Final Report No. 093001

Prepared for:

Newfoundland Labrador

Department of Environment and Conservation

Pilot Study to Develop an Action Plan on Indicators for Monitoring Corrosion Control in Drinking Water

June 2009

CBCL LIMITED

Consulting Engineers

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Chapter 1 Introduction

1.1 Background

On January 15th, 2009 a kickoff meeting was held at the offices of the Provincial Department of Environment and Conservation (DOEC) in St. John's to initiate a *Pilot Study to Develop Action Plan on Indicators for Monitoring Corrosion Control in Drinking Water* in the province of Newfoundland and Labrador. The project is a joint effort between the departments of Health and Community Services, Municipal Affairs, and Environment and Conservation to better understand the impacts of water distribution system corrosion rates on the water quality at a consumer's tap. This report represents the results of an intensive sampling and data collection program completed by CBCL since that time as well as an analysis of the resulting data trends with respect to overall water quality and distribution system parameters.

Although there are a number of corrosion byproducts that may be found in drinking water, lead was the primary focus of this study because of its well known effects on human health. Lead corrosion in the distribution system or plumbing can result in elevated levels of lead in water at a given tap and can then be ingested through the consumption of tap water. The primary sources of lead from corrosion in tap water come from the use of lead piping and lead components within a distribution system, private residence, or institution. Lead service lines from distribution mains to buildings were once common, as were lead pipes within a residence and for water distribution. Prior to 1990, when lead was removed from the plumbing code, pipe solder containing lead was ubiquitous in the plumbing systems of homes and institutions. As well, older types of internal brass water fixtures also contained lead. These multiple sources of lead in piping and plumbing combined with water chemistry and metal corrosion can lead to the dissolution of lead into tap water.

Much of the water sampling conducted by water utilities seeks to verify the water quality in the distribution system prior to a private service connection. This was not the case in this study. Whereas regular lead sampling includes flushing of sample points to obtain water which is representative of distribution system quality, this study sampled water which had stagnated within service lines and plumbing of individual residences and public buildings. One objective of this study was to assess the additive effects of any lead-containing components that municipal water may come into contact with between the source and the tap. Factors which may influence the amount of lead which may accumulate in water over time were identified. This approach was taken in an effort to picture of the actual lead concentrations present in the drinking water of various communities and to assess any potential health impacts across the province.

1.2 Objectives and Scope

The initial Terms of Reference (TOR) for the study included two objectives:

- Provide an estimate of the extent to which lead may be found in the plumbing systems in homes and public buildings,
- Determine the feasibility and acceptability of using specialized lead monitoring procedures as a measure of corrosive potential of municipal water supplies compared to standard lead monitoring procedures.

In terms of how the noted objectives were to be met the TOR identified three points of direction on which the study was to be carried out. These included:

- Identify any additional communities (other than identified in the study area) at higher risk of having lead services because of age of the municipal services,
- Identify any additional communities (other than identified in the study area) having more corrosive water supplies based on current information and water quality data and therefore at risk of leaching lead from service lines or plumbing,
- Test a purposeful sample of homes in the higher risk communities identified above using the proposed measures of corrosion control.

The methodology used to meet both the objectives and points of direction is described in Chapter 2. Generally the approach used was a combination of intensive sampling at each of the 29 communities identified by the province combined with the collection of information on the design and construction of each community's water system in order to develop relationships between the results and the physical system.

2.1 Study Approach

As outlined in the initial CBCL proposal the approach used to develop the objectives relied on the collection of as much information regarding the physical works of each water supply, treatment, and distribution system as it did on the actual results of the sampling program itself. A total of 29 communities were sampled in detail for lead and other water quality parameters. A 30th community (Deer Lake) was sampled at one location as a provision, but has not been included in the detailed analysis. The communities sampled in various regions are provided in Table 2.1 below.

The initial phase of work involved contacting relevant government departments and municipal representatives in each community on the sampling list to introduce the study and determine what, if any, information was available on which to base the eventual choice of sampling program sites. This work was completed and a contact person at each community was identified. A significant effort was made to locate relevant documentation on the design and construction of the physical works through the Department of Municipal Affairs. Unfortunately, due to the time constraints of the project it was not possible to obtain record information for use prior to sampling and evaluation. The effort required to locate information for each community was itself a process that would require months of work spread between multiple offices. It was therefore determined that primary information gathering would fall to the individuals conducting the sampling. This included a review of each system, the collection of any record drawings, masterplans etc., photos, and tour of pumphouses, treatment plants and associated works while in the community.

Table 2.1: Communities Selected for Participation in Corrosion Study

Location	Region
Branch	Eastern
Brigus	Eastern
Carbonear	Eastern
Ferryland	Eastern
Fortune	Eastern
Lamaline	Eastern
Newman’s Cove	Eastern
Port Blandford	Eastern
St. John’s (Bay Bulls Big Pond)	Eastern
Winterton	Eastern
Carmanville	Central
Campbellton	Central
Fogo	Central

Location	Region
Gambo	Central
Gander	Central
Glenwood	Central
Glovertown	Central
Grand Falls-Windsor	Central
Milltown	Central
Channel – Port aux Basques	Western
Corner Brook (Trout Pond)	Western
La Scie	Western
Rose Blanche – Harbour Le Cou	Western
St. George’s	Western
St. Anthony	Western
Deer Lake*	Western
Churchill Falls	Labrador
L’Anse au Loup	Labrador
Labrador City	Labrador
Cartwright	Labrador

* Only one sample was collected from Deer Lake prior to completion of full sampling at Milltown. Deer Lake is not included in further descriptions.

At the onset of the study and data collection phase the intent was to create an electronic database of all of the information collected for each community. As the study progressed information was collected both electronically and in hard copy format. A hard copy master file was created for each community which served as a reference for all available information for that community, both digitally and in hard copy format. For some communities only a very limited amount of information was available on the water supply, treatment and distribution system as it exists today. As a minimum an electronic database of basic criteria for each system has been developed. The community file contains any available drawings, sketches, or relevant information collected as well as field notes, sample notes, or even simple community maps indicating the sample locations within each community.

A representative of each community was contacted by phone and through a letter prepared by DOEC with a description of the study and the reason for sampling. CBCL worked with each community as well as with health boards and school boards to identify appropriate sampling locations based on the criteria described in Section 2.1.1. Once this was complete several field technicians began travelling from community to community conducting the sampling, touring each system, and collecting as much information as possible on the current design and operation of the water supply, treatment and distribution system. An information brochure (See

Appendix A) describing the study was prepared and distributed to homeowners and officials at the sample sites.

2.1.1 Site Selection and Documentation

A list of potential sample locations was developed by contacting representatives from each of the 29 communities to gather information about the distribution systems and buildings in each of the towns. The same basic selection criteria were used for each community and included factors which would be most likely to produce elevated results and thus indicate a “worst-case” scenario. Under this methodology the results for a given town would be assumed to represent the highest levels of lead among the entire system and thereby ensure that the complete extent of corrosion was captured.

There were three basic criteria used in the selection of each sample site. Ideal sample sites were determined to have the following characteristics:

- Locations where there were known lead distribution pipes, service connections, saddles or other components in contact with water,
- Locations with home construction prior to 1991 and using soldered copper pipe,
- Locations where the distribution system is known to have long stagnation periods, low chlorine residuals, or frequent water quality complaints.

These criteria were used for residential samples only. In addition to the targeted residential sampling, all schools, hospitals, daycares, and personal care homes in each community were sampled where possible. These locations are considered separately in terms of results and analyses, as it was not possible to ensure the same sample conditions as described in Section 2.2.

In nearly all instances, apart from larger centres (St. John’s and Corner Brook) community officials had little knowledge about the existence of lead pipe or service connections. In many cases the community lacked information about any remaining (or ever installed) lead in the system. When asked of community representatives, responses to questions of the presence of lead ranged from “I do not think there are any lead services” to “as far as I know all the lead services were removed a while ago” to “I have no idea if there’s any lead in the system”. In most cases, however, responses indicated that very few remaining lead services remained in the municipal distribution systems of the communities sampled during this study.

With the existence of lead distribution components undeterminable in many cases, the second and third site selection criteria was often used to choose sample locations. Therefore, sampling was conducted in buildings which were known to be built prior to 1991 using soldered copper pipe and/or were located in parts of the community where dead ends are present or other water quality problems are known to be persistent. Where possible the locations would be dispersed among different areas of the community.

This procedure was used to identify sample locations prior to the sample collection in each community. The selection criteria were initially supplied to the community in advance of the field technicians' visit. This gave the officials time to review the criteria and identify potential locations. Upon arriving at a community and meeting with the officials the technician would tour the water supply, treatment and distribution system and review the proposed areas for sampling.

Over the course of the entire sampling program, one practical limitation that was encountered was the reliance on homeowners being at home to allow the sampling to take place. In some instances it was possible to contact homeowners in advance of sampling to ensure they would be home at the approximate time the sampling was to take place. However, in many cases, an area of the town would be identified for sampling and the technician would try several locations to find an individual that both was at home and willing to participate in the sampling program.

2.2 Sampling Protocol

The protocol used for the actual sample collection was outlined in the initial TOR, detailed in the subsequent proposal and followed throughout the study. The procedure was as follows:

Within Canada, government technical guidance with respect to corrosion and corrosion control is provided by Health Canada through the Federal-Provincial-Territorial Committee on Drinking Water. The most current reference provided by this committee is a document, *Corrosion Control in Drinking Water Distribution Systems* from April 2007. This document was released for public comment in April 2007 and closed for comment on July 20th, 2007. The final version is still pending. The document provides the most comprehensive review of technical literature relating to corrosion in distribution systems, not just for lead, but also for iron and asbestos as it relates to asbestos-cement pipe common in distribution systems.

The Corrosion Control document is a culmination of many technical resources which are referenced throughout and is a primary document of consultation when interpreting both the methodology and results of the Newfoundland corrosion study. It also provides a reference for the sampling methodology used in this study. Referred to as the Section Action

Level a sample taken at a tap previously flushed for 5 minutes, stagnated for 30 minutes, and then sampled from the first 2-L is used as a standardized test to determine how wide-spread corrosion related issues are across a distribution system. The Second Action Level indicates using the current MAC of 0.010 mg/L for lead as a reference point for all results. The First Action Level, which includes sampling the first 1-L from a tap after at least 6 hours of stagnation, used 0.015 mg/L as a reference point, presumably since higher levels of lead would be expected after the much longer stagnation period.

A sampling program conducted using the First Action Level which reveals levels above 0.015 mg/L proceeds with multiple action items including sampling at the Second Action Level to determine the effect of shorter stagnation times on the corrosion rates.

The Departments of Health and Community Services and Environment and Conservation determined before initiating this study that the Second Action Level would be the basis of sampling. This is based on an assumption that a study on the First Action Level would have a very high probability of regular exceedances due to the known water corrosiveness in many communities. As well the Second Action level is logistically much easier to complete, more representative of normal conditions for drinking water, and many more samples can be collected in a given time. Conversely, at the First Action Level it is difficult and time-consuming to ensure proper stagnation times in typical residential locations.

2.3 Data Collection and Analysis

After contacting the communities to be sampled and allowing time to develop sampling locations the field technicians spent several weeks travelling across the province within each of the respective districts. All samples were collected in the period of Jan 29th to March 3rd. As lead samples have a maximum holding time of 7 days, samples were accumulated from one or more communities and then forwarded by courier to Maxxam Analytical in St. John's.

In addition to lead, which is the primary corrosion product of concern for the study, each community was sampled from one location for a more complete water analysis including a RCAP-MS. The selected location was not specifically determined but was one of the sites sampled for lead analysis. The RCAP sample was always collected at the end of the 5-minute flushing period prior to the stagnation period to represent water entering the pipes from the distribution system. The RCAP results provide very useful water quality data when assessing and comparing the final lead sampling results from each community. The rates of corrosion are as much a function of pipe materials and distribution system design as overall water quality including pH, hardness, alkalinity, ion concentrations, corrosion indices, and chlorine residual. The combined effects of the water quality and the physical system are discussed in detail in Chapter 3.

Chapter 3 Results and Findings

3.1 Data Presentation - Overview

All analytical results (with the exception of free chlorine) obtained during the study have been compiled into a single spreadsheet included in Appendix A. The spreadsheet includes coded tabs which separate data according to region and type of facility (residential, healthcare, and schools). A separate set of tabs includes all the data from the different regions compiled together. Both the lead and RCAp results are shown in the data tables.

In each community the residential samples are coded with the prefix R, healthcare with H, and schools with S. The healthcare samples include hospitals, daycares, and senior care facilities. While the data tables do not indicate the exact location of each sample within a community, the sample code can be referenced against a separate detailed spreadsheet database (provided) containing the description of every sample location. This detailed database is a composite of information collected during the sampling program at the time of sample collection from each location. Each community in which sampling was conducted was also asked to provide information to complete a series of questions detailing various aspects of the municipal water infrastructure. Referred to as Community Profiles, the hard copies of these forms are contained in the project folders in Appendix B. In Sections 3.2 through 3.4 the contents of the community profiles are described and summarized in conjunction with background water quality available through DOEC and sample data collected through this study. These sections tie together all components of the study with respect to every community sampling program.

3.2 Analytical Results - Overview

Table 3.1 below presents a summary of the entire lead data set with respect to residential samples. The residential lead sampling data shows that for the vast majority of samples the lead concentrations are below the 10 µg/L Maximum Acceptable Concentration (MAC). All communities had average concentrations below the MAC. The overall 90th percentile lead concentration was 4.8 µg/L. There were 6 communities that had samples at or above the MAC. These included Ferryland (1 exceedance), Fogo (3 exceedances), Brigus (1 sample at 10 µg/L), Corner Brook (1 exceedance), La Scie (1 exceedance), and Churchill Falls (2 exceedances). Of the total 298 residential lead samples all others were below the MAC. Many samples in the entire data set were below the minimum detection level of 0.5 µg/L. For these samples the value used in the calculation of trends was half the detection level or 0.25 µg/L. There was one anomaly sample collected in Fogo which had a lead concentration of 1,100 μg/L. While Fogo did have other samples above the MAC there were no others above 14 μg/L. The 1,100 μg/L sample has been excluded from the analysis of data as it would artificially inflate all results and is not considered representative of the system. It is not clear why this result was so high but may have been contaminated during sample. The same site with 1,100 μg/L was also used as the QA/QC sample which came back at 2.0 μg/L. Therefore it was determined that the sample was not representative and was artificially inflated.

A more detailed consideration of the broader water quality across the different communities is provided in Chapter 4. This includes analysis of historical water quality and the RCAp completed during this study. The Langelier Saturation Index (LSI) was not calculated in some RCAp samples taken during the study, presumably due to an imbalance of ions which commonly occurs in water samples with low hardness, alkalinity, and ionic strength. The LSI is one of a series standard industry practices for the general measurement of corrosiveness of water, and is recommended for use by the province of NL. The LSI indicates whether a water source is saturated with respect to calcium carbonate and whether scale will form in a distribution. Generally, water which will form scale is less corrosive to pipe as it builds on the pipe lining. A positive LSI is a scale-forming system and negative LSI is unsaturated and will dissolve available ions or metals into solution.

Table 3.1: Residential Lead Sampling Summary

Region	Community	No of Samples	Min (ug/L)	Max (ug/L)	Average (ug/L)	Median (ug/L)	Std Dev (ug/L)
Eastern	Branch	9	1.00	6.6	3.1	2.5	2.0
	Brigus	10	1.20	10.0	2.9	2.0	2.6
	Carbonear	10	0.60	6.8	2.8	1.9	2.3
	Ferryland	9	0.90	41.0	6.2	1.8	13.1
	Fortune	10	0.60	4.8	2.1	2.2	1.3
	Lamaline	10	0.25	3.3	1.5	1.4	1.0
	Newman's Cove	10	0.90	8.2	3.1	2.9	2.3
	Port Blandford	11	0.60	5.7	2.0	1.6	1.5
	St. John's	12	0.70	6.1	2.5	2.0	1.7
	Winterton	10	0.60	6.6	2.8	2.4	2.0
Central	Carmanville	9	0.25	3.2	0.8	0.3	1.0
	Campbellton	12	0.25	2.5	1.1	1.0	0.7
	Fogo	11	1.80	14.0	6.4	4.2	4.6
	Gambo	14	0.70	4.0	1.7	1.5	1.1
	Gander	11	0.25	3.7	1.3	1.0	1.0
	Glenwood	12	0.25	4.8	1.5	1.1	1.3
	Glovertown	11	0.90	5.6	2.4	1.9	1.7
	Grand Falls - Windsor	12	0.25	2.9	1.0	0.8	0.8
	Milltown	12	0.25	3.6	1.8	1.7	1.2
Western	Channel Port Aux Basques	8	0.25	1.4	0.4	0.3	0.4
	Corner Brook	9	0.25	12.0	3.3	1.2	4.2
	Deer Lake	1	3.90	3.9	3.9	3.9	N/A
	La Scie	10	0.50	21.0	3.2	1.2	6.3
	Rose Blanche	6	2.50	5.0	3.7	3.9	1.0
	St. Anthony	10	0.25	3.0	1.5	1.5	1.0
	St. George's	10	1.00	5.9	2.5	2.1	1.5
Labrador	Cartwright	10	0.25	2.3	0.8	0.6	0.6
	Churchill Falls	9	0.25	11.0	3.5	1.8	4.1
	Lanse au Loup	9	0.25	6.0	1.7	0.6	2.2
	Labrador City	10	0.25	4.4	1.6	1.4	1.4
	Min	1	0.25	1.4	0.4	0.3	0.4
	Max	14	3.9	41.0	6.4	4.2	13.1
	Average	9.9	0.73	7.3	2.4	1.7	2.3
	Median	10	0.55	5.3	2.3	1.7	1.5

Tables 3.2 and 3.3 show the results of lead sampling at healthcare and educational facilities respectively. Healthcare facilities include hospitals, daycares, and long-term care institutions. The educational facilities include all public schools regardless of whether they are connected to the public water supply within the community or not.

Table 3.2: Healthcare Facility Lead Sampling Summary

		No of Samples	Min (ug/L)	Max (ug/L)	Average (ug/L)	Median (ug/L)	Std Dev (ug/L)
Eastern	Branch	0					
	Brigus	1	1.00	0.9	0.9		
	Carbonear	5	0.50	2.7	1.5	1.3	0.9
	Ferryland	0					
	Fortune	0					
	Lamaline	0					
	Newman's Cove	0					
	Port Blandford	1	0.90	0.9	0.9	0.9	
	St. John's	6	0.50	1.1	0.8	0.8	0.2
	Winterton	1	2.00	2.0	2.0	2.0	
Central	Carmanville	0					
	Campbellton	0					
	Fogo	1	3.20	3.2	3.2	3.2	
	Gambo	1	0.60	0.6	0.6	0.6	
	Gander	7	0.25	0.9	0.5	0.3	0.3
	Glenwood	1	2.10	2.1	2.1	2.1	
	Glovertown	2	0.25	0.6	0.4	0.4	0.2
	Grand Falls - Windsor	5	0.25	3.5	1.3	0.8	1.3
	Milltown	1	0.60	0.6	0.6	0.6	
Western	Channel Port Aux Basques	2	13.00	130.0	71.5	71.5	82.7
	Corner Brook	6	0.80	17.0	6.9	7.3	5.9
	Deer Lake	0					
	La Scie	0					
	Rose Blanche	0					
	St. Anthony	4	0.80	2.3	1.5	1.5	0.6
	St. George's	0					
Labrador	Cartwright	0					
	Churchill Falls	1	3.20	3.2	3.2	3.2	
	Lanse au Loup	0					
	Labrador City	2	2.00	6.3	4.2	4.2	3.0
	Min	0	0.25	0.6	0.4	0.3	0.2
	Max	7	13	130.0	71.5	71.5	82.7
	Average	1.6	1.9	10.5	6.0	6.3	10.6
	Median	1	0.8	2.1	1.5	1.4	0.9

Overall, at an average value of 6.4 µg/L, the results of the healthcare facilities has a significantly higher value than those of the residential and school samples which had averages of 2.4 and 2.6 µg/L respectively. The 90th percentile values were 6.7 and 5.9 µg/L for the healthcare and school samples respectively. The highest healthcare value was at the hospital in Port Aux Basques with a concentration of 130 µg/L. This value is significantly higher than the MAC. The sample was taken from a fountain in the basement of the building. Little additional information is available as to the distance of the fountain from the service line, which could help estimate the residence time of the water at the time the sample was taken. The high lead concentration was not unexpected in Port Aux Basques as the community is known to have ongoing corrosion problems and the hospital reported regular pipe breaks during the sampling interview. However, the residential samples in Port Aux Basques did not have particularly elevated lead levels, possibly because it was difficult to find any locations that still had soldered copper pipe installed. Most residences have replaced copper plumbing with plastic due to recurring breaks in the copper piping due to corrosion. In constrast, the hospital still has copper plumbing installed which likely contributed to the high lead reading in that sample. Because the fountain is located in a relatively quiet area of the building, the usual retention time in the plumbing system at that location may also have contributed to the high reading.

The only other healthcare sample above 10 µg/L was in Corner Brook at Western Memorial Regional Hospital. As with the hospital in Port Aux Basques, the sample taken from the hospital in Corner Brook was taken inside the building (kitchen) at an unknown distance from the service line. The 5 minute flushing process may not have cleared the plumbing of stagnant water which could in turn have led to an elevated lead concentration.

Table 3.3: Education Facility Lead Sampling Summary

		No of Samples	Min (ug/L)	Max (ug/L)	Average (ug/L)	Median (ug/L)	Std Dev (ug/L)
Eastern	Branch	1	13.00	13.0	13.0		
	Brigus	0					
	Carbonear	2	0.60	1.3	1.0	1.0	0.5
	Ferryland	2	0.60	1.7	1.2	1.2	0.8
	Fortune	1	0.25	0.3	0.3		
	Lamaline	1	0.80	0.8	0.8		
	Newman's Cove	0					
	Port Blandford	0					
	St. John's	8	0.25	1.3	0.7	0.7	0.4
	Winterton	1	0.80	0.8	0.8		
Central	Carmanville	0					
	Campbellton	0					
	Fogo	0					
	Gambo	1	3.60	3.6	3.6		
	Gander	2	1.00	3.4	2.2	2.2	1.7
	Glenwood	1	5.70	5.7	5.7		
	Glovertown	1	0.80	0.8	0.8		
	Grand Falls - Windsor	3	0.25	7.0	3.5	3.3	3.4
	Milltown	1	0.90	0.9	0.9		
Western	Channel Port Aux Basques	2	1.00	3.3	2.2	2.2	1.6
	Corner Brook	6	0.80	5.3	2.5	2.3	1.5
	Deer Lake						
	La Scie	2	1.20	2.3	1.8	1.8	0.8
	Rose Blanche	0					
	St. Anthony	2	1.40	6.0	3.7	3.7	3.3
	St. George's	2	0.25	5.8	3.0	3.0	3.9
Labrador	Cartwright	1	1.60	1.6	1.6		
	Churchill Falls	1	3.40	3.4	3.4		
	Lanse au Loup	1	1.50	1.5	1.5		
	Labrador City	3	0.25	18.0	10.1	12.0	9.0
	Min	0	0.25	0.3	0.3	0.7	0.4
	Max	8	13	18.0	13.0	12.0	9.0
	Average	1.6	1.8	4.0	2.9	3.0	2.4
	Median	1	0.85	2.8	2.0	2.2	1.6

Lead sampling at schools produced only two results above the MAC, at Branch and Labrador City. The concentrations were 13.0 and 18.0 µg/L respectively. Neither community had particularly elevated results in the residential samples. The mechanisms responsible for the elevated lead levels at the schools are likely similar to those in the healthcare facilities described above. Larger plumbing systems produce longer average stagnation times and may result in incomplete flushing after 5 minutes. These results may suggest that the larger institutions would require a different sampling protocol depending on the size of the plumbing system and time required for flushing.

Many government programs, including those in the United States (USEPA) and Ontario use the 90th percentile lead concentration as an indication of the severity of lead concentrations in community drinking water systems. The USEPA regulations require that communities prove that fewer than 10% of residential samples are out of compliance (i.e. Above 10 µg/L). The Ontario regulations are stricter; communities must prove that no more than 10% of the sample sites in a given community have lead concentrations above 5 µg/L, and that no sites have lead concentrations above 10 µg/L.

In both cases, it is necessary to determine the 90th percentile lead concentration of all the samples collected in a given community. This is done by arranging the sample values in one column, numbering them and determining which value falls at 90%. For example, in a series of 100 samples arranged from lowest to highest lead concentration, the 90th value would be the 90th percentile value. In a series of 10 samples arranged from lowest to highest, the 9th value would be the 90th percentile value.

The 90th percentile lead concentration was calculated for all of the communities sampled during this project. The number of towns with 90th percentile concentrations in ranges from <2.5 to 15 are shown in Figure 3.1 below.

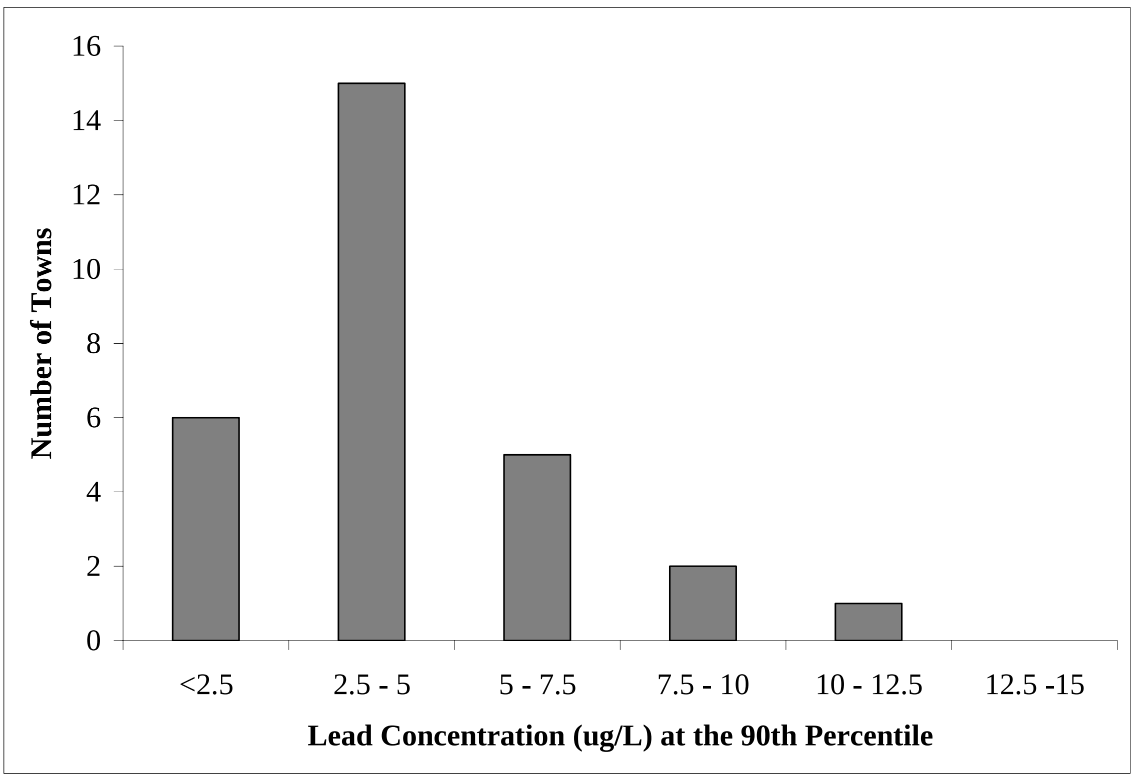

Figure 3.1: Distribution of 90th Percentile Lead Concentrations Among Residential Samples (Newfoundland and Labrador, Winter 2009)

Most of the towns that participated in the study had 90th percentile values below 5 µg/L. This means they were in compliance with both the USEPA and Ontario regulations. Seven towns had 90th percentile lead concentrations between 5 and 10 µg/L; putting them out of compliance according to Ontario regulations. One town had a 90th percentile concentration above 10 µg/L, putting it out of compliance with both the USEPA and Ontario regulations.

A 90th percentile lead concentration above 10 µg/L in a community suggests that the may have a problem with lead corrosion in the municipal water distribution system. This will likely be due to a combination of corrosive water and the presence of lead mains and services. If a community has a small number of exceedances but a 90th percentile lead concentration well below 10 µg/L, it may be a sign that the individual buildings are experiencing lead corrosion in their internal plumbing or in their fixtures (taps etc.).

90th percentile concentrations were also determined for the entire sets of residential, educational and health care sites. These are shown in Figure 3.2 below:

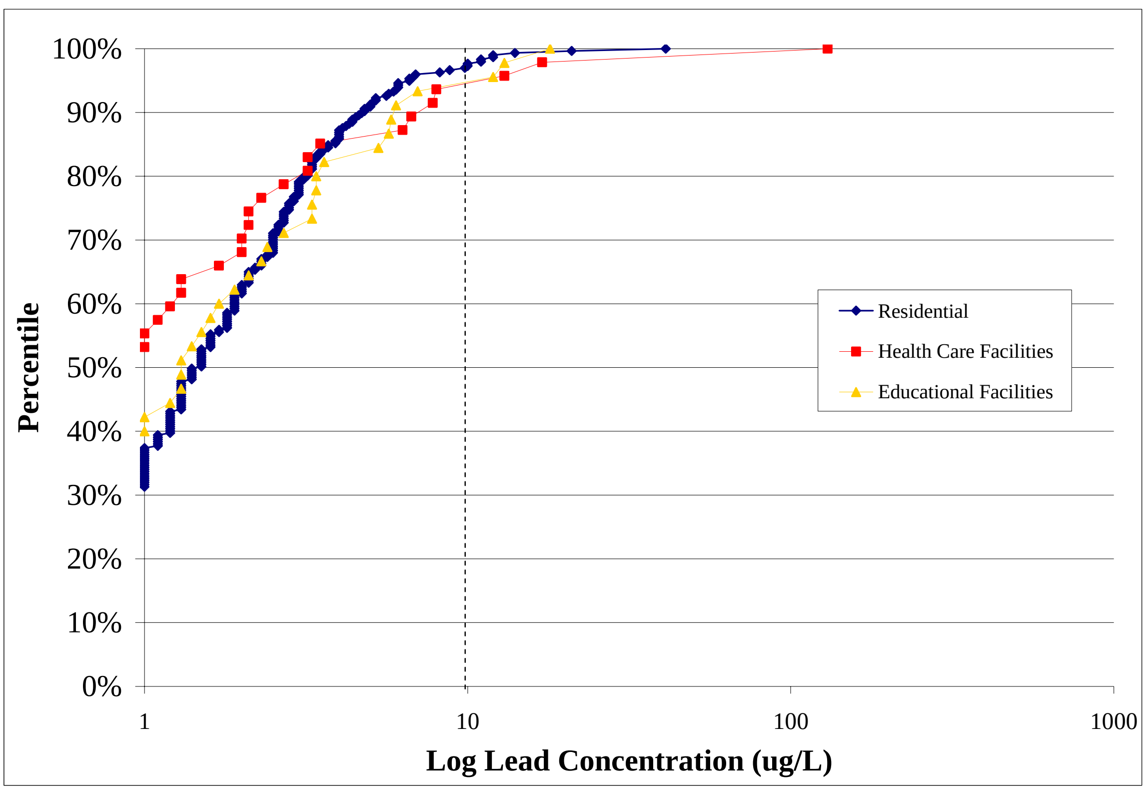

Figure 3.2: 90th Percentile Lead Concentrations for Residential Buildings, Health Care Facilities and Educational Facilities

The residential samples for the entire province had a 90th percentile lead concentration of 4.8 µg/L. The educational facilities and the health care facilities had 90th percentile concentrations of 5.9 µg/L and 6.7 µg/L respectively. This may indicate that the non-residential samples were more likely to have elevated lead levels than the residential samples. This would make sense because the taps in non-residential buildings are less likely to be used on a regular basis. However, the difference between residential and non-residential 90th percentile lead levels may simply be as a result of there being many more residential than non-residential sample points.

3.3 Community Profiles – Eastern

Figure 3.3 shows the lead concentrations measured in the tap water from various residential sample locations in the communities participating in this study located in the eastern region of the province.

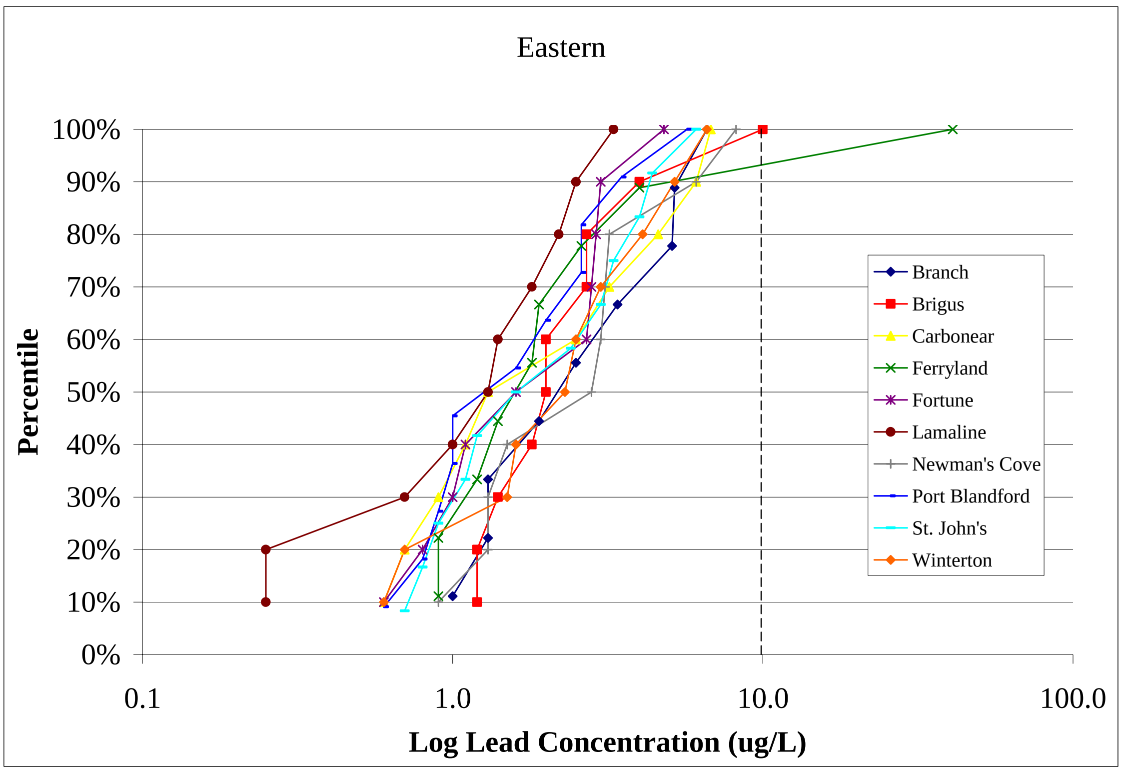

Figure 3.3: Determination of 90th Percentile Lead Concentration for Towns in the Eastern Region of Newfoundland and Labrador (Winter 2009)

None of the towns in this region had a 90th percentile lead concentration above the limit of 10 µg/L. The 90th percentile concentration ranged between 2.5 µg/L in Lamaline to 6.1 in Carbonear and Newman's Cove. Two towns, Ferryland and Winterton, had one residential lead sample reading above the limit.

Each community sampled in the Eastern region is described in detail in the following subsections.

3.3.1 Branch

The Town of Branch is located on the Western side of St. Mary's Bay. The 2006 population of the community was 309 people. The Town owns and operates a municipal water supply system to serve the residents of the community.

The water supply system was first installed in the 1930's using cast iron pipe. Later system extensions were completed in the 1970's and 1980's using PVC pipe. The public water system currently services approximately 70 of the 140 homes in the community or 50%.

The surface water source supply for the water system is Valleys Pond. There is currently a permanent long-term Boil Water Advisory (BWA) in place due to the lack of treatment and more specifically disinfection of the water supply. The surface water runs by gravity from the supply through the community without the addition of a disinfectant such as chlorine. As a result the water is deemed high-risk and a BWA is present.

There is a backup reservoir in the form of an alternate surface water, however this is rarely used. The system has no specific water quality issues on record however the presence of a BWA likely covers any kind of water quality problem from a consumer's perspective. The water mains are not known to be corroded.

Residents of the community connected to the water supply pay a fee of $150 per year for water service.

The town lacks formal water treatment so the quality of tap water is very similar to that of the source water. A review of historical water quality data shows that the tap water is generally high in dissolved organics (colour and DOC), low in buffering capacity (hardness and alkalinity), and low in pH, contains levels of iron and manganese above guidelines at times, and turbidity above drinking water quality guidelines. A brief summary of historical key water quality parameters sampled annually since 2001 is below.

Table 3.4: Branch Tap Water Quality Summary (2001 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	18	109	56	15
Turbidity	NTU	0.53	3.70	1.47	15
DOC	mg/L	3.4	9.5	5.9	15
pH		5.3	6.6	6.0	15
Hardness	mg/L as $CaCO_3$	0	62	9	15
Alkalinity	mg/L as $CaCO_3$	0	16	4	15
Iron	mg/L	0.11	0.72	0.28	15
Manganese	mg/L	0.01	0.73	0.12	15
LSI		-6.22	-3.45	-5.18	10
THMs	µg/L	0	0	0	4
HAAs	µg/L	n/a	n/a	n/a	n/a

**THMs and LSI monitored since 2002*

A total of 10 water samples were collected in Branch as part of the corrosion study on Feb 9th, 2009. Of those sampled 8 were residential, 1 was commercial, and 1 was educational. The locations were constructed and connected to the water system dating back to the original construction of the water system and continuing to 1989. Samples locations were spread throughout the community with selection made by the Town personnel based on criteria described in Chapter 2.

The results of the lead sampling showed that the residential and commercial concentrations ranged from 1.0 to 6.6 µg/L. The sample taken at the school was higher, at 13.0 µg/L. The average residential concentration was 3.1 µg/L, while the 90th percentile concentration was 5.2 µg/L. With the results consistently below the MAC for lead the screening demonstrates that at a 30 minute stagnation time there do not appear to be significant concentrations of lead corrosion products dissolving into the potable water system. This is not unexpected since the system does not have any chlorination or disinfection which could add to the rates of corrosion. The presence of some lead indicates some corrosion is taking place, and is expected given the corrosiveness of the water according to the LSI method.

The one sample which did exceed the MAC was taken at the Branch Community Centre. Such facilities may have longer runs of copper plumbing or have little use. Therefore despite a 5 minute flushing period, all corrosion products may not be removed. The lack of chlorine residual at any point prevents knowing whether the lines have been well flushed.

3.3.2 Brigus

Located in Conception Bay, the Town of Brigus is one of the oldest Towns in the province. Despite this fact the public water supply and distribution system was only installed in 1981-82. Residents of the community pay a fee of $200 per year for water service.

Currently, approximately 65-75% of the Town's 794 people (2006) are serviced by the public water supply. The water supply is fed from a surface water source, Brigus Long Pond, located near the community. It is the sole source of water for the system. It feeds the system entirely by gravity and no pumping systems for pressure boosting are used. There is no system reservoir for peak balancing or fire storage.

Since the initial installation of the system only repairs to existing pipes have been completed, resulting in a system with an age ranging between 28 years to 3 years. The original distribution system was entirely ductile iron. More recently, repairs and modifications have used some PVC pipe material.

While there is no formal water treatment plant for the supply, the water is disinfected at a central point using chlorine gas. The Town has indicated that no other type of corrosion or pH control is practiced although documentation shows that the community does have a pH correction system. There is however a yearly flushing program which assists with corrosion control. The insides of the mains are not known to be restricted due to corrosion by-products and there are no issues with the water system as it exists.

The system has a dedicated Class I operator who is the primary person responsible for the operation. The operator maintains the instrumentation at the disinfection station which also contains a main water meter for recording the total system flow.

Tap water quality is available for the source water dating from 2000 and includes 17 samples. THM data includes 53 samples dating from 1997. HAA monitoring started in 2001 and includes 12 samples. The available data for raw water quality and subsequent chlorinated DBP sampling from the distribution system is shown below.

Table 3.5: Brigus Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	8	45	19	16
Turbidity	NTU	0	1.19	0.45	16
DOC	mg/L	3.2	73.0	4.9	16
pH		4.8	6.7	5.5	16
Hardness	mg/L as $CaCO_3$	0	7	3	14
Alkalinity	mg/L as $CaCO_3$	0	8	2	16
Iron	mg/L	0.01	0.18	0.08	16
Manganese	mg/L	0.00	0.04	0.01	16
LSI		-6.65	-4.26	-5.62	13
THMs	µg/L	28	170	72	53
HAAs	µg/L	59	308	140	12

**THMs monitored since 1997, HAAs monitored since 2001*

During the corrosion study sampling period a total of eleven samples were collected from Brigus including 1 senior care home. Building construction dates for sampled locations ranged from the early 1900's to 1987 and contained a mixture of copper and PVC internal plumbing, most of which used lead solder during construction. There was some evidence of dark staining due to water quality at the tap.

Of the ten residential samples the results for lead ranged from 1.2 to 10.0 µg/L just at the MAC. The average concentration was well below the MAC at 2.9 µg/L and the median was 2.0 µg/L. The 90^{th} percentile sample was 4.0 µg/L. According to the field sheet database and hand-drawn map in the project folder the 10 µg/L sample, R9, was collected at a location at a dead end of the system. This dead end type location may be indicative of areas where corrosion is more of a concern due to water age and retention time in the distribution system.

The single healthcare sample collected in Brigus had a lead concentration of 0.9 µg/L. While the sample also appears to have been collected at a dead end of the system the lead concentration is much lower. Little information was able to be collected from the facility at the time of sampling including the age or pipe material in the facility. These may provide further information to differentiate the value of the sample from that of the higher concentration residential sample nearby.

Considering all samples for Brigus it does not appear that lead corrosion rates are excessive at a 30 minute retention time, despite the presence of corrosive water and low-level chlorine residual readings.

3.3.3 Carbonear

As with the Town of Brigus, the Town of Carbonear is located in Conception Bay. Carbonear is a larger centre within Conception Bay and has a population of 4,723 (2006). Customers of the water system do not pay a fixed rate for water. It is assumed however that some form of taxation is built in to the municipal tax rate to cover the cost of water supply and distribution.

The public water system in the Town is provided via a single source, Little Island Pond. The distribution system services 100% of the Town through a combination of gravity flow to the lower-lying portions and 4 pumping stations which provide adequate pressure to higher portions of the Town.

Water treatment consists of screening at the main intake building and gas chlorination. There are no other treatment chemicals, such as a corrosion inhibitor added to the water. The system has a designated operator; however that person is presently not certified. The distribution system is primarily composed of ductile iron with some intermittent or added sections of PVC (80% DI, 20% PVC). The original date of construction of the waterworks is not available however current upgrades and replacements are ongoing in some areas.

There are no known standardized maintenance practices on the water system nor are they any existing problems with the system. Distribution mains are not indicated to be restricted due to corrosion by-products.

Tap water monitoring dates back to 2000 and includes 22 samples. Subsequent to chlorination THM and HAA monitoring has been conducted across the system since 1996 and includes 63 samples. HAA monitoring began in 2003 and includes 4 samples. A summary of tap water and DBP data is included in the table below.

Table 3.6: Carbonear TapWater Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	1	19	9	21
Turbidity	NTU	0.00	1.20	0.35	21
DOC	mg/L	1.6	4.9	3.1	21
pH		5.1	7.2	6.2	21
Hardness	mg/L as $CaCO_3$	0	10	4	17
Alkalinity	mg/L as $CaCO_3$	0	10	3	21
Iron	mg/L	0.01	0.13	0.06	21
Manganese	mg/L	0.00	0.05	0.01	21
LSI		-6.54	-2.71	-5.04	16
THMs	µg/L	2	78	37	63
HAAs	µg/L	39	110	72	4

**THMs monitored from 1996-2008, HAAs monitored 2003-2008*

The tap water quality has been monitored for many years and is generally good in terms of organics content, metals, and turbidity. pH is often low and colour is elevated at times. The water has low hardness and alkalinity making it corrosive by conventional methods.

A total of 17 samples were collected for lead analysis in the Town of Carbonear on February 11th and 12th. Of those samples three were seniors care homes, two were education institutions, one was a child care facility, and one was a medical facility. The remaining sites were residential. Residential construction dates ranged from the early 1900's to 1989 and included copper plumbing in a number of locations. Only one facility was constructed after 1990 and was a senior care home. It was built in 2006 and used internal PVC plumbing.

The residential lead sample results had concentrations ranging from 0.6 to 6.8 µg/L, all below the MAC. The 90th percentile concentration for the residential samples was 6.1 µg/L. In addition, the five healthcare facility samples had an average concentration of 1.5 µg/L and a maximum of 2.7 µg/L. The two educational facility samples had concentrations of 1.3 and 0.6 µg/L.

None of the results for Carbonear showed significant levels of lead corrosion byproducts. The RCAp had concentrations of ions consistent with a low LSI reading, as with almost every location in the entire study. Chlorine residual readings taken at locations throughout the sampling also had very low or non-detectable levels, despite the 5 minute initial flushing period.

3.3.4 Ferryland

Ferryland is located 80 km south of St. John's on the coast of the Avalon Peninsula. It has a population of 529 people (2006), 70% of whom are served by the municipal water system. Water is drawn from Deep Cove Pond, a surface water source. The town currently has a designated system operator, information concerning his level of certification was not provided. Customers pay $180/year as a water tax in order to receive municipal water.

The town has no treatment system but does chlorinate the water using liquid chlorine. The water is then sent to the community using gravity flow. The chlorination and distribution system was built in 3 phases that began in 1988 and were completed in 1992. The piping in Phase 1 consists of 350 mm HDPE whereas in Phases 2 and 3 it consists of 12" and 6" black ductile respectively. Phase 3 also contains 4" PVC piping. Phases 1 and 3 contain copper services whereas Phase 2 contains polyethylene services.

No major problems have been reported in the supply system, although there have been some minor issues (stuck and broken valves etc.). The system is checked daily and flushed twice a year. No corrosion specific problems have been reported in the piping system and no corrosion prevention plan is in place.

As the water treatment consists of chlorination only, the tap water quality (Table 3.7) closely mirrors that of the raw source water:

Table 3.7: Ferryland Tap Water Quality and DBP Summary (2001 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	9	38	23	15
Turbidity	NTU	0.09	1.40	0.58	15
DOC	mg/L	3.6	9.2	6.3	15
pH		5.9	6.9	6.3	15
Hardness	mg/L as $CaCO_3$	3	9	5	15
Alkalinity	mg/L as $CaCO_3$	0	16	6	15
Iron	mg/L	0.07	0.17	0.11	15
Manganese	mg/L	0.00	0.10	0.02	15
LSI		-5.09	-3.46	-4.48	14
THMs	µg/L	0	573	166	40
HAAs	µg/L	177	1060	363	9

**THMs monitored 1996-2008, HAAs monitored 2002-2008*

Hardness and alkalinity are both low, which increases the potential corrosiveness of the water flowing through the distribution system. An average pH of 6.3 is not uncommon but may also contribute to increased corrosion. Elevated levels of THMs have been reported throughout the system, likely as a result of pond water high in colour and DOC being chlorinated without the presence of treatment for organics removal. HAAs have also been monitored in recent years and are consistently above the current Health Canada Guidelines of 80 µg/L.

A total of eleven lead samples were collected in the town from January 29th to 30th, 2009; eight residential samples, one commercial sample and two samples from educational facilities. The residences varied greatly in age, one was built in the 1920s, one in 1952 and the rest between 1968 and 1982. The piping in these buildings was generally a combination of copper and PVC, although the oldest building also contained cast iron piping and some of the newer residences contain only PVC. The commercial building was constructed relatively recently in 1994. It contained only PVC piping. The two educational facilities were built in 1967 and 1980. The older building had copper piping and the newer one had PVC piping. All of the buildings sampled were reported to have lead solder.

Only one sample point had a lead reading above the guideline of 10 µg/L. The commercial building had a reading of 41 µg/L, possibly because the tap sampled was in use less frequently than those in residential buildings, leading to increased stagnation times. The RCAp for the town was conducted on this sample and showed zinc levels higher than the historic levels recorded in the source water. Thus, some zinc may have been leaching into the tap water from a brass fitting such as a brass faucet. Brass faucets are known to be sources of lead (Gardels and Sorg, 1989; Lee et al., 1989) and often go unnoticed. They tend to leach zinc and lead when the tap water is corrosive (Kimbrough, 2007). The sample also had a LSI of -4.01 at 4ºC, indicating that the water from the tap was quite corrosive. This may also help to explain the high lead reading for this sample point. High levels of colour and aluminium were also noted in the RCAp for the commercial sample site.

The lead levels in the residential buildings ranged from 0.9 to 4.0 µg/L with an average of 1.8 µg/L and a 90th percentile concentration of 4.0 µg/L. The two educational facilities had lead levels of 0.6 and 1.7 µg/L.

3.3.5 Fortune

Fortune is a small town located on the Burin Peninsula at the mouth of Fortune Bay. 100% of its population of 1,458 (2006) are served by the municipal water services. Water is taken from the Horsebrook reservoir. Customers pay $25 a month for water services.

There is currently no treatment beyond intake screens, although a pH control system is being built. Chlorine gas is used for disinfection. The town's distribution system was installed in the 1950s and the piping is 90% ductile iron. A pumphouse was constructed in 1985. The water is distributed from the chlorination station using gravity flow.

The waterworks are under the supervision of a designated operator, having a Class 1 designation. There are no standardized maintenance procedures on the system. No water quality or corrosion issues have been reported, and the town currently has no corrosion prevention plan.

Since the water is not treated before chlorination and disinfection, the tap water quality closely resembles that of the raw source water in the parameters listed in Table 3.8 below, which have been monitored since 2000.

Table 3.8: Fortune Tap Water Quality and DBP Summary (2000 – 2008)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	3	34	14	20
Turbidity	NTU	0.00	2.70	0.48	20
DOC	mg/L	0.8	7.0	3.6	20
pH		4.7	6.5	5.5	20
Hardness	mg/L as $CaCO_3$	0	9	5	16
Alkalinity	mg/L as $CaCO_3$	0	9	2	20
Iron	mg/L	0.01	0.50	0.12	20
Manganese	mg/L	0.01	0.09	0.02	20
LSI		-7.27	-3.87	-5.70	15
THMs*	µg/L	2	123	52	40
HAAs	µg/L	0	300	151	13

**THMs monitored from 1998-2008*

Colour, turbidity and DOC are low and not considered to be of concern in this community. THMs are rarely a problem and have only twice exceeded the Health Canada Guidelines of 100 µg in the past 10 years. HAA readings, however, have often been above the 80 µg/L guideline since the bi-annual sampling program began in 2000. Alkalinity and hardness are both low, which, when combined with a low pH, has led to a high Langelier Index (i.e. increasingly negative value), indicating that the water in the distribution system is relatively corrosive. Iron and manganese levels have occasionally been above their aesthetic objectives, however, they have on average been within them.

Despite the high LSI, none of the eleven sites sampled in Fortune on February 4th and 5th, 2009, had lead levels above the 10 µg/L guideline. Ten of the sample sites were residential buildings, which ranged in age from 30 to 50 years old. The 90th percentile concentration for the residential samples was 3.0 µg/L. The final site was a school built in 1977. All of the buildings sampled (with the exception of one for which information was not available) had copper piping, and some of them also had PVC piping. They also all had lead solder. It would appear that at a 30 minute stagnation time significant concentrations of lead corrosion products were not dissolving into the potable water system.

The RCAp did not indicate any major problems besides a low pH (6.21). It was impossible to calculate the Langelier Index for reasons similar to those discussed earlier in Chapter 3.

3.3.6 Lamaline

Lamaline is a small community of 315 people (2006) located on the southern coast of the Burin Peninsula. Of this number, 79, or 25%, receive municipal water. Lamaline East is the only area serviced by the water system, it consists of 32 houses and a school. The surface water source used is Upper Hodges Pond. Customers pay $272 per year for their water services.

Treatment consists of intake screens and pH adjustment with soda ash. Disinfection is accomplished using chlorine gas. The chlorine station has been upgraded since it was initially built. The piping in the distribution system is ductile iron. It was installed in three phases from 1992-1994 and now extends from the pond to Lamaline East. There are two booster pumps in the chlorination station but flow through the distribution system is by gravity.

The town has a designated system operator, however, the operator is not certified. Standardized maintenance procedures consist of cleaning the intake screens and flushing the distribution lines twice a year.

No particular water quality concerns were reported during the investigation, however, there was boil order in the town in 2005 due to issues with the chlorination system.

No corrosion-related restrictions have been noted inside the distribution mains. The town has a corrosion control strategy which involves pH adjustment using soda ash.

Because the town doesn't treat the water before chlorination and distribution, the resulting record of historical water quality in the source water is similar to that of the tap water results shown in Table 3.9 below. Tap water samples have been analyzed twice or three times a year since 2000. THMs present in the tap water have been analyzed 2 to 4 times annually since 2000. HAAs have been monitored since 2004.

Table 3.9: Lamaline Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	6	121	52	19
Turbidity	NTU	0.00	2.90	0.76	19
DOC	mg/L	1.8	14.6	6.9	19
pH		4.3	7.1	6.1	19
Hardness	mg/L as $CaCO_3$	3	23	12	15
Alkalinity	mg/L as $CaCO_3$	0	16	6	19
Iron	mg/L	0.01	0.87	0.32	19
Manganese	mg/L	0.00	0.07	0.02	19
LSI		-6.61	-3.05	-4.67	14
THMs	µg/L	0	397	85	40
HAAs	µg/L	60	914	299	10

**HAAs monitored since 2004*

Colour and DOC levels in the tap water samples are very high, indicating that the water is high in organics. This is reflected in the high levels of THMs and HAAs measured in the tap water. Although the average THM reading is below the 100 µg/L guideline, a closer look at the data reveals thirteen exceedances since 2004. The pH, hardness and alkalinity of the water are all low, which has led to an average Langelier Index of -4.67, indicating that the water in the distribution system is relatively corrosive.

The 11 samples obtained from 10 residential buildings and a school in Lamaline on February 6th, 2009 all had lead levels below the 10 µg/L guideline. The residential buildings had readings ranging from below detection to 3.3 µg/L and a 90th percentile concentration of 2.5 µg/L. The sample from the school had a lead concentration of 0.8 µg/L.

Many of the residences sampled were quite old, with one dating from 1910 and another from 1920. Two other homes were thought to have been built 80 or more years ago. One owner was unsure of the age of the home and the remaining five homes were built between 1953 and 1982. All of the homes had copper piping (although one owner was unsure) and two of the older homes also reported PVC piping. All of the homes reported that lead solder had been used. The educational facility was built in 1977 and had copper piping and lead solder.

The RCAp, which was conducted on a tap water sample from one of the older houses, did not indicate any major points of concern. The colour and organic carbon results were much lower than the historical values. This was also the case with the Langelier Index, which was -2.85 at 4ºC, lower (i.e. closer to positive values) than the lowest value on record with the town.

3.3.7 Newman's Cove

Newman's Cove can be found 10 km south of Bonavista on the northeast coast of Newfoundland. The town has a population of 192 (2006), 99% of whom are served by the municipal water system. Customers pay a monthly fee for their water services which add up to $120 per year.

Heale Pond is the surface water source used to supply the town. Treatment consists of intake screens followed by pH control through the addition of soda ash. Disinfection, using liquid chlorine, was installed in 2006. The distribution system consists of PVC piping and was built in 1985. Water flows through the system by gravity.

There is a designated system operator but he/she is not certified. The eastern part of the town has had problems with low chlorine levels. There was a boil order issued in 1999 due to low readings of free chlorine and issues with the coliform count. Corrosion has also been a problem, for example, sludge has been reported in the piping system and complaints about red staining on hot water heaters and washed clothing in the community. The municipality has tried to address this by adjusting the pH of the water using soda ash.

The water is not treated before chlorination and distribution, therefore the non-microbiological source water quality is very similar to that of the tap water that the residents use. Tap water quality has been analyzed twice a year since 2000, the results for selected parameters are presented in Table 3.10. THMs have been monitored slightly more often, and HAAs have only been monitored since 2004.

Table 3.10: Newman's Cove Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	38	313	114	20
Turbidity	NTU	0.44	1.80	0.78	20
DOC	mg/L	5.9	25.9	13.5	20
pH		5.0	7.0	5.6	20
Hardness	mg/L as $CaCO_3$	0	17	4	16
Alkalinity	mg/L as $CaCO_3$	0	11	3	20
Iron	mg/L	0.16	7.91	0.87	20
Manganese	mg/L	0.00	2.56	0.16	20
LSI		-7.24	-3.91	-5.72	16
THMs	µg/L	0	55	8	36
HAAs	µg/L	0	20	5	6

**HAAs monitored since 2004*

Despite the high colour and DOC results, THMs and HAAs have never been outside of their respective guidelines. As with many of the other communities investigated in this study, pH, hardness and alkalinity are all low and therefore, the LSI indicates that the water in the distribution is quite corrosive. This may be why the iron and manganese levels have occasionally been very high, although these high levels do seem to be rare events.

For example, the maximum iron level recorded was 7.91 mg/L, which skews the average to 0.87 mg/L, although the median iron reading is only 0.46 mg/L. The RCAp conducted on a tap water sample from the town by Maxxam Analytics also indicated a very high iron concentration of 2 mg/L. The raw water iron readings only range from 0.15 to 0.74 mg/L. These results may suggest that iron is being leached from some portion of the distribution system at specific times, or that the source water has highly variable iron content which may change seasonally with water temperature or other factors (i.e. intermittent inflow from other water bodies etc.).

The ten residences sampled for lead on February 24^{th}, 2009 ranged in age from 4 to 160 years old. All of the homes had copper piping except for the one built in 2005, which reported plastic piping. Only one home reported lead solder. Many of the residents had water-quality complaints during the sampling program. None of the samples had lead concentrations above the 10 µg/L guideline. Lead readings ranged from 0.9 µg/L to 8.2 µg/L with an average of 3.1 µg/L and a 90^{th} percentile concentration of 6.1 µg/L.

In addition to the high iron levels discussed above, the RCAp also showed that the tap water sampled from one of the residences had elevated levels of colour, turbidity, aluminium and manganese. It also had a particularly low pH value at 6.0.

3.3.8 Port Blandford

Port Blandford is located on the eastern coast of Newfoundland in Colde Sound, just south of Terra Nova National Park on the Trans-Canada Highway. In 2006 the population of the town was 521 and 90% were serviced by the municipal water system. Residents pay $180 per year for their water services.

The town draws its water from Noseworthy's Pond and treats it using soda ash for pH adjustment followed by disinfection with chlorine gas. A new water intake was installed on Noseworthy's Pond in 1997 and in 2007, a new water tower, a secondary chlorination building (using sodium hypochlorite), and a new pH adjustment system was installed in the Noseworthy's Pond Chlorination Pumphouse. The piping in the distribution system is made up of ductile iron and PVC. The water system was constructed in a series of phases stretching from 1975 until 1997. Water flows to the distribution system through a combination of gravity and pumping.

The town has a system operator who has a Class 1 designation. Water quality complaints related to colour, taste and staining have been noted in the community. THM levels have also been known to exceed guidelines. There have been reports of leakage from the copper lines and also aesthetic complaints related municipal water used for food preparation. Corrosion has been noted inside the distribution mains. The municipality has attempted to address the corrosion problem through pH control using chlorine (gas and hypochlorite) and soda ash. The system is flushed periodically for maintenance.

The limited treatment applied to the raw water results in tap water that is very close in quality to the water obtained from the pond. A selection of water quality parameters monitored 2 to 4 times annually in the tap water provided to the residents of the town of Port Blandford are presented in Table 3.11.

Table 3.11: Port Blandford Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	3	29	14	20
Turbidity	NTU	0.00	0.90	0.32	20
DOC	mg/L	0.6	9.2	5.2	20
pH		4.2	7.4	5.5	20
Hardness	mg/L as $CaCO_3$	5	20	9	16
Alkalinity	mg/L as $CaCO_3$	0	15	2	20
Iron	mg/L	0.01	0.25	0.11	20
Manganese	mg/L	0.00	0.05	0.02	20
LSI		-6.90	-2.79	-5.31	16
THMs	µg/L	0	170	65	49
HAAs	µg/L	81	407	185	14

**THMs monitored 1996-2008, HAAs monitored 2005-2008*

The tap water is slightly elevated in colour and high in DOC, which likely accounts for the THM and HAA exceedances which have been noted over the years. THM levels have occasionally been slightly over the guideline (100 µg/L) and HAAs have consistently been above the guideline (80 µg/L). Hardness, alkalinity and pH have all been rather variable but tend to be low, which accounts for the average LSI of -5.31, indicating highly corrosive water.

Eleven residential buildings were sampled and tested for lead on February 23rd 2009. The homes were all built between the 1940s and the 1980s. All of the homeowners indicated that their homes had copper piping and a number of them also reported lead solder. The remainder were not sure whether or not they had lead solder. None of the sample sites had elevated lead levels. The readings ranged from 0.6 µg/L to 5.2 µg/L with an average of 2.0 µg/L and a 90th percentile concentration of 3.5 µg/L.

The one health institution sampled was built in the 1940s and has copper piping. The contact person was not aware of any lead solder used in the building but the construction date would suggest so. The lead reading for this sample site was 0.9 µg/L, well below the guideline.

3.3.9 St. John's (Bay Bulls Big Pond)

St. John's is the capital of Newfoundland and Labrador and is located in the northeast corner of the Avalon Peninsula. The Bay Bulls Big Pond WTP provides water for residents of the communities of St. John's West, Mount Pearl, CBS, Paradise and Portugal Cove-St. Phillips. The combined population of these areas is 81,517 people. Customers are billed for water based on their individual dwelling water meters.

Two treatment plants service the communities in and around the St. John’s area. The Bay Bulls Big Pond WTP is a conventional treatment facility, constructed in 1977 that was built to address concerns about colour and metals present in the source water. The system consists of intake screens, ozonation and direct filtration followed by chlorination with chlorine gas, lime (pH control) and chloramination (as reported by the city). Many of these components have been upgraded since the original construction. The piping in the distribution system includes asbestos cement, ductile iron and PVC. Water flows to the distribution system through a combination of pumping and gravity.

The plant has multiple operators of varying certification levels. The main contact person was not aware of any issues or complaints about the water treatment system, however, a number of people at the sample sites had taste and odour complaints. Distribution mains are not the responsibility of the water treatment plant, therefore, no information concerning the presence of corrosion within the mains was available. However, the plant does adjust the pH of the finished water using lime in order to minimize eventual corrosion in the pipes.

St. John’s has extensive water treatment facilities, resources, and operations department that provides a high quality finished water to the community. Therefore, the tap water is quite different than the raw water. However, as it is the tap water that flows through the distribution system, it is the historic tap water data that is presented in Table 3.12. Most of the parameters were measured 2 to 6 times per year from 2000 to 2008 with the exception of THMs, which have been monitored since 1993.

Table 3.12: St. John's Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	0	22	8	33
Turbidity	NTU	0.00	1.70	0.39	33
DOC	mg/L	1.7	4.6	3.3	30
pH		6.1	7.7	6.7	33
Hardness	mg/L as $CaCO_3$	3	30	10	26
Alkalinity	mg/L as $CaCO_3$	0	18	6	33
Iron	mg/L	0.01	0.30	0.10	33
Manganese	mg/L	0.00	0.10	0.02	33
LSI		-4.71	-2.53	-3.82	24
THMs	µg/L	0	79	18	66
HAAs	µg/L	4	150	54	17

**THMs monitored from 1993 to 2008*

Average colour, DOC and turbidity are all within normal limits for tap water, although the occasionally elevated levels of colour and DOC do correspond to higher levels of THMs. However, THM levels have never exceeded guidelines. HAAs have twice been over the acceptable guideline of 80 µg/L. The pH, hardness and alkalinity of the St. John's water are all low but better than those observed in many of the smaller communities addressed in this study. The average LSI of -3.82 indicates that the water is often corrosive.

A total of 26 sample sites were evaluated for lead in the St. John's area on February 14th, 15th, 26th and 27th, 2009. This included twelve residences, six health care facilities and eight schools. Lead levels were within the guidelines at all locations.

The residences were all built in the 1970s and 1980s. All of the owners reported either copper piping or unfamiliarity with the type of piping used. This was also true of lead solder. The lead readings ranged from 0.7 µg/L to 6.1 µg/L with an average of 2.5 µg/L and a 90th percentile concentration of 4.4 µg/L.

The healthcare facilities ranged in age from 18 to 53 years old, although the contact people at two facilities were unaware of the age of the building. Four of the six facilities reported copper piping (the other two did not know) and two of the facilities reported lead solder. The average lead reading at the health care facilities was 0.8 µg/L.

The educational facilities were all built between 1959 and 1982. All but two reported copper piping (the other two weren't sure) and 5 reported lead solder. Three of the eight schools investigated had lead levels below detection and the remainder had levels ranging from 0.6 to 1.3 µg/L.

The RCAp conducted on one tap water sample showed no major water quality issues.

3.3.10 Winterton

Winterton is located on the western end of the Avalon peninsula on Trinity Bay. It currently has a population of 518 (NL Statistics Agency), all of whom are currently receiving water from the municipal water system. Customers pay $288 per year for water services.

The Town draws all of its water from a single surface water source; Western Pond. Treatment consists of intake screens and disinfection with chlorine gas. The distribution system is made up of PVC and concrete asbestos piping. It was installed in three phases, the first phase ran from 1966-1977 and the last was completed in 1997. The water flows through the system by gravity.

The town has a Class I designated system operator. There have been complaints of breaks in copper lines within homes and buried surfaces, presumably due to corrosion. There was also a boil order issued in 2008 due to a mechanical failure in the disinfection process.

The water taken from Western Pond is not treated before disinfection and distribution, therefore the tap water closely resembles the source water on the parameters listed in Table 3.13 below. Most of the parameters were recorded two or three times a year starting in 2001. THMs have been measured once to six times per year since 1996 and HAAs approximately twice a year since 2004.

Table 3.13: Winterton Tap Water Quality and DBP Summary (2001 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	7	30	17	16
Turbidity	NTU	0.08	1.10	0.43	16
DOC	mg/L	3.3	8.5	4.4	16
pH		5.1	6.9	6.0	16
Hardness	mg/L as $CaCO_3$	0	28	6	16
Alkalinity	mg/L as $CaCO_3$	0	10	3	16
Iron	mg/L	0.00	0.09	0.05	16
Manganese	mg/L	0.00	0.06	0.01	16
LSI		-6.52	-3.63	-4.97	14
THMs	µg/L	9	184	43	46
HAAs	µg/L	22	84	61	8

**THMs monitored 1996-2008, HAAs monitored 2004-2008*

Colour and DOC are elevated in the tap water, which explains the occasional THM exceedances noted in Table 3.10. pH, hardness and alkalinity are all low, therefore the average LSI hovers around -5 and the water can be considered corrosive. Turbidity, iron and manganese are all within normal limits.

One school, one health care facility and ten residences were sampled for lead on February 9th and 10th. None of them had elevated levels of lead.

The residential buildings ranged in age from 22 to over 100 years old. All of them had copper piping and the one commercial building among them also had plastic piping. All of them reported lead solder. The average lead reading at the residential sample sites was 2.8 µg/L and the 90th percentile concentration was 5.2 µg/L.

The educational building was built in 1973, had a combination of copper and asbestos pipes and reported the presence of lead solder. The health care facility was of indeterminate age and the contact person was not aware of the type of piping or whether or not lead solder had been used. The lead level at the educational sample site was 0.8 µg/L.

The RCAp conducted on one of the tap water samples noted elevated colour and extremely low pH (4.58).

3.4 Community Profiles – Central

Figure 3.4 shows the lead concentrations measured in the tap water from various residential sample locations in the communities participating in this study located in the central region of the province.

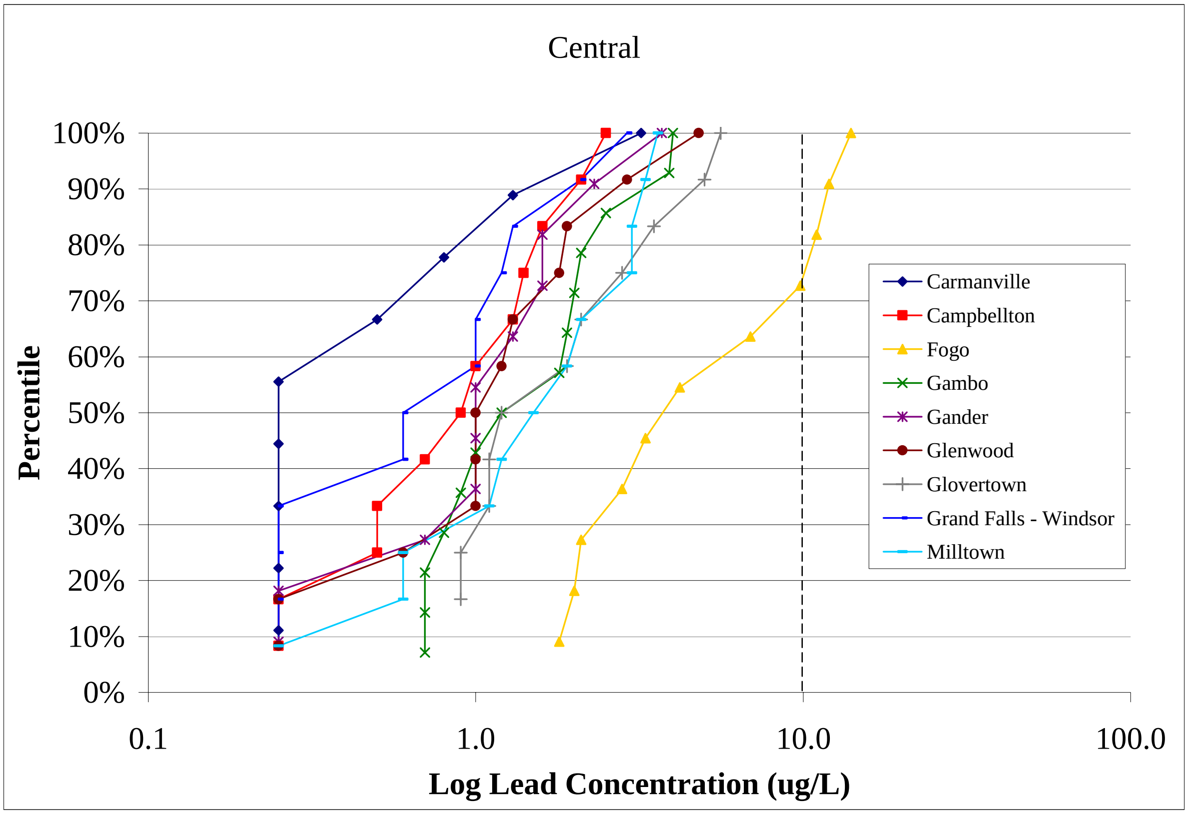

Figure 3.4: Determination of 90th Percentile Lead Concentration for Towns in the Central Region of Newfoundland and Labrador (Winter 2009)

One community, Fogo, had a 90th percentile concentration of lead of 12.0 µg/L and four samples at or above the 10 µg/L limit. None of the eight other communities had any residential readings above the limit. The 90th percentile concentrations in these eight towns ranged from 1.3 µg/L in Carmanville to 5.0 µg/L in Glovertown.

Detailed descriptions of the nine communities sampled in the central region of Newfoundland and Labrador follow in the sections below:

3.4.1 Carmanville

Carmanville is a town of 753 inhabitants (2006) located on the north-eastern coast of Newfoundland. It was formerly known as Rocky Bay. Water for the town is taken from 'Grandfather's Pond', a surface water source located a few kilometres south of the town. Approximately 90% of the population of Carmanville is served by the municipal water system. Residents pay $300 a year to be connected.

The town does not have a formal water treatment system. Water is drawn from the pond and passed through intake screens before being chlorinated using liquid chlorine (sodium hypochlorite) and sent to the distribution system. In 1978 the system was connected to artesian wells. In 1987-1988, the intake was switched to Grandfather's Pond.

The distribution system provides water to most of the town using gravity flow although water is pumped to the area near Howell's Avenue. The piping in the system consists of ductile iron (8") and plastic or PVC (6", 8" and 10"). There have been no official upgrades of the distribution system since 1987-1988 when the intake location was changed, however the system has been extended a number of times in order to reach greater numbers of residents. For example, Noggin Cove Road was completed in 1999 and Howell's Avenue in 2001.

The town has a designated system operator with a Class II Water Distribution Operator classification. The town contact person was not aware of any known water quality or corrosion problems in the system. Two residents had complaints related to excessive chlorine at the tap, which resulted in an unpleasant taste. There are no standard maintenance practices or a corrosion prevention plan in place at the current time.

The tap water provided to the residents is very similar to the raw water taken from Grandfather's Pond and is generally of good quality as shown in Table 3.14 below.

Table 3.14: Carmanville Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	3	15	8	16
Turbidity	NTU	0.03	0.90	0.34	16
DOC	mg/L	2.6	5.6	4.1	16
pH		6.1	7.0	6.5	16
Hardness	mg/L as $CaCO_3$	0	9	6	14
Alkalinity	mg/L as $CaCO_3$	0	17	8	16
Iron	mg/L	0.00	0.09	0.03	16
Manganese	mg/L	0.00	0.02	0.01	16
LSI		-4.99	-3.69	-4.32	16
THMs	µg/L	0	146	66	50
HAAs	µg/L	27	110	71	6

**THMs monitored since 1996, HAAs monitored since 2001*

The average colour, turbidity, iron and manganese are all below guidelines. The average DOC is slightly elevated, which may account for the occasional THM and HAA exceedances noted in the table above. pH, hardness and alkalinity are all low, indicating that the water is corrosive. This is confirmed by the average LSI of -4.32.

Nine buildings in Carmanville were sampled on February 9th and 11th 2009. No educational or health facilities were included in the sampling program, although one of the nine samples mentioned previously was taken from the lunchroom at the Town Hall. The eight sampled residences were all built between 1969 and 1989. They all reported copper piping and the majority reported lead solder. Three homeowners were not sure whether or not their homes contained lead solder. The Town Hall was built in the 1950s and contains copper and plastic piping as well as lead solder.

The sampled buildings did not show elevated levels of lead after a 30 minute stagnation period. Readings ranged from below detection to 3.2 µg/L with a 90th percentile concentration of 1.3 µg/L. In fact, the majority (5 out of 9) of the samples were below detection. This was somewhat unexpected given the general corrosiveness of the water. The RCAp did not indicate any important water quality deviations.

3.4.2 Campbellton

Campbellton is a town of 494 inhabitants (2006) located about halfway between Gander and Grand Falls-Windsor at Indian Arm on Notre Dame Bay. Approximately 80% of the population is serviced by the municipal water supply. Customers pay $204 a year for access to the municipal water services.

Raw surface water is drawn from the Indian Arm River and passes through intake screens before being disinfected using liquid chlorine (hypochlorite). The water is then pumped to the distribution system, which consists of ductile iron and PVC piping. The pumphouse was originally built in 1976 and has since undergone eight expansion phases.

There are no formally reported problems with the system, however, a number of water quality complaints were recorded by the technician in charge of sampling during the course of the investigation. Many homeowners complained of chlorine taste and odour in the water as well as green staining. One mentioned that there was sediment present in the water. There was no record of any corrosion-related restrictions in the water mains. The town has a designated system operator who is currently in training to become certified. The system is flushed periodically for maintenance. There is no corrosion control plan in place.

The town has no formal treatment so the tap water quality is roughly the same as the source water for the parameters listed below in Table 3.15. Most of the parameters have been sampled nineteen times since 2000 (approximately twice a year) with the exception of THMs, which have been measured since 1998 and HAAs, which have been measured since 2002.

Table 3.15: Campbellton Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	8	38	23	19
Turbidity	NTU	0.10	0.50	0.33	19
DOC	mg/L	3.1	9.2	5.6	19
pH		5.6	7.1	6.4	19
Hardness	mg/L as $CaCO_3$	3	34	10	15
Alkalinity	mg/L as $CaCO_3$	0	13	7	19
Iron	mg/L	0.01	0.18	0.08	19
Manganese	mg/L	0.00	0.08	0.01	19
LSI		-5.44	-2.59	-3.97	19
THMs	µg/L	12	146	82	35
HAAs	µg/L	16	260	114	11

**THMs monitored 1998-2008, HAAs monitored 2002-2008*

The tap water has a high concentration of organics as indicated by the high values for average colour and DOC. When these organics react with the chlorine used for disinfection, disinfection by-products such as THMs and HAAs are formed. The high colour and DOC readings are the likely causes of the THM and HAA exceedences reported in Table 3.11. As has been observed in many of the other communities investigated in this study, the water in Campbellton has low pH, hardness and alkalinity, which results in an LSI of -3.97. This is indicative of corrosive water.

A total of twelve homes were sampled in Campbellton on February 12th and 13th of 2009. One of the residences was built in 1902, four were built in the 1950s and the rest were built between 1964 and 1987. All twelve homes reported copper piping and lead solder. None of the samples taken from the homes had lead levels above the 10 µg/L guideline. Readings varied from below detection to 2.1 µg/L with a 90th percentile concentration of 2.1 µg/L. No educational or health facilities were sampled during the course of the study. The RCAp conducted on one of the residential samples had a higher than average colour reading (36 TCU) but was otherwise within guidelines.

3.4.3 Fogo

Fogo is located on Fogo Island, which is the largest offshore island north of Newfoundland. In 2006, the town had a population of 748. The municipal water system serves almost 100% of the population and draws its water from Freeman's Pond, a surface water source in the eastern portion of the town. The residents of Fogo pay a designated rate for the water system, however, exact details were not provided to the sampling team.

The water system was installed in a series of phases starting in 1987 and consists of intake screens, chlorination with chlorine gas and pH control using lime. Water is distributed using gravity flow after chlorination and pH control. The piping in the distribution system is primarily PVC but also contains a section of ductile iron leaving the treatment building.

A number of water quality problems have been reported by residents and were known to the Town contact person. Complaints include colour and sediment in the water, green staining in tubs and corrosion in pipes. The water mains are known to be restricted by corrosion in some areas. Many residents do not drink the water. pH control with lime has been used in an effort to mitigate some of the corrosion. The mains are also flushed in the summer as a standard maintenance procedure.

The tap water, which is presented in Table 3.16 below, is similar to the raw water because the town lacks a formal water treatment system. For most parameters, data has been collected twice a year since 2000. THMs have been monitored on a more frequent basis since 1996.

Table 3.16: Fogo Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	29	179	76	16
Turbidity	NTU	0.25	1.70	0.77	16
DOC	mg/L	8.0	20.5	12.9	16
pH		3.1	6.4	5.0	16
Hardness	mg/L as $CaCO_3$	7	53	15	14
Alkalinity	mg/L as $CaCO_3$	0	7	2	16
Iron	mg/L	0.08	0.94	0.48	16
Manganese	mg/L	0.02	0.11	0.05	16
LSI		-8.12	-3.88	-5.93	15
THMs	µg/L	2	415	131	51
HAAs	µg/L	0	790	316	12

**THMs monitored 1996-2008*

Colour and DOC are extremely high, which has consequently resulted in frequent THM and HAA exceedances. As in many of the other communities profiled in this study, the average pH, hardness and alkalinity are all low which leads to the water being quite corrosive. The average LSI is -5.93 and has been known to be as low as -8.12.

Twelve residential buildings were sampled on February 10th, 2009, and many of them had lead levels that exceeded the 10 µg/L guideline. The three homes with lead levels above the guideline were within 5 µg/L of it, ranging from 11 to 14 µg/L. One home had a reading of 9.8 µg/L. All of the homes where the age of the building was known were built between 1960 and 1978. Along with the other homes, these buildings all contained copper piping and lead solder. Two of the samples were taken from kitchens and one from a bathroom faucet. Only one of the homes was more than 50 m from the main water lines. The high lead levels are likely as a result of the extreme corrosiveness of the water and the known corrosion issues in the distribution system. The remaining homes, which had lead levels ranging from 1.8 to 6.9 µg/L, were between 20 and 90 years old. The 90th percentile concentration in Fogo was 12 µg/L, above the limit and therefore of concern.

The one health care facility sampled was built in 1995 and has a 50/50 combination of copper and PVC piping. The contact at the facility was unsure about the presence of lead solder. This building had a lead reading of 3.5 µg/L.

The RCAp, which was conducted on one of the residential samples, confirmed the water quality concerns discussed above. The pH of the water was extremely low (4.5) as was the alkalinity. It was not possible to calculate the LSI, however, the low pH and alkalinity readings suggest that the water sample was highly corrosive. The colour of the water was also very high at 140 TCU. Iron and aluminium levels were well above guidelines, the iron in particular may be another sign of corrosion in the water distribution system.

3.4.4 Gambo

Gambo, a town of 2,072 inhabitants located about halfway between Terra Nova National Park and the larger town of Gander, spent some time in the Canadian spotlight last year because of a severe flood that hit the area in August. It is also well-known within Newfoundland as the birthplace of the first provincial premier. Residents pay $396 per year to receive water from the municipality.

The town draws its water from Dark Cove Pond. The water does not undergo any treatment but is disinfected using liquid chlorine. It is then distributed to the town with a combination of pumping and gravity flow. There are two booster pumping stations throughout the community. The distribution system contains a variety of piping including ductile iron, cast iron, concrete and PVC. The system was installed during the 1950s and 1960s and has not been upgraded since.

Known water quality issues include taste and odour complaints described as being related to both chlorine and 'dead water' or stagnation and has evidently had an odour of sulphur (hydrogen sulphide). There are also reports of coloured water. The inhabitants and/or users of 9 of the 15 buildings sampled do not drink the water that comes out of the tap. The distribution mains in the town are known to be restricted by corrosion.

The town currently has a designated water system operator who has a Class II certification. There are established standard maintenance practices, however, details were not provided to the sampling team. There is no corrosion control program.

As with most small communities, the lack of formal water treatment in the town of Gambo results in tap water that is very similar in quality to the raw water obtained from the surface water source. Tap water quality data, collected approximately twice a year since 2001, is summarized in Table 3.17. THM data has been collected more frequently since 1998 and HAA data has only been collected since 2004.

Table 3.17: Gambo Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	2	29	10	15
Turbidity	NTU	0.06	1.20	0.58	15
DOC	mg/L	2.6	8.5	4.9	15
pH		5.5	6.5	6.2	15
Hardness	mg/L as $CaCO_3$	5	12	8	15
Alkalinity	mg/L as $CaCO_3$	0	13	5	15
Iron	mg/L	0.00	0.10	0.05	15
Manganese	mg/L	0.00	0.05	0.01	15
LSI		-5.31	-3.83	-4.39	15
THMs	µg/L	0	144	56	45
HAAs	µg/L	46	128	89	8

**THMs monitored 1998-2008, HAAs monitored 2004-2008*

Colour, turbidity, iron and manganese have generally been within guidelines, however DOC has often been elevated. Since THMs and HAAs are formed when DOC reacts with chlorine during disinfection, elevated DOC levels are the likely cause of the occasional THM and HAA exceedences noted over the years. HAAs are of particular concern since their level is on average, above the 80 µg/L guideline. As in many other communities, the water in Gambo is considered corrosive because it has, on average, a low pH, hardness and alkalinity. This results in an average LSI of -4.39. The corrosiveness of the water may explain some of the water quality complaints.

Of the fourteen residences, one school, and one health care facility sampled from February 18th to 21st, 2009, not one had a lead measurement above the 10 µg/L guideline. The average lead reading among the residences was 1.7 µg/L and the median reading was 1.5 µg/L, suggesting that lead levels after a 30 minute stagnation time are quite low in the tap water used by the residents of Gambo. The 90th percentile concentration of lead was determined to be 3.9 µg/L. Most of the residences were built in the 1960s and 1970s, although two of them were built at the very beginning of the 20th century and one in 1930. All of them reported copper piping and lead solder. The house built in 1930 also reported some plastic piping.

The health care facility (a seniors home) was built in 2005 and has all plastic piping. The sample taken from the facility had a lead reading of 0.6 µg/L. The educational facility dates from 1973 and has copper piping and lead solder. The lead reading from this facility was 3.6 µg/L.

The RCAp, which was performed on a sample taken from one of the residential sites, showed slightly low pH (6.2) and slightly elevated colour (19 TCU). Otherwise, no major exceedances were noted.

3.4.5 Gander

Gander is a relatively large town in the centre of Newfoundland with a proud history of aviation. There is a population of 9,951 (2006), 99.5% of whom are connected to the municipal water system. Customers do pay for their water but may be eligible for rebates depending on their household income. Tax exempt residential properties pay a flat rate of $500 per year for water and sewer services.

Water is drawn from Gander Lake. The original intake pumphouse was built in the 1950s and replaced in 1974. The water treatment system was installed in 2007 and consists of pH control and ozonation followed by sand filtration and disinfection using chlorination with chlorine gas. The treated water is then sent to a reservoir and the distribution system by pumping. The distribution system consists of cast iron, ductile iron and PVC piping. There is a booster station at the reservoir, which was installed in 1974. The town has also extended the water system to serve new subdivisions as the population has grown.

The town has a superintendant and two water treatment operators, who have Class III, Class I and II designations respectively. A hydrant flushing program occurs every summer in Gander. Some water quality issues were noted during sampling. One resident mentioned occasional bad taste in the water and another complained of sediment. Also, water taken directly from the tap often looks cloudy, however, this is as a result of the ozonation used during treatment and is not considered dangerous from the Town’s perspective. The town has undertaken a public awareness campaign to inform residents about the source of the cloudiness in the water.

Some of the water mains may be restricted due to corrosion. The sampler received conflicting reports on the subject. Cathodic protection has been installed at the reservoir in order to track the corrosiveness of the water. No other corrosion control program was reported.

Despite the water treatment system, many of the parameters shown in Table 3.18 are almost the same in the raw and tap water sample records. This data should be interpreted with caution however since a new treatment plant was commissioned in 2007 and would have affected the water quality trends.

Table 3.18: Gander Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	3	42	24	29
Turbidity	NTU	0.00	0.80	0.39	29
DOC	mg/L	3.6	12.7	6.1	29
pH		5.4	7.0	6.4	29
Hardness	mg/L as $CaCO_3$	3	33	12	27
Alkalinity	mg/L as $CaCO_3$	0	16	7	29
Iron	mg/L	0.01	0.13	0.07	29
Manganese	mg/L	0.00	0.05	0.01	29
LSI		-5.48	-3.05	-3.96	26
THMs	µg/L	36	336	192	113
HAAs	µg/L	0	322	113	17

**THMs monitored 1996-2008, HAAs monitored 1999-2008*

Gander’s tap water has historically been high in colour and DOC and low in pH, hardness and alkalinity. This has resulted in high levels of DBPs such as THMs and HAAs as well as highly corrosive water as measured by the LSI.

The sampling program in Gander encompassed eleven residential buildings, seven health care facilities and two schools. The residential buildings were all built between 1942 and 1980, have copper piping and lead solder. Of the health care facilities, one was built in the 1950s, two in the 1970s and two between 2000 and 2003. Contact people at the remaining two facilities were unable to provide the age of the buildings. Copper piping and lead solder were present at most of the sample sites, but in many cases the contact people were unsure as to the kind of piping and solder used during construction. The two schools were built in 1957 and 1972. Contact people at both schools reported that copper pipes existed in the buildings but were unsure about the presence of lead solder.

None of the sampling locations had a lead concentration higher than 10 µg/L after a 30 minute stagnation time, suggesting that most residents of Gander were not being exposed to dangerous levels of lead from their drinking water. In many locations, lead levels were below detection. The 90^{th} percentile value for the residential samples was 2.3 µg/L. The highest lead concentration found in Gander (3.4 µg/L).

The RCAp was conducted on a tap water sample taken from one of the residential sites. High colour and iron readings were obtained, the last may be a sign of corrosion in the distribution system or in some residential plumbing.

3.4.6 Glenwood

Glenwood is a community of 762 on the shores of Gander Lake in the north-eastern portion of Newfoundland. Gander Lake is a surface water source is used to supply 100% of the population of Glenwood with residential water services. Customers pay $32 per month for their water services.

The town does not have a water treatment system but does have an infiltration gallery at the intake site. They disinfect the water with chlorine gas before distributing the water to the community using a combination of pumping and gravity flow. The water system was first installed in 1963 and contains common pipe materials. It has been periodically extended to include new streets and residences but has never been formally upgraded.

There is a designated water system operator, however he is not certified by provincial standards. There are established maintenance procedures, but no details were provided to the sampling team during the investigation.

Some Glenwood residents who participated in the sampling program reported that their tap water occasionally had some bad tastes and odours during the summer months. However, there were no official records on hand of particular water quality issues.

There is no record of corrosion in the water distribution system and there is no corrosion control program.

The water that the town of Glenwood draws from Gander Lake is high in colour and DOC and low in pH, hardness and alkalinity. Because they don't treat the water before disinfecting and distributing it, the tap water quality is very similar to that of the raw water. A summary of tap water quality observed over since 2000 is shown in Table 3.19. THMs have been monitored frequently since 1996.

Table 3.19: Glenwood Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	25	44	32	19
Turbidity	NTU	0.00	0.50	0.32	19
DOC	mg/L	4.2	7.9	5.9	19
pH		4.7	7.0	5.6	19
Hardness	mg/L as $CaCO_3$	0	30	7	15
Alkalinity	mg/L as $CaCO_3$	0	20	3	19
Iron	mg/L	0.01	0.17	0.08	19
Manganese	mg/L	0.00	0.11	0.02	19
LSI		-7.24	-3.09	-5.56	19
THMs	µg/L	0	152	52	49
HAAs	µg/L	5	170	86	11

**THMs monitored since 1996*

The tap water in Glenwood has often had DBP levels above the 100 µg/L and 80 µg/L guidelines for THMs and HAAs respectively. However, the average THM reading is well within guidelines. The water is corrosive, as indicated by the LSI which ranges from -7.24 to -3.09.

On February 3rd and 4th, 2009, twelve residential buildings, a school and a health care facility were sampled for lead in the town of Glenwood. None of them had lead levels above the 10 µg/L guideline.

The homes that were sampled ranged from 20 to 100 years old. All of them have copper piping and many reported the presence of lead solder. The school was built in 1984 and has copper piping and lead solder. The health care facility (a preschool) was built in 2006 and the contact person did not know what kind of piping or solder was used during construction.

Lead levels in the residential buildings ranged from below detection to 4.8 µg/L, the 90th percentile concentration was 2.9 µg/L. The sample from the school contained 5.7 µg/L of lead and the sample from the health care facility had a concentration of 2.1 µg/L.

The RCAp performed on one of the tap water samples indicated a particularly high level of colour (34 TCU) and a very low pH (5.7).

3.4.7 Glovertown

Glovertown is a relatively large community (2,062 inhabitants in 2006) on the northern boundary of Terra Nova National Park on the northeast coast of Newfoundland. The town uses Northwest Pond as a surface water source to supply the community with potable water. Everyone in the town is connected to the water system and pays $378 a year for it.

The water system was installed from 1967 to 1968 and has since been upgraded by the addition of a chlorination system and a pH control process. The distribution system was extended three times, in 1978, 1980 and 1985/1986. It contains PVC and ductile iron piping. The system also includes a booster pumping station on the appropriately named Station Road. Flow through the system is powered by gravity and pumps.

The municipality checks the soda ash and chlorine levels daily, the hydrants annually and flushes the manholes periodically to maintain the system. However, specific water quality problems persist. Almost all of the residents contacted during the course of the project reported taste and odour problems, coloured water as well as green and black staining. The entire distribution system is known to be corroded.

The tap water quality parameters presented in Table 3.20 have been monitored since 2000 except for THMs and HAAs, which have been monitored since 1996 and 2002 respectively.

Table 3.20: Glovertown Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	5	63	32	19
Turbidity	NTU	0.16	0.90	0.42	19
DOC	mg/L	5.3	9.6	6.5	19
pH		4.7	6.3	5.2	19
Hardness	mg/L as $CaCO_3$	3	18	5	16
Alkalinity	mg/L as $CaCO_3$	0	9	1	19
Iron	mg/L	0.02	0.93	0.13	19
Manganese	mg/L	0.00	0.03	0.00	19
LSI		-7.41	-3.71	-6.03	18
THMs	µg/L	25	170	69	63
HAAs	µg/L	17	310	145	10

**THMs monitored 1996-2008, HAAs monitored 2002-2008*

Much like most of the other municipalities investigated during this project, the water in Glovertown is high in organics as measured by colour and DOC and low in pH, alkalinity and hardness. This means that the water is highly coloured, likely to form DBPs upon disinfection with chlorine, and corrosive.

Eleven residences, two health care facilities and a school were sampled on February 19th and 20th, 2009, for lead. All of the homes sampled were built between 1950 and1987. Their owners all reported that copper pipes were used in the home as well as lead solder. The concentration of lead in the residential samples ranged from 0.9 to 5.6 µg/L with an average of 2.4 µg/L and a median of 1.9 µg/L. The 90th percentile lead concentration was determined to be 5.0 µg/L.

One of the health care facilities was built in 1993 and contains copper piping and lead solder. The sample taken from this site did not contain a measurable concentration of lead. The age of the second health care facility was unknown. It also contains copper piping and lead solder. Only 0.6 µg/L of lead was found in this sample after the 30 minute stagnation time.

The school was built in 1974 and contains copper piping and lead solder. It was the only location sampled where the users did not have complaints about the quality of the tap water. The lead reading at this location was 0.8 µg/L.

The RCAp conducted on one of the residential tap water samples showed that the water had low pH (5.9) and high colour (46 TCU). There was also an uncommonly high concentration of aluminum.

3.4.8 Grand Falls – Windsor

Grand Falls-Windsor is a large town in the centre of Newfoundland with a population of 13,558 people (2006), 100% of whom are connected to the municipal water supply. They draw their water from a surface water source called Northern Arm Pond. Residents pay $245 per year for their water services.

The water from the pond is highly coloured and somewhat acidic, however the town has a water treatment plant that manages to treat these and other parameters of concern to more reasonable levels. The conventional water treatment plant was installed in 1996 to update the water supply (installed in 1976) and consists of intake screens, pH adjustment, coagulation/ flocculation with aluminium sulphate, sedimentation and filtration. Sodium hypochlorite is used for disinfection before the water is sent to the community via a pumphouse located a short distance from the plant. Water flows from the plant to the pumphouse by gravity. The distribution system contains 80% ductile iron piping, 10% cast iron piping and 10% steel.

The town has three water treatment operators all of whom have Class II certification. There are no established standard maintenance practices and no established corrosion control program.

Although there are no recorded issues with regards to water quality or the water supply system in general, a number of the residents interviewed during the sampling program had complaints about taste, odour and sediment in their tap water. The distribution mains are not known to be corroded or restricted.

The tap water in Grand Falls-Windsor has historically been of much better quality than that available in many of the smaller towns in the same general area. This is due to their treatment system, which manages to remove a substantial portion of the organics – limiting the formation of DBPs such as THMs and HAAs. Most of the parameters listed below have been measured since 1999, except for THMs, which have been measured regularly since 1996 and HAAs, measured since 2000.

Table 3.21: Grand Falls-Windsor Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	0	6	2	32
Turbidity	NTU	0.00	2.40	0.53	32
DOC	mg/L	1.3	4.1	2.3	32
pH		6.2	7.4	6.8	32
Hardness	mg/L as $CaCO_3$	15	42	22	27
Alkalinity	mg/L as $CaCO_3$	0	19	10	31
Iron	mg/L	0.00	0.31	0.08	31
Manganese	mg/L	0.00	0.12	0.02	31
LSI		-4.03	-2.30	-2.98	29
THMs	µg/L	33	180	81	106
HAAs	µg/L	40	220	86	16

**THMs monitored 1996-2008, HAAs monitored 2000-2008*

pH control at the plant results in water that is less corrosive than that available in communities without treatment, although with an average LSI of -2.98, the water is still fairly corrosive compared to other provinces. Lead concentrations in the tap water sampled at twelve residential buildings, five health care facilities and three schools were all below the 10 µg/L guideline.

Many of the houses sampled in Grand Falls-Windsor were fairly old, all but one (of those whose ages were known) were built in the 1960s or earlier. One home was built in 1979. About half of the homes contain copper piping and the other half contain galvanized steel piping. One home recently had their copper piping replaced by PVC piping. Many of the homes reported the presence of lead solder in the plumbing system. Lead levels ranged from below detection to 2.9 µg/L. The 90th percentile concentration of lead in the residential samples was 2.1 µg/L.

In contrast with the older homes, 3 of the 5 health care facilities sampled during the project were built within the past 15 years. The other two were of indeterminate age. The contact people at the health care facilities were often not aware of the type of piping or solder in their buildings, although two of them did report copper piping. Lead levels in these facilities ranged from below detection to 3.5 µg/L.

Lead levels in the schools were more variable, one school had no detectable lead while another had 7 µg/L. This last value is within guidelines and does not pose a risk to users. The contact person at the school did not know the age of the building or the types of pipes and solder used during construction.

The RCAp reported a high concentration of aluminium in the tap water, possibly as a result of inaccurate pH control during the coagulation/flocculation portion of the water treatment process. All other parameters were found to be within guidelines.

3.4.9 Milltown

Milltown-Head of Bay d'Espoir is located on an estuary known as Bay d'Espoir on the south coast of Newfoundland. It has a population of 865 people (2006). Customers are charged a designated rate for water services, but the exact amount was not disclosed.

Jersey Pond is the surface water source that provides 100% of the inhabitants of the town with raw water. After the water is drawn from the pond, it is treated with rapid sand filtration, disinfected with chlorine gas and sent to the distribution system, through which it flows by gravity. The piping in the distribution system is made up of ductile iron. The original water system was installed in the 1960s and has been upgraded with a filtration plant in 1994 and a new chlorine system 5 years ago. The distribution system has been gradually expanded over the years, with the most important upgrades occurring between 1972 and 1974.

The town has a designated water system operator but he/she is not certified by provincial standards. The system is flushed periodically and was cleaned by pigging in 1984. There is no corrosion control program.

There are historical water quality issues with respect to the tap water in Milltown. A boil advisory issued last August was still fresh in the minds of those interviewed during the sampling program. They also complained of taste and odour, colour, sediment and excessive chlorine.

Tap water quality is available since 2000 (1996 for THMs) for the parameters listed in Table 3.22.

Table 3.22: Milltown Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	20	63	36	18
Turbidity	NTU	0.17	4.30	1.17	17
DOC	mg/L	5.0	9.6	7.2	15
pH		5.2	6.3	6.1	18
Hardness	mg/L as $CaCO_3$	5	21	14	15
Alkalinity	mg/L as $CaCO_3$	0	11	5	18
Iron	mg/L	0.15	0.66	0.37	18
Manganese	mg/L	0.00	0.06	0.01	18
LSI		-5.74	-3.64	-4.38	15
THMs	µg/L	21.9	280	127.2	68
HAAs	µg/L	0	240	63.5	8

**THMs monitored since 1996*

The tap water that arrives at the residences and public buildings in Milltown-Bay d'Espoir is highly coloured and contains elevated levels of DOC. It is often turbid and has low pH, hardness and alkalinity. Consequently, the LSI is quite low at -4.38.

The sampling program in Milltown-Bay d'Espoir consisted of 12 residential buildings, a seniors care facility and a school. The residential buildings were built between 1955 and 1986, although most of them date from the 1980s. All but one location reported copper piping only, the last one reported a combination of copper and PVC piping. All of the residential buildings reported the use of lead solder. The seniors facility was built in 1991 and has copper piping and lead solder. The residents do not drink the water. The school, built in 1960, is also outfitted with copper piping and although the contact person was unsure about the presence of lead solder it is assumed so given the date of construction.

None of the sample sites had lead levels above the 10 µg/L guideline. Lead levels ranged from below detection to 3.6 µg/L with a 90^{th} percentile concentration of 3.3 µg/L in the residential samples after a 30 minute stagnation period. The seniors care facility had a lead concentration of 0.6 µg/L and the school had a concentration of 0.9 µg/L.

The RCAp conducted on one of the residential tap water samples showed elevated colour (24 TCU) and very high concentrations of copper. This last may be an indication of corrosion in the distribution system or in the plumbing at the sample site.

3.5 Community Profiles - Western

Figure 3.5 shows the lead concentrations measured in the tap water from various residential sample locations in the communities participating in this study located in the central region of the province.

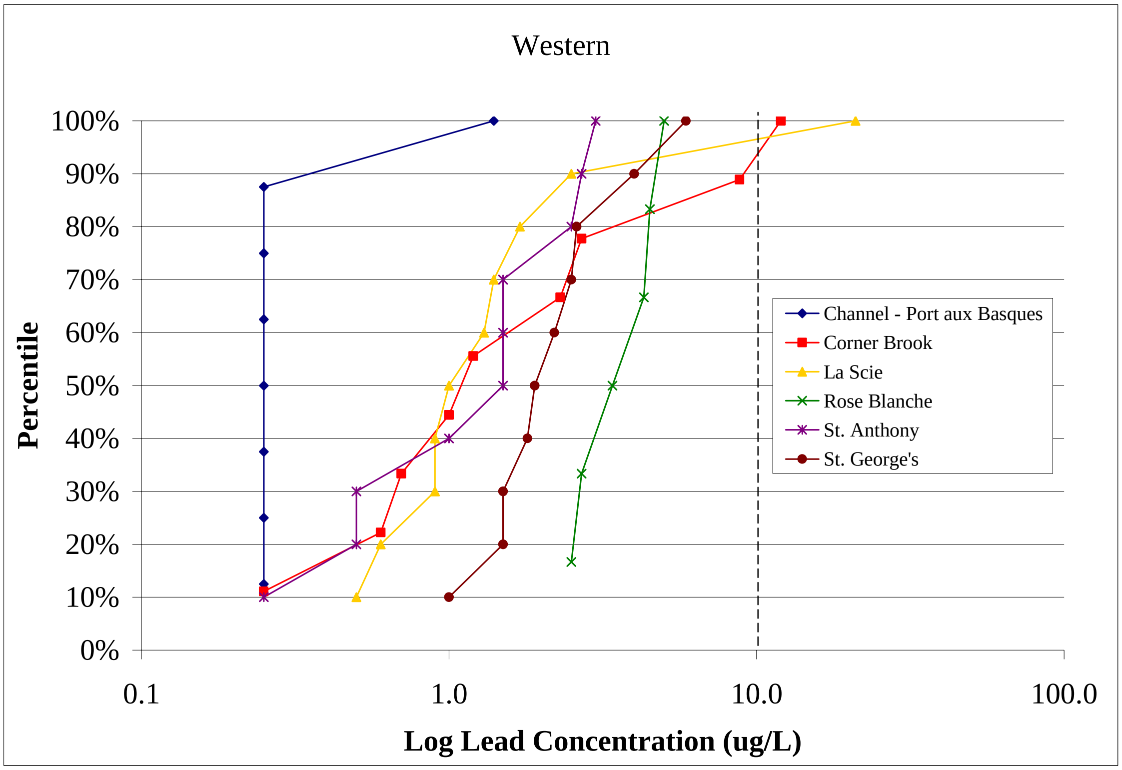

Figure 3.5: Determination of 90th Percentile Lead Concentration for Towns in the Western Region of Newfoundland and Labrador (Winter 2009)

None of the communities sampled in the western region of Newfoundland had 90th percentile lead concentrations above the 10 µg/L. Corner Brook came close, with a 90th percentile reading of 8.8 µg/L. The remainder of the towns in this region had 90th percentile concentrations ranging from undetectable in Channel – Port aux Basques to 4.5 µg/L in Rose Blanche.

Details about each community sampled in the western region follow in the sections below:

3.5.1 Channel – Port Aux Basques

The town of Channel-Port Aux Basques has an interesting and extensive history and continues to bustle as the 'Gate to Newfoundland' for visitors from the mainland. Ferries continue to regularly ply the waters between Cape Breton and Channel-Port Aux Basques. The town has 4,319 inhabitants, all of whom are connected to the municipal water system.

Water for the system is drawn from Gull Pond and Wilcox Pond. A water treatment system was installed in 1988. It consists of prescreening followed by coagulation/flocculation, sedimentation and dual media filtration. The water is then disinfected with chlorine gas and sent to the distribution system mostly via gravity. Some of the finished water is pumped directly to the fish processing plant. The distribution system contains PVC, asbestos cement, and some ductile iron piping.

The town has a number of water system operators. One has Level III certification for Water Treatment and Water Distribution and three others have Level I Water Distribution certification. The operators flush the system twice a year and are about to start a valve exercising program.

There are a couple known issues with the water system. The area around Grand Bay West occasionally has low chlorine residual and other areas have been known to have a chlorine taste at times. One homeowner also complained of musky, rotten odours in the water. The distribution mains are not known to be restricted by corrosion and there is no formal corrosion control program in place.

The tap water available in the town is of much better quality, particularly with respect to organics, than the raw source water that is drawn from the ponds. Table 3.23 summarizes the tap water quality data collected for the town of Channel-Port Aux Basque since 2001. The THM results have been collected regularly since 1996. HAA results were collected in 2000, 2007 and 2008.

Table 3.23: Channel-Port Aux Basques Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	0	6	2	16
Turbidity	NTU	0.00	1.90	0.56	16
DOC	mg/L	0.8	5.0	2.4	16
pH		4.8	6.7	5.8	16
Hardness	mg/L as $CaCO_3$	18	30	24	16
Alkalinity	mg/L as $CaCO_3$	0	8	2	16
Iron	mg/L	0.00	0.12	0.04	16
Manganese	mg/L	0.00	0.03	0.01	16
LSI		-5.60	-3.88	-4.55	15
THMs	µg/L	3	168	60	86
HAAs	µg/L	0	320	147	13

**THMs monitored since 1996, HAAs monitored in 2000, 2007, 2008*

Colour and DOC are usually low, which usually translates to low DBP levels. However, at times, THMs and HAAs have exceeded their guidelines. HAAs, in particular, have often been quite high, especially in 2008. As in most of the other communities profiled, pH, hardness and alkalinity are all quite low. This is why the LSI value is so low, on average -4.55 indicating that the water is quite corrosive.

Most of the eight residential buildings sampled on February 3rd and 5th 2009 had undetectable concentrations of lead in their tap water. The home that did have a detectable concentration of lead had only 1.4 µg/L after a thirty minute stagnation period. The homes vary in age from 15 to 55 years. Most have PVC piping, although one also contains some copper piping. The Town Hall, which was included as a residential sample, has 100% copper piping. Only one of the homes (the one with some copper piping) reported the use of lead solder in the plumbing system.

Two health care facilities were also sampled, and both had elevated lead levels. One, which had 13 µg/L of lead in the water, is a seniors home built in 1994 with copper piping and lead solder. The building is 150 metres away from the water main. The sample was taken from the washroom. The other facility sampled was the hospital. The lead concentration in that water sample was very high at 130 µg/L. The hospital was built from 1983 to 1984 and has copper piping with lead solder. The contact person at the hospital reported that the pipes leak frequently, which may indicate that they are quite corroded. The hospital is located 100 metres from the water main that services it. The sample was taken from a fountain in the hospital's basement.

Two schools were also sampled but neither had particularly high concentrations of lead. One had 1 µg/L and the other had 3.3 µg/L. Both are outfitted with copper piping and lead solder. One was built from 1983 to 1983 and the other in 1991.

No water quality parameters were abnormally high in the RCAp.

3.5.2 Corner Brook (Trout Pond)

Corner Brook is a city of 20, 083 (NL Statistics Agency) located in the western portion of Newfoundland on the Trans Canada Highway about an hour south of Gros Morne National Park. Raw surface water is drawn from three ponds; Burnt Pond, Second Pond and Trout Pond. Each of the ponds has its own small disinfection system and serves a specific part of the community as listed below (as provided by DOEC):

- Trout Pond – 15,077
- Second Pond – 3,116
- Burnt Pond – 1,910

This study focused on customers served by the Trout Pond system. Customers do no pay a designated price for their water.

Raw surface water from the pond is passed through intake screens before being disinfected with chlorine gas. The distribution system, which was originally installed between 1925 and 1926, contains ductile iron, cast iron, concrete and PVC piping. Water flows to the town via a combination of gravity and pumping provided by booster pumping stations.

The town has a Water and Sewer Division which is operated by a superintendent and a number of other employees with various levels of certification. They conduct some established standard maintenance activities, details of which were not provided. There is no official corrosion prevention plan in place.

Many of the residents interviewed in Corner Brook had concerns about the water system and the quality of their tap water. A number of them treated their tap water using carbon filters before drinking it or using it for food preparation. One reported that the water had a strange taste and another that sediment was present in the tap water. City staff did not report any restrictions in the distribution system due to corrosion.

Tap water quality has been monitored in Corner Brook by the Department of Environment since 2000. The results, summarized in Table 3.24, are all from buildings served by the Trout Pond supply. THMs have been measured regularly since 1995 and HAAs since 2002.

Table 3.24: Corner Brook –Trout Pond Tap Water Quality and DBP Summary (2002 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	11	26	18	30
Turbidity	NTU	0.20	0.70	0.37	30
DOC	mg/L	3.3	7.8	4.9	30
pH		6.2	7.5	6.8	30
Hardness	mg/L as $CaCO_3$	13	47	27	27
Alkalinity	mg/L as $CaCO_3$	8	31	19	30
Iron	mg/L	0.00	0.14	0.08	30
Manganese	mg/L	0.00	0.01	0.00	30
LSI		-3.39	-1.97	-2.72	25
THMs	µg/L	0	205	90	62
HAAs	µg/L	119	260	175	17

**THMs monitored since 1995, HAAs monitored since 2002*

Organics, as measured by colour and DOC, are usually high in Trout Pond. This accounts for the frequent DBP exceedances noted in the tap water. The pH, alkalinity and hardness of the water are more moderate than those found in many other communities in Newfoundland and Labrador. This accounts for the average LSI value of -2.72, which indicates that the water is slightly, but not excessively, corrosive.

Nine residential buildings, six health care facilities and six schools were sampled on February 28th and March 3rd, 2009. Water samples taken from one of the residences and one of the health care facilities had elevated concentrations of lead. The residence, which was built in 1955 and reported that the plumbing system contained copper piping and lead solder, had a lead concentration of 12 µg/L. The sample was taken from the kitchen sink. The contact person at the residence had no specific water quality complaints but did use a carbon filter to treat their tap water before consumption. The health care facility had a lead reading of 17 µg/L. The remaining residential buildings had lead readings ranging from below the detection level to 8.8 µg/L. All of them reported that their plumbing systems contained copper piping and all but one reported the use of lead solder. One home was built in 1930, five were built in the 1950s and the remainder was built between 1972 and 1989. The 90th percentile lead concentration of the residential samples was 8.8 µg/L.

The contact people at many of the health care facilities were unsure of the exact ages of the buildings in which they worked. The two locations for which ages were known were between 20 and 35 years old. Lead levels in the water samples taken from these buildings ranged from 0.8 to 8.0 µg/L with an average of 6.9 µg/L. All of the buildings contained copper piping and lead solder in their plumbing systems.

The ages of all but one of the educational buildings were unknown. The one that was known was built in 1969. Copper piping was reported at one school, lead solder was not reported at any of them but is likely present given the construction date and presence of copper plumbing. Lead levels in the water samples taken from the schools averaged 2.5 µg/L with a low of 0.8 µg/L and a high of 5.3 µg/L.

The RCAp was conducted on a water sample taken from the washroom at one of the residential sample sites. Colour was elevated at 20 TCU, but otherwise the water quality was not abnormal.

3.5.3 La Scie

On the northeast coast of Newfoundland at the head of the Baie Verte peninsula, La Scie is a community that grew up around the fishing industry. The current population is 955 people (NL Statistics Agency, 2006), all of whom receive water from the municipal water system. Water services cost $30 per month. Stake’s Pond serves as the main source of raw surface water for the town.

The water is pumped from the pond through an intake screen before being sent to the distribution system. The town has been on a nearly permanent boil order since 1991 due to problems with the disinfection system. The distribution system, which was constructed between 1960 and 1962, consists of ductile iron and copper services. It has not been upgraded since its original installation; however it has been extended to service various parts of the community a number of times. Two such extensions occurred in the early 1970s and one approximately twenty years ago.

There is no designated system operator; however the hydrants are flushed periodically. This is done to clean the system and prevent corrosion. Corrosion is known to be a problem in the distribution system.

In terms of water quality complaints problems due to corrosion are often overlooked due to underlying disinfection and aesthetic concerns. Most of the residents interviewed for the study reported that the water that exits the taps is barely useable and certainly not suitable for consumption. Complaints include debris, odours (fishiness), oily residues and concerns about microorganisms due to the frequent boil water advisories. The sampler was informed that some of the issues may be as a result of fish and eels becoming stuck on the intake screens. The town provides the residents with bottled water for drinking.

The town's tap water quality has been regularly monitored by the Department of Environment and Conservation since 2000. The results are summarized in table 3.25 below:

Table 3.25: La Scie Tap Water Quality and DBP Summary (2000-2008)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	9	35	22	16
Turbidity	NTU	0.00	0.60	0.32	16
DOC	mg/L	3.4	6.0	4.6	16
pH		6.2	6.8	6.5	16
Hardness	mg/L as $CaCO_3$	3	40	10	15
Alkalinity	mg/L as $CaCO_3$	0	16	7	16
Iron	mg/L	0.00	0.11	0.02	16
Manganese	mg/L	0.00	0.03	0.00	16
LSI		-4.49	-3.14	-4.03	15
THMs	µg/L	n/a	n/a	n/a	n/a
HAAs	µg/L	n/a	n/a	n/a	n/a

The tap water quality (as measured by the parameters listed in Table 3.22) in La Scie is fairly typical for small communities in Newfoundland and Labrador. Organics are moderately high and pH, hardness and alkalinity are relatively low. This type of water would be expected to create DBPs upon chlorination, but as the town currently does not chlorinate the water or monitor for DBPs, this is somewhat irrelevant. The water would also be expected to be rather corrosive, which is confirmed by the average LSI value of -4.03. This likely explains the corrosion observed in the town's distribution mains.

Ten residences and two schools were sampled for lead in La Scie on February 17th and 18th, 2009. All but one sample location had acceptable lead levels that were below the 10 µg/L guidelines. One residence had a lead reading of 21 µg/L in a water sample taken from the kitchen. The home was built in 1982 and contains copper piping and lead solder. It is located five meters from the water main.

The other nine residences had lead levels ranging from 0.5 to 2.5 µg/L. The oldest home sampled was built in 1949, the newest in 1985 All have copper piping and lead solder. The 90th percentile concentration of all of the residential samples in La Scie was 2.5 µg/L. The two schools, built in 1967 and 1972 also have copper piping and lead solder. The first had a lead reading of 2.3 µg/L and the other had a reading of 1.2 µg/L.

The RCAp conducted on one of the residential samples did not have particularly high levels of many common contaminants. As expected, the colour was quite high (28 TCU) but all other parameters were within guidelines.

3.5.4 Rose Blanche – Harbour Le Cou

Rose Blanche – Harbour Le Cou is a small community of 547 inhabitants (NL Statistics Agency) on the southern coast of Newfoundland about 45 minutes east of Port Aux Basques. The town is famous for its recently restored granite lighthouse and beautiful vistas.

Raw surface water is drawn from Rose Blanche Brook to supply the town with water. Everyone in the town is served by the water supply system and pays a water tax of $255 per year. The water is not treated but it is disinfected using chlorine gas and the pH is adjusted with soda ash. Filters, originally installed in 1972 along with the rest of the water system, were once part of the process but have since fallen out of use. In 1985, new submersible pumps were installed and in 2002 a new chlorination system was installed along with two new booster pumps. A system reservoir is used to store the treated water before it is pumped to the distribution system. The reservoir will be replaced this spring. The distribution system contains PVC piping and was installed in 1972. It has been extended a couple of times. Water flows through the system because of pumps at the reservoir.

The town has a designated system operator approaching retirement. A new operator will commence training in 2009 and work towards certification. A number of standard maintenance procedures exist, including the flushing of the distribution lines. There is no corrosion prevention plan.

One resident complained of dark coloured water coming through the taps in the summer. There are no stated major water quality issues, although the system sometimes loses pressure in certain areas (High Street). Some valves in the distribution system are known to be corroded.

The tap water quality in Rose Blanche-Harbour Le Cou has been monitored by DOEC since 2000 except for THMs, which have been regularly monitored since 1996. Two THM samples were also taken in 1988. A summary of historic tap water quality parameters are presented in Table 3.26.

Table 3.26: Rose Blanche-Harbour Le Cou Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	13	59	25	18
Turbidity	NTU	0.00	0.80	0.52	18
DOC	mg/L	2.1	9.3	6.0	12
pH		3.7	4.5	4.2	18
Hardness	mg/L as $CaCO_3$	0	7	2	12
Alkalinity	mg/L as $CaCO_3$	0	3	1	18
Iron	mg/L	0.09	0.44	0.20	18
Manganese	mg/L	0.00	0.02	0.01	18
LSI		-7.96	-7.09	-7.38	10
THMs	µg/L	0	111	33	44
HAAs	µg/L	0	230	76	5

**THMs monitored 1988 and 1996-2008*

The tap water in the community of Rose Blanche - Harbour Le Cou is very typical of water found in small coastal communities in Newfoundland and Labrador. DBPs occasionally exceed guidelines due to the high level of organics present in the water during chlorination. However, the average levels of both THMs and HAAs are within the guidelines. The LSI of the tap water is particularly low, ranging from -7.96 to -7.09. This indicates that the water flowing through the distribution system is highly corrosive. The low LSI is a product of the extremely low pH, hardness and alkalinity of the water.

Only six sites were sampled in Rose Blanch, all were residential buildings. The sampling took place on February 4th, 2009 and none of the samples were outside of the lead guidelines. The average lead concentration in the water samples was 3.7 µg/L, with a high of 5 µg/L, a low of 2.5 µg/L and a 90th percentile concentration of 4.5 µg/L. One of the homes was over 100 years old, two were between 45 and 55 years old and the remaining three were all built in the 1970s and 1980s. Most of them contained PVC piping, although some also contained some leftover copper piping and one had a complete intact copper plumbing system. The house with the copper piping also reported the use of lead solder, which none of the other homes did.

The RCAp reported an extremely low pH of 4.43, but otherwise all the water quality parameters analyzed were within the guidelines.

3.5.5 St. Anthony

The Town of St. Anthony is located on the northern-most tip of the Northern Peninsula. It provides a regional service center for the residents of the upper Northern Peninsula and Southern Labrador. Residents of the community do not have individual water meters but pay a fixed rate of $306 per household per year. Commercial rates are $354/yr and the seafood processing facility has a bulk meter which is billed at a rate of $0.55/1000 gallons. The town has a population of 2, 476 (NL Statistics Agency).

The water supply and treatment system for the Town is entirely gravity fed. Water flows from the primary surface water source (St. Anthony Pond), which is located at a higher elevation than the rest of the Town, through an intake building, downstream flow control and chlorination station and is distributed through the community. The Town is built around a harbour with approximately half the population living on each side and a central part of the community located in the “bottom” of the harbour. A secondary water source, Western Long Pond, is hydraulically connected to St. Anthony Pond via an interconnecting transmission main which is used seasonally to supplement St. Anthony Pond. No storage reservoirs are currently installed on the system.

The entire community and a seafood processing facility are serviced by the water distribution system. The seafood processor represents the single largest water system demand and experience has shown that peak processing periods can decrease system water pressures in particular areas. The water supply system was first installed around 1970 using primarily ductile iron and cast iron distribution pipe and copper service connections. Upgrades and replacements of large portions of the distribution system have been completed in the last 7-10 years and included replacement of distribution mains with PVC pipe.

Water treatment consists primarily of chlorination using gaseous chlorine near the source of supply. There is no active corrosion control program or any other type of water treatment. There is however an annual system flushing program in place. There are two certified operators for the system including one with a Class I certification and one with a Class II certification.

Table 3.27: St. Anthony Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	22	50	36	18
Turbidity	NTU	0.15	1.10	0.53	18
DOC	mg/L	4.0	8.4	5.5	15
pH		6.4	7.4	6.9	18
Hardness	mg/L as $CaCO_3$	17	32	24	15
Alkalinity	mg/L as $CaCO_3$	13	27	19	18
Iron	mg/L	0.04	0.55	0.11	18
Manganese	mg/L	0.00	0.02	0.00	18
LSI		-4.22	-2.77	-3.34	13
THMs	µg/L	0	180	64	51
HAAs	µg/L	60	160	120	10

**THMs monitored 1988 and 1997-2008, HAAs since 2003*

Water quality issues in the community are those common to the majority of municipal supplies in the province and include elevated levels of THMs and DBPs, colored water, low pH, and an elevated corrosion index. While there do not appear to be any ongoing issues with restriction of distribution mains due to corrosion and tuberculation, there are reports of corroded and broken copper service lines running to individual customers.

Ten residences, four health care facilities and two schools were sampled on February 9th and 12th, 2009. None of them had lead levels above the 10 µg/L guideline after a thirty minute stagnation time.

Most of the sampled homes were built between 1960 and 1994, although one home was built around 1939. All but one contained exclusively copper piping. One home contained only plastic piping. No information was provided with respect to the presence of lead solder in the homes. Lead readings in the water samples ranged from below the detection limit to 3.0 µg/L. The 90th percentile concentration of lead in the residential samples was 2.7 µg/L.

The health care facilities had lead levels ranging from 0.8 µg/L in a seniors home to 2.3 µg/L in a child care facility. The facilities ranged in age from 15 to 50 years old and were all outfitted with copper piping. The elementary and secondary schools had lead readings of 6 and 1.4 µg/L in their respective water samples. The elementary school was built in 1972 and contains copper piping. The secondary school contains copper, steel and plastic piping.

High colour (40 TCU) was noted during the RCAp, but otherwise, the tap water was within accepted water quality guidelines.

3.5.6 St. George's

St. George's is a small community of 1,246 (NL Statistics Agency) inhabitants on the southeast coast of Bay St. George. Like many other communities in Newfoundland and Labrador, the town draws its water from a surface water source high in organics and low in pH, alkalinity and hardness. This leads to water quality concerns due to elevated levels of DBPs and corrosion. Customers pay $188 to be connected to the water system.

Dribble Brook (a reservoir) provides the town with its drinking water supply. Water is drawn from the reservoir and disinfected with chlorine gas before being pumped to a holding tank and distributed to the community by gravity flow. The town is currently in the midst of replacing the water system . The new system will be fed by groundwater. The original disinfection and distribution system was first installed in 1972. It was up-graded in 1982 and 1988 when two lift stations were constructed. The piping in the distribution system consists of PVC with copper service lines.

A designated system operator exists and has Class II certification. There are established maintenance practices for the system, but details were not provided to the sampling team. There is no corrosion control program in place.

The residents have a number of common complaints about the quality of the water that arrives at their taps. These complaints include taste, odour, colour and green and brown staining of clothing and tanks. The contact person interviewed for the community information sheet also mentioned that there tend to be problems with the low chlorine residual in the water at the ends of the distribution lines. The main distribution mains are not known to be corroded, however the copper lines that branch off from the main lines are restricted due to corrosion.

Table 3.28 provides a summary of the tap water quality recorded in the town since 2000. THMs have been measured since 1995 and HAAs since 1999.

Table 3.28: St. George's Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	19	57	39	23
Turbidity	NTU	0.00	1.10	0.46	23
DOC	mg/L	5.9	16.0	9.6	16
pH		3.9	6.6	5.6	23
Hardness	mg/L as $CaCO_3$	15	40	28	16
Alkalinity	mg/L as $CaCO_3$	0	10	3	23
Iron	mg/L	0.10	0.34	0.21	23
Manganese	mg/L	0.00	0.01	0.00	23
LSI		-6.45	-3.16	-4.84	16
THMs	µg/L	57	468	226	43
HAAs	µg/L	8	1200	378	20

**THMs monitored since 1995, HAAs since 1999*

As mentioned previously, the water in St. Georges is typical of the area. The concentration of organics, as measured by colour and DOC, are occasionally very high indeed, and average out at 39 TCU and 9.6 mg/L respectively. Thus, it is not surprising that THMs and HAAs are also very high and almost never within guidelines. The water is corrosive, with an average pH of 5.6, a low alkalinity and an average LSI of nearly -5. Hardness is somewhat more moderate with an average of 28 mg/L as $CaCO_3$.

Despite this corrosiveness, the twelve sample sites, which included ten residences and two schools, all had lead levels below the guidelines in their water. The residential buildings sampled were all around twenty or thirty years old, except one that was built from 1944 to 1945. All but the oldest home contain copper (or majority copper) piping. The oldest house was recently renovated with PVC piping. All but one of the buildings reported the presence of some lead solder. Lead levels in the residential buildings ranged from 1 to 5.9 µg/L with an average of 2.5 µg/L and a 90th percentile concentration of 4.0 µg/L.

The town's high school was built in 1985 and expanded in 2001. It contains copper piping and lead solder. The water sample was taken from the janitors closet in the old portion of the school had a lead reading of 5.8 µg/L. The elementary school was built from 1974 to 1976, has copper piping and lead solder and a water sample taken from the janitors closet had a negligible (below detection) concentration of lead.

An RCAp performed on one of the residential tap water samples indicated that colour and aluminum were abnormally high at 45 TCU and 170 µg/L respectively. Elevated colour was expected but the source of the high concentration of aluminum is not clear.

3.6 Community Profiles - Labrador

Figure 3.6 shows the lead concentrations measured in the tap water from various residential sample locations in the communities participating in this study located in the central region of the province.

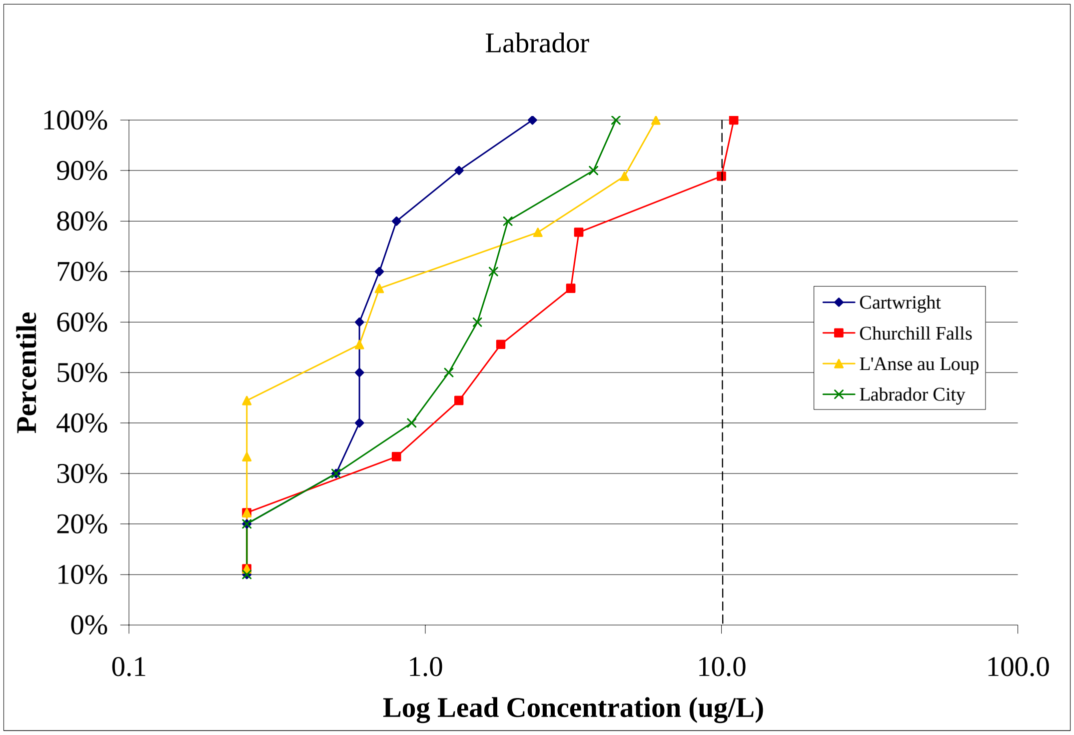

Figure 3.5: Determination of 90th Percentile Lead Concentration for Towns in Labrador (Winter 2009)

Churchill Falls was the only community with a 90th percentile lead concentration at or above the 10 µg/L limit at exactly 10 µg/L. The other three communities had 90th percentile readings ranging from 1.3 µg/L in Cartwright to 4.7 µg/L in L'Anse au Loup.

Detailed descriptions of the communities and buildings sampled in Labrador during this study follow in the sections below:

3.6.1 Cartwright

Founded in 1775 by Captain George Cartwright, Cartwright is a community of 552 (NL Statistics Agency, 2006) located in Southern Labrador. All of the buildings in the town are connected to the municipal water system, which draws its raw water from Burdettes Bank Pond. Users pay $210 per year for water services. Construction of the water system began in 1981 and was continued in various stages until the entire population was served. Most notably, in 2004 a number of modifications were made to the existing wet well, chlorination system and soda ash dispensing process.

There is no formal water treatment system beyond the intake screens used to remove larger contaminants at the raw water intake. The water is disinfected with powdered chlorine before being distributed to the community using gravity flow. The system contains a reservoir and a booster pumping station. The distribution system contains HDPE and PVC but is mostly ductile iron piping.

Cartwright has a designated system operator with 20 years experience who has completed a number of training courses, although the actual certification level was unknown at the time of sampling. The system is flushed several times annually as a standardized maintenance procedure.

Tap water quality is known to be at a higher risk, the community is currently on a ‘permanent’ boil advisory which is updated every month. The distribution system is known to be corroded at several nodes. There is no official corrosion prevention plan in place; however the town does adjust the pH of the water using soda ash, which may have some effect upon the rate of corrosion.

Some important tap water quality parameters that have been monitored since 2001 are listed in Table 3.29 below. HAAs have been monitored since 2002.

Table 3.29: Cartwright Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	39	93	61	12
Turbidity	NTU	0.24	1.40	0.90	12
DOC	mg/L	7.2	14.0	9.4	12
pH		5.6	6.8	6.3	12
Hardness	mg/L as $CaCO_3$	3	13	7	12
Alkalinity	mg/L as $CaCO_3$	0	11	5	12
Iron	mg/L	0.29	0.69	0.53	12
Manganese	mg/L	0.00	0.03	0.01	12
LSI		-5.15	-3.61	-4.34	10
THMs	µg/L	46	449	212	15
HAAs	µg/L	65	688	328	8

**HAAs monitored 2002-2008*

As is common in coastal communities in Newfoundland and Labrador, the tap water (which is effectively the same as the raw source water) is high in organics as measured by colour and DOC. The town chlorinates the water, which leads to the formation of DBPs from these organic molecules. THM and HAA readings regularly exceed the guidelines of 100 µg/L and 80 µg/L respectively. pH, alkalinity and hardness are all low, resulting in corrosive water with an average LSI of -4.34.

Ten residential sites and a school were sampled for lead on February 5th, 2009. None of them exceeded the 10 µg/L lead guideline. Readings in the residences ranged from below detection to 2.3 µg/L with a 90th percentile concentration of 1.3 µg/L and the school had a lead concentration of 1.6 µg/L.

The homes sampled were of varying ages, with many dating from between the 1940s and the 1980s. One was built in 1993. Most of them reported copper piping in the plumbing system and two were aware of lead solder. The school was built in the late sixties and its plumbing system consists of copper piping with lead solder.

The RCAp, which was conducted on one of the residential samples with a low lead reading, reported very high colour (140 TCU) and elevated levels of aluminium and iron. These may be as a result of corrosion in the distribution system. This corrosion does not seem to have lead to elevations in the concentration of chlorine, likely because of the materials present in the distribution and plumbing systems.

3.6.2 Churchill Falls

Churchill Falls is a relatively new community in a remote part of Labrador that is well known in Canada as the site of one of the second largest hydro power system in the world. It is situated on the Churchill River and has a population of about 634 people all of whom are served by the municipal water system. The system was installed in 1967 when the power station was being built and has been upgraded many times since to fulfil the needs of the town's population. Customers are not charged for water services.

The source water is drawn from the Smallwood Reservoir and sent through micro-screens before being chlorinated using gaseous chlorine and sent to the distribution system. The distribution system contains ductile iron, PVC and HDPE piping. The service lines are copper and PVC. Water flows from the chlorination system to the town via gravity.

The water system has three operators who have Level I operator certification. They conduct a preventative maintenance program, which includes flushing the system annually. There is no official corrosion control program.

Most of the residents, as well as the contact person who filled out the community information sheet (Water System Questions) had no complaints about the water quality. One resident did note that the water was occasionally coloured and had a bad taste. Certain water lines are known to be corroded.

Some historical tap water quality information is summarized in Table 3.27 below. Measurements have been made for THMs since 1999 and for most of the remainder of the parameters since 2001. HAAs have been monitored since 2006.

Table 3.30: Churchill Falls Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	8	12	9	9
Turbidity	NTU	0.10	0.80	0.44	9
DOC	mg/L	2.3	3.6	2.9	9
pH		6.3	6.9	6.6	9
Hardness	mg/L as $CaCO_3$	3	12	7	9
Alkalinity	mg/L as $CaCO_3$	7	12	9	9
Iron	mg/L	0.01	0.21	0.13	9
Manganese	mg/L	0.00	0.02	0.01	9
LSI		-4.67	-3.48	-3.94	5
THMs	µg/L	32	95	54	16
HAAs	µg/L	49	87	66	4

** THMs monitored 1999-2008, HAAs monitored 2006-2008*

The tap water in Churchill Falls is of better quality than that seen in many other parts of the province. Colour has always been below the AO of 15 TCU and DOC is low. This is likely why THMs and HAAs rarely exceed their guidelines of 100 and 80 µg/L respectively. Alkalinity, hardness and pH are low however, which leads to corrosive water flowing through the pipes. The tap water has a LSI of -3.94, which likely explains the corrosion noted in the questionnaire.

The sampling program, conducted on February 20th, 2009, found two residences where lead levels met or exceeded the 10 µg/L guideline. The first, from a home built in 1974, had a lead concentration of 11 µg/L. The second, also built in 1974, had a lead reading of 10 µg/L. The plumbing systems at both homes contain copper piping but no information was provided as to the type of solder used. No one is currently living in the second home and it is undergoing renovations. Therefore, the plumbing system may not be getting the normal amount of use.

The remainder of the residences sampled in Churchill Falls had lead readings ranging from below the detection limit to 3.3 µg/L. The 90th percentile concentration of all of the residential samples was 10 µg/L. All of them were built in 1974, although the town hall (included as a residential sample) was renovated in 2003. They all have copper piping. No information was provided about the type of solder used in the plumbing systems.

The health clinic, built in 1969 and outfitted with copper piping, had a lead concentration of 3.2 µg/L. The school had a lead reading of 3.4 µg/L. It was built in 1967 and has copper piping.

The RCAp was conducted on a residential sample with a lead concentration under the guideline. It showed no abnormal levels of any common water quality parameter.

3.6.3 Labrador City

The Town of Labrador City grew up around the iron trade. Located on the far western edge of Labrador, near the Quebec border, it was built in the 1960s to accommodate the miners and other workers who lived and worked in the area. It currently has a population of 7,240 (NL Statistics Agency, 2006).

The town draws its water from Beverly Lake, a surface water source. There is no water treatment; the water is taken from the lake, disinfected with chlorine gas, pumped to an elevated tower and allowed to flow by gravity throughout the distribution system. The system piping is made up of ductile iron and cast iron. The system was initially installed in 1959.

Two people are in charge of monitoring and maintaining the water system, one (supervisor) has a Level II certification and the other holds a Level I certification and is working on their Level II. There are a number of standard maintenance procedures conducted by the operators. These include valve exercising, annual flushing, annual chlorinator overhaul, chlorine injector service, chlorine detector service, annual reservoir draining, cleaning and inspection. The municipality is currently evaluating the watershed capacity in order to determine their ability to meet future projected demands for water.

No corrosion-related problems were reported and the town lacks a corrosion control program.

Tap water data collected by the municipality since 2000 has been summarized and is presented in Table 3.31 below. THMs have been monitored since 1996 and HAAs since 2004.

Table 3.31: Labrador City Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	0	8	3	21
Turbidity	NTU	0.00	0.70	0.37	21
DOC	mg/L	0.0	2.9	2.0	21
pH		6.7	7.8	7.4	21
Hardness	mg/L as $CaCO_3$	37	90	50	20
Alkalinity	mg/L as $CaCO_3$	42	55	46	21
Iron	mg/L	0.00	0.06	0.02	21
Manganese	mg/L	0.00	0.05	0.02	21
LSI		-2.52	-1.27	-1.79	17
THMs	µg/L	15	121	50	37
HAAs	µg/L	10	81	33	14

**THMs 1996 to 2008, HAAs 2004 to 2008*

The water used by Labrador City has low organics as measured by colour and DOC. Therefore, THM and HAA levels are rarely over their respective guidelines of 100 and 80 µg/L, and on average are quite far below them. The pH, hardness and alkalinity of the water are higher than those found in most other parts of the province, leading to a moderate LSI of -1.79, indicating that the water is mildly corrosive.

Ten residences, two health care facilities and three schools were sampled for lead on February 18th and 19th, 2009. Lead levels were within acceptable guidelines at all ten residences and at the two health care facilities, however, two of the three schools had elevated levels of lead.

The two schools with elevated concentrations of lead were built in 1961. They both contain copper piping. In the first, which had a lead reading of 18 µg/L, the sample was taken from a janitor closet. The sample for the second school, with a lead concentration of 12 µg/L, was taken from the staff room.

It was not possible to detect any lead in the water sample from the other school, which was built in 1970 and also has copper piping.

All but one of the homes sampled were built in the 1960s and 1970s. The one outlier was built in 2000. They all have copper piping; no information was provided with respect to the solder used. Lead concentrations in the residential buildings ranged from below the detection limit to 3.7 µg/L with a 90th percentile lead concentration of 3.7 µg/L.

The first health care facility had a lead reading of 2 µg/L. It was built in 1979 and has copper plumbing. The second facility had a reading of 6.3 µg/L, was built in 1965 and also has copper piping.

An RCAp conducted on one of the residential samples showed no abnormal levels of any water quality parameter.

3.6.4 L'Anse Au Loup

The largest community in the Labrador Straits area, L'Anse au Loup had a population of 593 (NL Statistics Agency) in 2006. It is located in the south of Labrador near the Atlantic Ocean and the Quebec border. The water system serves 98% of the community with water obtained from L'Anse au Loup Brook, actually a river. Customers pay $200 per year for their water services.

Water treatment consists of intake screens and disinfection with liquid chlorine. The water is then distributed through a system of ductile iron and plastic piping using gravity flow and two sets of booster pumps. The system was first installed from 1983 to 1984. The distribution system has been extended and repaired as required.

There is a designated system operator but his/her level of certification was not provided to the sampling team. Standard maintenance procedures were not described but do exist.

Residential customers had no complaints about the quality of their tap water. However, the school is currently on a boil order advisory for reasons that were not explained. The distribution mains are not known to be restricted by corrosion. The town's corrosion control program consists of flushing the system twice a year.

Tap water quality has been monitored for many years and is summarized in Table 3.32. Most of the parameters have been monitored since 2000, although THMs and HAAs have only been measured since 2005.

Table 3.32: L'Anse Au Loup Tap Water Quality and DBP Summary (2000 – 2008*)

Parameter	Units	Low	High	Average	No. of Samples
Colour	TCU	9	36	17	14
Turbidity	NTU	0.11	1.30	0.45	14
DOC	mg/L	1.3	3.6	2.5	14
pH		6.3	7.3	6.9	14
Hardness	mg/L as $CaCO_3$	5	27	12	13
Alkalinity	mg/L as $CaCO_3$	10	22	14	14
Iron	mg/L	0.02	0.11	0.07	14
Manganese	mg/L	0.00	0.02	0.00	14
LSI		-3.69	-2.70	-3.17	10
THMs	µg/L	0	98	31	14
HAAs	µg/L	0	47	22	4

**THMs and HAAs monitored 2005-2008*

Colour and DOC levels in the tap water are generally moderate relative to many of the other sites investigated during this project. These low values likely account for the fact that THMs and HAAs have been within guidelines at all times since the DBP monitoring program was put in place. The LSI is somewhat high, indicating that the tap water is corrosive. This is due to the low pH, hardness and alkalinity of the water.

Nine residences and a school were sampled on February 7th, 2009. None of the buildings had elevated concentrations of lead after a thirty minute stagnation period. Lead concentrations in the residential buildings varied from below the detection limit to 6 µg/L with a 90th percentile concentration of 4.7 µg/L. The water sample from the school had a lead reading of 1.5 µg/L.

All of the buildings were built after 1960, and two of them are less than ten years old. The older buildings all have copper piping and the newest home, built in 2007, has plastic piping. None of them reported the type of solder used in their buildings.

The RCAp did not show any abnormal contaminant levels.

Chapter 4 Discussion

A sampling program conducted in province of Newfoundland during the winter months of 2009 found that lead levels in drinking water, as measured at the Second Action Level (Health Canada, 2007) using a 30 minute stagnation time, rarely exceeded the guideline of 10 µg/L. Water samples were taken from over 300 residential, health care and educational buildings in 29 communities scattered across the island and Labrador. Only 14 of them had lead concentrations above the guideline.

The presence of lead in tap water can be as a result of many, seemingly unconnected factors. Lead levels can be affected by:

- the quality of the treated water flowing through the pipes (pH, alkalinity, natural organic matter);
- the type of disinfectant used;
- the piping material used in the distribution system;
- the piping material used in the building's plumbing system;
- the presence of lead solder;
- the presence of brass fittings and faucets;
- the amount of time the water spends in the distribution and piping systems (stagnation time);

Many of the communities sampled in this study would appear to be probable cases for lead problems. Some of them lack formal water treatment and the quality of their tap water matches that of their source water. The surface water sources available to them are typical of the Atlantic Coast of Canada; low pH, low alkalinity and hardness and a high concentration of natural organic matter (NOM) as measured by colour and TOC. This means that the water is corrosive by traditional definitions (LSI) and will tend to encourage the leaching of lead from piping, solder and faucets into the drinking water (Health Canada, 2007).

However, the fact remains that a rigorous sampling program conducted at the Second Action Level as defined by Health Canada in their guide to Corrosion Control in Drinking Water Distribution Systems (2007) detected lead in only a few buildings. This section will address the possible causes of the elevated concentrations of lead in these isolated cases. It will also attempt to offer corrosion control options for the buildings and communities affected.

4.1 Background - Lead Corrosion

As has been pointed out elsewhere, the results of the sampling and data collection program have shown that lead detection in this study is more likely to be a result of lead solder and brass plumbing fixture corrosion than due to lead pipe or service line corrosion. This is important because it limits the analysis of lead release mechanisms to those which relate to lead corrosion from solder and brass fixtures.

Lead corrosion from solder is somewhat special because it occurs by galvanic corrosion as opposed to solubilisation of corrosion products. This is due to the presence of two different metals (Schock et al., 1996). Solders containing lead have been prohibited by the National Plumbing Code since 1986 but may still exist in homes that have not had their plumbing redone since then.

Galvanic corrosion is particularly sensitive to pH and increased pH generally leads to decreased corrosion of lead solders (Oliphant et al., 1996). One factor that is known to increase this type of lead corrosion is a longer period of stagnation. Alkalinity, temperature, calcium, and chlorine residual are known to have conflicting and varying effects depending on the dominant species of lead and other compounding factors. For example, one may find [cerussite ($PbCO_3$), hydrocerussite ($Pb(CO_3)_2(OH)_2$), and lead hydroxide ($Pb(OH)_2$)] in a given piping system.

4.2 Impacts of Pipe Material and System Configuration

No lead pipes were reported in the distribution systems of the communities that participated in this study. Most of the community information sheets reported the presence of ductile iron, cast iron, PVC and concrete/asbestos piping. As well, none of the residents of the homes, schools and health care facilities visited during the sampling program reported the use of lead pipes in their plumbing systems. Most of the piping in these buildings was reported to be copper or PVC.

The only communities where lead service lines may have been in existence were St. John's and Corner Brook. In these communities, the samplers were directed to areas where lead services had been known to exist in the past. However, there was no verification as to whether a given location actually had a lead service pipe. Regardless, the residential samples from these areas did not return significant concentrations of lead.

Although no lead piping was used in the communities who participated in the study, lead levels were still of concern in certain locations. Many other factors have been implicated in the release of lead in distribution and plumbing systems, most notably the use of lead solder and brass fittings in homes.

Lead Solder

The leaching of lead from lead-based solders has been identified as a major source of dissolved lead in tap water (Treweek et al., 1985; Ramon et al., 1989). It is of particular concern when the solder is newly applied.
Many of the residents interviewed during the sampling program reported the use of lead solder in their plumbing systems. All of the sample sites (residential/educational/health care) where lead concentrations were over 10 µg/L after a 30 minute stagnation period had lead solder in the plumbing systems. However, most of their neighbours also had lead solder, indicating that other factors must have also been affecting the sample sites with elevated levels of lead.

An additional concern with regards to the corrosion of lead solder in plumbing systems is that in some cases, the analytical methods used to detect lead are unable to accurately confirm the amount of lead in a given sample when the lead itself is in particulate form. A recent study at Virginia Tech suggested that standard USEPA analytical methods are currently biased towards the detection of solubilised lead, as opposed to lead particles. Lead solder is a common source of lead particles, and recent lead poisoning cases in the United States have been connected to lead solder particles in their drinking water that was not detected by laboratories using the standard methods (Triantafyllidou et al., 2007). However, the authors of that study were quick to point out that the recent cases of lead poisoning were exceptional and that in most cases, the current analytical methods are sufficient.

Brass Fittings

Brass fittings are often overlooked as sources of lead because in many cases, they are reported to be lead-free. However, even 'lead-free' brass can contain up to 8% lead. Often, plated faucets (chrome, etc) have 'all-brass' interiors. Many researchers have found that brass fittings, especially faucets, are a major source of lead in tap water (Samuels and Meranger, 1984; Schock and Neff, 1988; Gardels and Sorg, 1989, Lee et al., 1989; Korshin et al., 1999; Kimbrough, 2007). New, reasonably priced brass alloys are now available that have less than 0.25% lead (Health Canada, 2007), but it is assumed that some homes that have not undergone recent renovations likely contain at least a few brass fittings.

No information about the presence of brass fittings was collected during the sampling program. However, one of the samples taken from a residential building that had elevated levels of lead was chosen as the site for the RCAp for the town. The RCAp reported 170 µg/L of zinc, which is much higher than the average historical zinc readings in the source water (7.8 µg/L) and in the tap water (7.7 µg/L) sampled by the DOEC. Zinc and lead are both products of brass corrosion, and the presence of high levels of both suggests that a brass fitting may be causing the issue. The presence of a brass fitting at the sample location was not confirmed and it was not possible to link any other high lead readings with high zinc readings. Therefore, although it appears plausible, it is not possible to say with confidence that a brass fitting was a direct contributor to the lead levels.

Stagnation Time

In order to sample over 300 sites around the province of Newfoundland and Labrador, it was necessary to limit the sampling time at each location. Therefore, the Second Action Level plan, as outlined in the Health Canada document 'Corrosion Control in Drinking Water Systems' was used in the design of the sampling procedure. The Second Action Level includes a stagnation time of 30 minutes after a flushing period of 5 minutes, which was selected because the sample obtained is most likely to represent the average weekly amount of lead ingested by a consumer (European Commission, 1999). This short stagnation time may help to explain why lead levels in the tap water around the province were generally low despite the extreme corrosiveness of the water flowing through the pipes. Longer stagnation times and less flushing would likely have resulted in higher lead readings, however, these would not have been indicative of the actual amount of lead liable to be ingested by one person in a week.

The concept of stagnation time may also explain some of the high levels of lead obtained in the health care facilities and schools. A study in Vancouver by Wong and Berrang (1976) found that unused or underused plumbing systems leach more lead from lead-soldered joints than do regularly used systems. They even recommended flushing a new system with a year's worth of water before using it to provide water for human consumption.

In our study, samples that turned out to have high levels of lead were often taken from underused areas such as janitor closets (Labrador City), storage rooms (Corner Brook), basement faucets (Channel-Port Aux Basques) or the kitchens of commercial buildings (Ferryland). The long stagnation periods that occur between uses in these facilities may result in increased lead solder corrosion and subsequently increased levels of lead in the tap water.

Age of Building

The age of a building, or more specifically, its plumbing system, can help to explain the levels of lead measured in the tap water. Systems in older homes often contain more lead parts, including lead pipes, lead solders and leaded brass fixtures. The use of lead piping in plumbing systems has been forbidden in Canada by the National Plumbing Code since 1975, and lead solders have been forbidden since 1986 (Health Canada, 2007), but many brass fixtures such as faucets still contain enough lead to result in tap water lead concentrations above guidelines.

Interestingly, most of the buildings where elevated levels of lead were found in the tap water were built between 1970 and 1995. Three were built between 1955 and 1965. This suggests that the high lead concentrations were not as a result of old, forgotten lead pipes, but more likely as a result of lead solder or brass fittings. Homes that have recently installed a new brass faucet would likely be at the greatest risk, as lead levels tend to level off and decrease as the system ages and corrosion products accumulate on the surface of the metal, stifling the initially high rate of corrosion (Snoeyink and Wagner, 1996).

4.3 Impacts of Water Quality

All of the values for the water quality parameters discussed in this section were taken from the RCAp conducted on residential samples taken from each community. One RCAp report was available from each town as part of the study in addition to historical water quality data. Lead results were compiled from the residential water samples taken from each community. Between 6 and 14 lead readings were available from each community. In many cases, the 90^{th} percentile lead concentration was used to compare between towns.

pH

The pH of the water flowing through a pipe has a strong influence on the amount of corrosion that will occur. Low pH is associated with elevated rates of corrosion and concentrations of lead in tap water. A pH above 8 is generally recommended to prevent corrosion in water distribution systems (Lee et al., 1989; Health Canada, 2007).

The pH of the water taken from the taps in the various communities seemed to have a weak relationship with the 90^{th} percentile concentration of lead in a given community as shown in Figure 4.1.

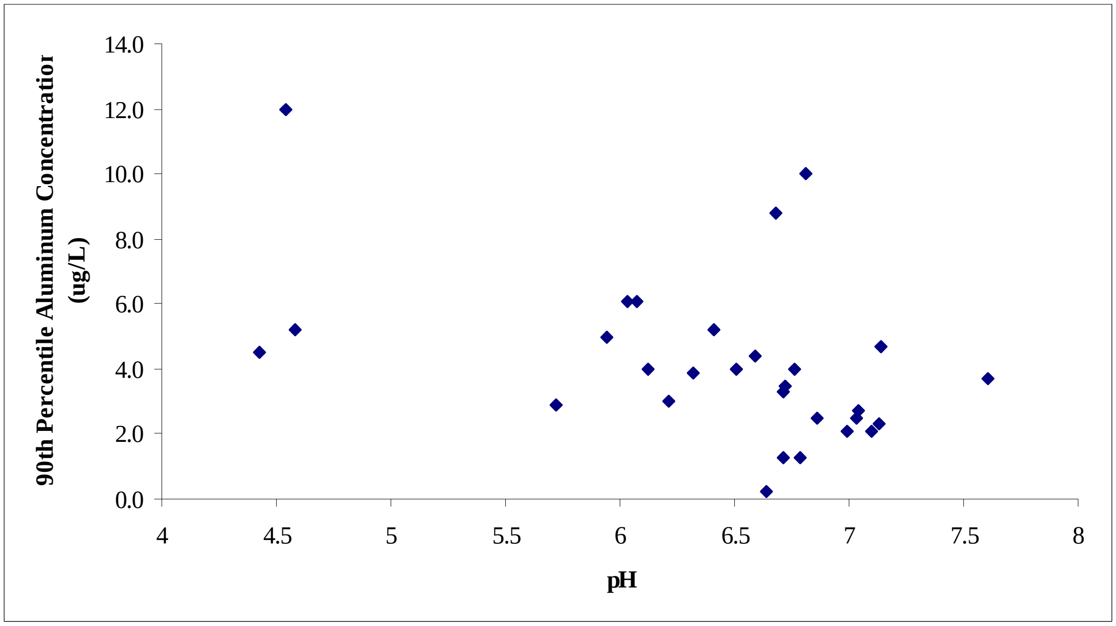

Figure 4.1: The Effect of pH on 90th Percentile Lead Concentrations in Tap Water

As expected, towns where the water was extremely low in pH at the tap often had higher levels of lead, however, the relationship was not definite. Other studies have found that the relationship between pH and lead is not exact and can be influenced by other water quality parameters such as alkalinity. It is also highly dependent on the materials present in the distribution and plumbing systems. Galvanic corrosion of solders containing lead is particularly affected by pH (Oliphant and Schock, 1996), so buildings with lead solder would be more likely to have elevated lead levels when the pH of the water was lower than buildings without lead solder.

In this study, another confounding factor was the data itself. pH was only measured at one sample location, whereas lead was measured at all locations. In order to present the data an assumption had to be made that the pH at the one sample site would be constant throughout the distribution system. This is known to be unlikely (USEPA, 2003), which introduces some error into the data.

The two towns where health care facilities had lead levels exceeding the guidelines (Table 3.2) had pHs of 6.41 and 7.41.The communities that had schools where lead was present in concentrations above the guideline (Table 3.3) had water with a pH between 6 and 7.

Further sampling of the pH in concert with lead would be required in order to determine whether pH was the main factor causing elevated levels of lead in the tap water in the residential, educational and health-care buildings.

Alkalinity

Alkalinity is a measure of the capacity of a given water sample to neutralize acids. It could also be referred to as the buffering capacity of the water. Therefore, a certain amount of alkalinity is desirable in order to keep the pH steady throughout the distribution system. Some studies have found links between the amount of alkalinity present in the water and the amount of lead corrosion. For example, Dodrill and Edwards (1995) found that at a pH less than 8.4 lead release was significantly higher at low alkalinity (<30 mg/L as $CaCO_3$) than at moderate alkalinity (30-74 mg/L as $CaCO_3$). Other studies have found that alkalinity has no effect on lead release (Lee et al., 1989).

Alkalinity measurements from the sampling program conducted in Newfoundland and Labrador have been compared to the 90th percentile lead concentration in various communities and shown in Figure 4.2:

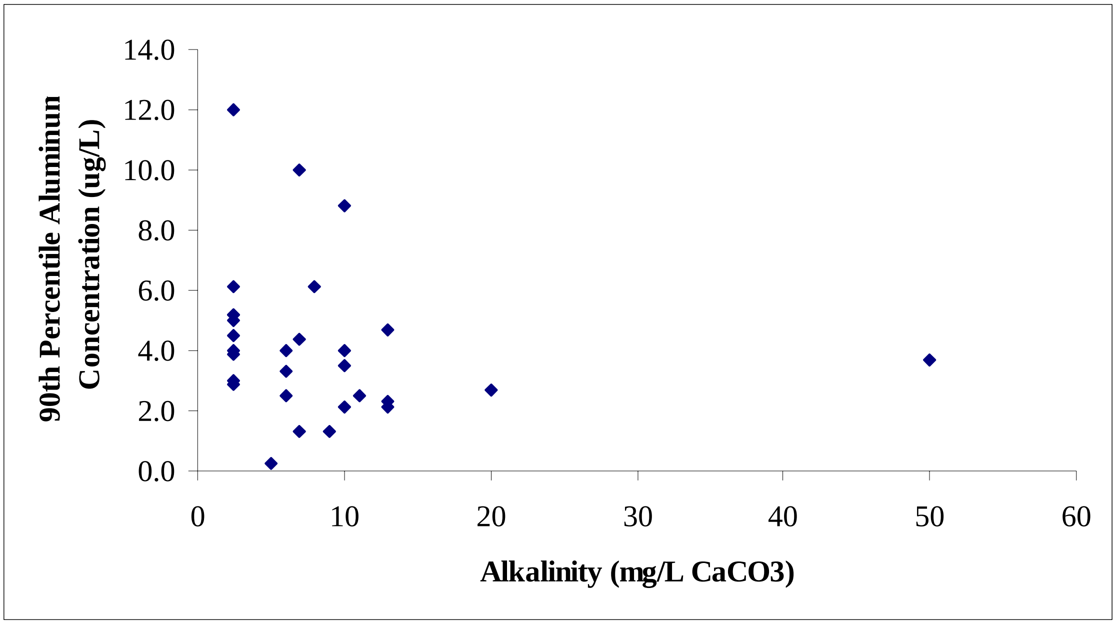

Figure 4.2: The Influence of Alkalinity on 90th Percentile Lead Concentrations in Tap Water in Communities in Newfoundland and Labrador.

No definite trend was apparent between the level of alkalinity measured in the RCAp and the 90th percentile lead concentration of the town. However, the highest lead readings did occur in towns with very low alkalinity measurements. In some cases, the low level of alkalinity present in the water may have influenced the amount of lead that ended up at the tap. However, the prevalence of low alkalinity water in Newfoundland suggests that although it may be an exacerbating factor, low alkalinity in and of itself is unlikely to be the main cause of the high lead readings found in some individual buildings.

Hardness

Hardness is the measure of divalent ions present in a given water sample. Most hardness in the water is caused by calcium ions. Until recently, it was widely thought that calcium ions in the water formed a protective film on pipes that could prevent corrosion. More recently however, this has been shown to be an ineffective mechanism for corrosion control (Schock, 1989; Health Canada, 2007). 90th percentile lead levels are compared to community water hardness measurements in Figure 4.3 below:

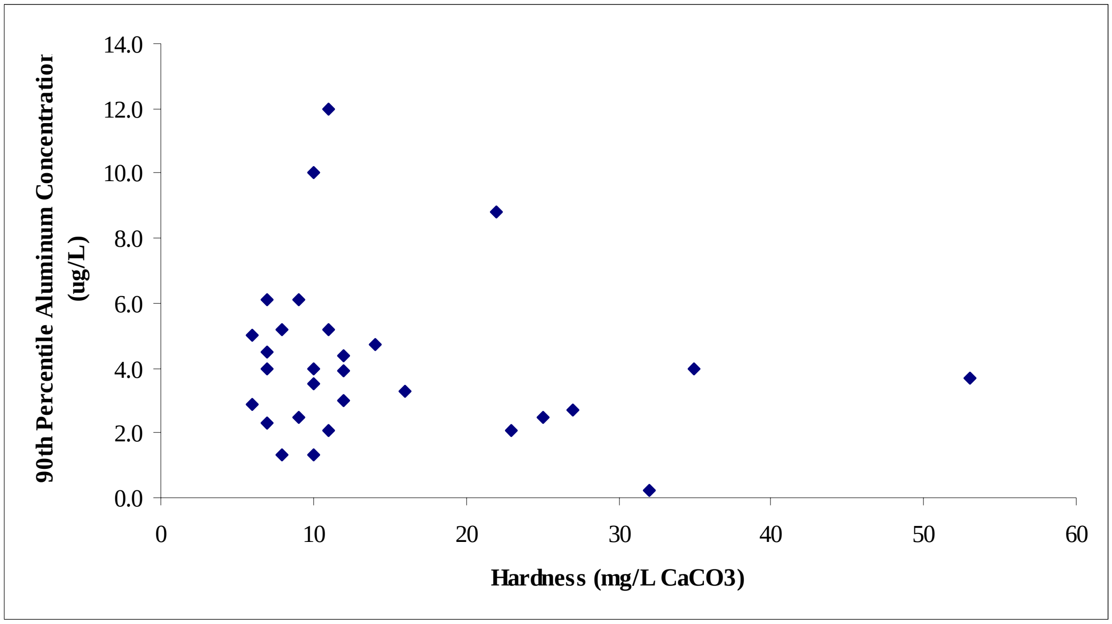

Figure 4.3: Comparison of Water Hardness and 90th Percentile Lead Levels in Tap Water from Newfoundland and Labrador

The highest lead levels occurred in towns where the RCAp showed a particularly low level of hardness. However, otherwise, no strong link could be drawn between hardness and the amount of lead present at the tap.

Langelier Saturation Index

The Langelier Saturation Index, or LSI, is calculated using pH, hardness and alkalinity values. It provides information about the equilibrium reaction of calcium carbonate in water; whether it is more likely to dissolve or precipitate out of solution. Thus, it is not a direct measurement of the corrosiveness of water (Health Canada, 2007), although water with low pH, alkalinity and hardness does tend to be corrosive in certain situations (DOEC, 2009). The AWWA Research Foundation has recommended that the Langelier Index and similar corrosion indices not be used for the regulation of water utilities because they fail to take into account the complexity of the corrosion process and may in fact contribute to additional corrosion of copper and iron pipes (Edwards et al., 1996;

McNeill and Edwards, 2001). However, the LSI is still used by many operators to balance the chemistry of their water and to obtain an aesthetically acceptable product.

It was not possible to calculate the LSI in some of the communities visited during the study because the ions in the water samples taken for the RCAp were not balanced. The values that were obtained are presented along with the corresponding 90th percentile lead concentrations in Figure 4.4 below.

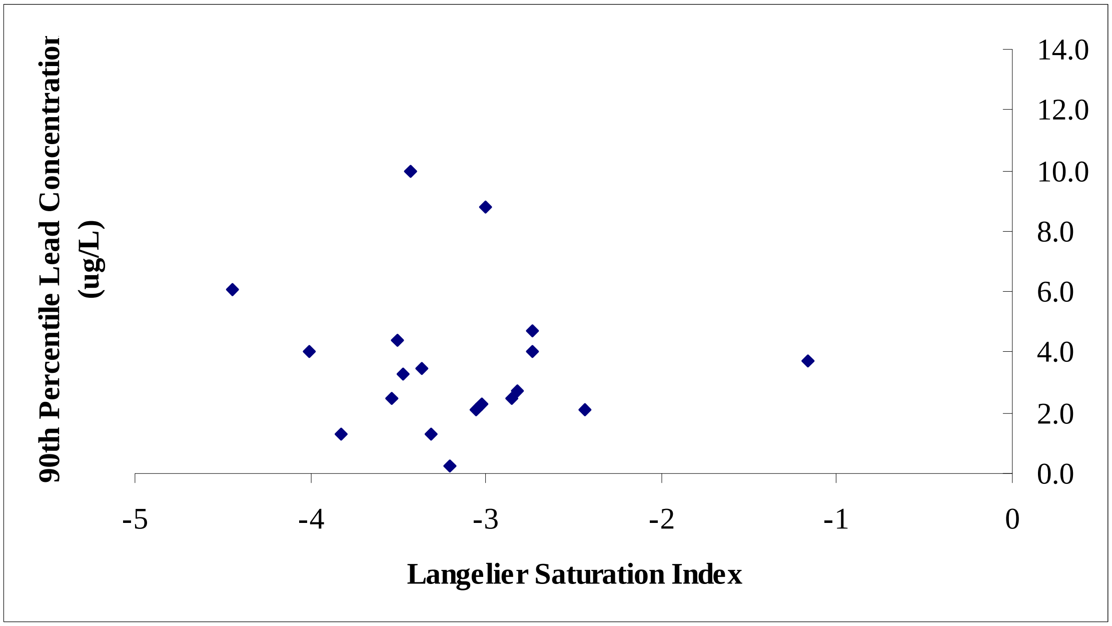

Figure 4.4: Langelier Saturation Index (LSI) Compared to 90th Percentile Lead Concentration in Residential Tap Water Samples.

Alkalinity and hardness are known not to be strongly or reliably correlated to lead concentrations in tap water (Lee et al., 1989; Schock, 1989), therefore it was not surprising that the LSI did not have a direct relationship with the amount of lead in the tap water samples.

Natural Organic Matter

Natural organic matter (NOM), is composed of a large mixture of molecules containing carbon and exists mainly in surface water sources. Many of these molecules are formed through the decomposition of plant and animal matter. Some are able to absorb UV and visible light, lending a distinctive yellow-brown (tea-like) colour to the water. NOM is measured using a number of common water quality parameters such as Total Organic Carbon (TOC), Dissolved Organic Carbon (DOC), colour and UV-Vis light absorption. TOC and colour are usually correlated to one another. TOC measures all the organic carbon in a given water sample while the colour measurement can be used as an indicator of the amount of light-absorbing, DBP-forming organics. In many surface water sources, a large fraction of the organic carbon is of the coloured variety. The relationship between TOC and colour in this study is shown in Figure 4.5 below:

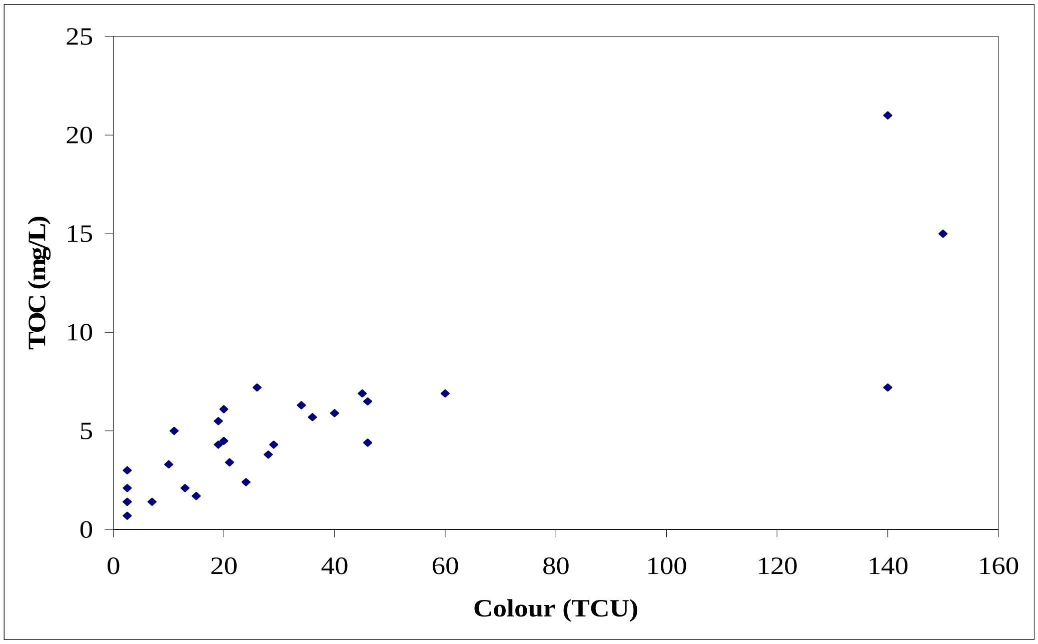

Figure 4.5: Correlation of TOC and Colour Readings from 29 Communities in Newfoundland and Labrador

In most of the communities sampled in the study, the colour reading in the tap water was correlated with the amount of TOC.

The effects of high concentrations of NOM on lead levels at the tap are not conclusive (Schock, 1996), likely because NOM itself is extremely heterogeneous in size and reactivity. Different NOM fractions may have different effects upon lead. One recent study found that NOM interfered with the formation of some insoluble lead products and contributed to increased levels of dissolved lead (Korshin et al., 2005). The same researchers had previously found similar results with brass fittings (Korshin et al., 2000). Another recent study found that NOM increased the release of lead from PbO_2 (Lin and Valentine, 2008), a solid present in lead pipes when free chlorine is used as a disinfectant (Schock, 2001; Renner, 2004). This was especially true at low pH.

The historical records of water quality provided by the Department of Environment and Conservation indicate that most of the communities that participated in this study have coloured water. 90th percentile lead concentrations in the various towns are compared to TOC levels from the RCAps conducted during the sampling program in Figures 4.6 below:

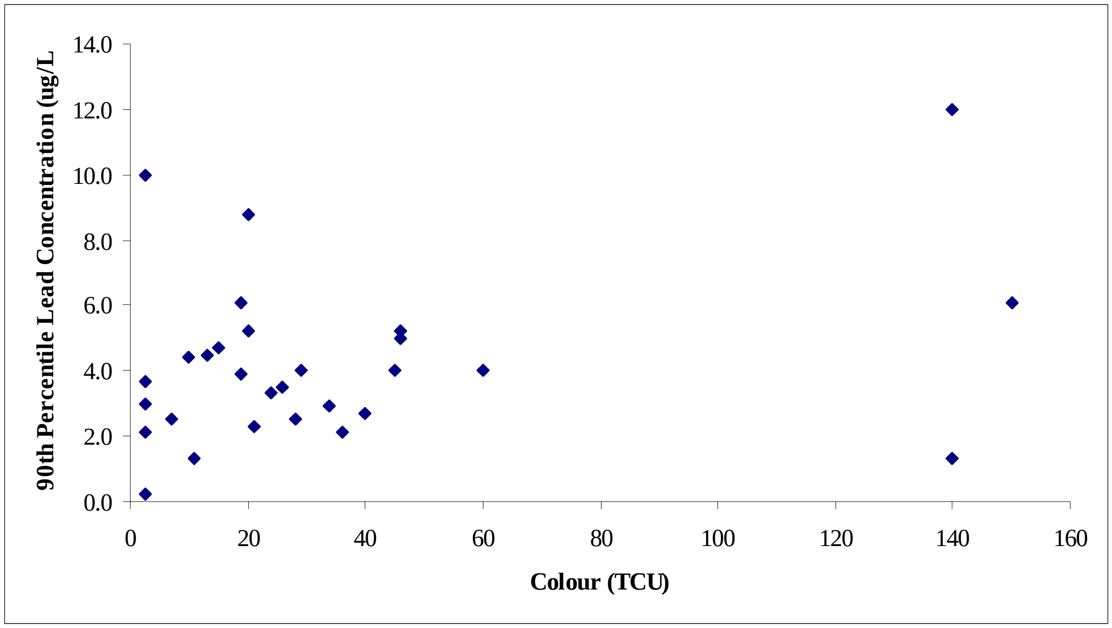

Figure 4.6: **90th Percentile Lead Concentration as a Function of TOC**

TOC level did not seem to be tightly correlated to the 90th percentile lead concentrations in the various towns. The town with the highest concentration of TOC also had a high average lead concentration, however, many towns with low levels of TOC also had high concentrations of lead.

Figure 4.7 shows the relationship between colour and the 90th percentile lead concentrations found in the various communities:

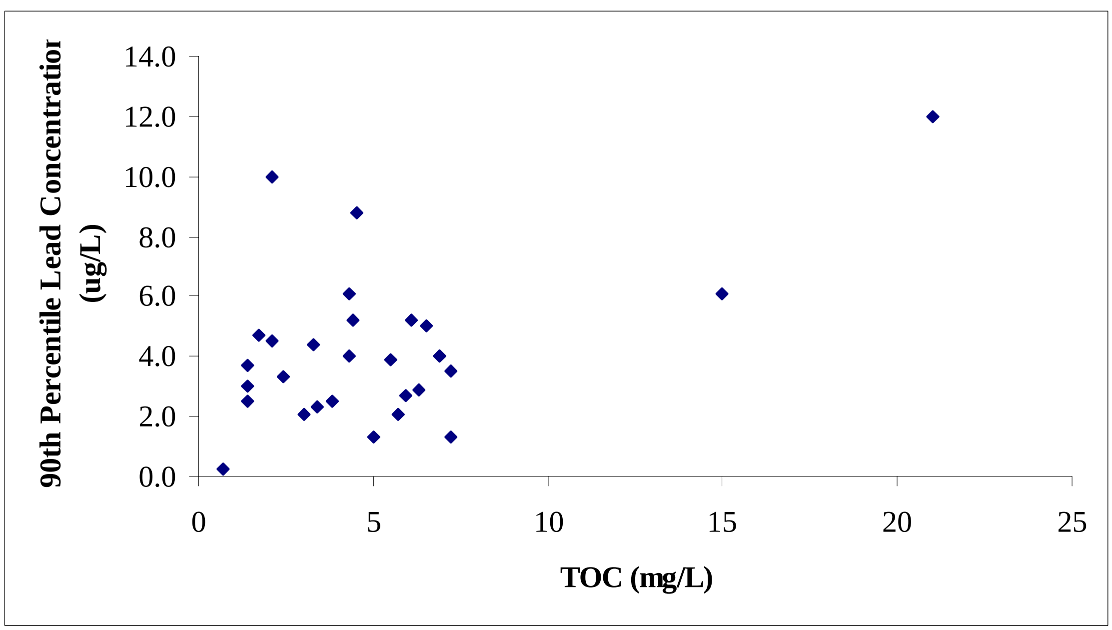

Figure 4.7: **90th Percentile Concentration of Lead in Tap Water as a Function of Colour**

Colour was also not correlated with the 90th percentile residential lead concentration.

Neither TOC or colour appeared to be correlated with elevated lead levels in the educational and health-care facilities.

Although high levels of NOM may have contributed to lead corrosion in some way or another in some towns, the relationship was not determined to be conclusive at the level of sampling and analysis completed in this study. Other water quality conditions that favour corrosion (low pH, low alkalinity) also favour high levels of colour and TOC, and likely contributed to the observed lead results.

Disinfection

The disinfection strategy used by a municipality can have an effect on the amount of lead that reaches the customer at the tap because disinfection has a strong impact on water chemistry. Figure 4.8 shows the relative distribution of disinfection strategies throughout the province:

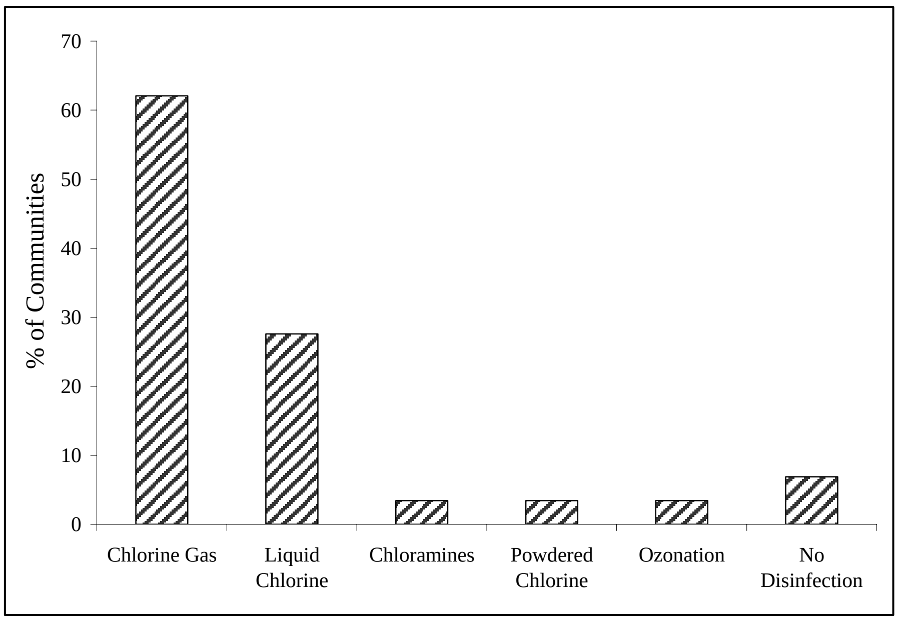

Figure 4.8: Self-reported Disinfection Strategies Used in Newfoundland and Labrador in the Winter of 2009

Most of the communities participating in this project use liquid or gaseous chlorine to disinfect their water. In both cases, this refers to free chlorine (Cl_2). The systems in the towns of Branch and La Scie do not have any form of disinfection. Researchers are somewhat at odds about the effects of chlorine disinfection on pipe corrosion.

The Big Bay Bulls WTP in St. John's uses chloramines in addition to chlorine disinfection. The switch from chlorine to chloramines has been implicated in increased concentrations of lead at the tap (Switzer et al., 2006). However, none of the buildings sampled in St. John's had lead levels above the guideline.

No link was found between the type of disinfection used in a municipality and the levels of lead present in the residential, educational or health-care buildings.

Temperature

The sampling program was conducted in January and February, the coldest months of the year. Lead concentration in tap water tends to be lowest in the winter and highest in the summer (Health Canada, 2007) because temperature augments many factors that can increase the release of lead from piping, solder and plumbing fixtures into drinking water. However, the relationships between these variables are complicated and the relationship is not as simple as might be assumed. For example, a recent survey of over 350 utilities in the United States did not find a definite link between temperature and lead levels (Dodrill and Edwards, 1995).

Lead levels may have been at their lowest point of the year during the sampling program as it was conducted in the coldest months of the year. There is a chance that a similar study conducted in the summer would find higher concentrations of lead present in the tap water. This is supported by the fact that in Ontario, some lead sampling programs are required to be conducted in the summer (MOE, 2002).

Water Quality Conclusions

Lead concentrations in the municipalities who participated in this project did not seem to be well correlated to the noted water quality parameters of the tap water. Many of the towns had water with similar characteristics, and those with higher lead concentrations didn't stand out strongly from the others. The towns with the most significant water quality issues in terms of high organic content and low LSI did tend to have more lead exceedances, but no one parameter seemed to control it. Water quality was judged by the historic record and the RCAp conducted on a water sample from the town during sample.

4.4 Corrosion Control

4.4.1 Corrosion Reports from Communities

Distribution Mains

The distribution mains in the 29 towns surveyed were not reported to contain lead piping (with the possible exceptions of St. John's and Corner Brook), therefore, it was not expected that corrosion in the water mains would lead to elevated lead concentrations at the tap. However, the towns where corrosion was common were more likely to have lead problems, likely because water that is corrosive enough to affect water mains will also affect in home plumbing and faucets. The following communities reported corrosion in the water distribution mains:

- Newman's Cove
- Port Blandford
- Fogo
- Gambo
- Gander
- Glovertown
- La Scie
- Rose Blanche
- St. Anthony
- St. George's
- Cartwright
- Churchill Falls

Three of these communities had buildings with tap water samples that exceeded the lead concentration limit of 10 µg/L: Fogo, La Scie and Churchill Falls. Two of these had 90th percentile lead concentrations above the limit (Fogo and Churchill Falls).

It is also expected that some communities where corrosion problems were not reported in the distribution system may in fact have undiscovered corrosion issues or did not feel the need to report known issues. This is based on the data showing similar water quality parameters across many communities as well as common distribution system pipe materials.

4.4.2 Other Corrosion

Staining

Red and green stains on sinks, faucets, tanks and clothing are frequently caused by iron and copper corrosion respectively within the water distribution system or in individual plumbing systems. The following communities had complaints about staining due to the water exiting the taps:

- Newman's Cove

- Fogo
- Glovertown
- St. George's

In all four cases, staining was noted at many different residences, therefore, the corrosion was likely occurring within the distribution system as opposed to being limited to within the plumbing systems at individual homes.

Copper and Iron Concentrations from RCAps

Copper and iron levels were measured as part of the standard RCAp. Corrosion in piping systems can result in increased levels of metals in the tap water which can result in staining. As mentioned previously, corrosion is often correlated with low pH. In Figure 4.9 the concentrations of iron and copper measured in the various towns in Newfoundland and Labrador are shown as a function of pH.

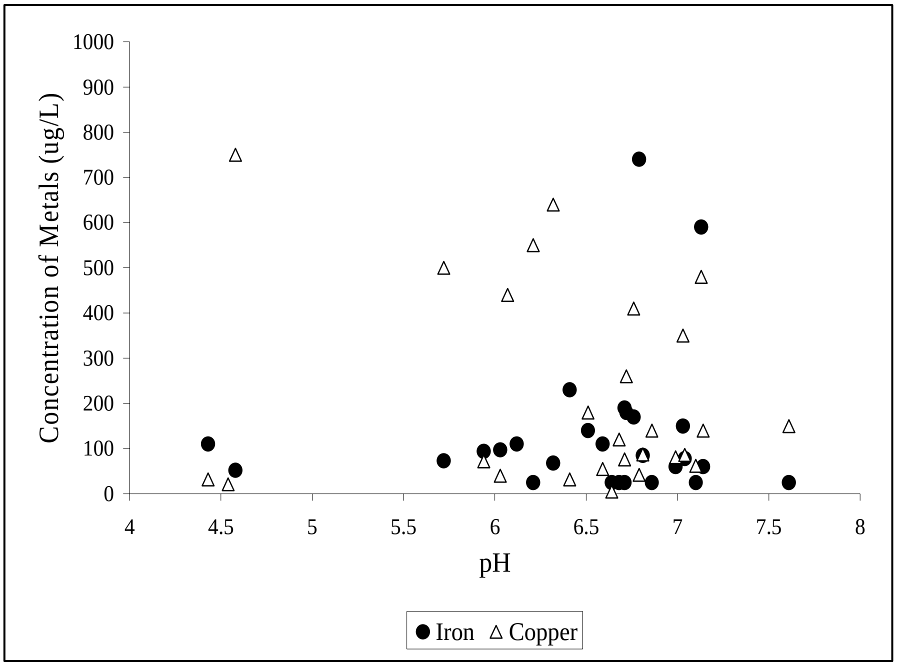

Figure 4.9: Iron and Copper Concentrations as a Function of pH

High concentrations of iron and copper were not well correlated with low pH during this study using water sampled after five minutes of flushing and thirty minutes of stagnation time. Experience has shown that prolonged stagnation time can increase corrosion (Wong and Berrang, 1976), therefore samples taken using a different method may have produced a different result.

4.5 Summary

Factors such as water quality, type of disinfectant used, distribution system materials, plumbing materials in the home, the methods of analysis and frequency of use of the plumbing system can all affect the amount of lead detected at the tap. In this study, most of the towns had corrosive water as defined by pH, alkalinity and traditional assessments of LSI and hardness. However, very few of them had buildings with lead concentrations above the 10 µg/L guideline. This may be as a result of the sampling or analysis methods used or other complex interactions between water quality, age of plumbing, system age and the scarcity of lead in the distribution systems investigated. The buildings that did have elevated lead levels were:

- Often in communities with particularly compromised water quality as measured by pH and organics;
- From buildings where lead solder was used;
- Often from unused or underused taps;
- In buildings built between 1955 and 1995;

Brass faucets and fixtures were not tracked during the study, but may also have been the cause of some of the lead present in the tap water.

Chapter 5 Conclusions

5.1 Summary of Key Findings

1. Lead levels met Health Canada (2007) guidelines in most of the 29 communities sampled during the study using the Second Level Lead Sampling Protocol, suggesting that elevated lead in tap water for taps that are used frequently is not a major issue in the communities that participated in the study.

2. Samples were taken in the winter when temperatures were very low. This may have affected the concentrations of lead measured in the tap water samples. Sampling in the summer may result in a greater number of lead exceedances.

3. Communities where lead concentrations frequently exceeded the guidelines also tended to have the worst tap water quality as determined by historic records and RCAps conducted on water samples collected during the sampling program.

4. No specific water quality parameter could be reliably linked to the high levels of lead although the following issues were apparent in the tap water of most of the communities where high lead levels were present in some samples:
    a. Low pH
    b. Low alkalinity and hardness
    c. High concentrations of organics (colour, TOC/DOC)

5. No evidence of lead piping was found; most distribution systems in Newfoundland and Labrador contain iron (ductile or cast) and PVC piping. Therefore, any lead in the tap water was not as a result of the materials used in the distribution system.

6. Most homes contained copper and PVC piping and many contained lead solder. The lead solder may have been the cause of some of the high lead readings.

7. Brass and chrome-plated brass faucets and fixtures have been linked with elevated lead concentrations in drinking water. Although no information on faucet type was collected during the sampling program, some evidence of zinc leaching into the system was found at one of the sample points where the lead level was above the guideline. Zinc in tap water is often a sign of brass corrosion and may indicate that the lead in the sample leached from a brass fitting, although this could not be absolutely confirmed.

5.2 Future Work

While the results of the current study do not suggest a widespread lead corrosion problem across the province there remain some significant unknowns which could be addressed through future work. Some components would require relatively low effort, while others would require larger changes across the province.

CBCL has developed the following recommendations which the DOEC could consider to ensure that the residents of Newfoundland and Labrador have access to safe drinking water with the lowest possible levels and lead corrosion by-products:

Contact and Inform Residents

The owners and residents of the buildings where high levels of lead (> 10 µg/L) were detected should be contacted as soon as possible and informed about the presence of lead in their drinking water. Particular recommendations can be provided to residents depending on the type of building they are using. This is of particular importance in locations where young children (< 6 years) or pregnant women may be consuming water from the municipal water distribution system (drinking or cooking). A list of residences, schools and health care facilities with lead readings above 10 µg/L can be found in Appendix C.

In its document ‘Response to Standard Exceedances of Lead in Drinking Water Supplies under O.Reg.170/03’, the Ontario Ministry of Health and Long Term Care recommends certain actions when lead levels above 10 µg/L are detected, an abridged version of these recommendations can be found below (Ministry of Health and Long Term Care, 2008):

Single Family Residences:

- Recommend cold water tap be flushed for five minutes any time water has not been used for longer than six hours
- Recommend that hot water from the tap not be used for drinking or cooking
- Children under six and pregnant women should use an alternate source of drinking water
- Consider installing tap/faucet mounted filters or filters installed in the plumbing (certified NSF/ANSI-53 for lead removal)
- Consider carrying out a plumbing assessment by a plumber or other water quality professional

Designated Facilities for Children (Other than those covered by O.Reg.243/07, i.e. Schools, Private Schools and Nurseries) :

- Recommend cold water tap be flushed for five minutes any time water has not been used for longer than six hours

- An alternate source of water should be used for drinking, preparing infant formula and reconstituting beverages
- Only cold water should be used for food preparation
- Consider installing tap/faucet mounted filters or filters installed in the plumbing (certified NSF/ANSI-53 for lead removal)
- Drinking water fountains should be taken out of service or fitted with lead removing filters as described in the previous bullet
- Consider carrying out a plumbing assessment by a plumber or other water quality professional

Public Facilities and Health Care Facilities:

- Recommend cold water tap be flushed for five minutes any time water has not been used for longer than six hours
- Consider installing tap/faucet mounted filters or filters installed in the plumbing (certified NSF/ANSI-53 for lead removal)
- Consider carrying out a plumbing assessment by a plumber or other water quality professional
- Special considerations may have to be taken when children use the facilities

Schools, private schools and nurseries are covered under the Safe Water Act of 2002, O.Reg. 243/07 (Province of Ontario, 2002) and have different sampling and maintenance requirements. School water systems are to be flushed weekly or daily depending on the age of the building (weekly – after 1990, daily – before 1990). Schools must be sampled annually for lead during the warmest portion of the year. Samples must be tested at an accredited laboratory and any exceedances must be communicated to the operator of the school, the medical officer and a variety of others. Corrective actions for lead exceedances in schools are recommended by the medical officer.

The government of Newfoundland should recommend that the actions described above be taken in residential, health-care and child-used buildings with lead exceedances. The province should also potentially consider creating regulations similar to those in Ontario to encourage regular lead testing and reporting in communities, and particularly schools around the province.

Focused Sampling and Data Collection

Re-sample and test all buildings (or communities) that had lead levels above 10 µg/L

- Inquire about the presence of brass fixtures and better document the condition and composition of the plumbing system.

- Test pH, lead, zinc, iron, copper or other corrosion byproducts at each site. Collect samples both before and after the stagnation period for the different metals.
- Record the temperature of the water
- Sample during the warmest months of the year
- Attempt to collect some samples at the First Action Level

These steps will help to determine the exact cause and extent of the high lead concentrations. Once the source is identified, steps can be taken to address it where possible. In most cases, high lead levels were not shown to be directly connected to measured water quality parameters or lead in the municipal distribution system. There remains however an abundance of unknowns with respect to whether pH varies from location to location within a community or whether RCAp results would vary between the before and after stagnation samples. It is also unknown what impact varying water temperature or increased stagnation times would have on the results.

Regulations in the Province of Ontario do not recommend re-sampling for lead except in cases where it is necessary to confirm prior test results or in order to detect the exact cause of lead. The definitive causes of the lead in the tap water at the various sample sites in this study are not known, therefore, re-sampling to pinpoint the exact source of the lead is recommended by CBCL Limited.

Establish Dedicated Residential Sample Sites
Develop and implement a system of sample sites and known water-sample volunteers who can be called upon for water testing initiatives.

- Provide an incentive for volunteers to take part (ex. subsidized water quality results)
- Volunteers could be trained to take samples or alternatively, they could wait for sampling technicians to arrive and simply make themselves/their homes available for the time required.

This type of program has been used successfully by other jurisdictions such as the USEPA for several years. Such a system would also allow collection of lead data at the First Action Level in a much more convenient manner. It generally requires a volunteer with a basic understanding of water supply and distribution and the ability to integrate new information about particular parameters into ongoing sampling programs.

Public Education and Lead Component Elimination
Begin a public information campaign about the leaching of lead from lead solder and brass fixtures. This could encourage proper flushing before consumption or the replacement of lead containing components from a home. Various incentives could be provided to help residents implement

changes. For example, the City of Hamilton, in Ontario, has a lead water service replacement program. When a lead service pipe is discovered, the City will pay for the replacement of the portion of pipe on City property and the owner is responsible for the cost of replacing the portion of pipe on their own property. However, the City has a program where residents can apply for loans to cover the cost of the pipe replacement on their own property if they cannot afford to do it. The loans are paid back through municipal taxes (City of Hamilton, 2009) over a number of years. A similar (but smaller scale) program may be helpful in eliminating any lead containing fixtures or solders that are currently contributing to high lead levels at the tap.

Water Treatment for Corrosion Control

Where elevated rates of corrosion indicate lead, copper, or other metal concentrations of concern a more complete assessment of the water supply and treatment system can be undertaken to determine where opportunity exists for the improvement of the corrosion issue specifically.

As described earlier in the report, the LSI method for prediction of lead corrosion is questionable. Further, the adjustment of pH with soda ash or even lime will not necessarily result in a treated water with stable pH. Experience across Atlantic Canada shows that the pH of low alkalinity water may not be stabilized by the addition of one pH adjustment chemical at the point of treatment.

Only the proper balancing of the carbonate system within a given water supply will produce completely stable pH readings and consequently assists with lowering rates of corrosion. This type of chemical adjustment is often complex and may include the addition of multiple chemicals to both increase and decrease the pH of the water. Such chemicals include soda ash, lime, carbon dioxide, calcium carbontate, caustic, and sulphate salts. This strategy, which is often based around producing a positive LSI is difficult to implement and operate, particularly at a small scale.

In light of this many smaller utilities have opted for a combined strategy of pH adjustment using the best means possible in conjunction with the addition of a sequestering corrosion inhibitor, usually a polyphosphate or orthopolyphosphate compound. These compounds react with the products of corrosion in the system to prevent them from dissolving into the water and ending up at the tap. Various forms of these chemicals are commercially available. In general, the treatment solution for corrosion control combines pH adjustment with a corrosion inhibitor but is only effective where the pH can be maintained at the setpoint. The USEPA *Revised Guidance Manual for Selecting Lead and Copper Control Strategies* (2003) provides a useful reference indicating the parameters of concern for corrosion control and the type of decision tree to follow given the water quality factors. For all systems examined in this study the suggested corrosion control would be pH adjustment combined with an inhibitor provided the pH can be stabilized at 7.2 – 7.8.

The implications of this recommendation are potentially the most onerous in terms of the ability of the communities in this study to practice a corrosion control program. Where pH adjustment is currently in place, it does not appear sufficient to maintain a pH to the consumer’s tap, and in other places disinfection is a priority over corrosion control. In many cases an active corrosion control program is a follow-up to more complete water treatment. Given the conditions and needs for water treatment across the province we acknowledge that a chemical corrosion control strategy is beyond the means of many communities but is encouraged in larger centres with proper treatment currently in place. Gander, Grand Falls, and the future Corner Brook Trout Pond WTPs are examples of this.

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Appendix A
Data CD

Appendix B
Community Files

Appendix C
Sample Locations of Concern

Appendix C

Sample Locations of Concern (Above 10 ug/L)

Residential

Community	Sample Tag	Lead Concentration	Possible Source
Brigus	R9	10 µg/L	Lead Solder
Ferryland	R9	41 µg/L	Lead Solder
Fogo	R3	11 µg/L	Lead Solder, Distance from Water Main, Water Quality
Fogo	R7	14 µg/L	Lead Solder, Water Quality
Fogo	R11	12 µg/L	Lead Solder, Water Quality
Fogo*	R5	9.8 µg/L	Lead Solder, Water Quality
Corner Brook	R2	12 µg/L	Lead Solder
La Scie	R3	21 µg/L	Lead Solder, Water Quality
Churchill Falls	R4	11 µg/L	Lead Solder
Churchill Falls	R5	10 µg/L	Lead Solder

Educational

Community	Sample Tag	Lead Concentration	Possible Source
Branch	S1	13 µg/L	Lead Solder, Water Quality, Rarely Used Tap
Labrador City	S2	18 µg/L	Age of Building, Distance from Water Main, Rarely Used Tap
Labrador City	S3	12 µg/L	Age of Building, Distance from Water Main, Rarely Used Tap

Health Care Facilities

Community	Sample Tag	Lead Concentration	Possible Source
Channel – PAB	H1	130 µg/L	Rarely Used Tap, Pipe Corrosion, Lead Solder, Distance from Water Main
Channel – PAB	H2	13 µg/L	Lead Solder, Rarely Used Tap, Distance from Water Main
Corner Brook	H3	17 µg/L	Rarely Used Tap, Distance from Water Main, Age of Building?