supplies to be of a lesser quality than other drinking water sources. This is indicated by regular observations of residents collecting water from roadside springs. The use of spring water poses a health concern, since springs are not monitored under the provincial bacteriological monitoring program (NL 2009).

Finally, in Indian Bay and elsewhere across the province public perceptions and preferences related to drinking water sources are poorly understood. Due to individual or institutional initiatives, such as BWAs or education efforts, some users may be aware of the quality of the water from various sources and thus change their household water consumption. Users may also be conscious of possible detrimental health outcomes due to previous exposure and in turn be more vigilant of perceived illnesses. Households unaware of surface water or roadside spring water quality concerns may continue using water from these sources or may take some precautionary measures such as use of filters or boiling. Anecdotal evidence suggested that some residents have been concerned enough about the safety of roadside spring water to undertake testing at their own expense and have on occasion revealed high levels of iron in the water. These reports identified a need for further investigation of these concerns, of differing user group opinions on sustainable solutions for water quality monitoring, and watershed protection and use in general.

1.2 Project objectives

This project had three key objectives:

- To determine the presence of microbiological and/or chemical contaminants of surface waters and roadside springs in the Indian Bay watershed;
- To determine population perspectives and practices related to water consumption and contamination, environmental management and sustainable solutions; and
- To research community-based watershed water quality monitoring models employed elsewhere that may be applicable in Indian Bay along with their relative strengths and weaknesses.

2. Research Methodology and Approach

The research methodology was broken into several elements, each with a specific purpose. These included a household population survey on patterns of drinking water consumption and perceptions relating to recreational watershed use, a cabin inventory and assessment survey within the IBW, and site sample testing for microbiological and metal contamination throughout the IBW and at popular roadside springs. Another aspect of the project was to complete a scan of literature and websites pertaining to other watershed groups in Canada and their involvement in water quality monitoring and stewardship. Finally, engagement activities with local stakeholders and persons of special knowledge with regards to public water systems and watershed use were undertaken to gain additional insights from local knowledge and drinking water specialists.

2.1 Advisory committee

The first project steps included an initial literature and secondary documentation review and the formation of an advisory committee. The advisory committee included representatives from the Towns of Indian Bay (Crosby Bungay, Ron Collins, Max Pickett, Deanne Parsons and Christa Parsons Lane) and Centreville-Wareham-Trinity (Churence Rogers, Verna Matthews, Johann Pickett), DOEC (Robert Picco, Annette Tobin, Ben Hammond) and Dept. of Government Services (Stella Gilbert). The group met on three occasions to discuss the overall project and proposed sampling protocol (June 2012), the household survey and work plan for summer 2013 (May 2013) and the draft project report (November 2013).

2.2 Literature and secondary source review

An initial literature review included reviews of DOEC BWA and water quality reports for the two towns, as well as previous IBEC public reports, to get an initial understanding of the state of the water quality in the system. Additional website and document review was conducted to investigate how other watershed groups across Canada were tackling water quality monitoring, particularly in light of limited budgets and heavy reliance on volunteer activity.

2.3 Water quality sampling

Water quality is a term used "to describe the physical, chemical, and biological characteristics and conditions of water and aquatic ecosystems which influence the ability of water to support the uses designated for it" (CCME 2006). The uses of water in the case of the Indian Bay watershed must be considered both from an ecosystem perspective (e.g. support of fish species and other aquatic biological populations) and in terms of anthropogenic activities such as recreation (e.g. swimming) and potable water consumption.

Water quality monitoring can assist with the establishment of baseline or reference conditions and to determine trends, ensure regulatory compliance, detect emerging issues and threats, and/or measure response to remedial measures and regulatory decisions (Environment Canada 2009). With few past water quality monitoring activities for IBEC, this study represents an attempt to gather baseline conditions from which an ongoing program can be developed.

Water quality monitoring requires the determination of key sites for sample collection, a sampling schedule and parameters for analysis as well as data analysis, evaluation and reporting. For this project chemical and microbiological analysis has been conducted on seven source sites throughout the watershed and within participating municipalities (see Figure 2). The seven sites were chosen based on their proximity to the Town of Indian Bay's intake system, areas with relatively high concentrations of cabin development, as well as areas with high frequency of human use (in the case of two natural roadside spring water sources).

The initial intent for the testing was also to determine levels of hydrocarbons due to community concerns over the heavy use of recreational motor vehicles in the watershed. Unfortunately due to the expense of this testing, only one round of hydrocarbon testing was deemed feasible within the project budget (completed in March, post-snowmobiling season and during snow/ice melt). Thus the purpose of the testing shifted towards determining levels of metals, nitrates, sulphates, E. coli, and total and fecal coliforms in the water systems, all of which were additional material concerns. Four different laboratories were engaged for the testing: Stantec Consulting Ltd. (bacteriological/microbial), Memorial University Laboratory (metals, nitrates, sulphates), Provincial Health Lab (bacteriological), and Maxxam Labs (hydrocarbons).

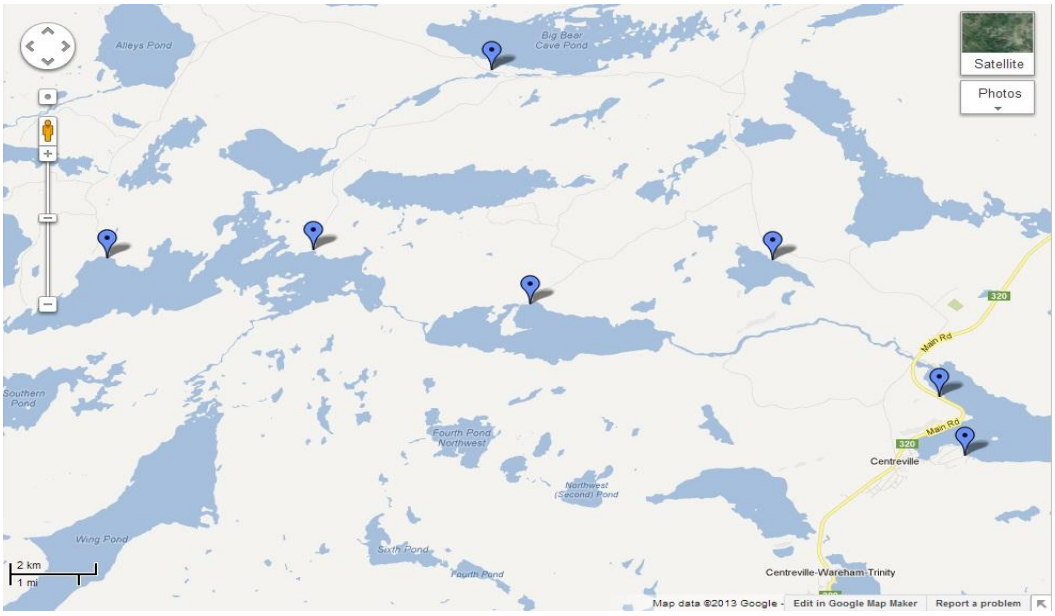


Figure 2. Location of sampling sites

In total, five rounds of testing were completed in the IBW and neighbouring natural spring locations to address potential seasonal variance (August and December 2012; March, June and August 2013 – conforming to provincial guidelines for seasonal water quality monitoring). A final, fifth round of testing was added (August 2013) to ensure consistent data for all four seasons. In the first round (August 2012) provincial labs were unable to provide testing support but after detection of E. coli in samples during the first sampling round, and given the inability of the private lab to capture levels below 1.8 MPN/100 ml, provincial services were made available and four subsequent testing rounds were completed.

Additional pilot testing of a portable water quality monitoring kit (*WET-PRO Field Kit)* was conducted in September 2013 (see section 5.5 for details). This testing was completed largely for training purposes with samples taken only from the two springs and from the tap within the IBEC building.

2.4 Household survey

A household survey was conducted to determine population perspectives and practices both within community households, as well as in the IBW (where the household members were deemed to be active users of the IBW). With input from the Advisory

Committee and staff and board members of IBEC, the researchers designed and implemented a survey entitled "Water Quality Survey for the Towns of Centreville-Wareham, Trinity, and Indian Bay". The instrument consisted of 40 questions that addressed residency, water source used, attitudes toward water-related health, use of the IBW, and several topics related to conservation of the IBW (please see Appendix 4 for the survey). The survey took approximately 15 – 20 minutes to complete and was filled out by the head of the household.

Announcements regarding the upcoming study were disseminated through posters (see Appendix 3), community television channels, and word of mouth. Researchers attempted to ensure that there was adequate warning of the upcoming survey to encourage participation.

Data collection occurred from May through July 2013. The researcher responsible for primary data collection was a graduate student with a background in environmental policy and a community outsider prior to the study. Four assistants from the target communities also assisted with data collection. The procedure for collecting data involved researchers approaching every occupied home in the communities on a minimum of two occasions with the intent of soliciting responses to the household survey. If residents were not home or were not available to provide information for the study, then researchers would return at a later date, where possible, at a time specified by the researcher. Second attempts at contact occurred approximately two weeks after initial contacts were made. While the first round of visits was conducted during work hours, researchers attempted to approach houses during evenings or weekends on additional visits to reduce potential concerns with respondent bias against working families.

Results were inputted into an Excel spreadsheet and the data was cleaned and subsequently exported to Predictive Analytic Software (PASW) for analysis. A graduate student who had experience in research and analysis, and had worked on similar databases in the past analyzed the data. Basic descriptive statistics were completed for all questions, in total and by community. Researchers then enumerated several research questions they wanted assessed, including comparisons between groups. The data analyst was able to provide information on the statistical outcomes associated with those questions. The data analyst used a variety of non-parametric and parametric tests to assess the various relationships (e.g., χ^2, Fisher's exact test, regression, etc.). For a technical description of the findings (associated statistics, critical values, etc.) see Appendix 5. In comparing results between the amalgamated communities of CWT, Centreville-Wareham and Trinity were analyzed independently because they do not share the same water supply.

2.5 Site inspections

A well-established practice within the communities of Indian Bay and CWT is the preference of, and reliance on, natural roadside springs for household drinking water supplies. Because sources of this nature fall outside the purview of government regulation, little is understood about these sources in terms of their frequency of use, the quality of the source water, as well as the physical nature of the locations themselves. Inspection of the physical sites was conducted in order to gain some understanding as to the nature of the sources (see Fig. 3).

Figure 3. Photo of Indian Bay spring source
Photo Credit: M. Simms, Indian Bay Ecosystem Corp.

Site inspection was also undertaken within the IBW in the form of a cabin inventory and inspection. As there are approximately 350 cabins within the IBW, the physical infrastructure within the IBW is significant. Cabin development poses significant potential environmental impact not only on specific sites where cabin development occurs, but also due to the resultant requirement for services such as roads and local resource extraction (e.g. woodcutting, fishing and hunting, increased human traffic within the watershed, etc.).

A cabin inventory and site assessment was performed on cabins with shoreline frontage on eight ponds within the IBW. These eight ponds were chosen based on the

density of their development as well as on choosing areas where water sampling had taken place. Cabins surveyed included: Number Two, Backup, Alleys, Skippers, Bear Cave, Four Mile, Number One, and Adurt Brook Pond. Additionally, the cabins surveyed were developed on property with shoreline frontage. The ponds ranged greatly in development density, from as few as two identified shorelines cabins (Adurt Brook, Alleys and Skippers) to as many as 39 (Number Two). Provincial Crown Lands provided a baseline map of cabin locations. Locations were then confirmed or modified through visual inspection. The properties were accessed by both canoe and road and were visually inspected based on a survey form developed by the research team (see Appendix 6).

The purpose of the survey was to develop an inventory of cabins with shoreline frontage and potential related water quality-related concerns, including the means of sewage disposal within those sites (septic system, outhouse, etc.), and any evidence of environmental damage (shoreline erosion, household waste on site, chemical contamination, etc). GPS coordinates and photos were taken of each property to assist with future analysis and identification (see Figure 4).

Figure 4. Example of cabin on No. 1 Pond, IBW
Photo Credit: M. Simms, Indian Bay Ecosystem Corp.

2.6 Interviews and additional stakeholder engagement

To supplement the above methods and fill in remaining gaps, interviews and consultations were conducted with persons holding insider knowledge regarding the workings of the town water supply, as well as more broadly issues relating to local environmental issues in spring through fall 2013. In addition, experts from University of Alberta, University of British Columbia, University of Calgary and the Centre for Disease Control's Division of Foodborne, Waterborne and Environmental Diseases were consulted regarding risks associated with E. coli. Open, ongoing dialogue formed the basis of interaction with government officials and stakeholders in order to gain specific expertise and "insider" information with regards to the functioning of the town water supplies. Informal interviews were conducted to fill out any remaining knowledge gaps.

Researchers took the opportunity to present preliminary results to colleagues and members of the general public during the June 2013 Community-University Expo (CU Expo) in Corner Brook, NL. A poster presentation on the project research was submitted to a public engagement forum for the CU Expo event to provide public outreach as well as feedback on topics relating to public drinking water supplies in small communities from conference participants (see Appendix 8).

Finally, in addition to seeking input from advisory committee, team members presented on the project results at the IBEC AGM Thursday November 21, 2013, prepared a short project summary for submission to the IBEC website and newsletter and have offered to present on the project to local town councils.

3. Results

3.1. Literature/secondary source review and introduction to area water systems

Indian Bay

A stream survey project completed by IBEC in 1995-1996, with funding provided by CASE/C and submitted to Inland Fisheries provided some initial data on water quality in the Indian Bay system (Norris 1997). The project commenced in August 1995 and lasted through the spring of 1996. The objective was to establish baseline parameters of water quality in the watershed to further IBEC's goal at the time of community watershed

management (Norris 1997). The primary concern over water quality was related to the health of salmon and trout stocks in the watershed.

The project had two components: 1) a field survey, and 2) water quality sampling. In total, five brooks were surveyed – Wings, Four-Mile, Big Bear Cave, and Little Bear – for obstructions or any habitat related problems. This included inspection for overly intrusive beaver dams, siltation, erosion, and human-caused waste. Water sampling stations were installed at three selected sites – Third, Four Mile, and Wings Brooks. Two water quality samples were taken, in September and October 1995, with the results analyzed at labs in St. John's and Fredericton, NB. The samples tested for water temperature, PH levels, Redox (reduction-oxidation), and specific conductivity. Nine samples were initially planned, however this was not possible due to the closing of the field season, weather conditions, and other factors. Unfortunately, as a result no baseline water quality data appears to have been captured or stored for future use.

All but one home in the Town of Indian Bay is served by the municipal drinking water system. Town representatives estimate that the distribution system was initially installed in the early 1970s. While much of this system is still in place, some portions have been replaced in recent years. There are two pump houses in the community and one treatment station (located near the river intake in Indian Bay Park) where chlorine is used as a disinfectant. Most NL communities use chlorine as their primary disinfectant (NL 2013).

A review of BWA reports reveals that the BWA currently in place in the town of Indian Bay was first issued in September 2008 due to repeat detection of total coliforms in drinking water sources. The presence of fecal coliform bacteria (E. Coli) in aquatic environments indicates that the water, at the time the sample was collected, was contaminated with the fecal material of human or other warm-blooded animals. While fecal coliforms themselves are not usually considered pathogenic, if large numbers are found in samples they may indicate the presence of other pathogenic organisms[1]. Some waterborne pathogenic diseases include typhoid fever; furthermore viral and bacterial gastroenteritis and hepatitis are relative to this microorganism (Perchard 2001). Because the Town of Indian Bay is subject to a BWA a Drinking Water Quality Index Score is not available for the town. Representatives of the Town report that the presence of coliforms after treatment is due to low levels of chlorine in parts of the town (north of the bog/on Country Road). An engineering study was conducted in 2011 and a proposal has recently been submitted for a new tank and booster to address the issue of low chlorine residual in

[1] The impact of E. coli presence for human health depend on the E. coli strain present. O157 is the major concern in food and water (e.g. The XL recall; Walkerton outbreak) and there is zero tolerance for this strain (should not be consumed). According to one expert consulted during the project "normal fecal E. coli does not cause disease… Enteropathogenic E. coli only infects kids, enteroinvasive E. coli is rare and takes a large dose. It is not really known for enteroaggrative E. coli or enteroadherent E. coli. " Penn State University Extension Services explain, "There are hundreds of strains of *E. coli*. Although most strains are harmless and live in the intestines of healthy humans and animals, a few strains can produce a powerful toxin and can cause severe illness and death."

parts of the system. The town does not have a filtration system and uses liquid chlorine for disinfection.

Vodden (2009) identified some concern within the Town of Indian Bay related to impacts of cabin development and recreational use on drinking water supplies, including concerns about fecal contamination, ultimately leading to the initiation of this study. Town of Indian Bay representatives also noted that a number of old buses are leaking and deteriorating in Number One Pond, with some concern from residents about whether this may impact the water supply source. Recreational use of Thwart Pond by recreational vehicles (e.g. Sea-doos) during the summer months was also mentioned in an initial Advisory Committee meeting. Researchers also noted people swimming in Thwart Pond during their rounds of site water sample testing (during the July 2013 testing round). Project partners reported that additional testing was completed by the Dept. of Environment and Conservation in 2011 after a recreational user drove a vehicle into Thwart Pond. Fortunately, no contamination concerns related to the incident were identified as a result of this testing. Further, concerns have been raised periodically about potential threats to the water supply from mineral exploration and forestry development activities in the watershed, including both domestic cutting near the main river stem and commercial harvesting in the headwaters of the watershed (see for example Wells 2002).

According to the Drinking Water Quality Index Summary for Public Water Supplies in NL (http://maps.gov.nl.ca/water/reports/), THM levels have exceeded current guideline values in the town of Indian Bay on several occasions in recent years, including November 17, 2011 (123.75 ug/l), Jun 22, 2011 (124.5 ug/l), Nov 23, 2010 (160.25 ug/l), June 9, 2010 (155.75 ug/l) and Nov. 4, 2009 (104.5 ug/l). 100 ug/l is considered acceptable under Health Canada guidelines. On Nov 23, 2010 and Jun 09, 2010 the HAA level also exceeded guidelines (139.7 ug/l in Nov. 2010). Dissolved organic carbon (DOC) or natural organic matter (NOM) occur due to "decomposition and metabolic reactions in a water supply and its surrounding watershed" and "some NOM compounds can react with chlorine and chloramines to produce disinfection by-products (DBPs) such as trihalomethanes (THMs) and haloacetic acids (HAA) that are thought to be carcinogenic and/or genotoxic" (CBCL Consulting, 2011a, p. i). One municipal representative explains, "there is no guideline for NOM/DOC, however literature suggests that surface waters with a DOC >4.2 mg/L contribute to THM and HAA formation, and are not recommended to be used as a source water" yet "most of our surface waters have a DOC at 4.2 mg/L or significantly higher, with no means to treat the water for DOC removal (most systems only have disinfection and, in some cases, pH adjustment as their treatment processes)." Seasonality and human activities that impact watershed drainage patterns have been shown to increase NOM in some water supplies. It is also suggested that optimal (neither too low nor too high) and consistent levels of chlorine must be maintained throughout the system. This requires training and expertise (NL 2013). The Town of Indian Bay's water operator is reported to be an Operator in Training.

A final concern noted in previous water reports for the Town of Indian Bay is aesthetics. Reports from 2006 and 2007 note that perceived water quality may be reduced due to exceedances in aesthetic parameters (colour and pH). pH levels are typically slightly

lower than desired levels in Indian Bay (e.g. 6.1-6.4 vs. 6.5-8.5 on a scale of 0 to 14), although higher than desired in June 2000 and Nov. 2001. Explaining that pH is considered an aesthetic parameter, the U.S. Water Systems Council (2007) states:

> Water with a low pH can be acidic, naturally soft and corrosive. Acidic water can leach metals from pipes and fixtures, such as copper, lead and zinc. It can also damage metal pipes and cause aesthetic problems, such as a metallic or sour taste, laundry staining or blue-green stains in sinks and drains.
>
> Water with a low pH may contain metals in addition to the before-mentioned copper, lead and zinc. Drinking water with a pH level above 8.5 indicates that a high level of alkalinity minerals are present. High alkalinity does not pose a health risk, but can cause aesthetic problems, such as an alkali taste to the water that makes coffee taste bitter; scale build-up in plumbing; and lowered efficiency of electric water heaters.

CWT

In CWT 100 percent of community households are serviced by the system, the Town is not currently on a BWA, and has a dedicated, full-time Class 1 Water Operator. There are two distinct water sources serving the community. Significant challenges for ongoing delivery include financial resources to repair or upgrade aging physical infrastructure such as pump house equipment that has not been functioning properly. Repairing or replacing current distribution infrastructure is a high priority for improving drinking water quality in the community. The pump house in Trinity has recently undergone an upgrade project; there have also been some upgrades to the Centreville pump house in recent years. Amongst the greatest concerns with pump house equipment failures is that there is rarely back-up equipment in place. As such, when new equipment must be ordered and shipped, there will be a period of downtime.

The Town has issued several BWAs in recent years, but they are generally of short duration (longest duration between 7-14 days). BWAs in CWT have generally been put in place due to equipment malfunction or maintenance (e.g. the disinfection system was off due to maintenance or mechanical failure, including BWAs for Northwest Pond in August and Southwest Pond in September 2013). The town has put BWAs in place as a preventative measure when power outages allow untreated water to enter the system or maintenance activities have had the potential to compromise water quality. On March 8, 2013 a BWA was issued for Southwest Pond (Trinity) because inadequately treated water was introduced into the system "due to fire flows, flushing operations, interconnections, minor power outage or other pressure loss." BWAs are communicated through a faxed BWA sent to local businesses, postings on Town website and/or Facebook pages, word of mouth, and sometimes through an automated phone message system.

As with many towns in the region using small systems with surface water supply and chlorination, THMs and HAAs are frequently above provincial guidelines. For

Northwest Pond (Centreville-Wareham) THMs above guideline levels were identified as a concern Feb 26, 2013 (150.5 ug/l), August 6, 2012 (180.75 ug/l) Nov. 17, 2011 (160.38 ug/l). HAAs have also exceeded guidelines on multiple occasions (Feb 26, 2013 - 465.1 ug/l vs. 80 ug/l considered acceptable under Health Canada guidelines); Aug. 6, 2012 - 219.6 ug/l; Nov. 17, 2011 - 199.9 ug/l; June 21, 2011 - 91.4 ug/l). A December 2, 2010 report indicated that it was not possible to provide a Drinking Water Quality Index rating due to an inadequate number of THM and HAA samples. An index ranking is not provided if exceedences occur for any parameters, however, one representative believes the 2010 statement was related to the fact that the disinfection system was off for a period prior to that sample being taken. THM/HAAs are ranked on a running average.

Despite these challenges the Town office receives complaints about discoloration, smell, and taste of water but does not receive complaints that the public feels drinking water is unsafe to drink. The Langelier Index figures indicate that the water is under saturated with calcium carbonate, which according to DOEC means it "will tend to be corrosive in the distribution system" (DOEC 2014). Like Indian Bay, both the source water and tap water have been outside of recommended range in terms of colour and pH.

3.2 Surface water quality sampling

Analysis of metals

Results from every lab test to date report no high levels of hazardous metals. However, there was found to be high (more than guideline values) levels of manganese (Aug, 2012 & 2013) and iron (Aug, 2013) in Site 2 (Number 2 Pond boat launch). There is some evidence in the literature regarding health impacts of high manganese levels such as neurological, reproductive and possible cardiovascular effects (U.S. Department of Health and Human Services 2012), however manganese is not considered a health risk according to official guidelines. Both manganese and iron are more associated with aesthetic aspects of drinking water (e.g. colour, taste or laundry staining).

Analysis of microbial contamination

Testing has taken place for total coliform, fecal coliform and E. coli. Total coliform describes natural microbes present in the environment. Within the study, the presence of total coliform was not unnatural as samples were collected directly from ponds/lakes/ streams and springs. However, its presence in public drinking water supply indicates inadequate or improper treatment. Presence of E. coli in water is a clear indication of fecal contamination and is considered hazardous to human health. Normally the treated public water should not have any E. coli and total coliform (acceptable levels are ‘0’ as per

provincial and federal guidelines). Additionally, presence of E. coli indicates the possibility of contamination of other disease causing microorganisms (bacteria, virus, and parasites).

Table 1 (below) describes the results from four testing rounds, indicating a recurring presence of E. coli throughout the watershed, with some seasonal variance. Absence of E. coli from the March samples were likely due to the winter/post winter season, as E. coli is less prominent in frozen conditions. Within the IBW, the presence of E. coli is neither surprising nor particularly troublesome, given that all public source water must be treated, however it does indicate a consistent level of human and/or animal interventions into the IBW water sources. It must be noted that drinking water directly from the ponds; a noted common practice within the IBW, needs to be strongly dissuaded amongst IBW users.

Table 1. Results from Public Health Lab, St. John's

Sample site	**December, 2012**		**March, 2013**		**June, 2013**		**August, 2013**	
	Total C	E Coli	Total C	E Coli	Total C	E Coli	Total C	E Coli
1. No. 2 Pond	√	√	√	X	√	x	√	x
2. No. 2 Pond (boat launch)	√	X	√	X	√	√	√	x
3. Jim's Steady	√	√	√	X	√	√	√	x
4. No. 1 Pond	√	√	√	X	√	√	√	x
5. Dirt Brook Pond	√	√	√	X	√	√	√	x
6. Rockcut Spring	√	X	√	X	√	x	√	x
7. Wareham Spring	√	X	√	X	√	x	√	√

Total C – total coliform, √ - detected, x – not detected

The indicated presence of E. coli in water from the Wareham spring in August 2013 demonstrates similar caution is needed with respect to roadside springs. This was further illustrated through initial testing of the CURAH20 portable water quality monitoring kit (*WET-PRO Field Kit)* in September 2013. Results of these tests (completed with assistance from St. Mary's University field staff) indicated that coliforms were present in both springs and the tap water in the IBEC administration building (located on Country Road, an area of concern as noted by the Town of Indian Bay). Table 2 (below) represents the results taken from a private lab in St. John's. There exists a level of discrepancy between the private and the public health labs. Most notably the Public Health Lab detected E. coli in Site 7 (Wareham Spring) in the August 2013 round, whereas the private lab did not.

Table 2. Test Results from a Private Lab, St John's

Site #	**August, 2012**			**December, 2012**			**March, 2013**			**June, 2013**			**August, 2013**		
	TC	FC	EC	TC	FC	EC	TC	FC	EC	TC	FC	EC	TC	FC	EC
1. No. 2 Pond	13	2	2	47	<1.8	<1.8	<1.8	<1.8	<1.8	31	13	13	79	<1.8	<1.8
2. No. 2 Boat Launch	<1.8	<1.8	<1.8	4	<1.8	<1.8	33	<1.8	<1.8	21	<1.8	<1.8	7.8	<1.8	<1.8
3. Jim's Steady	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	49	<1.8	<1.8	2	<1.8	<1.8
4. No. 1 Pond	4.5	4.5	2	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	49-79	49-79	49-79	4	<1.8	<1.8
5. Dirt Brook	70	13	13	11	2	2	<1.8	<1.8	<1.8	17	17.8	17.8	21	2	2
6. Rockcut Spring	7.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	14	<1.8	<1.8
7. Wareham Spring	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8

Indeed, it is interesting to note that with regard to E. coli there are some discrepancies on presence and absence. This may be accounted for in some cases by variant threshold measures between the two labs (e.g. public testing as presence/ absence and private lab at a minimum of 1.8 MPN/100 mL), however we could not ascertain the reports with absolute certainty. Each laboratory report shows that there is no clear consistency on water quality; however it is clear that at minimum this discrepancy warrants ongoing monitoring

Hydrocarbons, Nitrates and Sulphates

Hydrocarbons were not detectable in the March 2013 sample, nor were nitrate and sulphate levels outside threshold limits detected in any of the five sampling periods. These are encouraging signs given that hydrocarbon levels were a primary concern and major reasoning for water sample testing. Given that sampling was only conducted on one occasion during this study due to budget constraints, caution is needed in making conclusions regarding hydrocarbon presence.

3.3 Household survey results

Participants

Researchers sought feedback from all households that were in the communities of Centreville-Wareham, Trinity, and Indian Bay. A broad sampling frame was desired for the current study. The number of households was obtained from a previous IBEC mailing list. Households were also visually counted, and persons with community knowledge were engaged to assist, for example, with identifying occupied households. A number of households in the community were vacant, either permanently or seasonally or because residents travel on a multi-day or week basis for work. After visual inspection, local consultations, and reference to Canada Post's mailing list for the communities, 485 occupied households were identified.

In total 485 households were asked to complete the relevant survey. A total of 268 surveys were completed and returned to the researchers within the study's timeframe (55% response rate). In total, Centreville-Wareham contributed 166 surveys (62% of the surveys collected), Trinity contributed 52 surveys (19% of the surveys collected), and Indian Bay contributed 50 surveys (19% of the surveys collected). Refusal rates varied by community, ranging from only three refusals in Indian Bay (5%), to 15 in Centreville-Wareham (5%), and 31 in Trinity (24%). Response rates were highest in the Town of Indian Bay, which relies on the Indian

Bay watershed as its municipal drinking water source, and lowest in Trinity, the community furthest from Indian Bay. Possible reasons for the disproportionate refusal rate in Trinity include physical location (Trinity is located farthest from the IBW and therefore least immediately familiar with issues relating to the IBW and IBEC), as well as disparate drinking water issues (Trinity operates within a separate water system). Findings also suggest that persons from Trinity were far less likely to spend time in the IBW than persons from Centreville-Wareham or Indian Bay and, therefore, may have considered the study less relevant.

Table 3. Rate of Response by Town

	Centreville-Wareham	**Trinity**	**Indian Bay**
Returned/# of Occupied Households	166/290	52/130	50/65
Response Rate (%)	57.2%	40.0%	76.9%
% of Total Responses	61.9%	19.4%	18.7%
% of Total Households	59.8%	26.8%	13.4%

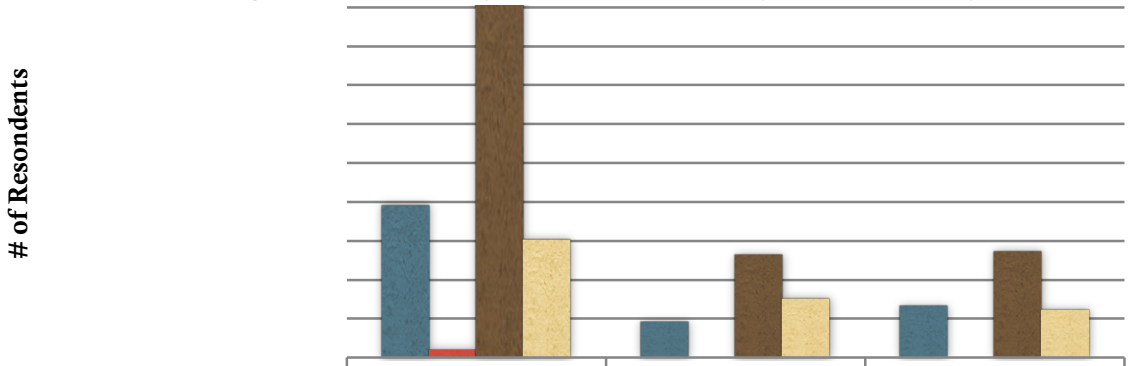
Division of respondents by sex was skewed in terms of response (125 female, 102 male) but the skew was not statistically significant. A total of 41 respondents (15%) did not specify their sex, primarily because a couple answered the survey jointly. The average number of people living in each household surveyed was 2.4. Age of respondents varied by community, with 38% of respondents being 60 years of age or older in Indian Bay for example and 46% in Centreville-Wareham (55% in Trinity). Of Indian Bay respondents 29% of respondents were 44 years of age or younger versus 20% in Trinity and 11% in Centreville-Wareham. These demographic characteristics are reasonably consistent with Government of Canada Census data (Community Accounts 2011).

Water Sources

On average, communities tended to use water sources (e.g. dug/drilled water, natural/roadside springs, tap water, and bottled water) at about the same rate. Overwhelmingly respondents of all communities indicated that their main source of drinking water was natural or roadside springs (55%, see Fig. 5). The second most

popular water source was bottled water (23%), followed closely by tap water (21%), then dug/drilled water (1%). Across communities, there was relative uniformity in response to this question, with CW having the highest rate of roadside spring users (57%), and each of Indian Bay and Trinity being equal (52%).

Figure 5: Primary Water Source by Community



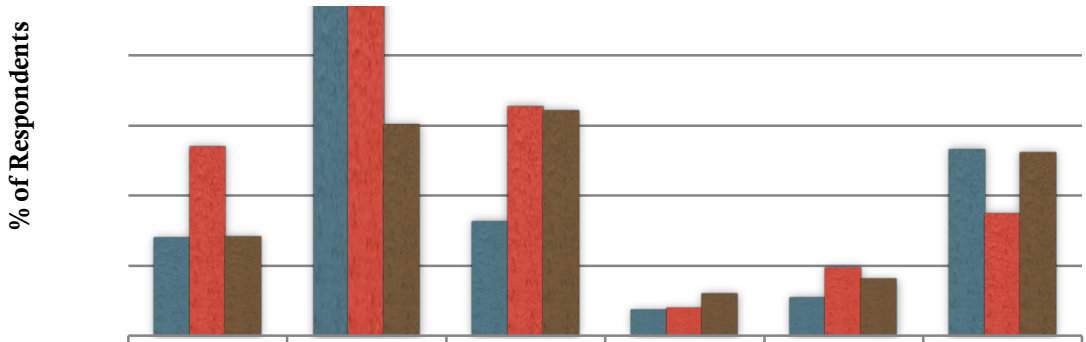
	Centerville/Wareham	Indian Bay	Trinity
Bottled Water	39	9	13
Dug/Drilled Well Water	2		
Natural/Roadside Springs	95	26	27
Tap Water	30	15	12

Researchers asked a series of questions that addressed factors that may influence resident choices in sources of drinking water, including accessibility, affordability, clarity, safety, smell, and taste. Overall, taste was perceived as being an important factor in why certain sources of drinking water were chosen, particularly in Centreville-Wareham and Trinity. When examined on a community-to-community basis, researchers found that persons from Trinity were more likely to indicate that accessibility was relevant in the choice of water supply than either Indian Bay or Centreville-Wareham. Conversely, for persons from Centreville-Wareham accessibility was less important than in Trinity or Indian Bay.

When the reason for selecting the water source chosen (i.e., accessibility, affordability, clarity, safety, smell, and taste) was compared to the source of water chosen (see Fig. 7), the data revealed a very significant finding. Natural/roadside spring water was perceived as being far less accessible than other forms of water. However, natural/roadside spring water was the most popular source of water amongst respondents. These results indicate that although there is an associated inconvenience with getting natural/roadside spring water, it is still preferred to the much more accessible tap water. Nearly two-thirds (62%) of the 148 respondents who drink spring water as their main source do so primarily because of taste. Taste is

also the most important consideration for those who chose to drink bottled water, while those who drink tap water are concerned primarily with accessibility.

Figure 6: Why is this the main source of your drinking water?

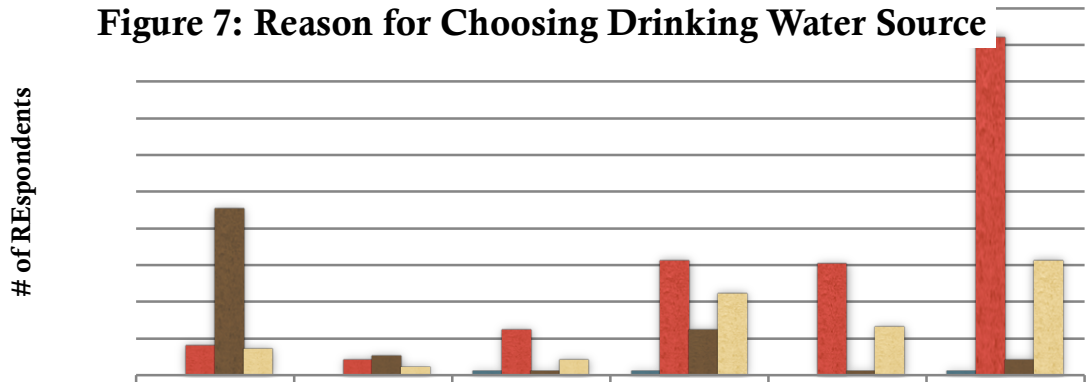


	Smell	Taste	Access	Affordability	Clarity/Colour	Safety
C/W	13.9%	50.6%	16.3%	3.6%	5.4%	26.5%
Trinity	26.9%	55.8%	32.7%	3.8%	9.6%	17.3%
IB	14.0%	30.0%	32.0%	6.0%	8.0%	26.0%

Results indicate that persons who drink bottled water or spring water are far more likely to agree with statement, "My tap water is unsafe". Conversely, persons who drink tap water are more likely than most to disagree with this statement. Of the persons who selected bottled water as their main source, 36% of persons who selected bottled water indicated it was due to safety concerns, while only 21% of the persons who selected tap water and 21% of persons who selected spring water indicated their choice was due to safety concerns.[2]

[2] The Pearson Chi Square Statistic (χ^2) used to determine if persons chose bottled water due to safety concerns was approaching significance (p=.07) but was not at significance (two-tailed, p=.05). However, given that researchers would expect safety concerns to be relevant to water source choice after finding that persons who drank bottled water did not believe their tap water was safe, it was reasoned that using a one-tailed significance level (i.e., p<.10) was acceptable. Thus, the finding was interpreted as significance. Functionally it means that researchers have a 7/100 chance of being wrong, instead of a 5/100 chance of being wrong.

Figure 7: Reason for Choosing Drinking Water Source



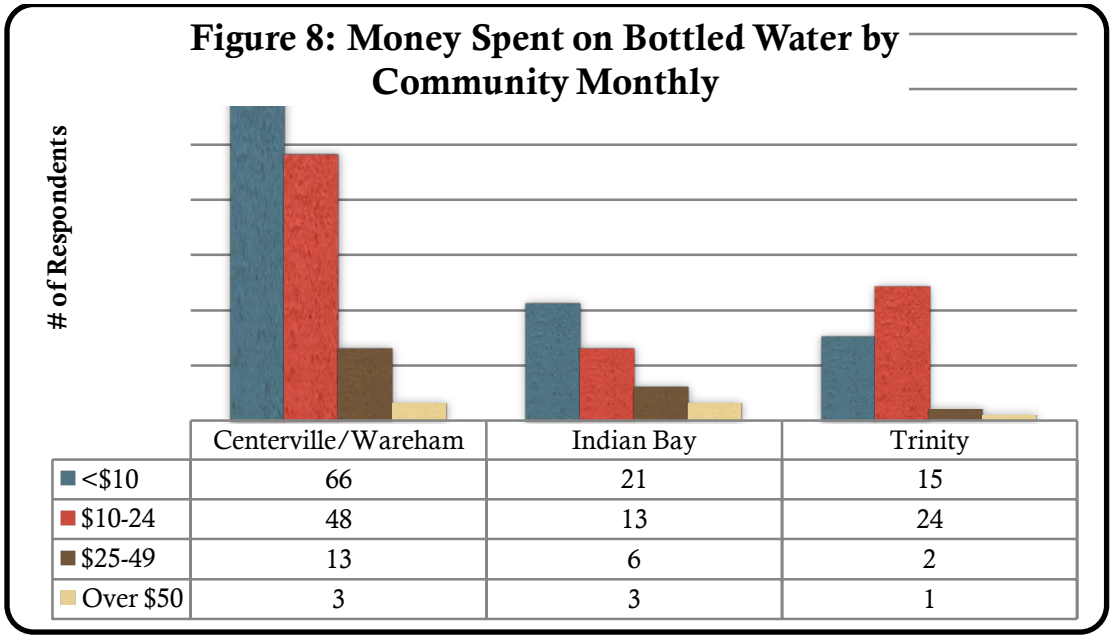
	Access	Affordability	Clarity/Colour	Safety	Smell	Taste
Dug	0	0	1	1	0	1
Springs	8	4	12	31	30	92
Tap	45	5	1	12	1	4
Bottled	7	2	4	22	13	31

These findings converge with the qualitative data collected that suggested that tap water has poor taste and smell. In addition to these findings, qualitative responses indicated that persons from Trinity were more likely to report issues with tap water tasting strongly of chlorine (21% of comments), frequent BWAs (21% of comments), and poor quality in general (33%). Somewhat disturbingly, 14% of respondents indicated apathy towards the quality of the drinking water – often citing that they had become accustomed to having to suffer through it.[3]

For respondents purchased bottled water at least once a month, researchers asked how much these households spend on water on a month-to-month basis. Results indicated that on average, households that responded to that question spent approximately $173 per year on bottled water (over $14 monthly)[4]. Although only 61 persons indicated that bottled water was their main source of drinking water, approximately 140 respondents indicated that they were drinking bottled water at least once a week. These responses suggest that many households complement their main water source with one or more additional sources. The rate of bottled water consumption is surprising given that bottled water was recognized as being more inconvenient than tap water. For bottled water drinkers, taste and safety are the primary factors influencing their choices related to drinking water source.

[3] Due to the nature of the question, "Why is this your main source of drinking water?" researchers are interpreting all responses to the question as *positive* aspects of the drinking water. For example, persons who respond with "Taste" are indicating that they have chosen that water source because it tastes good, *not* because their previous water source tasted bad. This assumption applies to all responses.

[4] Researchers used both low end and midpoint estimates of response ranges to determine this value by averaging the two (see Appendix 5).



	Centerville/Wareham	Indian Bay	Trinity
<$10	66	21	15
$10-24	48	13	24
$25-49	13	6	2
Over $50	3	3	1

Environmental Factors and Water Supply

Researchers identified potential threats to the water supply of different communities, and asked respondents whether they were concerned about these threats (see Table 4). Overwhelmingly respondents indicated that the topics researchers raised were not considered to be serious threats to their water supply. In a similar vein, approximately 2/3 of the respondents indicated that they did not believe there were any threats to their drinking water. The activity with the greatest concern was recreational use, although only 20% of the respondents believe that recreation is a threat to water supply.

Researchers investigated whether attitudes towards these threats were related to other factors. Sex, age, and watershed usage were not predictive of attitudes toward the various threats to the water supply. However, community was a significant predictor of some attitudes towards these threats. Residents of Trinity, for example, were more likely to perceive hunting/fishing as a threat to water supply. Of the total population surveyed, only 6% believed hunting/fishing constituted a threat to the drinking water (44% of those persons were from Trinity, where 14% of residents felt that hunting/fishing posed a threat to drinking water). The remaining 94% of persons believed that this activity posed no threat. Finally, while 53% of respondents suggest that they have seen effects of climate change in their area, only

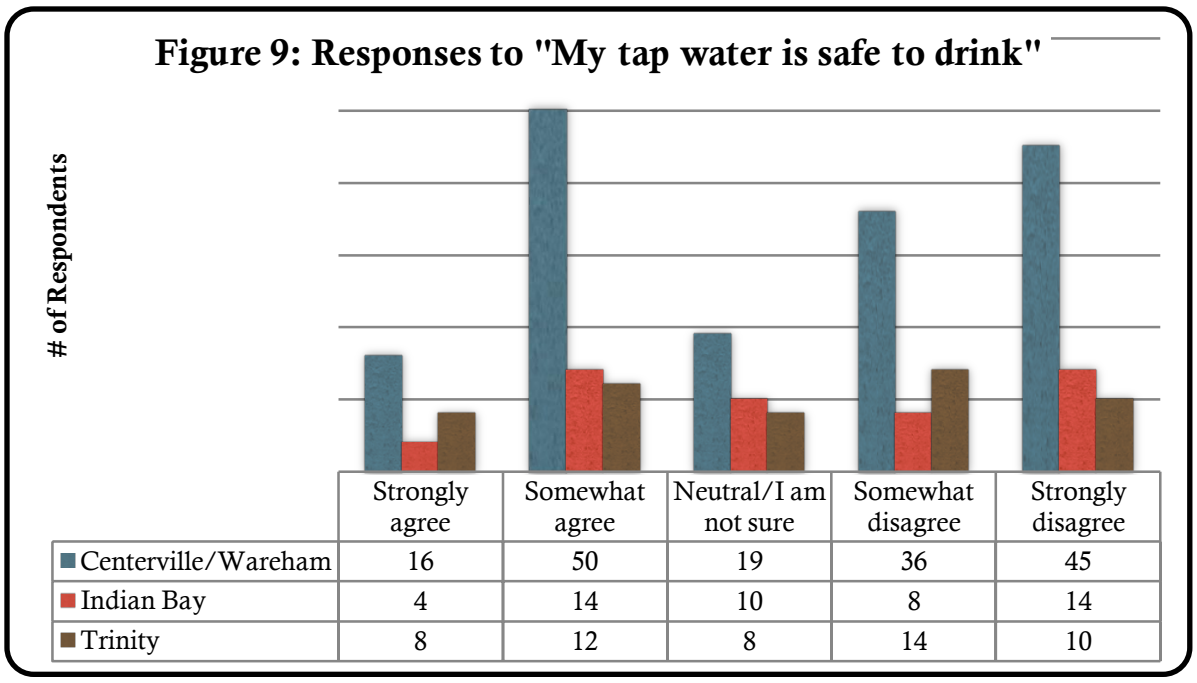
24% believe that climate change is affecting their drinking water (38% are unsure).

Table 4. Land-Use Activities Threatening to Your Water Supply		
Potential Threat	Yes, this is a threat	No, this is not a threat
Agriculture	1.1%	98.9%
Cabin Development	11.9%	88.1%
Forest Harvesting	3.7%	96.3%
Hunting/Fishing	6.0%	94.0%
Mining	3.4%	96.6%
Recreational Use	19.8%	80.2%
Transmission Lines/Road Construction	3.0%	97.0%
Other	.4%	99.6%

Water and Health

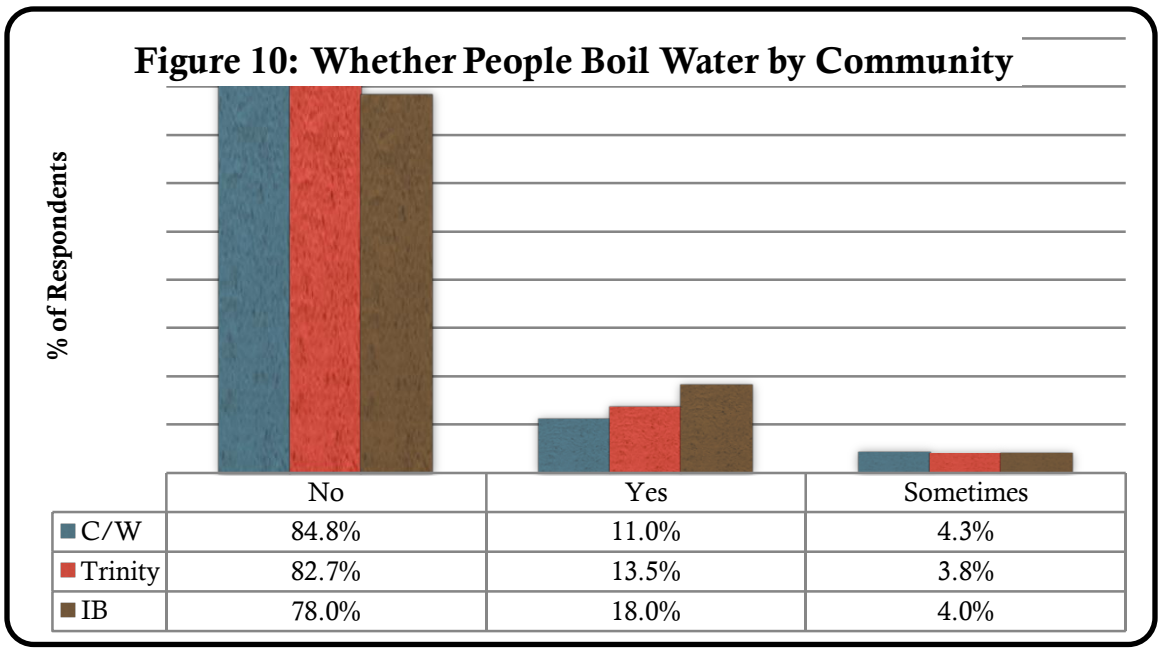
Researchers were also interested in the perception of water-related illness, or risk of illness affecting respondents. When asked if they were aware of any drinking water illnesses in their community in the past year, 97% of respondents answered "No" and 3% of respondents answered "I am not sure". While there were no cases of drinking water illnesses in the communities, a total of 54% of respondents indicated that they felt concerned regarding drinking water-illnesses. Further, approximately 47% of respondents disagreed (to varying extents) that their tap water was safe to drink.

These results suggest that there are significant concerns about water-related illness. Men and women did not differ in their concern for either concerns about illness or perceptions of tap water safety. However, persons over 60 years of age were more likely to express the opinion that they were mostly not concerned about water-related illness. In a related finding, persons from Indian Bay were more likely to report that they "were not concerned at all" about water-related illness in their community (see Fig. 9). Not surprisingly, results indicated that persons who were worried about water-related illnesses were also likely to have safety concerns about drinking water.

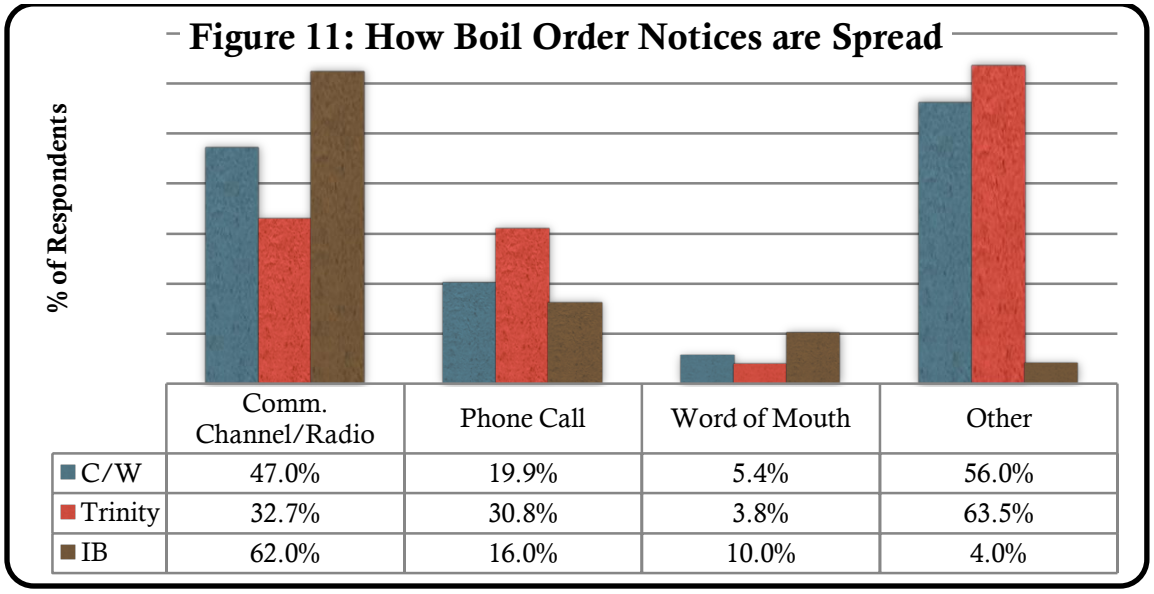


	Strongly agree	Somewhat agree	Neutral/I am not sure	Somewhat disagree	Strongly disagree
Centerville/Wareham	16	50	19	36	45
Indian Bay	4	14	10	8	14
Trinity	8	12	8	14	10

Figure 10 illustrates that despite safety concerns the majority of households do not boil their drinking water. This was a surprising finding given that the Town of Indian Bay has been on a BWA for more than five years (since September 2008). Despite the BWA only 18% of Indian Bay residents boil their drinking water. Also surprising was that fewer than average persons in Indian Bay reported that they were informed of BWA notices; persons in Centreville/Wareham reported higher levels of notification regarding BWA notices. This discrepancy is not explained by the current data, but it could be a product of communications strategies (Fig. 11). Indian Bay residents were more likely to be informed through a community channel than others. Centreville-Wareham and Trinity reported being informed through methods other than the community channel, word of mouth, or through phone calls. A Town representative further explained that BWAs are communicated through a faxed BWA being sent to local businesses, postings on the Town's website and/or Facebook pages, word of mouth, and sometimes through an automated phone message system.



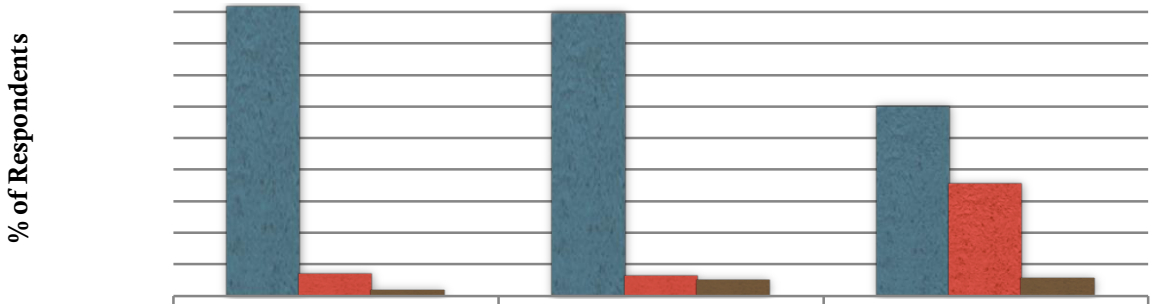
	No	Yes	Sometimes
C/W	84.8%	11.0%	4.3%
Trinity	82.7%	13.5%	3.8%
IB	78.0%	18.0%	4.0%



	Comm. Channel/Radio	Phone Call	Word of Mouth	Other
C/W	47.0%	19.9%	5.4%	56.0%
Trinity	32.7%	30.8%	3.8%	63.5%
IB	62.0%	16.0%	10.0%	4.0%

Persons who reported using natural or roadside springs were less likely to boil their water than persons who used tap water. In Figure 12 below water source is cross-referenced with the decision to boil water. As shown within this figure, tap water is approximately six times more likely to be boiled than either spring or bottled water. Dug/drilled water was omitted from the table because only two respondents had indicated that it was their main source of water.

Figure 12: Source by Whether Home Boils Water



	Bottled	Springs	Tap
No	91.53%	89.19%	59.65%
Yes	6.78%	6.08%	35.09%
Sometimes	1.69%	4.73%	5.26%

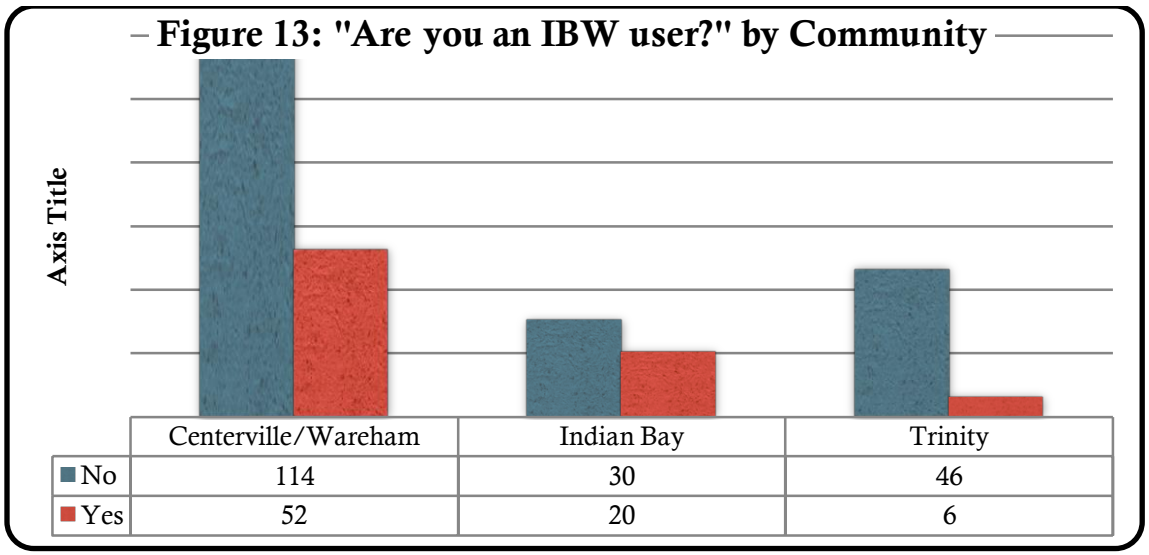
Water and Taxation

Researchers also collected data regarding taxation on water sources, and asked respondents whether a higher tax rate for water would be acceptable if there was significant improvement to water delivery. The researchers hypothesized that increased expenditure on non-tap water sources (e.g., bottled water) would increase respondents' agreeability to an increased water tax if this increased expenditure were to result in improved municipal drinking water (i.e., tap water). Surprisingly, there was no relationship between money spent on water source, and a willingness to pay a higher tax rate for water delivery. Unsurprisingly, persons who believed their water tax was too high were not supportive of an increased tax rate for water delivery. In contrast, persons who were comfortable with the current level of water tax were mostly ambivalent toward a tax increase or were supportive of a tax increase.

However, when researchers looked at the relationship between type of water source (e.g., dug/drilled, springs, etc.) and willingness to increase tax, there was a significant relationship. Persons who identified bottled water as their main drinking source were more amenable to paying an increased tax on water. Surprisingly, persons who used spring water expressed less interest than expected in paying a higher tax. There is not a clear explanation for why some persons were unwilling to pay a moderately higher tax for the added convenience of not having to fetch water from springs based on this study. One possible explanation is that people drinking spring water see this as free water and/or they may not see the trip to go get the water as an inconvenience. Rather than viewing spring water as a health risk they may view the spring water as more "natural", right from nature with no human intervention, or simply as a routine task they always have done.

Perspective from Indian Bay Watershed (IBW) Users

In addition to assessing community attitudes toward drinking water sources, researchers also asked respondents if they spent time in the IBW area (Fig. 13). Of the 268 households who responded to the survey, only 78 households (29%) indicated that they spend time within the IBW. Persons spending time in the IBW tended to be between the ages 33-44, while persons over the age of 60 were less likely to spend time in the IBW. Men and women reported spending about equal amounts of time in the IBW area. Respondents from Trinity were far less likely to spend time in the IBW (12%) than persons from Centreville-Wareham (31%) and Indian Bay (40%) were. Given that persons over the age of 60 are less likely to spend time in the IBW, the higher percentage of respondents in this age group in Centreville-Wareham is likely to be a key factor in differences between Centreville-Wareham and Indian Bay with respect to watershed use.



Indian Bay Watershed (IBW) Activities

Researchers investigated how the respondents to the survey used the IBW. Responses indicate that the IBW was used for a variety of recreational activities. Respondents also indicated that ATVs, snowmobiles, and boats were used frequently within the watershed, and that communities tended to use motorized vehicles in equal proportions.

Table 5. Recreational Activities within the IBW		
Activity	Yes, I do that	No, I do not do that
Fishing	79.5%	20.5%
Hiking	11.5%	88.5%
Hunt/trap	35.9%	64.1%
Motor vehicle	80.8%	19.2%
Work	3.8%	96.2%
Cut wood	16.7%	83.3%

Hunting/fishing (80%) and using motor vehicles (81%) were among the most popular activities in the IBW, while doing work and hiking were the least popular activities. There were no significant differences in watershed activities amongst users across communities.

Cabin Ownership

Of the 78 respondents who indicated that they spent time in the IBW, 36 of these respondents indicated that they or their family owned a cabin in the IBW area. Community residency did not have a statistically significant relationship with whether a person/family owned a cabin in the watershed. Of the cabin owners surveyed, nearly 70% used a septic system in their cabins while 25% used an outhouse. Approximately 2/3 of septic systems described were less than 10 years old, and 70% of septic systems had been serviced in the past decade. While the majority of cabin owners disposed of other wastewater (not including sewage) through their septic systems, over 40% of persons disposed of it outdoors (6% through a pipe directly into a pond or stream).

Of the cabin owners surveyed, 9% admitted to either refueling their boat on the water or within 50 feet of the shore. In terms of specific environmentally negative behaviours, persons in Indian Bay were more likely to refuel a boat on or near a water source while persons in Centreville-Wareham were less likely. In addition, there was no relationship between community membership and clearing vegetation or using eco-friendly products. Overall 54% of cabin owner respondents report that they use eco-friendly products in the watershed regularly, while another 31% use these products sometimes and only 14% do not use them at all.

Researchers asked respondents to indicate whether they engaged in environmentally risky behaviours but also whether they would be willing to alter

their behaviour if it was demonstrated to be causing harm. Approximately 75% of respondents agreed that they would alter their behaviour if they were harming the IBW, while approximately 20% of persons were neutral on the topic.

3.4 Cabin inventory and survey

To supplement the survey process, researchers surveyed the IBW for cabins and property development that may be in direct contact and interplay with the hydrologic cycle. No previous assessment of cabin ownership within the watershed of this kind had ever been undertaken. As the IBW is not only the critical source of drinking water supplies for the Town of Indian Bay but also an important recreational and cultural amenity, establishing an inventory of cabins and their characteristics was important in bridging this knowledge gap.

Of the 76 cabin sites identified on the shorelines of the eight selected ponds (of an estimated 350 cabins total in the watershed), 50 (66%) were identified as maintaining an outhouse on site, 14 (18%) had a septic system, and an additional 12 (16%) were classified as "other" or researchers were unable to identify the sewage system used. These findings appear to contradict the household survey results from cabin owners, in which nearly 70% responded that they use a septic system and only 25% replied that they use on outhouse. Some respondents may have been dishonest in their responses, possibly due to violations of provincial regulatory requirements that septic systems be installed in new cabins. Inspected cabins may also have multiple methods of sewage disposal – an old outhouse on site that is perhaps no longer in use, for example, would have been accounted for. Of the 50 cabins with outhouses throughout the IBW, a total of eight (16%) were identified as having their outhouse constructed within 50 feet of the shoreline. As such development is in violation of provincial regulation when located within a *protected water supply area,* further action may be required to deal with these outlier situations.

Shoreline clearing, most commonly undertaken for the purpose of improved viewscapes and general esthetic appeal, is a significant potential hazard to the water quality within the given area. Because shorelines are on the receiving end of uphill drainage, clearing may result in topsoil loss, shoreline erosion, and reduced capacity to absorb excessive moisture in the event of heavy rains or floods (Living by the Water Project 2013). Shoreline vegetation also helps keep pollutants out of water. Leaving vegetation intact, or at least providing for an ample buffer zone along the shoreline, can greatly reduce these risks. With 16 documented instances of complete shoreline clearing on a property (see Table 5) and substantial undeveloped shoreline, shoreline clearing does not appear to be a major issue within the IBW, however

education and public awareness is a strong recommendation for an organization such as IBEC to undertake to ensure appropriate development in the future.

Table 6. Method of Sewage Disposal in IBW

Ponds	Waterfront cabins	Septic system	Outhouse	Other/unknown	Outhouse within 50 ft. of shoreline
Thwart	2	1	1	0	1
Four Mile	3	1	2	0	0
Number 1	9	0	2	7	0
Number 2	39	10	24	5	7
Alley's	2	1	1	0	0
Skipper's	2	0	2	0	0
Back Up	2	0	2	0	0
Big Bear	17	1	16	0	0
Total	76	14	50	12	8

Table 7. Shoreline Clearing within the IBW

Ponds	No evidence of shoreline clearing	Some shoreline clearing	Shoreline completely cleared
Thwarts	1	1	0
Four Mile	0	2	1
Number 1	4	3	2
Number 2	15	13	11
Alley's	0	0	2
Skipper's	1	1	0
Back Up	2	0	0
Big Bear	9	8	0
Total	32	28	16

There is a strong correlation between shoreline clearing and shoreline erosion (Living by the Water Project 2013), however throughout the cabin survey there was

only one documented instance of "some" evidence of shoreline erosion. This data aligns with the household survey section for cabin owners within the IBW, in which cabin owners showed little tendency towards shoreline clearing or potentially environmentally risky behaviour such as refueling boats directly on the pond.

3.5 Role of watershed groups in water quality

Watershed groups, albeit of often greatly varying scales and mandates, have the potential to play a significant role in maintaining the well-being of the ecosystem in which they are situated (Robins 2007). An additional core objective of this study was to review the role of watershed groups in water quality monitoring, based on the experiences of other jurisdictions. The intent was to learn from the successes and challenges faced in these other jurisdictions, in order to achieve better outcomes. One such review conducted by IBEC in 2013 consisted of an overview of 114 watershed organizations throughout eight provinces. The review was framed around seven key parameters:

- type of organization;
- environment the organization operates in;
- type of organizational structure;
- funding levels;
- revenue streams;
- linkages to government; and
- partner engagement.

The review further examined the organizations' mandate, vision, objectives, past and ongoing projects, review of existing board structure/governance model, and a review of capacity in terms of facilities and staff. Additionally, there was a scan of relevant documents such as strategic and management plans, meeting minutes, annual reports, and project summaries. Particular attention was given to the operational environment, such as geography, in order to compare organizations operating in more rural environments with access to similar target markets and thus having a more likely common linkage to IBEC and the IBW in terms of strengths and challenges faced.

Results from the review indicate that there is significant inter-provincial disparity in terms of development of watershed management and planning, and the relationship between watershed groups and regional and provincial governments. Prairie provinces (Alberta, Saskatchewan, Manitoba) appear to be ahead of Newfoundland and Labrador and other Atlantic provinces in terms of support from provincial and municipal governments for watershed groups, sometimes including core funding. Regardless, many watershed groups operate with little in the way of staff and resources, and are funded primarily on a project-specific basis. Partnerships

and collaborations across a broad network of both public and private groups are critical for the long-term success of these efforts.

An additional scan of watershed groups across the country conducted for the purposes of this project demonstrates further that watershed groups are often task-oriented organizations with a high level of community engagement as part of their mandate and partnerships with outside entities, both public and private, across a broad spectrum of interests. Partnerships range from relationships with major governmental entities like Environment Canada, to academic partnerships such as the Canadian Rivers Institute, or non-profit private organizations such as Ducks Unlimited. Whereas watershed groups in Prairie Provinces were found to be more likely to be involved with interests related to industry and agriculture, groups in Atlantic Canada of similar scale and environmental setting as IBEC were found to share a more comparable set of partners and interests. These organizations involve themselves in activities such as habitat restoration, water testing, planning, and public education (see Table 8).

Government and community recognition and accompanying supports exist and are very prominent in the western provinces, and as we move further east, these supports are reduced. In Alberta, for example, the Water for Life Strategy provides funding supports to Watershed Planning and Advisory Councils (WPAC). These multi-stakeholder, non-profit organizations assess the conditions of their watershed and develop plans and activities to address watershed issues and are designated by Alberta Environment and Sustainable Resource Development (Alberta 2003). In Manitoba, Saskatchewan, Ontario, and British Columbia, similar legislation and government supports exist.

In other provinces throughout Atlantic Canada, whether it's pressure from industry, market size, or community recognition, there appears to be a much greater interest in terms watershed protection and conservation priority, particularly water conservation than in Newfoundland and Labrador. In PEI, for example, there are some 32 watershed organizations operating within a total land area of 5,660 km2, or an area approximately 8 times the size of the IBW. In addition, 43% of this land has been cleared for agriculture use. Despite being behind western Canada in terms of Strategic Government supports, PEI sustains these organizations through considerable support from citizens, communities, industry, and government.

While Newfoundland and Labrador is similar to other Atlantic Provinces in terms of water conservation legislation, the IBW and other watersheds throughout the Province of Newfoundland and Labrador remain very unique in terms of the size of the watershed, the market size (number of users), and the level of development (such as industrial activity) taking place within these environments. For this reason, researchers recognize the difficulty in drawing best practices from other jurisdictions across the country and thus lessons should be examined on a case-by-case basis.

Table 8. Examples of watershed organizations and their role in drinking water security

Organization	**Water-related Activities**
South East Alberta Watershed Alliance (SEAWA)	Integrated watershed management program with public awareness and involvement
Sienne Rat River Conservation District, MB	Grassed waterway program, habitat enhancement, rain gardens, riparian management, sealing abandoned wells, water storage retention programs, well head remediation and dormant well protection, well water testing
The Lot 11 & Area Community, PEI	Sediment/nutrient management
Friends of Covehead and Brackley Bay, PEI	Tree planting, clearing blockages in and along streams, Installing brushmats to collect silt and correct the flow of the stream
Clean Annapolis River Project (CARP), NS	Rural H2O water guardian program, Annapolis rivers guardian program, Broken brooks for fish life, moose river water restoration projects

A partnership that IBEC has developed with academic researchers based out of Saint Mary's University in Nova Scotia is CURA H20 (Community-University Research Alliance), a project based within the broader Community Based Environmental Monitoring Network (CBEMN). Established in 2004 and housed in Saint Mary's University's Geography department, CBEMN is tasked in part with assisting in the initiation of environmental monitoring by stewardship organizations. CURA H20 is working to enhance community capacity for integrated water monitoring and management in Canada and abroad. As a part of this mandate, CURA H20 has partnered with IBEC along with 29 other groups across Canada and internationally to: 1) implement a water quality monitoring training program, 2) integrate that data into broader watershed management initiatives, and 3) provide project guidance through academic research (CURA H20, 2013). CURA H20 has provided expertise, water quality monitoring training, and equipment in the form of a portable water quality monitoring kit (*WET-PRO Field Kit)* in order for IBEC to be a partner in this initiative in ongoing community-based water quality monitoring. The training and toolkit have been developed in consultation with Environment Canada and Nova Scotia Environment to ensure quality standards and standardize community level data collection with accurate, user-friendly, cost-effective tools.

Despite these opportunities, Moriarty et al. (2013, 329) offer a cautionary note when discussing community involvement in monitoring of drinking water supplies. They argue that despite some successes community management "is reaching the

limits of what can be realistically achieved in an approach based on informality and voluntarism." They further remind us that actions can also be taken by individuals and households, with increasing numbers of households financing their own water supplies, whether to provide or augment basic water services (Sutton, 2004; Butterworth et al. 2013; MacCarthy et al. 2013).

4. Conclusions

Water security is conceptualized in this project as a function of water access, availability, quality and preference (Goldhar et al. 2013) and is understood with the help of the DPSIR – or Drivers, Pressures, State, Impact, Response – framework. Some of the key considerations related to the drinking water systems in Indian Bay and CWT that have been identified are summarized in Table 9.

Table 9. Situation summary analyzed according to DPSIR Framework

	Description of DPSIR component	CWT/Indian Bay
Drivers	Major background processes or phenomena that help determine what is happening to water systems, e.g. ecological, social, demographic and economic developments. Drivers are the influences and conditions that underpin environmental change.	- Geology - Hydrology - Climate and climate change - Population ageing and decline - Need for drinking water - Lifestyles and preferences - Economic conditions
Pressures	Natural processes and human pressures (e.g. industrial, household institutional) that often occur as the result of the above drivers, e.g. exploitation of natural resources, modification of land use, creation of pollutants/waste.	**Ecological Pressures** - Flooding and extreme weather events - Natural organic matter - Microbiological contaminants - Minerals and metals **Industrial Pressures** - Pollution or disturbance related to logging and mineral exploration - Remaining logging infrastructure - **Household/Residential Pressures** - Household and cabin water use - Point source or diffuse source pollution related to cabin development - Water-based activities and outdoor recreation demands

		Water System Pressures - Aging infrastructure and need for repairs or upgrades - Chlorination management/ disinfection by-products - Asset management - Municipal budget and human resource constraints
State	Includes the current status of the water resource and drinking water system, including trends in key indicators	- Protected public water supplies but with little monitoring or enforcement of related provisions - IB is on a BWA and therefore doesn't have a DWQ rating - BWA's occur in both communities; long-term BWA and evidence of coliform in tap water is a serious concern in IB - THMs and HAAs above guidelines levels - Limited operator training levels
Impacts	Impacts of the state of drinking water systems on the quality of ecosystems and well-being of individuals	- Possibility of short-term or long term health impacts - Inability to access a basic material for life directly in the home without boiling/additional treatment -Possible impacts on demographics or economic development -Lower confidence in municipal government and additional stress for municipal officials and budgets
Response	Actions, policies and programs to address, minimize, and mitigate drinking water issues	- Seeking funding for and investments in infrastructure improvements - Public communication re. BWAs - Regional water operator (CWT) - Asset management improvements (CWT) - IBEC monitoring and stewardship efforts

Source: Adapted from Ramalho et al. 2013, UNEP 2009a, UNEP 2009b, p. 11

Multi-use watersheds pose significant challenges for the management of public drinking water supplies and for providing water quality. In part because of these challenges, there exists a strong distaste for public drinking water in IB/CWT, for reasons relating both to taste (preference) and concerns over safety (water quality and availability of safe drinking water supplies). Concerns over safety are both real

and perceived: the Town of Indian Bay has been on BWA since 2008, while the Town of CWT has been on and off BWA for several years. However that same concern appears not to apply when citizens select alternate sources such as natural or roadside spring water that may also have E. coli presence but not be recognized due to the absence of spring testing and notification.

A significant finding throughout the project has been that residents tend to correlate the "taste" and "smell" of a water source with safety, or lack thereof. Roadside spring water is a strong household preference primarily due to taste, smell, and distrust of the public water supply. Ongoing community-based monitoring of these sources will be necessary, therefore, to ensure safe consumption. Public education regarding risks associated with drinking water supplies is also needed.

Active users of the IBW appear knowledgeable of the state of the environment to the extent that awareness of the area being a protected water supply is high; however, knowledge and enforcement of restrictions is low. The survey finding that people would generally be willing to modify their activities in the watershed when presented with a proven threat indicates that public practices and perceptions are not inflexible. Education and public dialogue, leading to improved general knowledge of watershed issues will thus likely result in better practices and higher levels of accountability amongst watershed users. We highlight, therefore, the importance of community-based approaches towards managing issues that fall outside of the provincial or even municipal purview, such as the persistent choice amongst residents to bypass public water supplies in favor of untested and more difficult to access spring water supplies. The researchers identify community-based organizations such as IBEC as holding the potential to effectively fill this gap.

5. Future Directions

Future directions in seeking to resolve persistent drinking water issues in the Towns of Indian Bay and CWT, and in small communities throughout the province more broadly are priority considerations of this project. Through community and stakeholder consultation, a population survey, site sample water testing, and review of watershed management organizations elsewhere in Canada, the researchers suggest several possibilities for addressing the evident divide between the level of service and drinking water security currently provided to Indian Bay and CWT residents on the one hand, and the expectations, patterns and perceptions relating to household drinking water consumption on the other.

First, it is critical that the Town of Indian Bay come to a solution to remove itself from the BWA that has been in effect since September 2008. This cannot be achieved without substantial support and collaboration on the part of the Province through the Departments of Municipal Affairs, Government Services, and Health and Community Services. Our population survey suggests that trust in the public

water supply system is significantly eroded because of such a lengthy advisory. BWAs are disruptive to patterns in household consumption and leave residents distrustful of their local supply, supporting a continuation of the historical pattern of roadside spring use. Removing the Town of Indian Bay from BWA is a basic and necessary step in the right direction. Based on engineering studies and council review it has been determined that installation of a new proposed tank and booster station on Country Rd. can address this long-term concern related to water security in Indian Bay. While not the ideal solution, if issues with the current system cannot be addressed the Town might wish to explore the feasibility of installing a potable water dispensing unit (PWDU) as an alternative given that most residents are already accustomed to having to gather water from a spring. If this proves to be a low cost (to residents), filtered, purified water supply with low chlorine taste this may be an alternative supported by residents. Given resident concerns about water taste, town councils should continue to explore options for improving water taste and in particular decreasing chlorine taste in the water supply to reduce incentives to use roadside spring and more costly bottled water options.

A further key recommendation is for an ongoing support for community-based water monitoring of the highly preferred roadside spring water sources. As approximately 55% of all households take their drinking water from this source, household preferences are not likely to experience a major shift and thus ongoing monitoring will prove necessary to achieve a higher level of certainty with regards to water quality from this source. As such an operation falls outside the mandate of government monitoring, a community-based approach is well suited to fill this gap. The researchers recognize the potential for an organization such as IBEC to fulfill this role if municipalities are unwilling or unable to do so. The organization is well established throughout the communities and has the experience and existing potential capacity to provide such a service in addition to monitoring changes within the drinking water source (IBW).

In the absence of regular monitoring of roadside spring water sources, posting signage at the springs to inform residents that no regular testing is done (at current) is recommended and, possibly, of testing results in the future (as was done when E. coli presence was identified on one occasion in the Wareham spring during this project). It is recognized that great care is needed in how such testing results are communicated, and therefore collaboration and diverse input would be required. In addition, potential liability implications for IBEC or others taking on this responsibility require further exploration.

Continued monitoring of activities as well as water quality within the IBW should also be recognized as beneficial to the long-term health of the watershed. The baseline data gathered within this report sets a precedent for future measures, as well as for future proposed activities in the IBW such as industrial or commercial development. More detailed testing on types of E. coli present in the IBW, as well as further testing for hydrocarbons will strengthen this baseline data platform. Additionally, proactive measures such as shoreline replanting to enhance buffers

where vegetation clearing has taken place and prevent shoreline erosion and thus deteriorating ecosystem integrity and water quality within the IBW have been proposed by IBEC and should be supported given concerns related to organic compounds, disinfectant by-products and potential health implications. More careful monitoring of organic material (NOM/DOC) in the water supply may help identify ways to reduce one of the major factors leading to THM and HAA formation. We suggest that formal guidelines regarding NOM/DOC levels in water supplies may be needed (just as turbidity is not a contaminant but rather a parameter linked with microbial contamination).

This research has also identified the need for greater education, awareness, and communication between the town offices and the public throughout these communities. Significant concern was expressed throughout the household survey over the "safety" and "trust" in the public water supplies. The Town of CWT is not currently on BWA, which is commendable, however this does little to allay resident perceptions regarding the current water quality in the public system. Significant concern has been expressed over smell, taste, and appearance of public water, which although does not correlate with unsafe water supplies necessarily, does correlate to decisions to avoid consumption from that source. This reality may be perhaps remedied through improved communication and education within the communities. A related concern is that residents appear to be unaware of high THM levels and potential health implications, or of the more immediate risks associated with untreated water supplies (although acceptance of risk is also likely to be a factor in the case of the choice to drink spring water due to dissatisfaction with the public supply as an alternative). In the town of Centreville specifically, significant concern was voiced over water pipes potentially containing trace amounts of asbestos. Health Canada's position is that there is no proven threat in ingesting asbestos, and that health impacts related to asbestos exposure are limited to the inhalation of fibres (Charron 2013). This information needs to be effectively communicated with residents.

Bridging the divide between resident perceptions and official governmental positions on these matters is a critical step in the right direction. Town newsletters, mailouts, events and perhaps involvement of school classes in water quality monitoring and education can be used to help build public awareness about the risks associated with untested water sources and about the need to be responsible users of the water supply areas. Awareness and education about household treatment options and addressing chlorine taste through storage and refrigeration may also help to address concerns identified.

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Appendix 1 – Sampling Protocol

Sampling Sites & GPS Coordinates

Site 1 – No. 2 Pond (beach near field facility)	N49°02.887, W053°52.182
Site 2 – No. 2 Pond (boat launch)	N49°04.016, W054°04.402
Site 3 – Big Bear Cave Pond (Bridge at Jim's Steady)	N49°06.654, W054°00.960
Site 4 – No. 1 Pond	N49°03.222, W054°00.215
Site 5 – Thwart/Dirt/Adurt Brook Pond	N49°03.863, W053°55.542
Site 6 – Rockcut Spring	N49°01.850, W053°52.336
Site 7 – Wareham Spring	N49°00.995, W053°51.829

WATER SAMPLING FOR TRACE ELEMENT ANALYSIS BY ICP-MS

In order to make meaningful measurements at low levels meticulous care is requires to avoid contamination and to preserve the integrity of the samples. The following is a description of a simple sample collection procedure that, if utilized with care, should provide a sample set that will provide reliable data.

1.) Attempt to select a sample site that will provide a representative sample of the body of water requiring analysis. Avoid areas with a high content of suspended sediment or organic material, where possible. Due to the low tolerance of the ICP-MS to high total dissolved salts content, brines (e.g. sea water) cannot be analysed without very substantial prior dilution which will increase the detection limits proportionally.

2.) To obtain an analysis representative of the water, the sample must first be filtered to remove suspended particulate matter. Rinse out a syringe several times with the water to be sampled. Fill the syringe, attach a filter and evacuate the syringe. You are now ready to collect a sample. Remove the filter, fill the syringe, reattach the filter and evacuate the syringe into an acid washed plastic bottle. Repeat this step until you have approximately 100 ml. Use a new syringe and filter for each sample.

3.) To prevent absorption of metals onto the sample bottle and prevent growth of organic materials that can remove metals from solution, the sample must be preserved by acidification. Add approximately 2 ml of 8 N distilled nitric acid

(HNO3) to the sample bottle (hydrochloric acid (HCl) must not be used). Shake well.

4.) Label the bottle clearly, preferably twice, with a permanent marker or label that will remain affixed.

5.) For quality control purposes, it is advisable to collect at least two samples from some sites to monitor the effectiveness and reproducibility of the collection and preservation procedure.

6.) To measure the level of contamination from the equipment and nitric acid, one or more reagent blanks must be prepared (at least one blank per 10 samples). To do this, a sample of deionised distilled water must be "collected" using exactly the same procedure, equipment and reagent as for the samples. Although this should be done in the field by taking a bottle of deionised distilled water with you, it is more conveniently accomplished back in the lab. If the latter route is taken, ensure that you return the bottle of nitric acid and dispenser so that they can be used in the preparation process.

Regular Sampling

To take in the field:

- 60ml Sample bottles (HDPE)
- Syringe, Syringe Filters, Latex Gloves
- Gear for getting into the water (i.e. life vest, waders, rubber boots, etc)

Sampling

1. Put on latex gloves
2. Take out syringe and rinse it by filling and expunging water from the stream or groundwater well 3 times
3. Fill the syringe again to about 30 mL and place the pre-fabricated filter
- To attach, place tip on end and turn to lock it in place
4. You must push 30 mL of water through the filter before using the filter to collect sample.
5. You must remove the filter in order to draw up more water through the syringe!
6. Fill with about 40 mL of filtered water using the syringe markings.
7. Freeze until time of analysis.

Sampling seasons for the island of Newfoundland are defined as follows under the Drinking Water Quality Monitoring and Reporting for Public Water Supplies:

Spring: May 16th – June 30th

Summer: August 1st – September 30th

Fall: November 1st – December 15th

Winter: January 15th – March 15th

Appendix 2 - Cover Letter to Survey

Dear citizen,

We are conducting a household water quality survey in the Towns of Indian Bay and Centreville-Wareham-Trinity. This is part of a project being conducted by Memorial University in partnership with the Indian Bay Ecosystem Corporation (IBEC). The goal of this survey is to get a better sense of people's attitudes and opinions of their drinking water supply, as well as information on how people are using the Indian Bay watershed. Drinking water quality, accessibility, affordability, and safety are very important issues for all of us. With the information gathered through this survey, we will be in a better position to ensure that these issues are addressed, and that ultimately we may be able to make improvements to the public drinking water supply.

This survey is anonymous and voluntary. Once completed, the survey can either be mailed in with the provided envelope and postage, dropped off at the Indian Bay Ecosystem Corporation (IBEC) office, or arrangements can be made for pick-up from your household.

With your assistance, we will be better suited to make the best decisions with your watershed resources and town drinking water supply. Thank you so much for your time and assistance. We look forward to your input.

Sincerely,

Stephen Holisko – Researcher
stephenholisko@grenfell.mun.ca

Kelly Vodden – Principal Investigator
kvodden@grenfell.mun.ca

Appendix 3 – Poster

Drinking Water Quality Survey

Hello! My name is Steve Holisko. I am a student of Memorial University in Corner Brook, studying environmental policy.

I will be working for Indian Bay Ecosystem Corporation (IBEC) this summer, conducting a household survey on water quality in your community. The project is a partnership with the towns of Indian Bay and Centreville-Wareham-Trinity.

We are interested in your opinions on your drinking water and would appreciate your support and participation.

I very much look forward to meeting you,
and thank you for hosting me in your community!

Please feel free to contact me at any time:

Phone: 522-3222
Email: sholisko@grenfell.mun.ca

INDIAN BAY ECOSYSTEM CORP.

GRENFELL CAMPUS | MEMORIAL UNIVERSITY

Appendix 4 – Survey Instrument

A Water Quality Population Survey
for the Towns of Centreville-Wareham-Trinity and Indian Bay

The survey is comprised of 3 sections. As a head of your household, please complete Section 1. Please complete Section 2 if you are also an active user of the Indian Bay watershed (recreationally, commercially, etc.). Please complete Section 3 if you are also a cabin owner within the Indian Bay watershed.

The survey will take 15-20 minutes to complete.

Section 1: Household water supply

---

1. Gender
    - o Male
    - o Female

2. Age
    - o 18-29
    - o 30-44
    - o 45-59
    - o 60+

3. Number of people in your household
    - o 1
    - o 2
    - o 3
    - o 4
    - o 5
    - o 6
    - o More than 6

4. What is your favorite source of drinking water?
    - o Tap water
    - o Natural/Roadside springs
    - o Bottled Water
    - o Dug/drilled well water
    - o Water directly from local ponds or rivers

5. Why is this your favourite source of drinking water? (Check all that apply)

- o Taste
- o Smell
- o Clarity/colour
- o Freshness
- o Safety
- o Purity
- o Affordability
- o Accessibility
- o Other (please specify): _____

6. Do you boil or treat this water?

- o Yes
- o No
- o I'm not sure

7. Do you use a water filter?

- o Yes
- o No

If yes, what type of filter do you use (e.g. brand, style)? _____

8. Is your town currently on a boil order advisory?

- o Yes
- o No
- o I'm not sure

9. Do you receive notification from your town office when your town is on a boil order advisory?

- o Yes
- o No
- o I'm not sure

If yes, how is that communicated?

- o Phone call from the town office
- o Notice on community channel
- o Community bulletin posting
- o Other (please specify): _____

10. How often do you drink the following types of water …

Tap water
- o Every day
- o At least once per week
- o At least once per month
- o Almost never
- o Never

Roadside springs
- o Every day
- o At least once per week
- o At least once per month
- o Almost never
- o Never

Bottled water
- o Every day
- o At least once per week
- o At least once per month
- o Almost never
- o Never

Dug/drilled well
- o Every day
- o At least once per week
- o At least once per month
- o Almost never
- o Never

Water directly from local ponds or river
- o Every day
- o At least once per week
- o At least once per month
- o Almost never
- o Never

11. What is your main source of water for cooking?
- o Same as drinking
- o Other (please specify): _____

12. If you purchase bottled water at least once per month, on average how much do you spend on bottled water in one month?

- o Under $10
- o $10-24
- o $25-49
- o Over $50

13. Do you feel that the water portion of your tax bill is:

- o Too low
- o About the right amount
- o Too high
- o I'm not sure

14. If a moderate increase in water taxes would result in increased water quality and safety, would you support that increase?

- o Yes
- o No
- o I'm not sure

15. Please rate the following statement. My tap water is safe to drink:

- o Strongly disagree
- o Somewhat disagree
- o Neutral/I'm not sure
- o Somewhat agree
- o Strongly agree

If you feel that your tap water is <u>not</u> safe, what makes you feel that it is not safe? (check all that apply)

- o Chlorination/chemicals
- o Old/outdated pipes
- o Poor appearance or taste
- o I believe I have been sick from tap water in the past
- o I don't trust my local supply
- o Other (please specify) _____
- o Not applicable - I believe that my tap water is safe to drink

16. Has your household changed its main drinking water source in the past five years?

- o Yes
- o No
- o I'm not sure

If yes, why?

- o Change in quality
- o Ease of access
- o Cost

o Health concerns
o Other (please specify):_____

17. Have you heard of any drinking water-related illnesses in your community?
o Yes
o No
o I'm not sure

18. If yes, what kind of illness(es)? Do you know why or how it happened?

_____

19. How concerned are you about these types of illnesses in your community?
o Very concerned
o Somewhat concerned
o Neutral/I'm not sure
o Mostly not concerned
o Not concerned at all

20. Which, if any, of these land-use activities do you feel are a current threat to your water supply? (Check all that apply)
o Forest harvesting
o Transmission lines, roads
o Mining
o Agriculture
o Hunting and fishing
o Recreational use
o Cabin development
o Other (please specify): _____
o I do not see any current threats to my water supply

21. Have you noticed any effects of climate change in your area in the past two decades?
o Yes
o No
o I'm not sure

22. Do you feel that climate change is affecting drinking water in your area?
o Yes
o No
o I'm not sure

If yes, how has climate change affected drinking water in your area?

_____

Section 2: For Indian Bay watershed users (including cabin owners)

23. Do you spend time in the Indian Bay watershed (currently or within the past few years)?

o Yes
o No

If yes, please answer the remaining questions in this section.
If no, thank you for completing this survey.

24. Which of the following activities do you do in the watershed: (check all that apply)

o Fishing
o Motorized vehicles
o Hunting/Trapping
o Wood cutting
o Hiking, sight-seeing, nature activities
o I own a cabin in the watershed
o I know someone who owns a cabin in the watershed
o Work related
o Other (please specify):_____

25. If yes, what types and how often? (Check all that apply)

	At least once per week	At least once per month	At least once per 6 months	At least once per year	Almost never	Never
Motorized boat						
Snow mobile						
ATV						
Car/Truck						

26. Based on your current knowledge and opinion, please rate the overall water quality within the Indian Bay watershed

o Very good
o Good
o Neutral/I'm not sure
o Poor
o Very poor

27. When you are in the watershed, what is your source of drinking water? (Check all that apply)

- o Bottled water
- o Tap water brought in with you
- o Spring water
- o Water directly from ponds or streams

28. Do you boil or treat this drinking water?

- o Yes
- o No
- o I'm not sure

For the next four responses, please state to what extent you agree or disagree with the statements:

29. Commercial forestry operations in the watershed are a threat to drinking water quality in the watershed

- o Strongly disagree
- o Somewhat disagree
- o Neutral
- o Somewhat agree
- o Strongly agree

30. Recreational activities are a threat to drinking water quality in the watershed.

- o Strongly disagree
- o Somewhat disagree
- o Neutral
- o Somewhat agree
- o Strongly agree

31. Activities such as hunting, trapping and wood cutting are a threat to drinking water quality in the watershed.

- o Strongly disagree
- o Somewhat disagree
- o Neutral
- o Somewhat agree
- o Strongly agree

32. Cabin development is a threat to drinking water quality in the watershed.

- o Strongly disagree
- o Somewhat disagree
- o Neutral
- o Somewhat agree
- o Strongly agree

33. If the above activities were shown to be a threat to drinking water quality, I would be willing to modify my activities in the watershed

- o Strongly disagree
- o Somewhat disagree
- o Neutral
- o Somewhat agree
- o Strongly agree

34. Are you aware that the Indian Bay watershed is designated as a Protected Water Supply Area under the Department of Environment and Conservation?

- o Yes
- o No

If yes, are you aware of the related restrictions on activities within that area?

- o Yes
- o No

Section 3: For Indian Bay watershed cabin owners

35. Do you or anyone in your household own a cabin in the Indian Bay watershed?

- o Yes
- o No

If yes, please answer the remaining questions.
If no, thank you for completing this survey.

36. Type of sewage disposal system (check all that apply)

- o Septic system
- o Outhouse
- o Composting toilet
- o Chemical toilet
- o Other

If other please specify:_____

37. If you have a septic system, when was it installed?

- o Within the last year
- o Within the last 5 years
- o Within the last 10 years
- o More than 10 years ago

Year last maintained, serviced or upgraded:

- o Within the last year
- o Within the last 5 years
- o Within the last 10 years

o More than 10 years ago
o Never

38. How do you dispose of wastewater from sinks, baths, or showers?
o Discarded outdoors
o Capture/recycle system
o Piped into the septic system
o Piped directly to pond or stream
o Other

39. Do you use "environmentally friendly" cleaning and personal hygiene products in the watershed?
o Yes
o No
o Sometimes
o I'm not sure

40. Do you refuel your motorized vehicles (boats, snow mobiles, etc.) on the pond or within 50 feet of the shore?
o Yes
o No

If yes, how often?
o Very frequently
o Somewhat frequently
o Neutral
o Almost never
o Never

41. How often do you clear vegetation from your shoreline (e.g. brush cutting, tree removal, etc.)?
o Very often
o Often
o Neutral/I'm not sure
o Almost never
o Never

Do you have any additional comments? _____

_____

Thank you very much for your time!

Appendix 5 – Survey Analysis Technical Report

Data Analysis Tools
Analysis was conducted using a Predictive Analytic Software (PASW) 19 by International Business Machines (IBM).

Brief Note on Statistics
The majority of the data collected was nominal (i.e., categorical) in nature, so the primary assessment tests were χ^2 tests, or if in situations where the expectations of χ^2 were violated, Fisher's exact test were used. Violations of χ^2 expectations were primarily in situations where cells within a χ^2 test had fewer cases than the total groups (i.e., k) being assessed. Fisher's exact test is more conservative than χ^2 tests (lowered rates of Type I error, increased rates of Type II error), but given the large number of tests (which would artificially inflate the Type I error rate) this was seen as a manner to counterbalance the issue.
Regression was used in circumstances where binary categorical variables were used to assess outcomes determined by continuous variables.
Correlation was used to assess whether two or more variables acted in a similarly.

Specific Questions

Did community membership have a relationship with water source selected?
$\chi^2(6)=4.87$, p=.561 suggesting that there were not significant differences in the proportion of what communities chose in terms water supplies.
$\chi^2(3)=163.02$, p<.001 indicating that natural/roadside springs were the most preferred of all drinking sources for the communities.

Did community membership affect water source rationale?
$\chi^2(2)=9.42$, p=.009 for accessibility
$\chi^2(2)=.57$, p=.753, for affordability
$\chi^2(2)=1.27$, p=.529 for clarity
$\chi^2(2)=1.87$, p=.393 for safety
$\chi^2(2)=5.19$, p=.075 for smell
$\chi^2(2)=8.20$, p=.17 for taste

Were there sex differences?
Men and women responded at the same rate $\chi^2(1)=2.33$, p=.13
Men and women did not differ in their usage of the watershed $\chi^2(1)=.307$, p=.57

Sex was not a predictor over "Concern for Watershed"[5] $t(1)=.858$, $p=.394$
Men and women had comparable concern over watershed-related illness, $\chi^2(1)=2.45$, $p=.653$
Men and women did not differ in their observation of climate change, $\chi^2(2)=3.26$, $p=.196$

How did age interact with other variables?
Age did not have a relationship with the type of water source used $\chi^2(9)=11.28$, $p=.257$
Age and attitudes toward watershed-related illness are significantly related $F=19.48$, $p=.047$; with persons over 60 reporting being "mostly not concerned at all" at a higher rate
People in the age range of 30-44 spend more time in the IB watershed than expected, while persons who are 60+ spend less time $F=10.65$, $p=.011$
Age is unrelated to fishing $F=2.06$, $p=.584$
Age is related to hiking $F=11.88$, $p=.004$, persons 30-44 hike more often while persons who are 60+ hike less often than expected
Age is unrelated to hunting/trapping $F=5.02$, $p=.158$
Age is unrelated to cabin ownership $F=3.79$, $p=.277$
Age is related to knowing someone who owns a cabin $F=9.702$, $p=.015$,persons 30-44 know more persons than expected
Age is unrelated to using motor vehicles $F=2.80$, $p=.433$
Age is unrelated to working in the watershed $F=2.22$, $p=.796$
Age is unrelated to cutting wood $F=4.07$, $p=.231$

How does water source relate to health behaviours?
Water source is related to boiling one's water $F=33.23$, $p<.001$. Persons who use natural springs boil their water less frequently, and persons using tap water boil their water more frequently.
Water source is related to using a filter $F=41.80$, $p<.001$. People with tap water use water filters more frequently, and people with bottled water use filters less frequently

Is there a relationship between community and boiling water?
Boiling water is unrelated to living in a specific community $F=2.08$, $p=.725$
When persons are advised to boil water, persons are more likely to be notified in C/W and IB than what would be expected $\chi^2=14.50$, $p=.001$
There were significant differences between communities and whether being notified happened on a community channel $F=8.76$, $p=.013$; Trinity received fewer such notices while IB received more.
There were no significant difference between communities in terms of receiving phone calls from a town office $F=3.65$, $p=.166$.
There were no significant differences between communities in terms of communicating via word of mouth $F=1.87$, $p=.384$

[5] Calculated by averaging the responses from Questions 28 -32.

There were significant differences between communities in terms of non-determined methods F=56.35, p<.001; C/W and Trinity reported higher levels of another method, while IB reported lower levels.

How much do people spend on bottled water (monthly)?

$ Spent	<10	10-20	25-49	50+
M=8.023	102	85	21	7

Using minimum values for each column for each column persons who drink bottled water will likely spend {[(85*10)+(21*25)+(50*7)]/113}*12 = $183.19 yearly on this water (excluding those who drink less than $10 from the calculation under this assumption).
Using middle values for each column {[(102*5)+(85*15)+(21*37)+(50*7)]/215}*12 = $162.53 is the estimated value amount persons will likely spend yearly on bottled water.

Was there a relationship between refuelling boat near shore and clearing shore vegetation as predictors of willingness to change harmful behaviours?
These were not significant in a regression model R^2=.09, F(2, 32)=1.53, p=.234

Was there a relationship between using eco-friendly products and a willingness to change?
These variables were not significantly related, F=11.93, p=.601.

Was there a relationship between community and drinking water-related illness?
Overall, persons are most likely to be very concerned or somewhat concerned about water-related illness $\chi^2(4)=29.65$, p<.001. Persons were more likely to report that they were not at all concerned about drinking water related illness if they lived in Indian Bay. $\chi^2=20.66$, p=.008

What were respondents' attitudes toward tax?
"$ Spent on Water" and "Increase Tax" are unrelated F=5.64, p=.44
"Increase Tax" and "Perceptions of Tax" are related F=19.15, p=.002, with people believing that tax was already too high not supporting a tax increase, and with people who were comfortable with the current tax being underrepresented in "No for increasing the tax" and overrepresented in the "Yes for increasing the tax" and "I'm not sure if we should increase the tax".
Water type and Increase Tax were related, F=12.15, p=.037

Was there a relationship between worries over development and age, sex, IBW user status?

	Agro	Cab Dev	For Har	Hunting	Mining	Rec	Trans	Other	None
Age	No	No	No	No	No	No	No	No	No
F=	2.74, p=.66	2.04, p=.537	4.38, p=.180	.496, p=.908	3.74, p=.253	3.19, p=.348	2.73, p=.382	3.71, p=.538	2.69, p=.447
Sex	No	No	No	No	No	No	No	No	No
$\chi^2(1)$	3.73,	3.27,	.51,	.51,	.09,	2.26,	.01,	1.23,	.36,

	p=.054	p=.070	p=.475	p=.474	p=.769	p=.094	p=.911	p=.267	p=.546
User	No	No	No	No	No	No	No	No	No
$\chi^2(1)$	1.25, p=.264	.08, p=.776	2.20, p=.138	1.77, p=.184	.21, p=.644	.28, p=.595	.07, p=.795	2.45, p=.118	.55, p=.46

Were there patterns in the qualitative data and city?
Qualitative data for the following themes: boil orders, chlorine complaints, poor general quality, neutral statements, and unclear feedback
Results indicate that there are significant differences between communities F=22.34, p=.004; Trinity complained about higher levels of chlorine than either C/W or IB

Do some residents spend more time in the IBW than others?
People from Trinity spend less time in the IBW than others, F=11.89, p=.003

Is there a relationship between "Watershed Concern" and "Watershed Activities"?
There was no relationship F=1.19, p=.316

Are members from a specific community more likely to:

Own a cabin?
No, F=1.07, p=.656
Change their behaviours?
Yes, F=17.66, p=.009 –fewer people in Trinity selecting "somewhat agree with the statement "about modifying harmful behaviours" than expected
Clear vegetation?
No, F=5.65, p=.836
Refuel near shore?
Yes, F=6.48, p=.034, with fewer people in C/W doing it and more people in IB doing it than expected
Use eco-friendly products?
No, F=1.60, p=.905

Was rationale for water choice affected by the type of water respondents used?

	Access	Afford	Clarity	Safety	Smell	Taste	Other
F=	118.16, p<.001	4.46, p=.257	7.02, p=.071	6.63, p=.071	14.77, p=.001	57.27, p<.001	10.40, p=.01
Dug/Drilled	No				No	No	No
Natural/roadside	Yes, less				No	Yes, more	No
Tap	Yes, more				Yes, less	Yes, less	Yes, less
Bottled water	Yes, less				No	No	No

Are persons using a specific type of water more likely to worry about water-related illness?
No, F=18.03, p=.069

Drinking water is associated with the term "my tap water is safe to drink", F=65.69, p<.001; persons who used Natural/Roadside springs users agreed with "My tap water is safe to drink" far less often than other persons. Persons who used Tap Water are more likely to express agreement with the idea that tap water is safe to drink.

How did the motor vehicle use compare across communities?
ATV use is evenly spread, F=9.37, p=.414
Car/truck use is evenly spread, F=10.577, p=.364
Boat usage is evenly spread, F=6.83, p=.749
Snowmobile usage is evenly spread F=8.79, p=.573

Are persons who boil water outside of the IBW more likely to boil water in the IBW?
No, F=3.24, p=.463

Appendix 6 - Indian Bay Watershed Cabin Assessment Survey Form

Indian Bay Cabin Assessment Form – July 2013

1. **Location**

   General description (pond name and location on pond): _____

   GPS Coordinates: _____

2. **Cabin description**

   ☐ ☐

   Photo taken: Yes No

   Photo file name: _____

3. **Owner name if known: _____**

4. **Owner contact information if known: _____**

   _____

   Note: obtain phone + email and/or address if possible for future outreach or emergency purposes.

5. **Sewage and waste water disposal**

   Out house Septic Other/unknown

   ☐ ☐ ☐

   If outhouse, proximity to shore (est.): _____

   ☐ ☐

   Less than 50 ft.: Yes No

Sources of information:

Visual inspection	Provincial govt	Owner supplied info
☐	☐	☐

Notes:

6. Shore clearing (brush removal, etc.):

Completely cleared	Some clearing	No clearing
☐	☐	☐

Notes:

7. Garbage / waste on property close to shore:

Substantial	Some	No evidence
☐	☐	☐

Notes:

8. Shoreline Erosion:

Substantial	Some	No evidence
☐	☐	☐

Notes:

9. Motor vehicles/construction on shoreline:

Substantial	Some	No evidence
☐	☐	☐

Notes:

10. Additional Notes/Comments:

Appendix 7 – CUExpo Poster

From Source to Tap: Developing a community-based monitoring program for drinking water supplies in the Indian Bay Watershed

Stephen Holisko and Kelly Vodden

Scope

In rural Newfoundland, our watersheds are integral to our identity and way of life as well as providing critical drinking water supplies. Drinking water issues in rural areas are inextricably tied to the health of watersheds. Land-use practices occurring in watersheds have an impact on water quality and health of the overall ecosystem, including the individuals that rely on these resources for subsistence, culture, and recreation.

Figure 1. Indian Bay River
Photo source: Indian Bay Ecosystem

The occurrence of boil water advisories is widespread throughout the province. Baseline studies examining water quality, the presence of toxins, and contamination source points act as a tool in identifying potential health concerns in regards to drinking water and in informing future land-use management practices and policies.

As part of a community-based approach to grappling with these issues, the Indian Bay Ecosystem Corporation (IBEC) is collaborating with Memorial University's Environmental Policy Institute and other partners to find solutions to persistent challenges relating to rural drinking water supplies.

Objectives

- To determine the presence of microbiological and/or chemical contaminants of surface waters and roadside springs in the Indian Bay watershed
- To determine population perspectives and practices related to water consumption and contamination, environmental management and sustainable solutions
- To research community-based watershed water quality monitoring models employed elsewhere that may be applicable in Indian Bay along with their relative strengths and weaknesses

Funding support from the Harris Centre RBC Water Research and Outreach Fund and the Institute for Biodiversity, Ecosystem Science, and Sustainability (IBES) is gratefully acknowledged.

Figure 2. Study location
Source: Google Maps

Methods

- *Population survey*
  A household survey is being conducted on residents of Indian Bay and Centreville-Wareham-Trinity (CWT) to better understand habits and perceptions towards public drinking water supplies.
- *Multiple site sample testing*
  Chemical and microbiological analysis is being conducted on 7 source sites throughout the watershed and roadside spring sources to determine levels of metals, nitrates, sulphates, E. coli, and coliforms in the water systems.
- *Community stakeholder engagement*
  In concert with IBECs efforts, an advisory committee of community and government representatives has been established to ensure public representation and relevant expertise is incorporated into the ongoing dialogue.
- *Research on other watershed groups*
  Researchers are examining other similar groups and their water quality monitoring efforts to seek lessons for IBEC.

Preliminary Results

- *Sample testing*
  To date, 3 rounds of testing have been completed based on seasonal variance, with 2 more rounds scheduled for this summer and fall 2013. Tests indicate that chemical contamination is not an issue, though there has been recurrence of unacceptable microbiological contamination at 3 of the 7 sites. This suggests the justification for the ongoing boil order in the Town of Indian Bay, as well as the need to boil water obtained from the watershed during cabin and backcountry recreation use.
- *Population survey*
  Of 120 households surveyed to date, approximately 70% of these households are obtaining their drinking water from roadside springs – only 15% are drinking tap water, and the remaining 15% purchase bottled water. Reasons for averting from tap water are "taste" and "smell," though concern has also been expressed regarding the "safety" or "trust" of the public supply. Safety and trust issues are traced primarily to concerns over chlorination and old pipes in the system which contain asbestos. The frequency of past boil orders is also a concern; boil orders are disruptive to household habits and strongly affect future decision-making. Frequent boil orders tend to erode future trust in the public system.

Figure 3. Roadside spring
Photo source: S. Holisko

Discussion

Multi-use watersheds pose significant challenges for the management of public drinking water supplies. In no small part because of these challenges, there exists a strong distaste for public drinking water, for reasons relating both to tastes and concerns over safety. Concerns over safety are both real and perceived: the Town of Indian Bay has been on boil order since 2008, while the Town of CWT has been on and off boil order for several years. As roadside spring water is a strong household preference, ongoing community-based monitoring of these sources will prove necessary to ensure safe consumption.

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